Damascus Citizens for Sustainability

Dangers of Vertical oil gas Wells - the 2010 Reports - part 3 of 3

Continuing the comment begun in Part 1, and continued in part 2, this part has the remaining 4 of the 8 Reports submitted by Damascus Citizens for Sustainability and Delaware RiverKeeper Network attached. They are important information and give reasons to stress that NO gas or oil drilling should be allowed in the Delaware Basin. The proposed prohibition of high volume hydraulic fracturing is good and should be adopted, but additionally all - even low volume and/or vertical wells should also be prohibited.

Harvey and some exhibits
Harvey balance of exhibits
Owens
Rubin
Teitelbaum

Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells

Report to:

Delaware Riverkeeper Network
and
Damascus Citizens for Sustainability, Inc.

Prepared by:

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November 15, 2010

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Contents

A. Executive Summary

This report responds to the Delaware Riverkeeper Network's (DRN) and Damascus Citizens for Sustainability's (DCS) request to provide expert review and opinion on the Delaware River Basin Commission's (DRBC) decision to exclude 11 Pennsylvania state permitted wells in Wayne County from DRBC review of exploration wells under its June 14, 2010 and July 23, 2010 Supplemental Determinations. The findings contained in this report are based on the material provided by DRN and DCS, as shown in the attached exhibits. The opinions stated here are stated to a reasonable degree of scientific and professional certainty.

This report provides my opinion in response to five (5) questions. Each question is responded to more fully in Sections D1 through D5 of this report. An executive summary of each response is provided below:

(1) Do the wells listed by DRBC as grandfathered wells meet DRBC's definition of an exploration well eligible for grandfathered status?

It is my opinion that the 11 wells listed by DRBC as grandfathered wells, covered under its June 14, 2010 and July 23, 2010 Supplemental Determinations, do not meet DRBC's definition of an exploration well eligible for grandfathered status. DRBC defined a grandfathered exploration well as a well intended solely for exploratory purposes and one that is plugged and capped at the conclusion of exploratory activities, without future use for production. No information was provided for my review to show that the grandfathered wells were drilled exclusively for exploratory purposes and will be permanently plugged and abandoned after the wells are drilled. None of the grandfathered well permits specify the completion method or the final disposition of the wells, nor were the 30 day well completion reports available. None of the grandfathered wells appear to have submitted a Notice of Intent by Well Operator to Plug a Well, and/or a Certificate of Well Plugging. Instead, several of the grandfathered well documents confirm alternative plans for these wells, including gas production. Approval of an exploration well destined for production is in essence production well approval.

Well density and drilling pace are strong indicators of well type. True exploration wells are drilled on large spacing intervals to test hydrocarbon trap theories. The pace is slower than production well drilling, so data from preceding exploration wells can be used to avoid the economic risk of drilling several dry-holes in rapid succession. The density and pace of some of the grandfathered wells, especially Newfield's wells, are inconsistent with exploration well classification.

Most companies have exploration departments that are separate and distinct from production drilling departments. Exploration departments typically have higher levels of data security, dedicated exploratory budgets, and staff that specialize in finding new hydrocarbon sources. Very small companies may combine exploration and production drilling staff, however, funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well and whether the well was planned to be a test well only, destined for plugging and abandonment.

(2) Do exploration wells pose lower risk than production wells?

It is my opinion that exploration wells are riskier than production wells, because drilling hazards are unknown. The risk of a well blowout or well control situation occurring is higher due to the increased difficulty in designing and constructing a well based on unknown data. DRBC's decision to forego

regulation of the grandfathered wells, because they are "exploration wells" and thereby "lower risk," is inconsistent with the known higher risk profile for an exploration well. The risk of an exploration well blowout is approximately 7 wells in every 1000 drilled.

True exploration wells, by definition, explore into previously unknown and unmapped hydrocarbon formations; therefore, an exploration well drilling Operator must be prepared to encounter both oil and gas. The grandfathered wells should have been equipped to deal with either a gas and/or oil well blowout. While an exploration well Operator may target gas, as is the stated intent in these grandfathered wells, it cannot rule out the potential to encounter oil enroute to the gas target, or instead of hitting a gas target. In a true exploration well, the type of hydrocarbons, depth of burial and whether they are present in commercial quantities are all unknown.

There was no material provided for my review to show that the risk of drilling an exploration well in the Delaware River Basin is less than that of a production well, nor that the possibility of oil being encountered during exploration drilling can be completely ruled out.

(3) Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

It is my opinion that DRBC's decision to forego regulation of the grandfathered wells resulted in increased risk to water quality and water resources of the Delaware River Basin. This increased risk was created by:

- not stipulating additional site-specific mitigation measures to reduce environmental impacts above the minimum statewide standards required by PADEP to protect the waters of the Delaware River Basin;
- allowing wells to be drilled and sited in environmentally sensitive areas within the Delaware River Basin without adequate DRBC siting review;
- not requiring appropriate setbacks from sensitive locations; and
- creating a situation whereby an exploration well must be drilled and plugged (even if successful), such that drilling impacts are duplicated when a production well is re-drilled at the same or another location at a later date.

The DRBC's definition of an exploration well is inconsistent with industry practice. It is industry practice to convert successful exploration wells into production wells, if commercial quantities of hydrocarbons are found. DRBC's decision to forego review of the grandfathered wells if they are drilled solely to collect data, and then immediately plugged and abandoned, could result in two wells being drilled in the same area (first the exploration well and then later a production well). Drilling a well twice results in economic waste and increased impacts to air, land and water in the Delaware River Basin. Instead, the DRBC should have reviewed each exploration well to ensure it was properly sited and environmental impacts were mitigated. In this way, if Operators make a commercial find, DRBC would have already ensured the well was positioned at a low impact surface location and was drilled using the lowest impact methods. It is important to properly site and assess the impacts of any proposed exploration well in as much detail as is necessary for a production well, because a successful exploration well is in essence the first production well in the field.

DRBC should carefully examine the grandfathered wells that have been drilled to determine if they were properly sited and completed using technically sound well construction practices. Wells that were not properly sited or constructed should be plugged and abandoned.

DRBC grandfathered 11 wells based on economic and risk considerations, with no publicly available economic or risk assessments to support this decision. This decision appears to conflict with DRBC's mission to protect water resources in the Delaware River Basin. There is no evidence that the permit applications for each of the grandfathered wells confirm that they are in fact shale gas "exploration" wells or that the risk of these wells to the Delaware River Basin is low.

(4) Are there sufficient plans and protections included in PADEP's approval to mitigate and respond to the risks associated with exploration wells?

It is my opinion that the Pennsylvania Department of Environmental Protection (PADEP) permit materials and Preparedness, Prevention and Contingency Plans (PPC) provided for my review do not include sufficient plans and protections to mitigate and respond to the risks associated with exploration wells.

There are a number of risks posed by exploration wells, including air, water and land pollution, resulting from fuel and chemical spills, stray gas, well blowouts, water use, waste disposal, and other aspects of drilling operations. The most significant and potentially catastrophic risk of those listed is an uncontrolled blowout. An uncontrolled blowout must be considered when planning an exploration well. There is insufficient evidence to show that the grandfathered exploration wells are equipped to deal with either a gas and/or oil well blowout. Well permit applications filed with PADEP for the grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.

While blowouts are very infrequent, they do occur, and are a reasonably foreseeable consequence of exploratory drilling operations. Blowouts can last for days, weeks, or months until well control is finally achieved. The most common method, and best technology, to control an on-land blowout is well capping, requiring large volumes of water to deluge the rig, allowing well control experts to work near a blowout. Water requirements can range from 500,000 to 6,000,000 gallons of water per day. Well control experts also use foam and dry chemicals to respond to blowouts. Deluge operations create large pools of water on the surface that drain away from the well blowout. This can transport oil, chemicals, fuels, and any other materials released during a blowout toward lower elevation drainage areas.

Newfield's PPC for the proposed Newfield grandfathered wells does not meet PADEP's requirements; the adequacy of the other grandfathered wells' PPCs is not known, because they were not provided for review. Exploration well operations require fuel to operate drilling and completion equipment, and the process of drilling a well requires numerous chemicals. Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies or water resources. However, Newfield's PPC lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists.

The PPC Plans provided for my review did not adequately identify the environmentally sensitive areas within the Delaware River Basin that should be protected during exploration drilling, and did not include adequate tactics and strategies to protect those areas.

Pennsylvania only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator. Neither amount would provide sufficient funds to control, clean up,

and/or remediate the damage caused by a well blowout, chemical spill or large fuel spill from an exploration well operation.

(5) Was DRBC's assumption the risk of the grandfathered wells was small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well-founded?

It is my opinion that DRBC's assumption that the risks associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania is not well founded for the following reasons:

- PADEP's existing Chapter 78 Oil and Gas Well Regulations are known to be deficient;
- Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania;
- PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells;
- Fracture treatment operations are planned for the B&E well;
- Drilling waste can result in environmental harm if not properly managed, and some waste has already been buried on-site and not transported out of the Basin;
- Stray gas migration associated with oil and gas wells can impact water supplies, if wells are not properly constructed and operated;
- PADEP's well siting criteria allows wells to be placed very close to water resources; and
- Air pollution impacts, and corresponding impacts to water resources, are not well understood or mitigated.

B. Introduction

This report responds to the Delaware Riverkeeper Network's (DRN) and Damascus Citizens for Sustainability's (DCS) request to provide expert review and opinion on the Delaware River Basin Commission's (DRBC's) decision to exclude 11 Pennsylvania state permitted wells in Wayne County from DRBC review of exploration wells under its June 14, 2010 and July 23, 2010 Supplemental Determinations. The opinions stated here are stated to a reasonable degree of scientific and professional certainty.

C. DRBC's Contested Decisions and Chronology

On May 19, 2009, the DRBC issued a "Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 1**), directing natural gas extraction projects located in shale formations within the drainage area of Special Protection Waters to obtain DRBC approval for:

> *"…the drilling pad upon which a well intended for eventual production is located, all appurtenant facilities and activities related thereto and all locations of water withdrawals used or to be used to supply water to the project.*"

The May 19, 2009 determination exempted "wells intended solely for exploratory purposes."

On May 5, 2010, the DRBC issued a decision to finalize natural gas regulations before considering project approvals (**Exhibit 2**).

On June 14, 2010, the DRBC issued a "Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 3**), directing **all** natural gas extraction projects located in shale formations within the drainage area of Special Protection Waters to obtain DRBC approval. This determination withdrew the May 19, 2009 decision to exclude exploration wells. The DRBC wanted to remove:

> *"…any regulatory incentive for project sponsors to classify their wells as exploratory wells and install them without Commission review before the Commission's natural gas regulations are in place*."

However, the DRBC decided that:

> *"…where entities have invested in exploration well projects in reliance on [the] May 2009 Determination and information from staff, there are countervailing considerations that favor allowing these projects to move ahead*."

The DRBC determined that:

> *"[i]n contrast to the thousands of wells projected to be installed in the Basin over the next several years, the risk to Basin waters posed by only the wells approved by PADEP since May are comparatively small. Not only are these wells subject to state regulation as to their construction and operation, but they continue to require Commission approval before they can be fractured or otherwise modified for natural gas production*."

In other words, the DRBC determined that any exploration well that obtained a state natural gas well permit on or before June 14, 2010 was grandfathered, meaning DRBC review and approval was not required.

According to the DRBC's June 14, 2010 decision, there were no permits issued by the New York State Department of Environmental Conservation as of June 14, 2010, but there were a "limited" number of permits issued by the Pennsylvania Department of Environmental Protection (PADEP). The number and name of the PADEP permits issued were not listed in the DRBC decision. Later a spreadsheet was provided by DRBC listing the wells that DRBC thought qualified for "grandfather" status. According to the DRBC spreadsheet, 13 wells were approved by PADEP prior to June 14, 2010 (**Exhibit 4 and 4A**).

The notes that accompany DRBC's spreadsheet (**Exhibit 4**) state that three (3) wells of these 13 wells are not pertinent to the issue of grandfathered wells, because two wells were already drilled (Matoushek #1 OG Well, Stone Energy Corp and Robson 627528 #1 OG Well, Chesapeake Appalachia LLC) and the DL Teeple #1-2H OG Well, Newfield Appalachia PA LLC was designed as a horizontal well and does not meet the exploration well criteria. This left 10 wells subject to the June 14, 2010 grandfather provision.

1. HL Rutledge #1-1 OG well, Newfield Appalachia PA LLC, April 29, 2010, ("**Rutledge**");
2. VE Crum #1-1 OG Well, Newfield Appalachia PA LLC, April 30, 2010, ("**Crum**");
3. EM Schweighofer #1-1 OG Well, Newfield Appalachia PA LLC, May 7, 2010, ("**Schweighofer**");
4. Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, May 27, 2010, ("**Woodland**");
5. DL Teeple #1-1 OG Well, Newfield Appalachia PA LLC, April 23, 2010, ("**Teeple**");
6. Stockport Assn 1; Pennswood Oil & Gas LLC, July 22, 2009, ("**Stockport**");
7. Preston 38 LLC OG Well; Pennswood Oil & Gas LLC, July 22, 2009,("**Preston**");
8. Geuther #1 OG Well, Stone Energy Corp, April 28, 2008, ("**Geuther**");
9. Cabot #2 OG Well, Arbor Operating, LLC, April 13, 2010, ("**Cabot**"); and,
10. B&E Well #1 OG Well; Schrader Kevin E, March 5, 2009, ("**B&E**").

On July 23, 2010, the DRBC issued an "Amendment to Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 5**), allowing two additional Hess Corporation wells to be drilled that had not yet received PADEP permits, but had obtained Pennsylvania Erosion and Sediment Control General Permits (ESCGP-1). Hess argued that because these wells were in the final PADEP permit approval process, the wells represented a level of investment equivalent to the natural gas exploratory wells that were grandfathered by the DRBC June 14, 2010 decision. DRBC based its decision on economics and the need to obtain scientific data from the two exploration wells to plan future wells in the Delaware River Basin. DRBC noted in its decision that none of the other grandfathered wells had obtained Pennsylvania Erosion and Sediment Control General Permits, because the well pads fell below the five-acre threshold. Therefore, a total of 12 wells were grandfathered by DRBC, including:

11. Davidson 1V Well; Hess Corporation, July 13, 2010, ("**Davidson**"); and
12. Hammond 1V Well; Hess Corporation, July 20, 2010, ("**Hammond**").

On October 14, 2010, Arbor Operating, LLC withdrew its Cabot well permit (**Exhibit 6**), leaving 11 grandfathered wells that remain at issue in the Hearing.

According to DRBC's records, as of mid-October 2010, three (3) of the 11 grandfathered wells have been drilled:

1. Crum well (**Exhibit 7 and 7A**)[1];
2. Woodland well (**Exhibit 8 and 8A**)[2];
3. Teeple well (**Exhibit 9 and 9A**)[3];

[1] VE Crum# 1-1 OG Well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.
[2] Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.

As of mid-October, DRBC reports that eight (8) of the 11 grandfathered wells have not been drilled, but work has commenced on some wells, as noted below:

4. Rutledge well (**Exhibit 10 and 10A**)[4] – pad construction completed;
5. Schweighofer well (**Exhibit 11 and 11A**)[5];
6. Stockport well (**Exhibit 12**)[6];
7. Preston well (**Exhibit 13**)[7];
8. Geuther well (**Exhibit 14**)[8];
9. B&E well (**Exhibit 15**)[9];
10. Davidson well (**Exhibit 16**)[10] – site preparation underway; and
11. Hammond well (**Exhibit 17**)[11] – site preparation underway.

The Matoushek and Robson wells were drilled prior to the grandfathering decision. DRBC's information on these wells shows that the Matoushek well was "TAed" (presumably the code for temporary abandonment) and the Robson well was "PAed" (plugged and abandoned). Materials were provided for review on both the:

- Matoushek #1 OG Well, Stone Energy Corp, March 14, 2008, (**Exhibit 18 and 18A**)[12] ("**Matoushek**"); and,
- Robson #1 OG Well, Chesapeake Appalachia LLC, February 26, 2009, (**Exhibit 19**), ("**Robson**").

DRN explained that the DL Teeple #1-2H OG well application was determined to be a production well, and is pending DRBC production well review; therefore, it is not a grandfathered exploration well.

- DL Teeple #1-2H OG Well, Newfield Appalachia PA LLC, May 25, 2010, (**Exhibit 20**) [13], ("**Teeple 2H**").

D. Questions Responded to in this Report

This report provides my expert opinion on five (5) questions:

[3] Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, provided by DRN on October 23, 2010.
[4] HL Rutledge #1-1 OG well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.
[5] EM Schweighofer #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, provided by DRN on October 23, 2010.
[6] PADEP eFacts Information on Stockport Assn#1 well, retrieved October 23, 2010.
[7] PADEP eFacts Information on Preston 38 LLC OG Well, retrieved October 23, 2010.
[8] Geuther # 1 OG Well, Stone Energy Corp, permit documents, provided by DRN on October 20, 2010, only including two pages of the PADEP well permit application.
[9] B&E Wells #1 OG Well; Schrader Kevin E, permit documents, provided by DRN on October 20, 2010.
[10] Map of Davidson 1V Well Site.
[11] **Exhibit 17** is a map of the well location only. As of October 23, 2010 DRN confirmed that only E&S permits had been obtained for this well.
[12] Matoushek #1 OG Well, Stone Energy Corp, permit documents, provided by DRN on October 20, 2010.
[13] Robson 627528 1 OG Well, Chesapeake Appalachia LLC, permit documents, provided by DRN on October 23, 2010.

D.1 Do the wells listed by DRBC as grandfathered wells meet DRBC's definition of an exploration well eligible for grandfathered status?

D.2 Do exploration wells pose lower risk than production wells?

D.3 Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

D.4 Are there sufficient plans and protections included in PADEP's approval to mitigate and respond to the risk associated with exploration wells?

D.5 Was DRBC's assumption that the risk associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well founded?

D.1 Do the Grandfathered Wells Meet the Definition of Exploration Well?

The DRBC does not define the term "exploration well" in its regulations,[14] but uses the term "exploratory well" in its decisions to make a distinction between "exploration" and wells used for "production." DRBC clarified its definition of an exploration well in a May 19, 2009 news release that stated:

> *"Wells intended solely for exploratory purposes are not covered by this determination.* ***An exploratory well is one that the project sponsor intends to plug and cap at the conclusion of exploratory activities without use for production or fracking*** *[emphasis added]."* [15]

Later in August 2009, the DRBC wrote Arbor Operating, LLC regarding its Cabot #2 well further affirming that its exploration well definition included the requirement to be drilling the well "solely" for exploration purposes and the requirement for a "cap and plug plan."

> *"As Arbor has stated that they* ***propose to develop the well if a viable quantity of natural gas is discovered,*** *the* ***well is not therefore being drilled solely for exploratory purposes*** *and is again covered under the Executive Director's Determination. The well may not be covered under the determination* ***if a cap and plug plan is submitted to the Commission*** *and* ***it is affirmed that the well will be properly abandoned upon completion and collection of necessary exploratory data*** *[emphasis added]."*[16]

The Pennsylvania Code does not make a distinction between exploration and production wells. The Pennsylvania Code requires an Operator to obtain a permit for a well, but does not make a distinction between an exploration well and a production well for purposes of that application.[17] The Pennsylvania Code does define a Marcellus Shale Well as:

> *"A well that when drilled or altered produces gas or is anticipated to produce gas from the Marcellus Shale geologic formation*." [18]

[14] For example, DRBC, Ground Water Protected Area Regulations for Southeastern Pennsylvania, 1999.
[15] DRBC May 19, 2009 Press Release, "DRBC Eliminates Review Thresholds for Gas Extraction Projects in Shale Formations in Delaware's Basin's Special Protection Waters, (**Exhibit 26**).
[16] DRBC letter to Arbor Operating LLC, August 4, 2009, (**Exhibit 25**).
[17] 25 Pa.Code 78.11 Permit Requirements
[18] 25 Pa.Code 78.1 Definitions

The Pennsylvania Oil and Gas Act defines an "operating well" as any well not plugged and abandoned. Because there do not appear to be any plug and abandonment plans (P&A) for the grandfathered wells, these wells are "operating wells" under the Pennsylvania Oil and Gas Act.

The US Securities and Exchange Commission (SEC) governs oil and gas reserve reporting in the US. The SEC defines an exploratory well as:

> *"An exploratory well is a well drilled to find a new field or to find a new reservoir in a field previously found to be productive of oil or gas in another reservoir. Generally, **an exploratory well** is any well that **is not a development well, an extension well, a service well, or a stratigraphic test well** as those items are defined in this section [emphasis added]."*[19]

The SEC defines stratigraphic test wells as those wells that collect geologic data such as coring and expendable exploration holes, but this definition does not customarily include wells being drilled for hydrocarbon production:

> *"Stratigraphic test well is a drilling effort, geologically directed, to obtain information pertaining to a specific geologic condition. **Such wells customarily are drilled without the intent of being completed for hydrocarbon production**. The classification also includes tests identified as core tests and all types of expendable holes related to hydrocarbon exploration. **Stratigraphic tests are classified as ''exploratory type'' if not drilled in a known area or ''development type'' if drilled in a known area**.*[20]

The SEC also requires Operators to disclose the number of net productive and dry exploration wells drilled.[21] Therefore the Operator must identify the type of well that is being drilled as exploration or production for federal reporting purposes.

Therefore, both the DRBC definition and SEC definition of exploration well make it very clear that an exploration well is not a production well. The DRBC takes its exploratory well definition one step further by clearly articulating that an exploration well drilled in the Delaware River Basin, under grandfathered status, must be plugged and capped.

If DRBC's definition of an exploration well is applied to each of the 11 wells listed by DRBC as grandfathered, none of these wells would qualify as true "exploration wells" because none appear to be drilled "solely for exploration" and none appear to have a plug and cap plan.

For the three (3) wells already drilled (Crum, Woodland, and Teeple #1), there were no Well Records or Completion Reports[22] provided for my review to show the final well disposition, no Application for Inactive Well Status,[23] no Notice of Intent by Well Operator to Plug a Well,[24] and no Certificate of Well Plugging.[25] If those records exist they should be obtained and provided for review.

[19] 17 CFR Parts 210.4-10(a)(13); (**Exhibit 24**)
[20] 17 CFR Parts 210.4-10(a)(30); (**Exhibit 24**)
[21] 17 CFR Part 229.1205; (**Exhibit 25**)
[22] PADEP Form 5500-FM-0G0001
[23] PADEP Form 5500-FM-0G0056.
[24] PADEP Form 5500-FM-OG0005 or 5500-FM-OG0005A
[25] PADEP Form 5500-FM-0G0006.

For the remaining eight (8) wells that have not yet been drilled (Rutledge, Schweighofer, Stockport, Preston, Geuther, B&E, Davidson, and Hammond), there is no Notice of Intent by Well Operator to Plug a Well.[26] If these records exist they should be disclosed.

Absent documentation showing intent to plug the well, the well applications and supporting materials provided for my review were examined for Operator intent.

Newfield Appalachia PA, LLC is the Operator for a majority of the grandfathered wells. Newfield's permit application materials propose to explore for natural gas in the Marcellus Shale in Wayne County. Yet, the application also includes well **production** activities under the umbrella of exploration operations. Newfield's Preparedness, Prevention and Contingency (PPC) Plan states:

> *"Newfield Appalachia PA, LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will **involve natural gas exploration** of the Marcellus Shale formation, **which will include** site preparation, drilling and **well development and production activities** [emphasis added]."* [27]

Exploration and Production (E&P) operations are two separate and distinct activities. Production operations do not fall under exploration. The manner in which Newfield has blurred the line between exploration and production operations supports a reasonable assumption that their intent is to convert successful exploration wells into production wells. Unless Newfield submitted Notices of Intent to plug the grandfathered wells, Newfield's wells do not meet DRBC's definition of exploration wells.

April 1, 2010 letters from Newfield to PADEP explained the purpose of two wells, Teeple #1[28] and Schweighofer.[29] The same language was used in both letters:

> *"This permit [D.L. Teeple Well #1-1] is to develop a well which is **intended solely for exploration purposes**. A core is to be taken from several formations throughout the drilling process of this well and additional scientific study is to be performed on multiple formations including, but not limited to, geophysical logs, micro-seismic studies and fluid sampling. As permitted and configured, this well is not to be complete for production, not to be hydraulically fractured and is not to produce gas. **In the future, this wellbore will either** be plugged and abandoned per PADEP regulations, converted to inactive status and utilized as a monitoring well, **or reconfigured and converted to a production well**. Prior to either plugging and abandonment, conversion to inactive status **or reconfiguration and conversion to production**, we acknowledge that additional permitting will be necessary with approvals from the PADEP and other regulatory bodies with jurisdiction [emphasis added]."*

Both of Newfield's letters start off by stating that the Teeple #1 and Schweighofer wells are intended only for exploration purposes, yet leave the future utilization of the wells open, with a possibility to convert each well to a production well. Therefore, approval of these wells is de facto approval of production wells in the same location, because Newfield has not met DRBC's definition of an exploration well.

[26] PADEP Form 5500-FM-OG0005 or 5500-FM-OG0005A
[27] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency (PPC) Plan, May 2010, submitted with all its grandfathered wells.
[28] Newfield Appalachia PA, LLC, letter to PADEP, April 1, 2010 regarding D.L. Teeple Well #1-1, in **Exhibit 9**.
[29] Newfield Appalachia PA, LLC, letter to PADEP, April 1, 2010 regarding EM Schweighofer Well #1-1, in **Exhibit 11**.

Based on the data provided for my review, it is unclear how DRBC decided to include the 11 wells in its spreadsheet as grandfathered exploration wells (**Exhibit 4**), especially when these wells do not meet DRBC's own definition for an exploration well.

It is also unclear why DRBC included the Stockport and Preston wells in the list of grandfathered wells, because the renewal applications for the Stockport and Preston wells were not submitted until after June 14, 2010, and the renewal permits were not approved until July 20, 2010.[30] In other words, the currently approved permits were approved by PADEP after the June 14, 2010 DRBC cut-off date for grandfathered wells.

The main difference between an exploration well and a production well is that exploratory drilling, by definition, seeks to locate unknown subsurface hydrocarbons to determine if they exist and can be produced in commercial quantities. Most companies have exploration departments that are separate and distinct from production drilling departments. Exploration departments typically have higher levels of data security, designated exploratory budgets, and dedicated staff that specialize in finding new hydrocarbon sources. Very small companies may combine exploration and production drilling staff, however, funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well. Additionally, as explained above, the Operator also has to designate the exploration well type and track findings in its SEC reporting. The organizational structure of each company, funding documents for each well, and any SEC reporting data that has been developed were not available for review.

Exploration wells are typically drilled on low density spacing to cover large areas, especially when drilled by a single Operator. True exploration wells test geologic hydrocarbon trap theories, attempting to locate hydrocarbons that have been trapped in commercial quantities. Typically a team of geologists, geophysicists and reservoir engineers select an exploration well location based on seismic data, geologic information in the region, offset well data and other information that may be available. Financially it is too risky for a single Operator to drill multiple exploration wells in rapid succession in a small area, testing the same hydrocarbon trap theory. Typically, a single Operator would spread its exploration budget and risk, testing several hydrocarbon trap theories in different exploration areas and carefully examining the data from each exploration well to determine if an additional well in that same geologic trend is a worthwhile investment. Data collected from one exploration well is used to pin-point future exploratory well targets. A successful exploration well in one area may lead to a recommendation for subsequent appraisal wells around the original exploration well to further delineate the size of a hydrocarbon reservoir, so that engineers can properly size surface production facilities and pipeline needs. Later, production wells are drilled on a more dense spacing around the successful exploration wells.

Newfield received permits for five (5) wells in a 6 by 10 mile area. This is unusually dense spacing for a single Operator to be drilling exploratory wells in rapid succession, with little or no opportunity to inform future exploration well locations (**Exhibit 29** provides a map showing the well density). The pace of Newfield's drilling program strongly indicates that several of these wells are akin to production wells, rather than true exploration wells.

[30] The original permits expired in July 2010. The July 20, 2010 permit renewal post-dates the June 14, 2010 grandfather cut-off date (**Exhibits 12 and 13**). The original Stockport and Preston well applications were approved by PADEP prior to June 14, 2010 but the Operator Pennswood Oil & Gas LLC did not act on either well.

Findings:

- DRBC defined a grandfathered exploration well as a well intended solely for exploratory purposes and one that is plugged and capped at the conclusion of exploratory activities without future use for production.
- No information was provided for my review to show that the grandfathered wells will be permanently plugged and abandoned after the wells are drilled.
- The grandfathered well permits do not specify the completion method, and the 30 day completion reports showing the final disposition of each well were not available for review.
- A Notice of Intent by Well Operator to Plug a Well and/or a Certificate of Well Plugging do not appear to have been submitted for any of the grandfathered wells.
- Absent any new data showing that the Operators of the "grandfathered" wells listed in Exhibit 4 provided clear written evidence that they meet DRBC's exploration well standard, these wells do not meet DRBC's grandfathered exploration well definition.
- Newfield's application data and supporting information confirms it has alternative plans for these wells, including gas production.
- Newfield's 2010 PPC Plan shows clear intent to produce successful exploration wells. Approval of an exploration well destined for production is in essence production well approval.
- The Stockport and Preston well permits were renewed July 20, 2010, after the cut-off date for grandfathered wells.
- Well density and drilling pace are strong indicators of well type. The density and pace of some of the exploration wells, especially Newfield's wells, are inconsistent with exploration well classification.
- Funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well. Funding documents have not been available for review.

D.2 Do Exploration Wells Pose a Lower Risk Than Production Wells?

Exploration wells are riskier than production wells because factors such as pressures, temperatures and drilling hazards are not known or are uncertain. On average 7 out of every 1000 onshore exploration wells will result in a blowout. [31,32] Blowouts can eject drilling mud, gas, oil and/or formation water from the well and onto waters and lands adjacent to the well, within the radius of the blowout plume. Depending on the reservoir pressure, blowout circumstances, and wind speed these pollutants can be distributed hundreds to thousands of feet away from the well.[33] Pollutants that reach a water systems can be carried

[31] Rana, S., Environmental Risks- Oil and Gas Operations Reducing Compliance Cost Using Smarter Technologies, Society of Petroleum Engineering Paper 121595-MS, Asia Pacific Health, Safety, Security and Environment Conference, 4-6 August 2009, Jakarta, Indonesia, 2009.
[32] Rana, S., Facts and Data on Environmental Risks- Oil and Gas Drilling Operations, Society of Petroleum Engineering Paper 114993, October 2008.
[33] S.L. Ross Environmental Research Limited, Oil Deposition Modeling For Surface Oil Well Blowouts, 1998.

downstream and contaminate even larger areas. Pollutants that reach lands can migrate into groundwater resources.

The lack of information available to an exploration well driller increases the risk profile of a well. Exploration well design and planning is more difficult and typically requires more materials to be brought to the site, to deal with unknown pressures, depths, temperatures, casing needs, cementing needs, drilling mud needs, and other unknowns. Proper engineering design of drilling fluid and blowout preventer systems is critical to reducing the risk of a blowout. The inability to accurately predict pressures in an exploration well requires that mud and blowout prevention systems be designed with an adequate safety factor, to ensure unexpected pressures can be controlled while drilling.

> *"The uncontrolled eruption of a well is one of the most critical accidents that can occur both during exploration and exploitation of hydrocarbon fields. Significant HSE [health, safety and environmental] issues are associated to this event that introduces safety risks for the field operators, potential health injury for the population living in the area and impacts, mainly associated to the hydrocarbon contamination, on the environment."*[34]

Because true exploration wells, by definition, are exploring into previously unknown and unmapped hydrocarbon formations, an exploration Operator must be prepared to encounter both oil and gas. While an exploration Operator may seek gas, as is the stated intent in these grandfathered wells, it cannot rule out the potential to encounter oil enroute to the gas target, or instead of hitting a gas target. Exploration in other areas of Pennsylvania has resulted in finds of both oil and gas, therefore this is a reasonable assumption, unless the Operator has information to prove that no oil exists from offset well data. In that case, if there is sufficient information to rule out the presence of oil, there is likely sufficient information to make the case that the well is not a true exploration well.

In both Pennsylvania[35] and New York[36]oil has been found in the Upper Devonian Formations above the Marcellus Shale Therefore, the grandfathered exploration wells should have been equipped with detailed plans to prevent and respond to a gas and/or oil well blowout.

> *"Oil deposition in the area surrounding a blowout is one of the most visible consequences of the loss of control over well flow. Less visible, but equally serious, are the short- to medium-term effects of oil coverage on the environment… Apart from the* ***direct damage to*** *capital goods, crops, and* ***water basins*** *and the cost of subsequent cleanup operations, there are medium- to long-term effects, such as reduced tree growth over a period of many years following the incident…Hence, oil fallout, in the case of loss of well control, is a factor to be taken into account in decisions on well locations, emergency procedures, contingency planning, etc.* ***This requires an estimate of the area around the well likely to be affected by oil fallout, given the geomorphology of the terrain, prevailing winds, and expected outflow*** *conditions [emphasis added]."*[37]

[34] Blotto, P., ENI- Exploration & Production, Development of an Integrated Approach to the Risk Analysis of a Blow-out Accident, Society of Petroleum Engineers Paper 86704-MS, SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 29-31 March 2004, Calgary, Alberta, Canada, 2004.
[35] Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Geology, Vol 29, No.1, Spring 1998.
[36] New York State, Draft Supplemental Generic Environmental Impact Statement (DSGEIS) on the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, September 2009, Figure 4.2.
[37] Oudeman, P., Shell International E&P, Oil Fallout in the Vicinity of An Onshore Blowout: Observations on A Field Case, Society of Petroleum Engineers, Facilities & Construction Journal, Volume 1, Number 4, December 2006.

The Woodland, Teeple and Crum wells are all located very near designated High Quality tributaries of the Delaware River. For example, the Woodland well, is adjacent to Hollister Creek and is less than half a mile from the Delaware River itself. Hollister Creek flows into the River approximately 0.7 mile above a colony of Dwarf Wedge Mussels, a federally protected endangered species. Teeple is located adjacent to Shehawken/Rattlesnake Creek, and is approximately two miles from the River. The location of these wells in such sensitive areas increases the harms that might flow from these risks should a blowout occur. Instead, the surface location for these wells should have been sited in less sensitive locations with careful evaluation and planning.

DRBC's decision to forego regulation of these exploration wells because they are "lower risk" is inconsistent with the known higher risk profile for an exploration well. There was no data provided for this review to show that DRBC supported its lower risk finding with a written technical document.

Findings:

- Exploration wells are riskier than production wells, because drilling hazards are unknown. The risk of a well blowout or well control situation occurring is higher due to the increased difficulty in designing and constructing a well based on unknown data.
- DRBC's decision to forego regulation of these exploration wells because they are "lower risk" is inconsistent with the known higher risk profile for an exploration well.
- The grandfathered exploration wells should have been equipped to deal with a gas and/or oil well blowout.

D.3 Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

DRBC's primary responsibility is to protect water resources in the Delaware River Basin. DRBC reports to the public that its mission is one of: "providing comprehensive watershed management; acting as a steward of the Basin's water resources particularly with respect to: surface water quality, including both point and nonpoint sources of pollution; ground and surface water quantity, including water demands, water withdrawals, water allocations, water conservation, and protected areas; drought management; and in-stream flow management; promoting effective inter-agency coordination to prevent duplication of efforts and seeking increased public involvement" (**Exhibit 22**).[38]

Shale gas drilling operations use water and create wastewater. The amount of water that is used and waste that is generated depends on the well construction technique used, the depth of the well, formations encountered while drilling, well control incidents and other factors.

This report does not examine the exact amounts of water use or waste from a shale gas well drilling operation because **DRBC determined that all shale gas wells, regardless of water use or waste amounts, are subject to DRBC review**. However, Chesapeake Energy reports that a Marcellus Shale gas well can require 100,000 gallons[39] of water to drill a well, even if fracturing operations are not planned. This water is used for mixing cement, drilling mud, dust control and other routine uses.

[38] DRBC Vision Statement, http://www.state.nj.us/drbc/vision.htm, retrieved October 24, 2010.
[39] Chesapeake Energy, Water Use in Marcellus Deep Shale Gas Exploration, March 2010 (**Exhibit 31**).

On June 14, 2010, DRBC determined that all shale gas wells, regardless of water use or waste amounts, are subject to DRBC review. The DRBC issued a "Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 3**), eliminating any water or wastewater threshold for DRBC review of shale gas extraction projects, and requiring all shale gas wells to obtain DRBC review.

> *In my Determination of May 2009, I exercised the authority conferred on the Executive Director by section 2.3.5 B.18 of the Commission's Rules of Practice and Procedure (RPP) by directing* ***all sponsors of natural gas extraction projects in shale formations within the drainage area of Special Protection Waters to obtain Commission approval*** *before commencing such projects,* ***notwithstanding that the thresholds for review established by the RPP were not exceeded*** *[emphasis added].*

DRBC's decision to eliminate any review threshold was reconfirmed in a January 19, 2010 DRBC Presentation (**Exhibit 21**)[40] that stated:

> ***Natural gas well activities*** *(NGWA)* ***[are] covered regardless of DRBC thresholds*** *in RPP[41] and Water Code [emphasis added].*[42]

In this finding, DRBC concluded that shale gas well drilling warranted DRBC review; it did not provide any technical or scientific support for exempting review of the grandfathered shale gas wells, except to say companies would suffer economic harm if the projects were delayed, and the risk was "comparatively small."[43] DRBC reasoned that the number of grandfathered wells constituted a small risk compared to the thousands of wells projected to be installed in the Basin over the next several years.

There does not appear to be any written economic assessment supporting the claim that the grandfathered well Operators would suffer economic harm or weighing the economic harm against the potential harm to the watershed from the proposed drilling operations.

There does not appear to be any written risk assessment to support the claim that the risk of drilling the grandfathered wells was small. Likewise, there does not appear to be any evidence to show that the 11 wells listed in DRBC's spreadsheet of "grandfathered wells" (**Exhibit 4**) meet DRBC's definition of an "**exploration**" well.

Exploration wells that find commercial hydrocarbons are typically converted into the first production wells of a commercial hydrocarbon reservoir development, once surface production facilities are installed. Additionally PADEP has no requirement to plug and abandon successful exploration wells.

DRBC's definition for an exploration well, which requires the well to be solely used for exploration data gathering and immediately plugged and abandoned, (per the May 2009 EDD and accompanying press release), does not reflect typical industry practice or state approval processes. Furthermore, DRBC's decision to allow unregulated drilling impacts in sensitive watershed areas sets an unfavorable precedent

[40] Muszynski, W.J., DRBC Manager Water Resources Management Branch, Presentation, DRBC Engagement in Natural Gas Exploration and Development, Marcellus Shale Meeting, January 19, 2010.
[41] DRBC's Rules of Practice and Procedure (RPP), Section 2.3.5.B.6.
[42] DRBC's Water Code Section 3.40.
[43] DRBC, Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters, June 14, 2010.

by potentially doubling drilling impacts. There will be the initial impacts of the exploration well drilling, followed by repeated impacts when a production well is drilled to replace the plugged exploration well.

The more prudent approach would be for DRBC to review exploration wells to ensure they are properly sited, drilled, completed, tested, and suspended, using the best well construction and environmental practices, for potential later conversion to a production well.

The conversion of properly sited and robustly constructed exploration wells to production wells ensures the well is placed in the lowest environmental impact area, and eliminates the environmental impact of drilling a well into the same hydrocarbon target twice. For these reasons, it is important to properly site and assess the impacts of proposed exploration wells in as much detail as is needed for production wells. A successful exploration well is in essence the first production well in the field.

There are limited cases where exploration wells are drilled solely to obtain subsurface data (e.g. cores, well logs, drill stem tests), and in these cases the well is immediately and permanently plugged and abandoned after drilling. This approach is not common. Most Operators will convert a successful exploration well to a production well, unless there are unique circumstances preventing this from occurring. It is not economically attractive for an Operator to drill a well twice.

When an exploration well is destined to be a production well, it is cased and completed with production tubing and a producing wellhead. The well permits for the 11 grandfathered wells do not specify the completion method or the final disposition of the wells and the required 30 day well completion reports were not available for my review.

Findings:

- DRBC grandfathered wells based on economic and risk considerations, without the Operators providing any apparent written economic or risk assessments to support this decision, nor any analysis showing that these considerations trump DRBC's watershed protection obligations.
- There does not appear to be any evidence to show that the permit applications for each of the grandfathered wells are in fact shale gas "exploration" wells.
- DRBC's decision to forego regulation of the grandfathered wells resulted in greater harm to the Delaware River Basin. This harm was created by: allowing wells to be drilled without evaluating whether they are sited in environmentally sensitive areas within the Delaware River Basin; not requiring appropriate setbacks from sensitive locations; and creating a situation whereby an exploration well must be drilled and plugged (even if successful), such that drilling impacts are duplicated when a production well is re-drilled at the same or another location at a later date.
- The DRBC's definition of an exploration well is inconsistent with industry practice, because it is industry practice to convert successful exploration wells into production wells, if commercial quantities of hydrocarbons are found.
- DRBC's decision to forego review of the grandfathered wells, if they are drilled solely to collect data and immediately plugged and abandoned, does not provide the opportunity for DRBC to mitigate the impacts of exploratory operations on the Delaware River Basin. This decision also results in economic waste and creates increased impacts, by requiring successful wells to be drilled twice.

- DRBC should have reviewed each exploration well to ensure it was properly sited and environmental impacts were mitigated. In this way, if Operators make a commercial find, DRBC would have already ensured the well was positioned at a low impact surface location.
- It is important to properly site and assess the impacts of any proposed exploration well in as much detail as is necessary for a production well, because a successful exploration well is in essence the first production well in the field.

D.4 Are There Sufficient Plans and Protections Included in PADEP's Approval to Mitigate and Respond to the Risks Associated with an Exploration Well?

There are a number of risks posed by exploration wells, including air, water and land pollution, resulting from fuel and chemical spills, stray gas migration, well blowouts, water use, waste disposal, and other aspects of drilling operations. One of the most significant and potentially catastrophic risks posed by drilling is an uncontrolled blowout.

An uncontrolled blowout must be considered when planning an exploration well. The grandfathered wells should have been equipped to deal with a gas and/or oil well blowout. Well blowouts can release substantial amounts of oil, gas, drilling mud, and formation water, resulting in significant environmental damage to the surrounding air, water and land. Methods to control a well blowout can require significant water withdrawals and can create large volumes of waste. Well permit applications filed with the PADEP for these grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.

The Pennsylvania Oil & Gas Act at § 601.209 requires a drilling Operator to use safety devices[44] and the 25 PA Code § 78.72 requires the use of blowout prevention equipment and trained personnel. The PA Code focuses on the testing and inspection of blowout preventers, and requires at least one person certified in well control to be on the drill floor. However, neither Pennsylvania law nor regulation requires Operators to demonstrate that they have the expertise, equipment and capability to actually control a blowout and minimize environmental damage, if one occurs.

While Pennsylvania currently requires a Pollution Prevention and Contingency (PPC) Plan to be submitted as part of a drilling application, that plan is inadequate for response to a blowout. PADEP's PCC Guidance[45] (**Exhibit 27**) does not specifically require a well control plan, a written well control barrier policy, a well blowout response plan, or well control experts on contract. This is in sharp contrast to other state and federal agencies, which do currently require response plans to deal with a worst-case blowout scenario. Additionally, the World Bank's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development recommend comprehensive blowout planning, training and equipment as well as blowout modeling to ensure a well blowout plume radius is understood.[46]

To compound the problem, the Pennsylvania Oil & Gas Act at § 601.215 only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator. Neither

[44] Section 601.209 requires: "Any person engaged in drilling any oil or gas well shall equip the well with casings of sufficient strength and with such other safety devices, as may be necessary in a manner as prescribed by regulation of the department, and shall use every effort and endeavor effectively to prevent blowouts, explosions and fires."
[45] PADEP's PCC Guidance Document 400-220-001.
[46] World Bank's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development, 2007.

amount would provide sufficient funds to control, clean up and/or remediate the damage caused by a well blowout. Nor would $2,500 go very far to meet PADEP's stated uses for the bond which is to:

> *…act as a penalty for failure to comply with the drilling, water supply replacement, restoration and plugging requirements of the Act.*[47]

Blowout response and control plans should not only include methods for controlling the well, but identify environmentally sensitive areas, and list tactics and strategies for protecting those areas during a response. For example, a plan should provide for special protection of waters in the Delaware River Basin. Absent these plans, the Delaware River Basin is at increased risk in the event of an uncontrolled blowout.

Newfield's PPC lists the potential for a fire or explosion from its well drilling operations,[48] but provides no blowout prevention or response plan to address an oil and /or gas well blowout, if it were to occur. Newfield's PPC provides no information on blowout preventer sizing, testing methods, or maintenance programs; it provides no information on methods to control a blowout or tactics, strategies or equipment to respond to a blowout.

By comparison, other state and federal agencies require much more detailed Preparedness, Prevention and Contingency Plans, defining the worst-case blowout scenario, a well control response plan, and well control experts and equipment. Most companies have a separate written well control and blowout response plan that is referenced as part of their emergency plan, but there is no evidence of such a plan in the Newfield PPC. The PPCs from other companies with grandfathered wells were not available for review.

A well-thought-out, written blowout prevention and response plan, with trained and experienced drilling staff able to rapidly identify well control problems and control them, has proven critical in reducing the number and severity of well control incidents across the US. Additionally, plans should be in place to immediately access well control experts and equipment, preferably staging well control equipment nearby, in the event a well control situation exceeds a drilling company's capacity or expertise. Access to well control experts is especially critical for small companies that may have little or no well control experience.

While, PADEP has made some attempt at improving Pennsylvania's blowout control capability by partnering with CUDD Well Control to locate a new facility in Canton Township in Bradford County in response to "recent high-profile accidents at nature gas wells in Pennsylvania"[49] the type of equipment located in Pennsylvania is still insufficient to cap a well. Equipment at CUDD's new Bradford County facility will include: a 2,000-gallon-per-minute pump; heat shields; pneumatic cutting devices; trained crews, and a "hot tap," but does not include an athey wagon or a well capping stack. An athey wagon and well capping stack are both large and critical pieces of equipment used in well control. Because this equipment must still be brought in from the Gulf of Mexico, Houston, Canada or Alaska, places where much of the North America well control equipment is located, this will delay well control, increasing a blowout's impacts.

The potential spill volume from a blowout is equal to the volume of the reservoir contents (gas, oil, and/or formation water) that can flow to the surface, plus the discharge of the drilling mud that is in the hole at

[47] PADEP, Oil and Gas Manual, Chapter 3, October 2001.
[48] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.
[49] PADEP, DEP Says Specialized Natural Gas Emergency Responders Locating in PA, Improving Response Times, PADEP News Bureau Press Release, August 9, 2010.

the time of a blowout. Hydrocarbon reservoirs can contain large quantities of gas, oil and/or formation water, which could continue to be released into the environment until the well naturally bridges on its own (e.g. plugged with sand or debris), is controlled by human/mechanical intervention (e.g. well capping, drilling a relief well, well ignition), or the subsurface reservoir pressure finally drops to a level that the well stops flowing. While blowouts are very infrequent, they do occur, and are a reasonably foreseeable consequence of exploratory drilling operations. Blowouts can last for days, weeks, or months until well control is finally achieved. A blowout in the Delaware River Basin could have significant and irreversible environmental impacts.

The most common method, and best technology, to control an on-land blowout is typically well capping. However, well ignition or drilling a relief well could be alternatives. Well capping requires large volumes of water to allow well control experts to work near the fire with dozers, wagons, and well capping equipment. Water requirements to cap a well depend greatly on the nature of the well blowout, and whether it has ignited.

Surface (lakes, rivers and streams) or subsurface (water wells) water supplies may be tapped to draw the large volumes of water needed for well capping operations, or water may be trucked in, if no nearby surface water or supply well is available. Well control experts use high volume pumps to deluge the rig. Well control experts recommend water supply sourcing and deluging equipment be incorporated in drilling plans. Water requirements can range from 9 barrels of water per minute (9 bpm) [50] to upwards of 100 bpm.[51] This equates to 500,000 to 6,000,000 gallons of water per day, with the average blowout taking days to weeks to control. Deluge operations create large pools of water on the surface that drain away from the well blowout. Deluge fluids can transport oil, chemicals, fuels, and other materials released during the blowout toward lower elevation drainage areas.

Well control experts also use foam and dry chemicals to respond to blowouts. John Wright Co., a well control expert company, explains:

> *Foam consists of water, foam concentrate and air. It is used on liquid hydrocarbon fires to smother the fuel surface (excludes oxygen), suppress vapor emissions (explosive vapor release is restricted), generate steam (removes heat and displaces oxygen), cool surface (heat absorption) and reflect radiant heat. Use on blowouts is restricted to gas condensate fires and oil wells where lateral flow has led to a large fire surface area. Foam can help contain fire near the source and allow work near the flow source. Generally, water alone is adequate for this, but with large, low velocity, lateral oil flow, foam may be required. Modern firefighting foam such as 3M Lightwater ATC is commonly used… Nozzles are available to handle up to 6,000 gpm, but the 2,000-bpm nozzle is most used on oil well fires. Dry chemical extinguishers work like water, but principally act as a smothering agent. Common compounds used are sodium bicarbonate, Purple K (potassium bicarbonate base) and Monnex (highest efficiency rating). Use is generally on methane well fires where explosives cannot be used and water supply is inadequate.*[52]

Additionally, deliberate well ignition or spontaneous combustion can result in large amounts of local air pollution, which can distribute particulate matter and other airborne combustion materials that will eventually deposit on downstream waters, and lands.

[50] John Wright Co., well control expert, http://www.jwco.com/technical-litterature/p09.htm, and (**Exhibit 28**)
[51] Grace, R. d., Blowout and Well Control Handbook, Gulf Professional Publishing, 2003.
[52] John Wright Co., well control expert, http://www.jwco.com/technical-litterature/p09.htm, and (**Exhibit 28**)

PADEP's PPC Guidance[53] (**Exhibit 27**) does require a PPC to include: maps showing the well site layout, boundaries, storage locations, high risk areas, drainage, and topography; location of stored chemicals at wellsite; drawings and plot plans showing sources and quantities of materials and wastes; specific countermeasures to be taken in the event of a spill, including strategies and tactics for responders to follow to contain and control the spill to prevent it reaching water sources, or environmentally sensitive areas; inspection and monitoring programs; security plans; and external factor planning. Yet, many PPCs in Pennsylvania that I have reviewed[54] do not include these components in practice. PADEP has on occasion required PPC Plans to be revised after large spills to remedy plan deficiencies, but this is of little assistance for the damaged environment, especially damaged water resources that are not easily remediated. A more thorough review of these plans prior to drilling is needed to ensure that they are adequate.

For example,[55] Newfield's May 2010 PPC (the only PPC available for this review) did not include many of the elements required by PADEP's PPC Guidance Document 400-220-001. These required elements are critical to preventing and responding to spills in areas and waters of concern to DRBC. Missing plan elements include:

- Drawings showing high-risk areas where spills and leaks most likely would occur;
- Drawings showing drains, pipes, and channels that lead away from potential leak or spill areas;
- Drawings showing outfall pipes that discharge to surface streams or drainage channels;
- Locations of surface drainage courses leading away from the site, and major surface streams and tributaries near the site;
- Locations of any known public and private surface water intakes downstream from the site;
- Descriptions of any existing plans previously developed for the project for the purpose of pollution incident prevention or emergency response preparedness;
- Descriptions of the sources and areas where potential spills and leaks may occur, the direction of flow of spilled materials, and the pollution incident prevention practices specific to the source or area;
- Separate drawings, showing sources and quantities of materials and wastes, sources and areas where potential spills may occur, and pollution incident prevention practices, including a prediction of the direction of the flow of materials spilled as a result of equipment failure, accident, or human error;
- Summary of the engineering practices followed with regard to material compatibility, such as the materials of tanks, piping and other equipment, including their contents and the reaction of materials or wastes when intentionally or inadvertently mixed or combined;
- Summary of the compatibility of a container such as a storage tank or pipeline with its environment;
- A preventive maintenance program for equipment and systems relating to conditions that could cause environmental degradation or endangerment of public health and safety;

[53] PADEP's PCC Guidance Document 400-220-001.
[54] In 2010, I completed a technical review of the Atlas Energy Inc., Cabot Oil & Gas Corporation, EOG Resources, Inc., Newfield Appalachia, and Range Resources PPC, none of which met the PADEP PPC guidelines requirements.
[55] Additional information on the other grandfathered wells PPC plans would be needed to determine the adequacy of the other plans.

- Detailed explanation of the employee training program to ensure that personnel are able to respond effectively to emergencies, by familiarizing them with emergency procedures and emergency equipment systems, including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for automatic cut-off systems; communications and alarm systems; response to fires and explosions; site evacuation procedures; and shut down of operations procedures;
- Specific countermeasures which will be undertaken by facility personnel in the event of a release, including: valve activations, equipment isolations, flow diversions, boom deployment, and any other activities that will be undertaken to halt the migration of the contaminant off site and to mitigate the consequences of the release;
- A summary of the services of nearby contractors and pre-made arrangements for contractual services on short notice. (PADEP requires equipment suppliers to be contacted to determine the availability and delivery means of equipment needed for removing pollution or hazards to public health and safety).
- A list of available emergency equipment.[56] The list should include the location, a physical description, and a description of the intended use and capabilities of each item on the list. All installations should have equipment available to allow personnel to respond safely and quickly to emergency situations. Some examples of emergency equipment are portable fire extinguishers, fire control equipment (including special extinguishing equipment such as that using foam, inert gas, or dry chemicals), spill control equipment, decontamination equipment, self-contained breathing apparatus, gas masks, and emergency tool and patching kits.

Both exploration and production well operations require fuel to operate drilling and completion equipment and the process of drilling a well requires chemicals. Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies, or water resources.[57] Newfield's PPCP states:

> *"**For large spills or spills of oils or hazardous materials which may reach surface water or impact the environment**, the employee who first discovers the spill should contact the Emergency Coordinator [emphasis added]."*[58]

TABLE 4

On-Site Emergency Response Equipment

On-Site Emergency Response Equipment
Fire Extinguishers
Tyvek Suits
Nitrile Gloves
Hearing Protection
Particulate Adsorbent
Absorbent Pads
Shovels
Earth Moving Equipment
Decontamination Equipment

Yet Newfield's PPC lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists. Newfield's onsite resources are listed in Table 4[59] as shown to the right.

[56] Newfield's PPC lists spill response equipment but the type and amount is insufficient, and there is no explanation of its intended use or capability as required.
[57] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, included in **Exhibit 7**.
[58] http://www.epa.gov/radiation/tenorm/oilandgas.html#disposalpast.
[59] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.

Newfield's PPC, at Table 1, shown below, provides a list of materials that it plans to use at its exploratory drilling operations. This list shows there is a potential for hazardous materials to spill, including fuels, lubricants, drilling mud, and cement additives. To minimize environmental hazards, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability, and bioaccumulation potential. There is no indication in the PPC that this work was completed.

The list provided by Newfield does not make a distinction between exploration or production drilling operations. And, Newfield's PPC does not contain sufficient information to verify whether it has trained and qualified staff able to respond to the potential fuel and chemical spills it lists in Table 1 of its PPC Plan.

TABLE 1

LIST OF MATERIALS & WASTES

CONSTUCTION

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	250 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	180 gallons	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

DRILLING

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	2000 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	320 gallons	Well Pad	Sorbent pads; shovels/Gang box
DURATONE HT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
GELTONE V	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Lime	7,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Base Fluid	300 bbl	Well Pad	Sorbent pads; shovels/Gang box
Rig Wash	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Calcium Chloride (CaCl-)	4,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
RHEMOD L	1,770 lbs	Well Pad	Sorbent pads; shovels/Gang box
LE SUPERMUL	8,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
BARACARB 25, 50 (2 pallets each)	12,600 lbs	Well Pad	Sorbent pads; shovels/Gang box
WALNUT	2,400 lbs	Well Pad	Sorbent pads; shovels/Gang box
DRILTREAT	1,900 lbs	Well Pad	Sorbent pads; shovels/Gang box
Liquid Mud	1,500 bbl	Well Pad	Sorbent pads; shovels/Gang box
BAROID REGULAR / **BAROID BULK (barite)	125,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Drill Cuttings	100,000 lbs	Air Pit	Sorbent pads; shovels/Gang box
Cement	130,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

Findings:

- An uncontrolled blowout is a catastrophic risk, but one that must be considered when planning an exploration well. The grandfathered wells should have been equipped to deal with a gas and/or oil well blowout.
- Well blowouts and spills can release substantial amounts of oil, gas, drilling mud, and formation water, resulting in significant environmental damage to the surrounding air, water, and land.
- Well permit applications filed with the PADEP for these grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.
- Pennsylvania requires a Preparedness, Prevention and Contingency (PPC) Plan but that plan does not require a written blowout control plan. Nor does the plan require evidence of trained and qualified personnel to respond to well control situations or evidence of contracts with experts to control well blowouts. In contrast, other state and federal agencies require response plans to deal with worst-case blowout scenarios.
- Pennsylvania only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator; neither amount would provide sufficient funds to control, clean up and/or remediate the damage caused by a well blowout.
- There are inadequate plans in place to identify environmentally sensitive areas, such as special protection waters of the Delaware River Basin. Tactics and strategies for protecting those areas during a spill response are also inadequate.
- The most common method, and best technology, to control an on-land blowout is typically well capping. Well capping requires large volumes of water to allow well control experts to work near the blowout. Water requirements can range from 500,000 to 6,000,000 gallons per day. Deluge operations create large pools of water on the surface that drain away from the well blowout. This water can transport oil, chemicals, fuels, and any other materials released during the blowout toward lower elevation drainage areas.
- Exploration well operations require fuel to operate drilling and completion equipment and the process of drilling a well requires chemicals.
- Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies, or water resources; yet lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists.

D.5 Was DRBC's assumption that the risk associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well-founded?

DRBC's assumption that the risk associated with grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania is not well founded for the following reasons:

- PADEP's Chapter 78 Oil and Gas Well Regulations are known to be deficient;
- Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania;
- PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells;
- Fracture treatment operations are planned for the B&E well;
- Drilling waste can result in environmental harm if not properly managed, and some drilling waste has already been buried on-site and not transported out of the Basin;
- Stray gas migration associated with oil and gas wells can impact water supplies, if wells are not properly constructed and operated;
- PADEP's well siting criteria allows wells to be placed very close to water resources; and
- Air pollution impacts are not well understood or mitigated.

D.5.1 PADEP's Chapter 78 Oil and Gas Well Regulations are known to be deficient

DRBC's June 14, 2010 decision to grandfather wells was based, in part, on the "existing safeguards" offered by PADEP permits issued under Chapter 78. DRBC concluded:

> *In contrast to the thousands of wells projected to be installed in the Basin over the next several years, **the risk to Basin waters posed by only the wells approved by PADEP since May 2009 are comparatively small**. **Not only are these wells subject to state regulation as to their construction and operation**, but they continue to require Commission approval before they can be fractured or otherwise modified for natural gas production. **In light of these existing safeguards** and the investment-backed expectations of the sponsors of these projects, this Supplemental Determination does not prohibit any exploratory natural gas well project from proceeding if the applicant has obtained a state natural gas well permit for the project on or before the date of issuance set forth below [emphasis added].*[60]

Yet PADEP's current regulatory initiative to substantially revise the Pennsylvania regulations at 25 PA Code Ch. 78 (Chapter 78) for Oil and Gas Wells is evidence that Pennsylvania itself acknowledges that the existing Chapter 78 regulations are not currently reflective of best practices, and do not go far enough to protect human health and the environment, especially for sensitive resources.

[60] DRBC, Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters, June 14, 2010 (**Exhibit 3**).

The majority of PADEP's well construction and water supply replacement regulations were promulgated in July 1989 and remained largely unchanged until PADEP proposed revisions to Chapter 78 in 2009. Therefore, Pennsylvania's existing well construction standards are more than 20 years old and do not reflect best technology or practice. Several of the grandfathered wells have already been constructed using these out-dated rules.

PADEP summarizes the problems with the existing Chapter 78 regulations:

> *Many of the regulations governing well construction and water supply replacement were promulgated in July 1989 and remained largely unchanged until this rulemaking. Since that time, recent advances in drilling technology have attracted interest in producing natural gas from the Marcellus Shale, a rock formation that underlies approximately two-thirds of Pennsylvania. New well drilling and completion practices now employed to extract natural gas from the Marcellus Shale and other similar shale formations in Pennsylvania, as well as* ***several recent incidents of contaminated drinking water caused by traditional and Marcellus Shale wells resulted in the Department's decision to re-evaluate the existing well construction requirements.***
>
> ***It was determined that the existing regulations were not specific enough in detailing the Department's expectations of a properly cased and cemented well****, especially in light of the new techniques used by Marcellus Shale operators. The Department also determined that the* ***existing regulations did not address the need for an immediate response by operators to a gas migration complaint and did not require routine inspection of existing wells by the operator***
>
> *The final rulemaking contains* ***revised design, construction, operational, monitoring, plugging, water supply replacement, and hydraulic fracturing reporting requirements****. The final rulemaking also provides material specifications and performance testing to ensure the proper casing, cementing and operation of a well. Additionally, the final rulemaking contains new provisions that require routine inspection of wells and outline the actions an operator and the Department must take in the event of a gas migration incident [emphasis added].*[61]

Therefore, DRBC's lack of review of the grandfathered exploratory wells, as well as any other drilling that DRBC allows before the new PADEP Chapter 78 regulations are in place, will allow the current well construction deficiencies, known to be a problem in Pennsylvania, to be repeated in the DRBC watershed.

In 2009 PADEP proposed numerous revisions to Chapter 78 and sought industry and public comment to improve the regulations consistent with PADEP's stated goals of: minimizing public concerns associated with gas migration into public drinking water supplies; updating material specifications and performance testing requirements; and revising design, construction, operations, monitoring, plugging, water supply replacement, and gas migration reporting requirements.

The fact that Pennsylvania has acknowledged deficiencies in its own regulations, and the fact that the current, unimproved Chapter 78 regulations were used as criteria for review and approval of the grandfathered wells is evidence that the grandfathered wells do not have sufficient protections in place.

PADEP received more than 2,000 comments from industry and the public recommending Chapter 78 improvements, including comments written by HCLLC (**Exhibit 23)**.[62] PADEP has developed final

[61] PADEP Notice of Final Rulemaking, Department of Environmental Protection Environmental Quality Board, 25 Pa. Code, Chapter 78 Oil and Gas Well Cementing and Casing, 2010 (**Exhibit 30A**).
[62] Harvey Consulting, LLC, Recommendations for Pennsylvania's Proposed Changes to Oil and Gas Well Construction Regulations, Report to Earthjustice and Sierra Club, March 2010.

revisions to Chapter 78 (**Exhibit 30 and 30A**), but these changes will not be codified until early 2011. Chapter 78 regulatory changes still must undergo review by the Independent Regulatory Review Commission (planned for November 18, 2010) and then must be published in the *Pennsylvania Bulletin* as final rulemaking (planned for early 2011). [63]

Proposed Chapter 78 improvements that do not apply to the grandfathered wells include:

- Additional protections for water supplies (§ 78.51) including improvements to restoration or replacement of impaired water supplies due to oil and gas well operations;
- Additional requirements for waste control and disposal plans (§ 78.55);
- Improved instructions on when a blowout preventer and other well control safety control devices are required (§ 78.72);
- Improved well construction and operational standards (§ 78.73), including standards to ensure that: oil, brine, completion and well servicing fluids do not pollute groundwater; annular overpressuring does not cause gas migration into subsurface water supplies; and gas is safely flared, captured or diverted during well drilling operations;
- Improved well cementing and casing standards (§ 78.83-78.85) to: prevent subsurface infiltration of surface waters; establish more rigorous requirements to centralize casing, install cement, and verify the cement integrity to protect ground water; require the Operator to prepare and maintain a casing and cementing plan; and require use of new pipe and pressure testing and quality standards for that pipe;
- Improved mechanical integrity standards for operating wells (§ 78.88);
- Gas migration response (§ 78.89);
- Improved well plugging standards (§ 78.92-78.95); and
- A requirement for the Operator to certify that the well has been constructed to Pennsylvania's well construction standards (§ 78.122).

Three (3) of the eleven (11) grandfathered wells were drilled under the existing regulatory structure that is known to be inadequate. The remaining eight (8) grandfathered wells were permitted under the existing Chapter 78 regulatory scheme, and may not be required to comply with the new Chapter 78 regulatory requirements, depending on when the wells are actually drilled and when the Chapter 78 revisions are codified.

Findings:

- Existing PADEP oil and gas well regulations at Chapter 78 are known by PADEP to be inadequate to protect human health and the environment.
- PADEP is in the process of revising Chapter 78 with the stated goals of minimizing public concerns associated with gas migration into public drinking water supplies; updating material specifications and performance testing requirements; and revising design, construction, operations, monitoring, plugging, water supply replacement, and gas migration reporting requirements.

[63] November 3, 2010 phone conversation with Scott Perry, Director of Pennsylvania Bureau of Oil and Gas Management.

- PADEP has not yet promulgated Chapter 78 regulations that are adequate to protect human health and the environment; grandfathered wells are being drilled under regulations known to be deficient.

D.5.2. Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania

Because PADEP does not require well casing and cementing plans to be submitted, reviewed, and approved as part of a well permit application, there is insufficient information available on the grandfathered wells to verify the integrity of the planned or installed casing and cementing configuration. This problem will not be resolved as part of the proposed Part 78 revisions, because the proposed Part 78 rules still do not require a well construction plan to be submitted and approved as part of the permit to drill.

The permit to drill issued by PADEP approves the well location and directs the applicant to follow PADEP regulations, but does not include any PADEP engineering review of the proposed well construction plans.[64] Because there is no engineering review of the permit application prior to drilling, PADEP's process does not ensure that the well will be constructed to best industry/best technology practices at the time the well is drilled. Therefore, the grandfathered well applications at issue here did not include well construction plans, nor was there any engineering review completed by PADEP.

PADEP's proposed Chapter 78 regulations do include an improvement that requires an Operator to certify that the well has been constructed to Pennsylvania's well construction standards (§ 78.122) after the well has been drilled. However, major casing and cement design flaws are difficult to remedy once the well has been drilled.

Recognizing the importance of proper wellbore design prior to construction, the federal government and many states require wellbore construction plans as part of the permit application, subject to agency engineering review and approval prior to well construction.

PADEP does currently require an after-the-fact drilling completion report to be submitted providing information on the final well construction configuration. However, the well completion reports for the three grandfathered wells that have been drilled were not available for my review. Therefore, there was insufficient information available on the well construction method used for these wells to verify if the wells were drilled to best industry practice using best technology standards.

Wells being drilled in the Delaware River Basin, that may be later used as production wells, and subject to high-volume, high-pressure fracturing should be designed and constructed using best industry practice to protect ground water resources.

[64] November 3, 2010 phone conversation with Scott Perry, Director of Pennsylvania Bureau of Oil and Gas Management

Findings:

- PADEP's rules do not require mandatory use of robust well construction practices and designs for Marcellus Shale wells.
- PADEP's well permit application process does not include any engineering review of the proposed well construction plans. Because there is no engineering review of the permit application prior to drilling, PADEP's process does not ensure that the well will be constructed to best industry/best technology practices at the time the well is drilled.
- There is insufficient information available on the grandfathered wells to verify the planned or installed casing and cementing configurations and whether they have a robust design.

D.5.3 PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells

Recognizing the increased water use associated with shale gas drilling and completions, PADEP typically adds a Special Permit Condition to shale gas wells requiring a Water Management Plan to be submitted. The Water Management Plan must describe water sources that will be used for the drilling operation, including safe yield calculations for surface water withdrawals for each new well. The Water Management Plan must include Best Management Practices (BMPs) and must verify that anti-degradation requirements are met and that designated uses of surface waters are protected.

PADEP required a Water Management Plan be submitted as a Special Permit Condition for the B&E well, but did not require a Water Management Plan be submitted for the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson wells. There was insufficient information available on the permit history for the remaining grandfathered wells to determine if Special Permit Conditions had or had not been applied to them.

Because the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson permits did not include a Water Management Plan Special Permit Condition, and there were no documents provided for my review showing that the Operators of these wells prepared a Water Management Plan, it appears that PADEP did not approve the method of water withdrawal, use, storage, or distribution for these wells. There is a lack of consistency in permit conditions applied to the grandfathered wells and a lack of Water Management Plans for many of the grandfathered wells.

Findings:

- PADEP did not require a Water Management Plan for the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson wells.
- There is a lack of consistency in permit conditions applied to the grandfathered wells and a lack of Water Management Plans for many of the grandfathered wells.

D.5.4. Fracture treatment operations are planned for the B&E well.

DRBC lists the B&E Well #1 as one of the 11 grandfathered wells. DRBC maintains that the grandfathered wells are limited to exploration shale gas wells that will not undergo fracture stimulation treatments; however, the B&E Well #1 permit issued by PADEP on March 5, 2009 includes a "Special Permit" condition that requires the Operator to:

> *…not drill the well until the permittee submits to the Department and the Department has approved the method by which the permittee will withdraw, use, store, distribute, process and dispose of water* ***for well drilling and hydraulic fracturing purposes*** *("Water Management Plan").*[65]

The fact that PADEP included a Water Management Plan requirement on the B&E Well #1 well is noteworthy because it must have had a reason to believe that the Operator, Kevin E. Schrader, was planning fracturing operations for this well, which are clearly prohibited under the grandfathering provisions.

Findings:

- PADEP permit indicates fracturing treatments are planned for the B&E Well #1 well. Fracture treatments are not allowed under the grandfathered well provisions.

D.5.5. Drilling waste can result in environmental harm if not properly managed

There is no assurance that a driller's waste management plan will meet DRBC's water protection requirements, because PADEP allows waste disposal methods that DRBC does not. For example, PADEP allows drill cuttings and residual waste to be disposed onsite, under certain circumstances (§ 78.61 disposal of drill cuttings, § 78.62 disposal of residual waste-pits, § 78.61 disposal of residual waste-land application and § 78.60 disposal of tophole water by land application).

For example, a September 8, 2010 PADEP inspection report at the Matoushek wellsite shows that drilling waste was left on-site and buried there. The Matoushek inspection report states that: drilling fluids were being removed from the drilling reserve pit; two workers were observed skimming an oil sheen off of the pit; and the pit's solid wastes would be encapsulated within liner and buried on site. Onsite waste burial within Delaware River Basin is inconsistent with DRBC's requirement to collect drilling waste to be treated at an approved DRBC facility, or transported out of the Delaware River Basin. Produced water from the Matoushek well was transported to a sewage treatment facility that was not approved for drilling waste.[66]

[65] B&E Well #1, PADEP Permit, March 5, 2009, in **Exhibit 15.**

[66] **Exhibit 18B** shows an email exchange between Stone Energy (Woodland Well Operator), DRBC and PADEP. This information was obtained from DRBC through a DRN March 15, 2010 FOIA request. This email exchange questioned whether Valley Joint Sewer Authority had accepted 270,000 gallons of Woodland produced water waste. PADEP confirmed with Valley Joint Sewer Authority that they had stopped taking drilling waste as of April 2009, but DRBC later confirmed that the drilling waste was sent to Valley Joint Sewer Authority prior to April 2009. This series of events was confirmed on November 4, 2010 via a phone call between DRN and DRBC staff.

Because the PPCs for some of the grandfathered wells were not available for my review, it is unclear what the waste management plan is/was for all of the wells. There was also no information provided for my review showing that DRBC had reviewed the waste management plans for the grandfathered wells to ensure that the waste management plans met the DRBC's water protection requirements.

Best waste management practices in other states do not allow onsite burial of drilling waste. For example, New Mexico requires all fluids be removed from the reserve pit and recycled or disposed of in accordance with state regulations.[67] New Mexico also requires the drill cuttings and reserve pit liners be sent to a disposal facility in accordance with state regulations, and the soil under the reserve pit be tested for benzene, total BTEX[68], TPH[69], the GRO,[70] and DRO[71] combined fraction, and chlorides.[72] If contamination is found, it must be excavated and remediated. If the soil is clean it can be backfilled. The City of Fort Worth, Texas, prohibits onsite burial of drilling muds and cuttings.[73] The reserve pits are temporary and all muds and cuttings must be removed and handled at an approved waste management facility.

Although large-volume, high pressure fracture treatments are not currently permitted for the grandfathered wells, in the future there will be requirements for very large impoundments that warrant careful design and limits.

The use of closed loop tank systems, instead of reserve pits and impoundment, is best practice. The Bureau of Land Management (BLM) recommends the use of closed loop tank systems as a best practice instead of reserve pits and impoundments, whenever technically feasible.[74] Texas requires closed looped mud systems with steel tanks. [75] It is much more efficient (from an energy standpoint) to collect waste in the container that will be used to transport it offsite to a waste disposal facility than it is to create an intermediate storage pit. The use of temporary reserve pits and impoundments results in surface disturbance. It also has the potential for leakage to occur through the liner, impacting groundwater. Impoundments also generate air pollution.

None of the other grandfathered wells include the Special Permit Condition applied to the Teeple #1-2H production well,[76] which requires an environmental assessment from PADEP for any impoundments and chemical analysis and characterization of drilling waste prior to processing or disposal. It is not clear why PADEP would have required a more stringent Special Permit Condition for the Teeple #1-2H production well than the other grandfathered exploration wells. There is inconsistency in permit conditions applied to wells subject to this Hearing.

Reported waste handling concerns at the Teeple[77] and Mastoushek[78] wells are strong indications that additional waste management oversight is needed.

[67] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009
[68] BTEX= benzene, toluene, ethylbenzene, and xylene.
[69] THP= total petroleum hydrocarbons.
[70] GRO= gasoline range organics.
[71] DRO= diesel range organics.
[72] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009.
[73] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009.
[74] Bureau of Land Management, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development, The Gold Book, 2007.
[75] Fort Worth Texas, Ordinance No. 18449-02-2009.
[76] See **Exhibit 20**, PADEP well permit for DL Teeple 1 2H for Special Permit Conditions.
[77] **Exhibit 9B** shows a May 26, 2020 violation at the Teeple well for an improperly lined pit.
[78] **Exhibit 18B**

The amount and type of waste generated during the drilling and completion of an exploration well varies based on: the drilling method (air or a drilling mud system), the completion and stimulation method, and the amount of well testing that is conducted.

Typical waste streams from an exploration drilling operation can include: domestic wastewater from on-site septic tanks and portable toilets; produced formation water during well drilling, testing, and stimulation; solids waste including drill cuttings, scrap metal, and debris; waste chemicals; waste oils; and materials associated with chemical and fuel spills. Newfield's PPC lists its expected waste streams from its "natural gas exploration of the Marcellus Shale formation" to include:

> *Wastes generated during these activities will be typical for gas drilling operations and will include **drill cuttings**, **produced water**, **drilling and frac fluids**, **waste oil** and **municipal waste** and **trash** [emphasis added].*[79]

According to the DRBC, there are no DRBC approved non-domestic wastewater treatment facilities in the Delaware River Basin at this time (**Exhibit 21**).[80] Absent DRBC review of exploration well permit applications, there is no process to limit the amount and type of waste generated at exploration wells in the Delaware River Basin, and there is no method to ensure that it is collected and shipped to a state approved waste treatment and storage facility outside of the Delaware River Basin, because PADEP is not providing this additional level of oversight and assurance. PADEP only assures that PADEP's standards are met, not incremental local standards.

Examples of significant wastes that could be generated by an exploration well includes drilling mud, cuttings and produced water. This is not an exhaustive list, but rather these drilling wastes are described in more detail below to highlight some of the more significant environmental concerns.

Drilling Muds & Drill Cuttings: Drilling muds are used to control the hydrostatic pressure in a wellbore.[81] The most common weighting agent used is barite. Barite can contain mercury and other heavy metals.

Drilling muds are not used in air drilling techniques; however, it must be assumed that drilling muds will be used, because there is no state statute in Pennsylvania limiting shale gas drilling to air drilling methods only, [82] and the PPCs provided for review include drilling mud.

U.S. Department of Energy studies show that barite contains mercury (1ppm-10ppm Hg, depending on its origin).[83] Mercury concentrations can be reduced by using thermal methods, leaching with dilute acids, or selecting barite with naturally occurring lower concentration levels of mercury.[84]

The U.S. Department of Interior estimates that 0.8 metric tons of mercury is discharged into the Gulf of Mexico (GOM) annually (1839 lb Hg/yr) from mud disposed from drilling operations.[85] This equates to approximately 1.69 lbs[86] of mercury per well for wells drilled to a total depth of approximately 12,000'.

[79] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.
[80] Muszynski, W.J., DRBC Manager Water Resources Management Branch, Presentation, DRBC Engagement in Natural Gas Exploration and Development, Marcellus Shale Meeting, January 19, 2010.
[81] DRN communication with HCLLC on October 23, 2010.
[82] While DRN reports that Newfield stated publically at a September 15, 2010 meeting that its wells use air drilling methods, Newfield's PPC documents plan for use of drilling muds, not air drilling. DRN reports that the top-hole section of some wells may be drilled with air, and the remaining section of the well drilled with mud.
[83] http://www.fossil.energy.gov, "Mercury Removal from Barite for the Oil Industry."
[84] http://www.fossil.energy.gov, "Mercury Removal from Barite for the Oil Industry."

Assuming that the top-hole of some of these wells is drilled using air drilling methods, an average wellbore length of 5,000' for the remaining section of the well is drilled with mud, and there is a lower barite use rate of 100 lbs/ft, to account for lower expected pressures, the mercury content in drilling mud is estimated at 0.5- 5.0 lbs[87] per well, depending on barite quality.

Drilling muds may also contain the heavy metal cadmium, leading the EPA to establish cadmium concentration limits in drilling muds.[88]

Drill cuttings can also contain Naturally Occurring Radioactive Material (NORM). Absent data to support otherwise, there is the potential for NORM content in drill cuttings in the Delaware River Basin. Gas shales are known to contain NORM in some regions. Shales can be heterogeneous and the NORM compositions can vary substantially. Recent studies on the Marcellus Shale in New York State acknowledge that drilling and production waste and equipment may contain NORM. The New York State Department of Environmental Conservation (NYSDEC) reports that the Marcellus Shale contains Uranium-238 and Radium-226, and that this NORM may be present in drill cuttings, produced water and stimulation treatment waste.[89] NYSDEC identified Radium-226 as the most significant NORM of concern, because it is water soluble and has a half-life of 1,600 years.[90] Radiation pathways can include external gamma radiation, injection, inhalation of particulates, and radon gas.[91] Therefore, exploration drill cuttings should be tested to determine NORM content and be disposed of accordingly at a licensed radioactive waste disposal facility. Other oil and gas states, such as Texas and Louisiana, have adopted stringent NORM regulations for E&P operations, including: occupational dose control, surveys, testing and monitoring, record keeping, signs and labeling, and treatment and disposal methods.

Best practice for managing drilling muds and cuttings includes the use of "closed loop tank systems," instead of a reserve pit, and transportation to an approved waste disposal facility. This avoids the impact of constructing a reserve pit and the potential for leakage into the environment.

Yet PADEP did not require the best practice of closed loop tank systems for these grandfathered wells. Instead, PADEP allows drilling muds and cuttings in Pennsylvania to be disposed of in a variety of methods, including subsurface injection into a disposal well, annular injection into the annulus[92] of a previously drilled well, burial on site in pits, or transportation to an offsite waste treatment and disposal facility. There is no assurance that exploration well waste handling will meet DRBC water protection standards. Because PADEP allows onsite burial of drilling cuttings and land spreading of other E&P wastes, we must assume that onsite burial may occur.

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[85] http://www.gomr.mms.gov/homepg/regulate/environ/Hg%20discharge%20estimate.pdf.

[86] (1,091 wells/yr drilled in GOM))* (12,038 ft/well)*(140 lbs barite/ft)*(1x10^{-6} Hg/g barite)= 1,839 lb Hg/yr. (1,839 lb/Hg)/(1,091 wells) = 1.69 lbs of mercury per well.

[87] 1ppm Hg in barite= (1 Marcellus well)* (5,000 ft/well)*(100 lbs barite/ft)*(1x10^{-6} Hg/g barite) = 0.5 lb Hg/well
10ppm Hg in barite= (1 Marcellus well)* (5,000 ft/well)*(100 lbs barite/ft)*(10x10^{-6} Hg/g barite) = 5.0 lb Hg/well

[88] U.S. Environmental Protection Agency, Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and Gas Extraction Point Source Category, EPA 821-R-93-003, 1993.

[89] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 4-36.

[90] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 6-129.

[91] US Department of Interior, Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment- an Issue for the Energy Industry, USGS Fact Sheet FS-142-99.

[92] Annulus is the space between the wellbore and the casing.

The drilling permits issued by PADEP for the 11 grandfathered wells do not limit drilling method, do not set limits on drilling mud composition, and do not specify waste disposal method.

Produced Water Waste: Formation water (commonly referred to as "produced water") can be generated as a waste during exploration drilling and well testing operations. PADEP reports that air drilling operations can produce larger quantities of produced water than those wells drilled with mud.[93] Produced waters that are discharged to surface waters or lands of the US are regulated under the federal Clean Water Act, under a National Pollutant Discharge Elimination System (NPDES) permit. PADEP administers the NPDES program in Pennsylvania.[94]

The primary method for disposal of oil field wastewater in Pennsylvania is through pre-treatment facilities that clarify and filter the waste and dispose of it to surface water or sewage treatment plants.[95] A smaller amount of wastewater is disposed of into Class II injection wells.[96] Absent waste management plans for most of the grandfathered wells, it is unclear what the waste management plan is for produced water, because PADEP also allows produced water to be disposed of by land or road spreading, under some circumstances.

Produced water is typically rich in chloride, which enhances the solubility of other elements, including the radioactive element radium. This often makes produced water unsuitable for land application or surface water disposal, especially in sensitive areas such as the Delaware River Basin.[97]

Other states, such as Texas, require extensive produced water testing and specifically prohibit road spreading of waste containing NORM.[98] A study conducted by Argonne National Lab for the US Department of Interior (DOI) concluded that land spreading of diluted NORM waste presented the highest potential dose of exposure to the general public of all waste disposal methods studied.[99]

Furthermore, EPA identified produced water pits as an outdated practice if produced water contains NORM. EPA reports that:

> *Lined and/or earthen pits were previously used for storing produced water and other nonhazardous oil field wastes, hydrocarbon storage brine, or mining wastes. In this case, TENORM[100] in the water will concentrate in the bottom sludges or residual salts of the ponds.* ***Thus the pond sediments pose a potential radiological health risk****.…produced waters are now generally reinjected into deep wells…No added radiological risks appear to be associated with this disposal method as long as the radioactive material carried by the produced water is*

[93] PADEP Oil and Gas Manual Chapter 4, October 2001.
[94] PADEP Oil and Gas Manual Chapter 2, October 2001.
[95] Gaudlio, A.W., Paugh, L.O. (Range Resources) and Hayes, T.D. (Gas Technology Institute), Marcellus Shale Water Management Challenges in Pennsylvania, 2008.
[96] The Underground Injection Control Program (UIC) of the federal Safe Drinking Water Act governs control of the injection of flowback and produced waters to ensure that injected waste is confined to the injection zone in a manner that does not contaminate fresh water bearing formations that may serve as Underground Sources of Drinking Water (USDW).
[97] US Department of Interior, Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment- an Issue for the Energy Industry, USGS Fact Sheet FS-142-99.
[98] Texas Railroad Commission (TXRRC), 16 Texas Administrative Code, Title 16, Part 1, Chapter 4, Subchapter F, §4.601 - 4.632. "Disposal of Oil and Gas NORM Waste". The TCEQ has jurisdiction over the disposal of other NORM wastes.
[99] Argonne National Laboratory, Radiological Dose Assessment Related to Management of Naturally Occurring Radioactive Materials Generated by the Petroleum Industry, Publication ANL/EAD-2, 1996.
[100] TENORM is Technologically Enhanced Natural Occurring Radioactive Material.

returned in the same or lower concentration to the formations from which it was derived [emphasis added].[101]

Newfield's Preparedness, Prevention and Contingency (PPC) Plan states:

> ***Produced water will be removed periodically from the tanks at each wellsite and transported by a licensed residual waste hauler to a permitted disposal facility*** *[emphasis added].* [102]

Newfield does not specify who the waste hauler is, nor does it name the permitted disposal facility. Therefore, it is not possible to confirm whether this waste handling plan conforms to DRBC's requirements for waste from industrial operations in the Delaware River Basin.

Findings:

- Drilling waste can result in environmental harm if not properly managed.
- Because waste management plans were not available, it is unclear what the waste management plan is/was for most of the grandfathered wells.
- Reported waste handling concern at the Teeple and Mastoushek wells are strong indications that additional waste management oversight is needed.
- There is no assurance that a driller's waste management plan will meet DRBC's water protection requirements, because PADEP allows waste disposal methods that DRBC does not.
- Best waste management practices in other states do not allow onsite burial of drilling waste.
- The used of closed loop tank systems is a best practice, preferred over reserve pits and impoundments.
- Drilling waste can include Naturally Occurring Radioactive Material (NORM), mercury, cadmium and other heavy metals.

D.5.6. Stray gas migration associated with oil and gas wells can impact water supplies

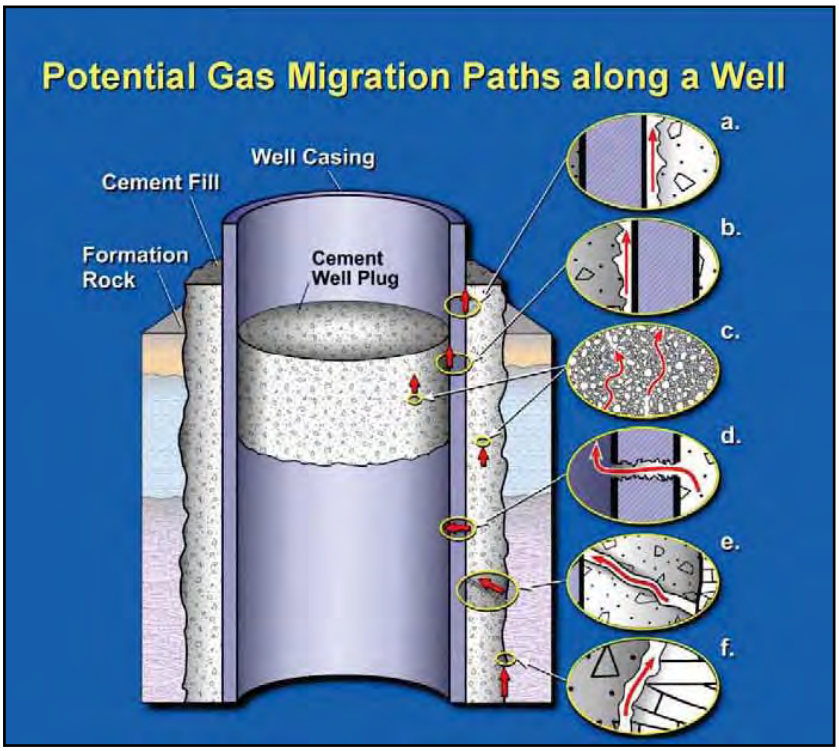
PADEP stresses the importance of proper well construction to mitigate stray gas, noting that these protections are not currently found in PADEP's regulations at Chapter 78, but will be when the rulemaking is finalized in 2011:

> ***Properly constructed and operated oil and gas wells are critical to protecting water supplies*** *and public safety.* ***If a well is not properly cased and cemented, natural gas in subsurface formations may potentially migrate from the wellbore through bedrock and soil. This stray gas may adversely affect water supplies****, as well as accumulate in or adjacent to structures such as residences and water wells. Under certain conditions,* ***stray gas has the potential to cause a fire or explosion. These situations present a serious threat to public health and safety as well as the***

[101] http://www.epa.gov/radiation/tenorm/oilandgas.html#disposalpast.
[102] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.

> ***environment.*** *The purpose of this final rulemaking is to improve drilling, casing, cement, testing, monitoring and plugging requirements for oil and gas wells to minimize gas migration and protect water supplies [emphasis added].*[103]

In October 2009, PADEP released a draft report summarizing 65 cases of stray natural gas migration associated with oil and gas wells (**Exhibit 32**), where improperly constructed and operated oil and gas wells have reportedly introduced gas into drinking water wells, aquifers, top soils, and structures. Most of these cases were attributed to inadequate well design and construction, improper well operation, poor well abandonment procedures, or a failure to abandon a well that is no longer in use.



The risks associated with well annulus over-pressuring, well casing failure, improperly constructed wells, and improperly abandoned wells could result in stray natural gas migration in the Delaware River Basin, if these risks are not mitigated.

There is insufficient information available on the grandfathered wells to verify whether the planned or installed casing and cementing configuration is a robust design. Therefore, it is not possible to verify whether stray gas problems associated with well construction practices have been mitigated in the grandfathered wells. Because there are no plug and abandonment applications or approvals for the grandfathered wells, it is not possible to verify whether the wells have been plugged or will be plugged in a manner that mitigates stray gas. Stray gas mitigation is a design concern for all types of well construction, including vertical and horizontal wells.

As shown in the figure above,[104] there are a number of ways that gas can migrate in a wellbore through failed piping (e.g. casing damage, corrosion, erosion) or through poor quality or improperly placed cement.

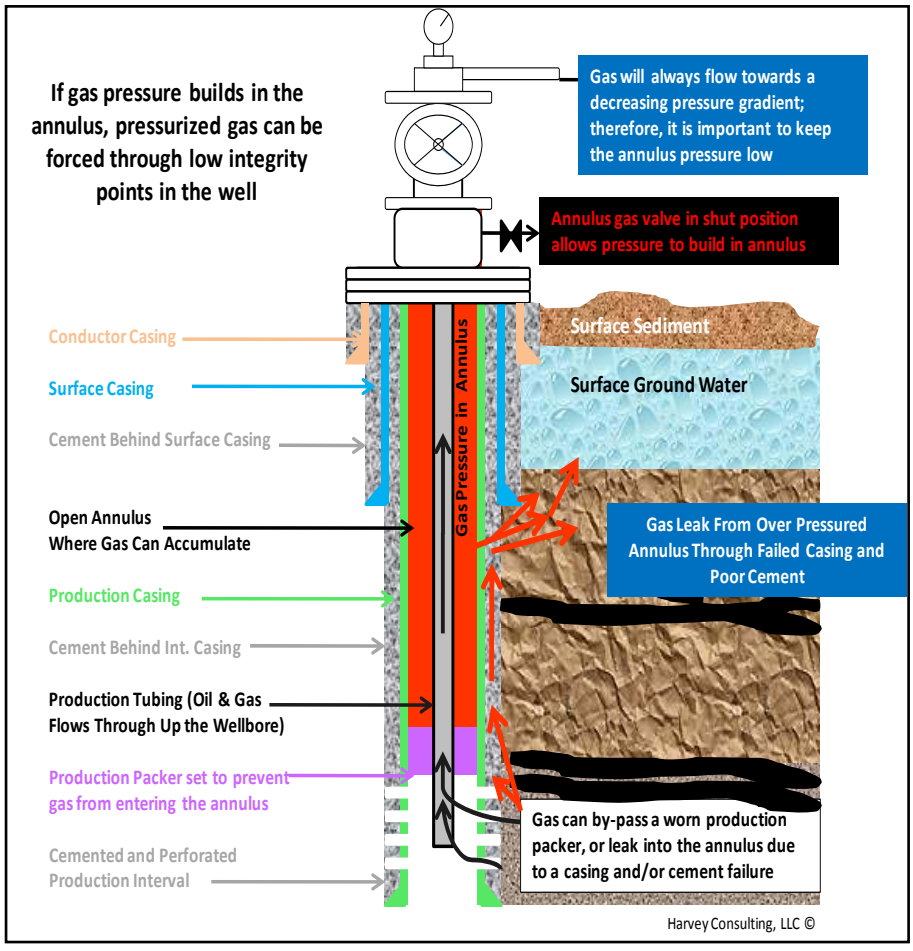
Open hole completions, where no cement or casing is installed across hydrocarbon bearing intervals, can increase the likelihood of gas migration.

[103] PADEP Notice of Final Rulemaking, Department of Environmental Protection Environmental Quality Board, 25 Pa. Code, Chapter 78 Oil and Gas Well Cementing and Casing, 2010 (**Exhibit 30A**).
[104] Potential Gas Migration Pathways Diagram, Alberta Energy Utilities Board.

Unmonitored annulus pressure in completed, temporarily suspended wells can also provide opportunities for stray gas problems. Over pressured well annulus (see diagrams on next pages) can force gas through low integrity points in the well.

For the grandfathered wells that have been drilled, but not yet plugged, it is important that the well is monitored to ensure that the annulus does not over-pressure, forcing high pressure gas from the well annulus into lower pressure ground water zones. This happens under certain circumstances, such as when a wellbore is not cased and cemented; casing failure occurs; cement is poorly bonded; or a production packer fails.

The diagrams shown in this report are simplified schematics showing the risk posed by gas migration due to annular over-pressuring (in a completed well) or a well that is left open hole (uncased) and uncompleted. These diagrams are not intended to show how the grandfathered wells may have been constructed, because those construction diagrams were not available for my review. Rather these diagrams are intended to show the types of stray gas problems that can occur in cased and completed wells, and in open hole completions.

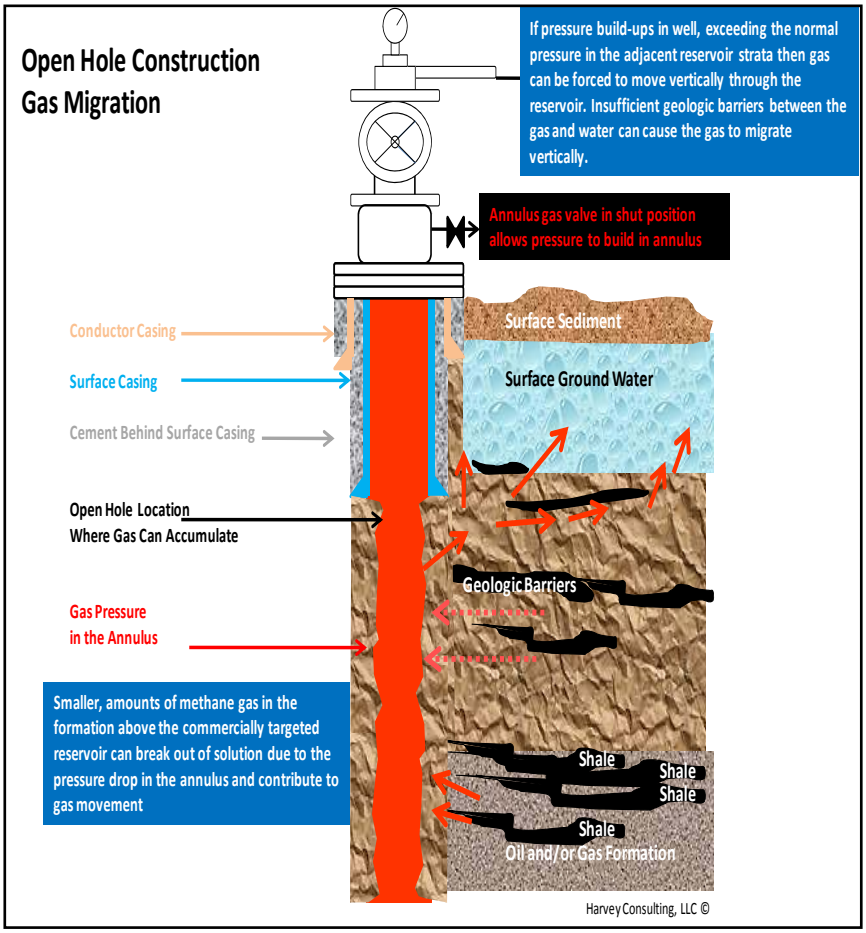


New construction practices do not guarantee stray gas migration will not occur, but these practices do significantly reduce risk. Over time production packers can wear out or casing can fail due to corrosive and erosive conditions in the wellbore, resulting in gas leaks into the annular space. Poor cementing practices can also result in gas movement.

Proper monitoring of the annulus pressure can help prevent gas migration. Even in wells constructed with more modern well construction techniques, gas pressure can build in the annulus. For example, gas can bypass a worn out production packer or leak into the annulus due to a casing and/or cement failure. Gas from a higher pressure oil and gas formation will move into the annulus through a leak because the annulus is of lower pressure. By the laws of physics, gas will always flow toward a decreasing pressure gradient. Therefore, the higher pressure gas will move from the oil and gas reservoir into the lower pressure annulus. As long as the annulus is not over pressured, this gas can be extracted at the surface. However,

if the annulus becomes over pressured, formation gas will take the path of least resistance, which may cause it to migrate into shallower formations.

An open-hole provides several pathways for gas to migrate from deeper, higher pressure formations to shallower, lower pressure formations. Gas can leak though poor cement placed at the bottom of the production casing. Smaller amounts of methane gas in the formation above the commercially targeted reservoir can break out of solution, and move toward the lower pressure open-annulus. An over-pressured annulus can cause gas to move from the higher pressure annulus into lower pressure, shallower zones.



The problem of ground water contamination by open-hole completions in Pennsylvania is well documented in two articles published in the Ground Water Journal by Samuel Harrison, a Professor of Geology and Environmental Science from Allegheny College, Meadville, Pennsylvania.[105,106]

Dr. Harrison concluded:

> *This annulus is a potential avenue of migration of contaminants from strata of higher hydrodynamic pressure into formations of lower hydrodynamic pressure.* ***If gas from the strata exposed to the annulus is not permitted to escape to the atmosphere, the annulus may become pressurized and a hydraulic gradient may be created between the potential contaminants in the annulus (e.g. brine and/or natural gas) and the overlying fresh-water aquifers.*** *If a permeability pathway exists between the pressurized annulus and an overlying fresh-water aquifer,* ***contamination of the aquifer will result*** *[emphasis added].”*[107]

Of note, Dr. Harrison’s article from 1985 stated that gas should be vented to atmosphere to relieve pressure on the annulus. However, best practices to mitigate greenhouse gas emissions, such as methane,

[105] Harrison, S.S., Evaluating System for Ground-Water Contamination Hazards Due to Gas-Well Drilling on Glaciated Appalachian Plateau, Groundwater, November-December 1983, Vol. 21, No.6.
[106] Harrison, S.S., Contamination of Aquifers by Overpressuring the Annulus of Oil and Gas Wells, Groundwater, May-June 1985, Vol. 23, No.3.
[107] Harrison, S.S., Evaluating System for Ground-Water Contamination Hazards Due to Gas-Well Drilling on Glaciated Appalachian Plateau, Groundwater, November-December 1983, Vol. 21, No.6.

now recommend collecting this gas in a low pressure gas system or using it as fuel at the well site, rather than venting it to atmosphere, where technically feasible.

Dr. Harrison goes on to write:

> *The risk of contaminating fresh ground water with the contents of a gas- or oil-well annulus could be greatly reduced by filling the annulus with cement.*

The oil and gas industry has learned from experience that casing and cementing the wells along the entire length of the hole provides added protection to ground water resources, as shown in the more current wellbore construction approaches used today.

Gas pressure buildup in the annulus can cause gas to move vertically in the reservoir toward the lower pressure ground water aquifer. This problem can be mitigated by opening the annulus valve and producing the gas to the surface, thereby decreasing the pressure in the annulus ("gas annulus de-pressuring"). An open-hole design does not guarantee that gas will migrate vertically to the lower pressure groundwater aquifer. It is just more likely to occur than in a more robust well construction design, with multiple barriers of cement and casing.

Geologic barriers to vertical flow, such as thick continuous shale layers, can trap gas and prevent vertical migration. Sealed faults and other sealed geologic unconformities can also provide barriers to vertical flow. Moreover, the pressure of the gas in the annulus must exceed the normal hydrostatic pressure gradient for it to flow vertically. Higher pressure gas will naturally seek equilibrium pressure and flow toward areas of lower pressure. If the gas pressure is sufficient enough to overcome the natural hydrostatic pressure gradient, and there are insufficient geologic barriers to prevent vertical gas migration, then gas may reach the ground water reservoir.

Pennsylvania has casing pressure regulations at Subchapter D, § 78.73 requiring Operators to monitor and prevent gas well annulus over-pressuring. The fact that gas well annulus over-pressuring is occurring, despite this rule being in place points to the need for additional agency monitoring and oversight to ensure the regulation is being complied with in the field.

Findings:

- Stray gas migration associated with oil and gas wells can impact water supplies.
- Well construction improvements to mitigate stray gas problems associated with oil and gas drilling have been proposed by PADEP for adoption in 2011, but will not apply to most of the grandfathered wells.
- Risks associated with well annulus over-pressuring, well casing failure, improperly constructed wells and improperly abandoned wells could result in stray natural gas migration in the Delaware River Basin, if these risks are not mitigated.
- Because there are no plug and abandonment applications or approvals for the grandfathered wells, it is not possible to verify whether the wells have been plugged or will be plugged in a manner that mitigates stray gas.
- Open hole completions and/or unmonitored annulus pressure in completed, temporarily suspended wells can provide opportunities for stray gas problems.

D.5.7. PADEP's well siting criteria allow wells to be placed very close to water resources

The Oil and Gas Act, §601.205(a) only requires oil and gas wells be located at least 200 feet from existing buildings and existing water wells, and allows for granting a variance[108] to place the well even closer.

The Oil and Gas Act, §601.205(b) only requires oil and gas wells be located at least 100 feet from any stream, spring or body of water, as identified on the most current 7½ minute topographic map, and at least 100 feet from any wetland greater than one acre in size, and allows for granting a variance[109] to place the well even closer.

These surface siting criteria do not provide sufficient setbacks from sensitive water resources in the Delaware River Basin. For example, blowouts can eject drilling mud, gas, oil and/or formation water from the well and onto waters and lands adjacent to the well, within the radius of the blowout plume. Depending on the reservoir pressure, blowout circumstances, and wind speed these pollutants can be distributed hundreds to thousands of feet away from the well.[110] Pressurized fluids can spray hundreds of feet, and spilled fluids can travel across surface terrain, or seep into the ground and travel towards water resources though the soil. For example, in September 2009 well chemicals spilled at the Cabot Heitsman 4H well flowed to the nearby Steven's Creeks located more than 100' away.[111]

The Crum well site is on the North Branch of Calkins Creek, a "High Quality" Creek, as classified by PADEP. It has high quality biota in the stream that will be impacted by influxes of sediment and pollution, and changes in stream flow. Calkins Creek supports brook trout, brown trout (both are temperature sensitive), merganser ducks, and great blue herons. It is also habitat for black bear and bald eagles that fish the river and roost the forest in this sub-watershed.[112] The Woodland well site is less than one-half mile from the river, on Hollister Creek, a "High Quality" stream, as classified by PADEP. Black bear and bald eagles use this area for hunting, foraging and nesting.

Findings:

- PADEP's setback requirements of 100' from a water body or 200' from a well are not sufficient to protect high-value water resources.

D.5.8 Air pollution impacts are not well understood or mitigated.

The 25 PA Code § 127.14 (38) exempts oil and gas drilling operations from air quality control requirements (**Exhibit 33**).

[108] Where the restriction would deprive the owner of the oil and gas rights, the right to produce or share in production, the Department may grant a variance upon submission and approval of form 5500-FM-OG0058, Request for Variance From Distance Restriction From Existing Building or Water Supply.
[109] The Department may waive distance requirements upon submission and approval of form 5500-FM-OG0057, Request for Waiver for Distance Requirements From Springs, Streams, Body of Water or Wetland.
[110] S.L. Ross Environmental Research Limited, Oil Deposition Modeling For Surface Oil Well Blowouts, 1998.
[111] Cabot Oil & Gas Corporation, Engineering Study, Prepared for PADEP, In Response to Order Dated September 24, 2009, prepared by URS Corporation for Cabot, October 9, 2009.
[112]Biological Information provided by DRN November 1, 2010.

> *"38. Oil and gas exploration and production facilities and operations that include wells and associated equipment and processes used either to: a) drill or alter oil and gas wells; b) extract, process and deliver crude oil and natural gas to the point of lease custody transfer; c) plug abandoned wells and restore well sites, or d) treat and dispose of associated wastes. This includes petroleum liquid storage tanks which are used to store produced crude oil and condensate prior to lease custody transfer."*

This exemption includes shale gas drilling; therefore, air pollution impacts from the grandfathered wells are currently unregulated and unmitigated.

PADEP is in the process of determining whether this air permitting exemption is warranted for Marcellus Shale Drilling Operations. PADEP is currently studying short-term air quality impacts and is expected to complete these studies in early 2011 (**Exhibit 33** includes a news report summarizing PADEP's study).

PADEP's study does not examine combined and cumulative impacts of multiple drilling operations, nor does PADEP's study examine the impacts of air pollutant transport and deposition on waters and lands downwind of drilling operations.

Components of atmosphere pollution caused by exploration drilling includes gaseous products of hydrocarbon evaporation and burning as well as aerosol particles of unburned fuel, including nitrogen oxide, sulfur oxides, carbon monoxide, particulate matter, and hazardous air pollutants. These airborne pollutants interact with atmospheric moisture, and transform in the presence of solar radiation and precipitate onto land and water surfaces causing both local and regional pollution.[113]

There are a number of potential air emission sources from drilling operations, including combustion source emissions (drilling engines and flares), direct venting of gas, and fugitive emissions from pits, impoundments and other leaks.

Since PADEP does not require a permit and there is no list of emission sources, or any assessment of the air pollution impact, it is not clear whether air pollution impacts from the grandfathered wells are significant and warrant mitigation to protect the Delaware River Basin airshed and associated waters. Air pollution can transport airborne pollutants downwind, depositing pollutants to water and land surfaces. These impacts are not well understood or mitigated for the grandfathered wells.

EPA explains the direct relationship between air pollution and water quality impacts:

> ***Airborne pollutants*** *from human and natural sources* ***can deposit back onto*** *land and* ***water bodies, sometimes at great distances from the source, and can be an important contributor to declining water quality.*** *Pollutants in waterbodies that may originate in part from atmospheric sources include nitrogen compounds, sulfur compounds, mercury, pesticides, and other toxics [emphasis added]."*[114]
>
> *Airborne pollution can fall to the ground in precipitation, in dust, or simply due to gravity. This type of pollution is called "atmospheric deposition" or "air deposition." Pollution deposited from the air can reach water bodies in two ways. It can either be deposited directly onto the surface of the water (direct deposition) or be deposited onto land and be carried to water bodies*

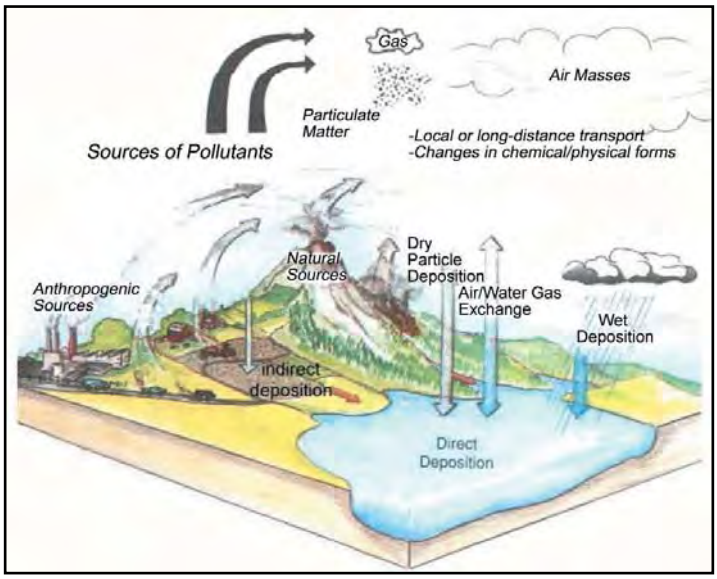
[113] Rana, S., Facts and Data on Environmental Risks- Oil and Gas Drilling Operations, Society of Petroleum Engineering Paper 114993, October 2008.
[114] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/airdeposition_index.cfm

through run off (indirect deposition). ***Once these pollutants are in the water, they can have undesirable health and environmental impacts, such as contaminated fish, harmful algal blooms, and unsafe drinking water*** *[emphasis added].*[115]

The diagram below shows the air pollution pathway from industrial sources to water resources. [116]

EPA explains that there are several pathways for air pollution to contaminate water resources, including:

- Direct deposition where air pollutants are directly deposited to the water resource;
- Indirect deposition where the air pollutant is deposited to the water resource, initially only impacting one part of the water resource, but later those pollutants are transported through runoff, rivers, streams and groundwater contaminating larger areas;
- Wet deposition where pollutants are deposited in rain, snow clouds or fog. Acid rain is an example of wet deposition of sulfur and nitrogen compounds associated with fossil fuel combustion;



- Dry deposition where air pollutant particles settle on water surfaces via gravity.

In many states, drilling equipment has been exempt from air permitting requirements because of its mobile, short-term nature, but upon further study regulators are finding that the air pollution impacts are more substantial than initially expected especially the amount of hazardous air pollution that is emitted, when large open-air impoundments are used to store fracture fluids and drilling chemicals.

A recent Environmental Impact Statement completed for Marcellus Shale drilling in New York State identified the potential for large amounts of hazardous air pollution (methanol[117]) may be present at central impoundments (32.5 tons per year).[118] A major source of hazardous air pollution is one that emits more than 10 tons/yr of any single hazardous air pollutant, or 25 tons/yr of multiple hazardous air pollutants, therefore New York's study found that shale drilling operations exceeded the hazardous pollutant threshold by more than three times.

[115] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/airdeposition_index.cfm
[116] EPA's Office of Air and Radiation (OAR) and Office of Water (OW), Frequently Asked Questions about Atmospheric Deposition Handbook: A Handbook for Watershed Managers, EPA-453/R-01-009, September 2001.
[117] EPA lists methanol as a hazardous air pollutant, but has not yet classified methanol with respect to carcinogenicity. http://www.epa.gov/ttn/atw/hlthef/methanol.html. Chronic inhalation or oral exposure may result in headache, dizziness, giddiness, insomnia, nausea, gastric disturbances, conjunctivitis, blurred vision, and blindness in humans. Neurological damage, specifically permanent motor dysfunction, may also result. The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals. 11th ed. Ed. S. Budavari. Merck and Co. Inc., Rahway, NJ. 1989.
[118] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 6-57.

The New York State Environmental Impact Statement did not estimate significant amounts of benzene emissions; however, recent reports indicate the Texas Commission on Environmental Quality is finding surprisingly high levels of benzene emitted from Barnett Gas Shale activities in Texas.[119] Benzene is a known, EPA-listed human carcinogen.

Air toxics do not just remain airborne when emitted from industrial operations, these toxins can deposit onto soils or surface waters where they are taken up by plants and ingested by animals and can be magnified through the food chain.[120]

Findings:

- PADEP exempts oil shale gas drilling operations from air quality control requirements, but has yet to complete a study to verify that short and long-term (cumulative impacts) meet the Clean Air Act requirements and are protective of human health and the environment.
- PADEP is in the process of determining whether this air permitting exemption is warranted for Marcellus Shale Drilling Operations. PADEP is currently studying short-term air quality impacts and is expected to complete these studies in early 2011.
- PADEP's study does not examine combined and cumulative impacts of multiple drilling operations, nor does it examine the impacts of air pollutant transport and deposition on waters and lands downwind of drilling operations.
- Shale gas drilling operations, when combined with use of fracture and drilling chemical impoundments, can be major sources of hazardous air pollutants.
- The use of closed looped collection and tank systems can mitigate water, land and air pollution impacts and are best pollution mitigation practices for shale gas drilling.
- Fuel and power selection options can also be considered to reduce air pollution impacts.

[119] Dr. Michael Honeycutt, Head of TCEQ's Toxicology Division, quoted in WFAA-TV new report, November 20, 2009. Dr. Michael Honeycutt "was shocked to see air sampling revealed high levels of benzene, a cancer-causing toxin, near some natural gas facilities."
[120] http://www.epa.gov/oar/toxicair/newtoxics.html

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Executive Director

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Deputy Executive Director

DETERMINATION OF THE EXECUTIVE DIRECTOR CONCERNING NATURAL GAS EXTRACTION ACTIVITIES IN SHALE FORMATIONS WITHIN THE DRAINAGE AREA OF SPECIAL PROTECTION WATERS

Technological advances in horizontal drilling and hydraulic fracturing have led to an increase in the number of active and planned natural gas extraction projects in shale formations within the Delaware River Basin. Each of these projects typically involves the construction of a well pad and associated roadways at or about surface elevations, the drilling of a well bore to depths of as much as 6000 feet or more, the withdrawal and transport of surface or ground water, the injection of the water and chemical fracturing mixtures into the wells to release the trapped gas, the recovery and storage of recovered fracturing fluid, water and associated leached constituents extracted with the gas, the storage and potentially the reuse of the recovered wastewater and chemicals and the eventual disposal of the water and chemicals. Each of these activities if not properly performed may cause adverse environmental effects, including effects on water resources.

Section 3.8 of the Delaware River Basin Compact provides in part: "No project having a substantial effect on the water resources of the basin shall hereafter be undertaken by any person, corporation or governmental authority unless it shall have been first submitted to and approved by the Commission…." In section 2.3.5 of the Commission's *Rules of Practice and Procedure* ("RPP"), the Commission has defined those projects that may have a substantial effect on the water resources of the basin in part by establishing thresholds for the daily average gross water withdrawal during any 30 consecutive day period and by the daily average design capacity of domestic sewage treatment facilities. Some natural gas extraction projects may exceed these thresholds and therefore be subject to review pursuant to these provisions, while others may fall below the thresholds and therefore not be subject to review pursuant to these provisions. The RPP further require the sponsor of any project that involves any discharge of pollutants into surface or ground waters of the basin irrespective of quantity to obtain Commission approval. RPP section 2.3.5B.6. See also Commission Water Code section 3.40

In recognition of the importance of protecting high quality waters that are subject to the Commission's antidegradation regulations, the RPP also give the Executive Director the authority in her discretion to require a project sponsor to obtain Commission approval notwithstanding the fact that the thresholds in the RPP have not been exceeded. Section 2.3.5B.18 of the RPP includes as a reviewable project: "Any other project that the Executive Director may specially direct by notice to the project sponsor or land owner as having a potential substantial water quality impact on waters classified as Special Protection Waters." Most of the shale formations that may be subject to the new horizontal drilling and hydraulic fracturing techniques are located within the drainage area to Special Protection Waters. The Executive Director has considered and has now determined that as a result of water withdrawals,

wastewater disposal and other activities, natural gas extraction projects in these shale formations may individually or cumulatively affect the water quality of Special Protection Waters by altering their physical, biological, chemical or hydrological characteristics.

The Executive Director therefore specially directs by this notice to natural gas extraction project sponsors that they may not commence any natural gas extraction project located in shale formations within the drainage area of Special Protection Waters without first applying for and obtaining Commission approval. For this purpose a project encompasses the drilling pad upon which a well intended for eventual production is located, all appurtenant facilities and activities related thereto and all locations of water withdrawals used or to be used to supply water to the project. Wells intended solely for exploratory purposes are not covered by this Determination. Commencing a project encompasses performing any of the activities associated with the project, including the activities identified in the first paragraph above. The Commission recognizes that each natural gas extraction project will also be subject to the review of the environmental agency of the state or Commonwealth in which the project is located and in some cases, subject to federal agency review. The Commission intends to coordinate with and where feasible to utilize the review process and approvals of the applicable state or federal agency to minimize duplication of effort and redundant requirements imposed on project sponsors.

A copy of this Declaration will be posted on the Commission's website, and additional copies will be mailed directly to those project sponsors and potential project sponsors that the Commission has identified. The Commission intends to promulgate regulations pertaining to the subject matter of this Declaration after public notice and a full opportunity for public comment.

Any person adversely affected by this Determination may request a hearing by submitting a request in writing to the Commission Secretary within thirty (30) days of the date of this Determination in accordance with the RPP.

Carol R. Collier

Carol R. Collier, Executive Director
Dated: May 19, 2009

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

COPY

CORRECTED WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 825419
Watershed Name:	Quality:

Permittee: NEWFIELD APPALACHIA PA LLC	OGO.#: OGO-67425		Permit Number: 37-127-20012-	Date Issued: 04/29/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020			Farm Name & Well Number: HL RUTLEDGE 1 1	Well Serial #:
			Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424			7½ ' Quadrangle Name: Galilee	Map Section #: 2
Phone: (281) 847-6031	Project #:		Latitude: 41-43-43.2000	Longitude: -75-11-32.1000
Surf Elev at Site: 1440 feet	Anticipated Total Depth: 8350 feet	Well Type: TE	Offset distances referenced to NE corner of map section. South 7820 feet West 6983 feet	

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/29/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 825419
Watershed Name: N. Branch Culkins Creek	Quality HQ

WELL PERMIT COPY

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20012-	04/29/2010
Address		Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E STE 2020		HL RUTLEDGE 1 1	
		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½' Quadrangle Name: Galilee	Map Section #: 2
Phone: (281) 847-6031	Project #	Latitude: 41-43-43.2000	Longitude: -75-11-32.1000
Surf Elev at Site: 1440 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 7820 feet West 6983 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/29/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Stacy Gustafson, for S. Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

COPY

DEP USE ONLY	
Site ID	Primary Fac ID: 728266
Client Id: 277879	Subfacility Id

Well Record and Completion Report

ll Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20012-		

Address	Well Farm Name & Well #	Serial #
363 N SAM HOUSTON PKWY E STE 2020,	HL RUTLEDGE 1 1	

City	State	Zip Code	County	Municipality
HOUSTON	TX	77060-2424	Wayne	Damascus

Phone	Fax	USGS 7.5 min. quadrangle map
(281) 847-6031		Galilee

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved,

Name	Name	Name
Address	Address	Address
City - State - Zip	City - State - Zip	City - State - Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20012--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728266
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879	Well API # (Permit / Reg): 37-127-20012-	
Address: 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well #: HL RUTLEDGE 1 1	Serial #
City: HOUSTON	State: TX / Zip Code: 77060-2424	County: Wayne	Municipality: Damascus
Phone: (281) 847-6031	Fax		

B. Land Application of Tophole Water

Date applied	pH
Volume (bbls)	Spec. cond. (µmhos/cm)

C. Off-site Waste Disposal

Type: ☐ Driling Fluid (803) Amount: bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: Qty: bbls or tons

Method of disposal or reuse

☐ Sewage Treatment Plant (10)
☐ Disposal Well (04)
☐ Brine Treatment Plant (12)
☐ Landfill (05)
☐ Other (08)

Facility Information

Name | Permit #

Hauler Information

Name

Address

City | State | Zip Code

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees | Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E.
☐ Lined pit, complete Section E.
☐ Land application, complete Section F.
☐ Dusting
☐ Solidification
☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Dear Operator:

Enclosed please find well permit(s) issued for drilling or altering a well. Developing this resource in a safe and environmentally protective manner is of utmost importance. As you may be aware, there have been several recent incidences where water supplies have been affected by natural gas migration. In order to prevent future impacts to the Commonwealth's water resources and provide a mechanism for ensuring public safety, the Department is providing the following information as a reminder of the cementing requirements for oil and gas wells.

Cementing

Properly cementing the casing of a well is critical to protecting water resources, preventing gas migration, and ensuring well integrity. If the casing is improperly cemented or if insufficient cement is used, such as when cement is not returned to the surface, the operator should notify the Department pursuant to 25 Pa. Code § 78.86.

In addition, when cementing surface casing, 25 Pa. Code § 78.85 states that the cement must be allowed to set for at least 8 hours *and* until the cement attains a compressive strength of at least 350 psi. While the cement is setting, the casing must not be disturbed. This includes any activity that may cause movement or pressure changes to the casing or the cement sheath surrounding the casing. After the cement is set, care must be taken when drilling through the plug to prevent damaging the seal at the casing seat. Disturbing the casing while cement is setting or damaging the seal at the casing seat may provide a mechanism for gas and other fluids to escape from the well and contaminate groundwater and water supplies. If this occurs, the operator must notify the Department.

In addition, the Department also reminds you of the following reporting requirements for oil and gas wells.

Reporting

1. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(a) of Chapter 78 of the Oil and Gas Regulations, a **Well Record** must be submitted to the Department within thirty (30) days of cessation of drilling or altering a well.

2. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(b) of Chapter 78 of the Oil and Gas Regulations, a **Completion Report** must be submitted to the Department within thirty (30) days of completion of the well. A copy of the Well Record and Completion Report is enclosed with this letter. This is a newly revised form which requires the operator to certify that the well has been cased and cemented according to the requirements of 25 Pa. Code Chapter 78. Well Record and Completion Report forms that do not contain this certification will not be accepted by the Department. Additional copies of this form can be obtained from the Department's eLibrary at http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-9841

3. Pursuant to Section 212(a) of the Oil and Gas Act, a report specifying the well status and production on the most well-specific basis available is to be provided to the Department. Section 78.121 of Chapter 78 details the reporting time frames required for various well types, waste reporting, and the acceptable format for the **Well and Waste Production Report** submissions.

4. Also note that pursuant to Section 212(b) of the Oil and Gas Act, the Department has the authority to request and does hereby request you submit a digital copy on CD of **ALL Well Logs** (temperature, electrical, radioactive, gamma ray, neutron, induction, resistivity, multi-arm caliper, acoustic, optical, etc.) that have been run on this well.

The above records and logs are to be submitted to the Department of Environmental Protections, Oil and Gas Management, 230 Chestnut St., Meadville, Pa 16335-3481 to the attention of the Regional Oil and Gas Manager.

Thank you for your cooperation in this matter.

Sincerely,

S. Craig Lobins
Regional Manager
Oil and Gas Management

Please note that the most recent revision of the Application for Drilling or Altering a Well must be submitted with all drilling applications. Please check the website below for the most recent revisions for all forms.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/o_gforms.htm

The Erosion,Sediment& Storm water Control Module is no longer being accepted for ESCGP-1 applications. Please submit the complete ESCGP-1 application for any projects. The most recent revisions must be submitted along with the application fee of $500.00

RUTLEDGE WELL PAD
NEWFIELD APPALACHIA PA LLC.

DAMASCUS TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

EROSION & SEDIMENT CONTROL PLAN

MAY 2010

DRAWING INDEX	
No.	DRAWING TITLE
C-1	EROSION & SEDIMENT CONTROL PLAN
C-2	EROSION & SEDIMENT CONTROL NOTES
C-3	EROSION & SEDIMENT CONTROL DETAILS
C-4	STAKEOUT & SITE GEOMETRY PLAN
C-5	SITE SECTIONS
C-6	CONSTRUCTION DETAILS & BID QUANTITIES
C-7	CONSTRUCTION SPECIFICATIONS

TETRA TECH

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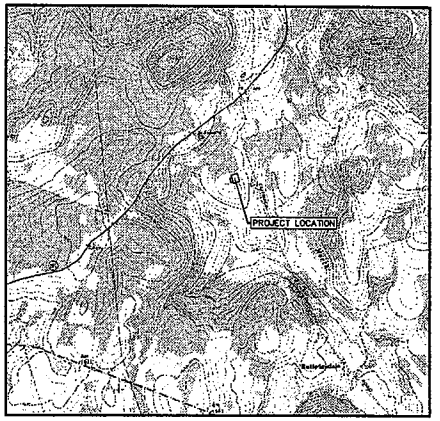
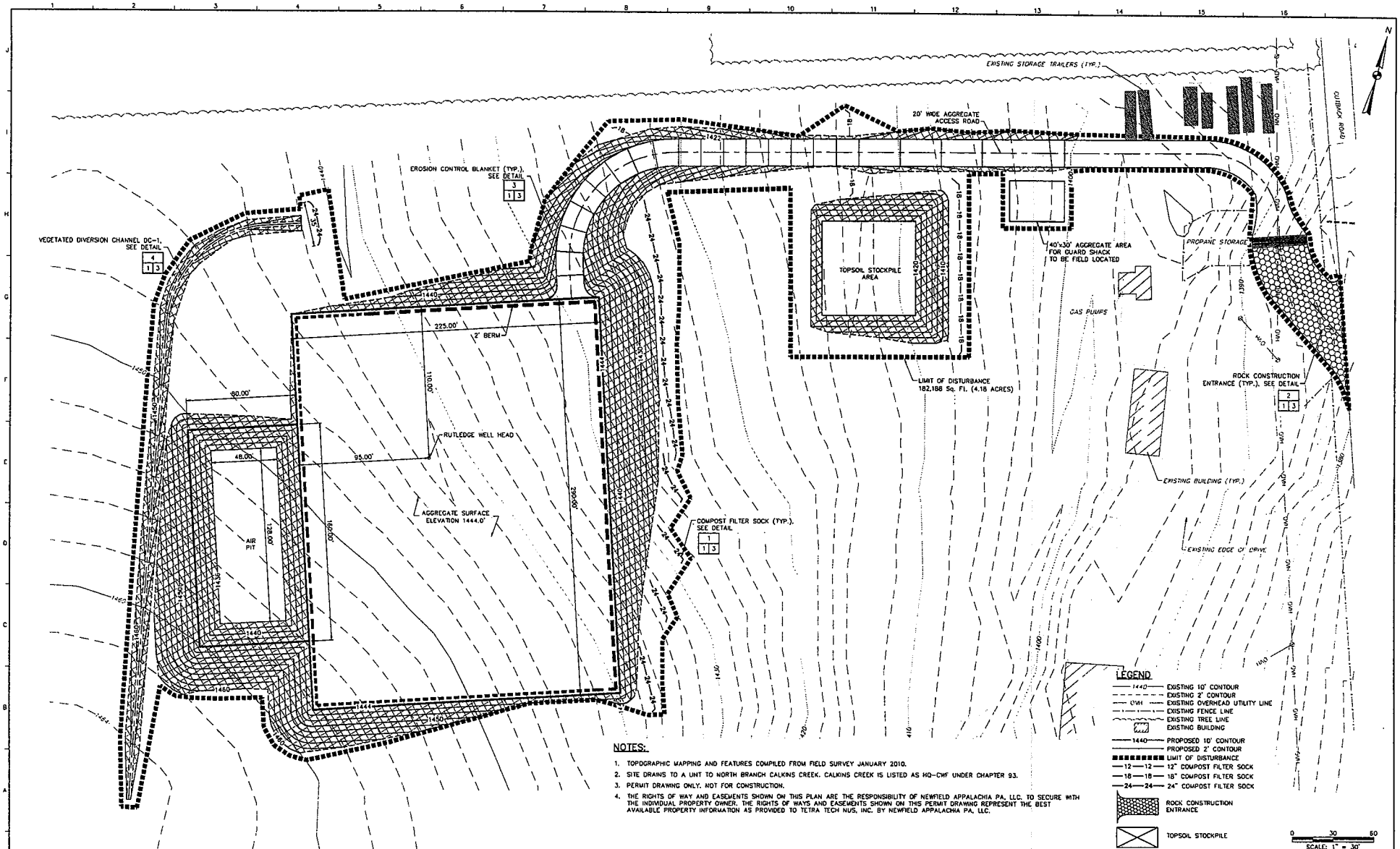
661 ANDERSEN DRIVE – FOSTER PLAZA VII, PITTSBURGH, PA 15220
TEL: (412) 921-7090 | FAX: (412) 921-4040



LOCATION MAP
GALILEE, PA. – USGS 7.5' QUADRANGLE
RUTLEDGE WELL PAD
WAYNE COUNTY, PENNSYLVANIA
SCALE: 1" = 2000'

0 2000 4000
SCALE: 1" = 2000'



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO A UNT TO NORTH BRANCH CALKINS CREEK. CALKINS CREEK IS LISTED AS HQ-CWF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 30'

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	1 OF 7

C-1

STANDARD EROSION AND SEDIMENT CONTROL PLAN NOTES

1. STOCKPILE HEIGHTS MUST NOT EXCEED 35 FEET. STOCKPILE SLOPES MUST BE 2:1 OR FLATTER.
2. THE OPERATOR SHALL ASSURE THAT THE APPROVED EROSION AND SEDIMENT CONTROL PLAN IS PROPERLY IMPLEMENTED.
3. UNTIL THE SITE ACHIEVES FINAL STABILIZATION, THE OPERATOR SHALL ASSURE THAT THE BEST MANAGEMENT PRACTICES ARE IMPLEMENTED, INSPECTED, OPERATED, AND MAINTAINED. THE OPERATOR SHALL MAINTAIN AND MAKE AVAILABLE TO DEPARTMENT OF ENVIRONMENTAL PROTECTION, WRITTEN INSPECTION LOGS. ALL MAINTENANCE WORK, INCLUDING CLEANING, REPAIR, REPLACEMENT, REGRADING, AND RESTABILIZATION SHALL BE PERFORMED IMMEDIATELY UPON DISCOVERY OF DEFICIENCY.
4. ALL PUMPING OF SEDIMENT LADEN WATER SHALL BE THROUGH A SEDIMENT CONTROL BMP, SUCH AS A PUMPED WATER FILTER BAG DISCHARGING OVER NON-DISTURBED AREAS.
5. THE CONTRACTOR SHALL REVIEW THE PROVISIONS OF THE APPENDIX 64, EROSION CONTROL RULES AND REGULATIONS, TITLE 25, PART 1, DEPARTMENT OF ENVIRONMENTAL PROTECTION, SUBPART C. PROTECTION OF NATURAL RESOURCES, ARTICLE III, WATER RESOURCES, CHAPTER 102, EROSION CONTROL.
6. A COPY OF THE EROSION AND SEDIMENT CONTROL PLAN MUST BE ON THE PROJECT SITE AT ALL TIMES.
7. EROSION AND SEDIMENT BMPS MUST BE CONSTRUCTED, STABILIZED, AND FUNCTIONAL BEFORE SITE DISTURBANCE BEGINS WITHIN THE TRIBUTARY AREAS OF THOSE BMPS.
8. AFTER FINAL SITE STABILIZATION HAS BEEN ACHIEVED, TEMPORARY EROSION AND SEDIMENT BMPS CONTROLS SHALL BE REMOVED. AREAS DISTURBED DURING REMOVAL OF THE BMPS MUST BE STABILIZED IMMEDIATELY.
9. AN AREA SHALL BE CONSIDERED TO HAVE ACHIEVED FINAL STABILIZATION WHEN IT HAS A MINIMUM UNIFORM 70% PERENNIAL VEGETATIVE COVER OR OTHER PERMANENT NON-VEGETATIVE COVER WITH A DENSITY SUFFICIENT TO RESIST ACCELERATED SURFACE EROSION AND SUBSURFACE CHARACTERISTICS SUFFICIENT TO RESIST SLIDING AND OTHER MOVEMENTS.
10. AT LEAST 3 DAYS BEFORE STARTING ANY EARTH DISTURBANCE ACTIVITIES, ALL CONTRACTORS INVOLVED IN THOSE ACTIVITIES SHALL NOTIFY THE PENNSYLVANIA ONE CALL SYSTEM AT 1-800-242-1776 FOR BURIED UTILITIES LOCATIONS.
11. IN A TIMELY MANNER AFTER EARTH DISTURBANCE ACTIVITIES CEASE, THE OPERATOR SHALL STABILIZE ANY AREAS DISTURBED BY THE ACTIVITIES. DURING NON-GERMINATING PERIODS, MULCH MUST BE APPLIED AT THE SPECIFIED RATES. DISTURBED AREAS WHICH ARE NOT AT FINISHED GRADE AND WHICH WILL BE REDISTURBED WITHIN 1 YEAR MUST BE STABILIZED IN ACCORDANCE WITH THE TEMPORARY VEGETATIVE STABILIZATION SPECIFICATIONS. DISTURBED AREAS WHICH ARE AT FINISHED GRADE OR WHICH WILL NOT BE REDISTURBED WITHIN 1 YEAR MUST BE STABILIZED IN ACCORDANCE WITH THE PERMANENT VEGETATIVE STABILIZATION SPECIFICATIONS.
12. AT STREAM CROSSINGS, 50' BUFFER AREAS SHOULD BE MAINTAINED. ON BUFFERS, CLEARING, SOD DISTURBANCES, EXCAVATION, AND EQUIPMENT TRAFFIC SHOULD BE MINIMIZED. ACTIVITIES SHOULD AS STACKING LOGS, BURNING CLEARED BRUSH, DISCHARGING RAINWATER FROM TRENCHES, WELDING PIPE SECTIONS, REFUELING AND MAINTAINING EQUIPMENT SHOULD BE ACCOMPLISHED OUTSIDE OF BUFFERS.
13. MULCH OR EROSION CONTROL BLANKETS MUST BE INSTALLED ON ALL SLOPES 3:1 AND STEEPER.
14. SEDIMENT REMOVED FROM BMPS SHALL BE DISPOSED OF IN LANDSCAPED AREAS OUTSIDE OF STEEP SLOPES, WETLANDS, FLOODPLAINS OR DRAINAGE SWALES AND IMMEDIATELY STABILIZED, OR PLACED IN TOPSOIL STOCKPILES.
15. THE OPERATOR SHALL REMOVE FROM THE SITE, RECYCLE, OR DISPOSE OF ALL BUILDING MATERIALS AND WASTES IN ACCORDANCE WITH THE DEPARTMENT'S SOLID WASTE MANAGEMENT REGULATIONS AT 25 PA. CODE 260.1 ET SEQ., 271.1 ET SEQ., AND 287.1 ET SEQ. THE CONTRACTOR SHALL NOT ILLEGALLY BURY, DUMP, OR DISCHARGE ANY BUILDING MATERIAL OR WASTES AT THE SITE.

TEMPORARY EROSION AND SEDIMENT CONTROLS
INSPECTION AND MAINTENANCE SCHEDULE

BMP	INSPECTION FREQUENCY	MAINTENANCE TO BE PERFORMED
COMPOST FILTER SOCK	WEEKLY AND AFTER RAINFALL EVENTS	MAINTENANCE SHALL BE PERFORMED AS NEEDED . SEDIMENT SHALL BE REMOVED ONCE IT HAS ACCUMULATED TO ONE HALF THE ORIGINAL HEIGHT OF THE BARRIER. COMPOST FILTER SOCK SHALL BE REPLACED WHENEVER IT HAS DETERIORATED TO SUCH AN EXTENT THAT THE EFFECTIVENESS OF COMPOST FILTER SOCK IS REDUCED. COMPOST FILTER SOCKS SHALL REMAIN IN PLACE UNTIL DISTURBED AREAS HAVE BEEN PERMANENTLY STABILIZED. ALL SEDIMENT ACCUMULATION AT THE COMPOST FILTER SOCK SHALL BE REMOVED AND PROPERLY DISPOSED OF BEFORE THE COMPOST FILTER SOCK IS REMOVED.
ROCK CONSTRUCTION ENTRANCE	DAILY	CONTRACTOR SHALL MAINTAIN/REPLACE MATERIAL AS NEEDED THROUGHOUT CONSTRUCTION TO MAINTAIN MINIMUM THICKNESS DURING USE OF ACCESS ROAD. A STOCKPILE OF ROCK WILL MAINTAINED ON SITE FOR THIS PURPOSE
MULCH STABILIZATION PEG AND TWINE	WEEKLY AND AFTER RAINFALL EVENTS	REPLACE MULCH, PEGS AND TWINE AS REQUIRED. RESTORE SEEDING IN AFFECTED AREA IF NECESSARY.

REVEGETATION

A. TEMPORARY GRASS COVER SHALL BE ESTABLISHED IN THE FOLLOWING AREAS:

1. WHERE SOIL STOCKPILES ARE TO BE EXPOSED FOR A PERIOD GREATER THAN THIRTY (30) DAYS, THE STOCKPILE SHALL BE SEEDED.
2. WHERE VEGETATIVE FILTERS MUST BE ESTABLISHED BELOW FILTER BAGS, A MINIMUM DISTANCE OF 10 FT SHALL BE SEEDED DOWNSLOPE OF THE TRAP OUTLET. TEMPORARY COVER - SEED MIXTURE FOR TEMPORARY COVER SHALL CONSIST OF 100% ANNUAL RYEGRASS. SEED SHALL BE APPLIED AT THE RATE OF 40 LB/ACRE OR AS RECOMMENDED BY A LOCAL RECOGNIZED SEED SUPPLIER APPROVED BY THE OWNER'S REPRESENTATIVE, PRIOR TO SEEDING, APPLY 1 TON OF AGRICULTURAL GRADE LIMESTONE PER ACRE PLUS FERTILIZER AT THE RATE OF 15-30-30 LB. PER ACRE AND WORK INTO SOIL.

B. PERMANENT COVER:

RECOMMENDED PERMANENT SEED MIXTURES
COOL AND WARM SEASON GRASS

MIXTURE NUMBER	SEASON	SEASON [SEEDING RATE LB/AC.]
1	COOL	TALL FESCUE*[79], OR FINE FESCUE[45], PLUS REDTOP[4], OR PERENNIAL RYEGRASS[15], PLUS BIRDSFOOT TREFOIL[6]
2	COOL	BIRDSFOOT TREFOIL[8], PLUS TALL FESCUE*[40]
3	COOL	ORCHARDGRASS[26], OR SMOOTH BROMEGRASS[33], PLUS BIRDSFOOT TREFOIL[8]
4	WARM	FLATPEA[27], PLUS TALL FESCUE*[26], OR PERENNIAL RYEGRASS[25]
5	WARM	DEERTOUNGE[21], PLUS BIRDSFOOT TREFOIL[8]
6	WARM	SWITCHGRASS[15], OR BIG BLUESTEM[15], PLUS BIRDSFOOT TREFOIL[8]

RECOMMENDED PERMANENT SEED MIXTURES
FOR STABILIZING DISTURBED AREAS

SITE CONDITION	SEED MIXTURE
CUT SLOPES & FILLS (NOT MOWED)	
WELL-DRAINED	2, 4 OR 6
VARIABLE DRAINAGE	2
CUT SLOPES & FILLS (MOWED)	1
CUT SLOPES & FILLS (GRAZED/HAY)	1, 2 OR 3
GULLIES & ERODABLE AREAS	2 OR 6
EROSION CONTROL BMP'S	
CHANNELS, DRAINAGE DITCHES, TRAP EMBANKMENTS, ETC	1 OR 2
FOR HAY OR SILAGE	2 OR 3
RIGHT-OF-WAY	
WELL-DRAINED	4 OR 6
VARIABLE DRAINAGE	2
WELL-DRAINED AREAS FOR GRAZING/HAY	2 OR 3
STRIP MINED AREAS	
SPOILS, WASTE AREAS, FLY ASH, SLAG, ETC. (LIME TO SOIL TEST)	2, 4 OR 5
FOR GRAZING/HAY	2, 3 OR 6

CONSTRUCTION SEQUENCE

REFER TO THE E&SC PLAN DRAWINGS FOR THE LOCATION OF THE PROPOSED WORK AND THE ASSOCIATED BMPS. A GENERALIZED CONSTRUCTION SEQUENCE IS PROVIDED BELOW. THE CONSTRUCTION SEQUENCE IS INTENDED TO PROVIDE A GENERAL COURSE OF ACTION IN ORDER TO CONFORM TO THE APPLICABLE REGULATORY AGENCY REQUIREMENTS FOR TEMPORARY AND PERMANENT SOIL EROSION AND SEDIMENTATION CONTROL. ALL NECESSARY PARTS FOR PROPER AND COMPLETE EXECUTION OF WORK PERTAINING TO THIS PLAN, WHETHER SPECIFICALLY MENTIONED OR NOT, ARE TO BE PERFORMED BY THE CONTRACTOR. IT IS NOT INTENDED THAT THE DRAWINGS AND THIS REPORT SHOW EVERY DETAILED PIECE OF MATERIAL OR EQUIPMENT. THE CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS LISTED IN THIS SECTION. THE CONTRACTOR MAY BE REQUIRED TO ALTER CONTROLS BASED ON EFFECTIVENESS OF CONTROLS OR DIFFERING CONDITIONS ENCOUNTERED IN THE FIELD.

1. LOCATE STAGING AREAS AND ACCESS POINTS INCLUDING CONSTRUCTION ENTRANCES. INSTALL COMPOST FILTER SOCKS DOWN SLOPE OF THESE AREAS.
2. INSTALL ROCK CONSTRUCTION ENTRANCE. REFER TO THE ROCK CONSTRUCTION ENTRANCE DETAIL ON DRAWINGS FOR SUGGESTED DIMENSIONS.
3. INSTALL COMPOST FILTER SOCKS ALONG THE PERIMETERS OF THE SITE AS SHOWN ON THE CONSTRUCTION DRAWINGS.
4. INSTALL THE DIVERSION CHANNEL AROUND THE PROJECT AREA AND INSTALL 24" COMPOST FILTER SOCK AT CHANNEL DISCHARGE LOCATION. LOCATIONS ARE MARKED ON PLAN SHEET C-1.
5. CLEAR AND GRUB THE SITE.
6. STRIP AND STOCKPILE TOPSOIL. CONSTRUCT STOCKPILES AS SHOWN IN THE DETAILS ON THE CONSTRUCTION DRAWINGS.
7. MINIMIZE TOTAL AREA OF DISTURBANCE. MAINTAIN ALL TEMPORARY SOIL STOCKPILES WITHIN EXISTING SOIL EROSION AND SEDIMENT CONTROLS.
8. GRADE SURFACE TO FINISHED GRADE ELEVATIONS AS SOON AS PRACTICABLE.
9. INSTALL EROSION CONTROL BLANKET ON ALL SLOPES GREATER THAN 3:1 AS SHOWN ON THE CONSTRUCTION DRAWINGS.
10. AS FINAL GRADES ARE REACHED, IMMEDIATELY SEED AND MULCH DISTURBED AREAS OR PREPARE FOR AGGREGATE PAVING ON ACCESS ROAD OR PAD AREA.
11. MAINTAIN ALL EROSION AND SEDIMENTATION CONTROL DEVICES UNTIL SITE WORK IS COMPLETE AND A UNIFORM 70% PERENNIAL VEGETATIVE COVER AND AGGREGATE STABILIZATION IS ESTABLISHED.
12. REMOVE ALL SOIL AND EROSION SEDIMENT CONTROL MEASURES UPON ESTABLISHMENT OF A UNIFORM 70% VEGETATIVE COVER AND AGGREGATE STABILIZATION OVER THE DISTURBED AREA. RE-GRADE AND REVEGETATE AREAS DISTURBED DURING THE REMOVAL OF THE SOIL EROSION AND SEDIMENT CONTROLS. REMOVE ALL SOIL AND EROSION SEDIMENT CONTROL MEASURES UPON ESTABLISHMENT OF A UNIFORM 70% VEGETATIVE COVER AND AGGREGATE STABILIZATION OVER THE DISTURBED AREA. RE-GRADE AND REVEGETATE AREAS DISTURBED DURING THE REMOVAL OF THE SOIL EROSION AND SEDIMENT CONTROLS.
13. WITHIN 9 MONTHS FROM THE COMPLETION OF DRILLING, RESTORE SITE AS PER SECTION 3.6 (SITE RESTORATION) OF THIS E&S PLAN.

SITE RESTORATION

AREAS AT FINAL GRADE ARE TO BE SEEDED, MULCHED AND STABILIZED IMMEDIATELY AS SPECIFIED ABOVE. WITHIN NINE MONTHS AFTER COMPLETION OF DRILLING THE WELL, THE OIL AND GAS WELL OWNER OR OPERATOR MUST RESTORE THE LAND SURFACE WITHIN THE AREA DISTURBED IN SITING, DRILLING, COMPLETING AND PRODUCING THE WELL. THIS INCLUDES:

a. REMOVING OR FILLING THE PIT USED TO CONTAIN PRODUCED FLUIDS OR INDUSTRIAL WASTES AND DRILL CUTTINGS. PROCEDURES FOR PROPER WASTE HANDLING AND DISPOSAL SHALL BE IN ACCORDANCE WITH DEP ACCEPTED PRACTICES AND STANDARDS.

b. REMOVING ALL DRILLING SUPPLIES NOT NEEDED FOR PRODUCTION. DRILLING SUPPLIES AND EQUIPMENT NOT NEEDED FOR PRODUCTION MAY BE STORED AT THE WELL SITE IF THE EXPRESS WRITTEN CONSENT OF THE SURFACE LANDOWNER IS OBTAINED.

c. REMOVING ALL DRILLING SUPPLIES NOT NEEDED FOR PRODUCTION. DRILLING SUPPLIES AND EQUIPMENT NOT NEEDED FOR PRODUCTION MAY BE STORED AT THE WELL SITE IF THE EXPRESS WRITTEN CONSENT OF THE SURFACE LANDOWNER IS OBTAINED.

d. IMPLEMENT TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES TO MINIMIZE THE POTENTIAL FOR ACCELERATED EROSION AND SEDIMENTATION DUE TO EARTH DISTURBANCES NECESSARY FOR SITE RESTORATION. THESE AREAS ARE TO BE SEEDED AND MULCHED UPON COMPLETION

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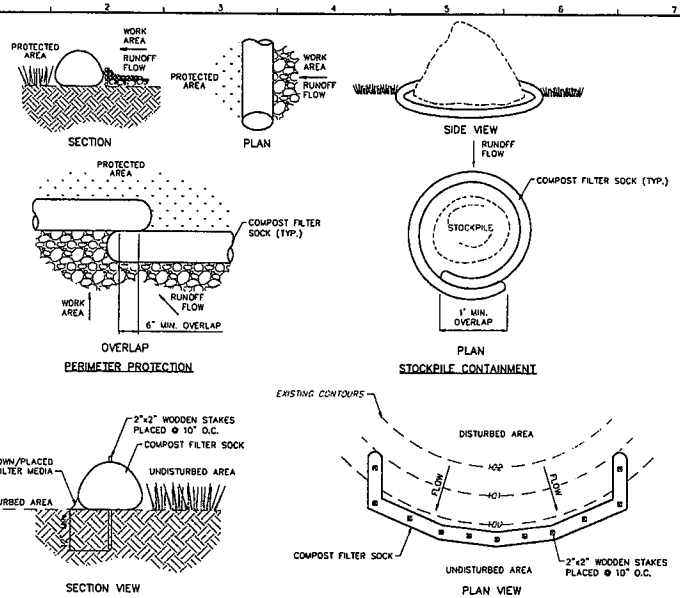
MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
EROSION & SEDIMENT CONTROL NOTES
SCALE: NOT TO SCALE

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	2 OF 7

C-2



COMPOST STANDARDS	
ORGANIC MATTER CONTENT	80%-100% (DRY WEIGHT BASIS)
ORGANIC	FIBROUS & ELONGATED
pH	5.5-8.0
MOISTURE CONTENT	35%-55%
PARTICLE SIZE	98% PASS THROUGH 1" SCREEN
SOLUBLE SALT CONCENTRATION	5.0 dS MAXIMUM

MAXIMUM SLOPE LENGTHS FOR COMPOST FILTER SOCK			
% SLOPE	12" DIAMETER	18" DIAMETER	24" DIAMETER
2 (OR LESS)	150	500	1000
5	100	250	550
10	50	150	325
15	35	100	215
20	25	70	175
25	20	55	135
30	15	45	100
35	15	40	85
40	15	35	75
45	10	30	60
50	10	25	50

COMPOST FILTER SOCK SHALL BE PLACED AT EXISTING LEVEL GRADE. BOTH ENDS OF THE SOCK SHALL BE EXTENDED AT LEAST 8 FEET UP SLOPE AT 45 DEGREES TO THE MAIN SOCK ALIGNMENT. MAXIMUM SLOPE LENGTH ABOVE ANY 18" DIAMETER SOCK SHALL NOT EXCEED THAT SHOWN ON ABOVE TABLE FOR REINFORCED SILT FENCE. MAXIMUM SLOPE LENGTH FOR A 24" DIAMTERE SOCK SHALL NOT EXCEED THAT FOR SUPER SILT FENCE.

TRAFFIC SHALL NOT BE PERMITTED TO CROSS FILTER SOCKS.

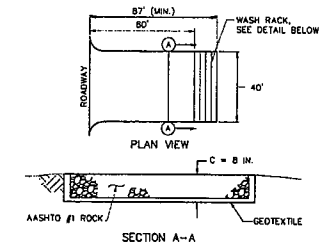
ACCUMULATED SEDIMENT SHALL BE REMOVED WHEN IT REACHES 1/2 THE ABOVE GROUND HEIGHT OF THE SOCK AND DISPOSED IN THE MANNER DESCRIBED ELSEWHERE IN THE PLAN.

SOCKS SHALL BE INSPECTED WEEKLY AND AFTER EACH RUNOFF EVENT. DAMAGED SOCKS SHALL BE REPAIRED ACCORDING TO MANUFACTURER'S SPECIFICATIONS OR REPLACED WITHIN 24 HOURS OF INSPECTION.

BIODEGRADABLE FILTER SOCK SHALL BE REPLACED AFTER 6 MONTHS; PHOTODEGRADABLE SOCKS AFTER 1 YEAR. POLYPROPYLENE SOCKS SHALL BE REPLACED ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

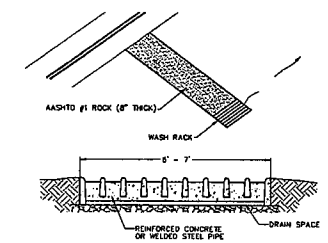
UPON STABILIZATION OF THE AREA TRIBUTARY TO THE SOCK, STAKES SHALL BE REMOVED. THE SOCK MAY BE LEFT IN PLACE AND VEGETATED OR REMOVED. IN THE LATTER CASE, THE MESH SHALL BE CUT OPEN AND THE MULCH SPREAD AS A SOIL SUPPLEMENT.

COMPOST FILTER SOCK | 1 | 1 | 3
NOT TO SCALE



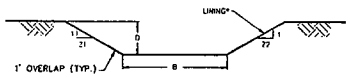
MAINTENANCE: ROCK CONSTRUCTION ENTRANCE THICKNESS SHALL BE CONSTANTLY MAINTAINED TO THE SPECIFIED DIMENSIONS BY ADDING ROCK. A STOCKPILE SHALL BE MAINTAINED ON SITE FOR THIS PURPOSE. AT THE END OF EACH CONSTRUCTION DAY, ALL SEDIMENT DEPOSITED ON PAVED ROADWAYS SHALL BE REMOVED AND RETURNED TO THE CONSTRUCTION SITE.

ROCK CONSTRUCTION ENTRANCE | 2 | 1 | 3
NOT TO SCALE



MAINTENANCE:
ROCK CONSTRUCTION ENTRANCE THICKNESS SHALL BE CONSTANTLY MAINTAINED TO THE SPECIFIED DIMENSIONS BY ADDING ROCK. A STOCKPILE OF ROCK MATERIAL SHALL BE MAINTAINED ON SITE FOR THIS PURPOSE. DRAIN SPACE UNDER WASH RACK SHALL BE KEPT OPEN AT ALL TIMES. DAMAGE TO THE WASH RACK SHALL BE REPAIRED PRIOR TO FUTHER USE OF THE RACK. AT THE END OF EACH CONSTRUCTION DAY, ALL SEDIMENT DEPOSITED ON PAVED ROADWAYS SHALL BE REMOVED AND RETURNED TO THE CONSTRUCTION SITE.

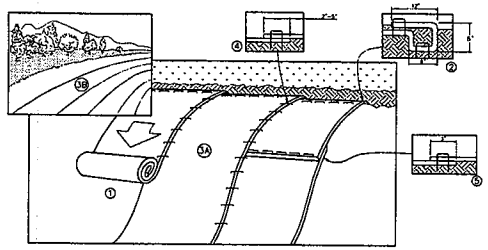
WASH RACK DETAIL
NOT TO SCALE



CHANNEL NO.	BOTTOM WIDTH B (FT)	DEPTH D (FT)	Z1 (FT)	Z2 (FT)	LINING*
DC-1	2.0	1.5	2:1	2:1	VEGETATED

* SEE MANUFACTURER'S LINING INSTALLATION DETAIL FOR STAPLE PATTERNS, AND VEGETATION STABILIZATION SPECIFICATIONS FOR SOIL AMENDMENTS, SEED MIXTURES, AND MULCHING INFORMATION.

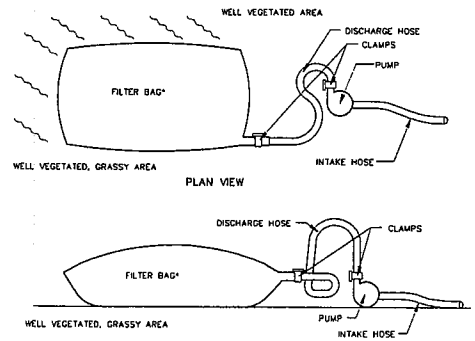
VEGETATED CHANNELS | 4 | 1 | 3
NOT TO SCALE



NOTES:

1. PREPARE SOIL BEFORE INSTALLING ROLLED EROSION CONTROL PRODUCTS (RECP's), INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
   NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE RECP's IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF RECP's EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE RECP's WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF RECP's BACK OVER SEED AND COMPACTED SOIL. SECURE RECP's OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE RECP's.
3. ROLL THE RECP's (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. RECP's WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL RECP's MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. THE EDGES OF PARALLEL RECP's MUST BE STAPLED WITH APPROXIMATELY 2" - 3" (5 CM - 12.5 CM) OVERLAP DEPENDING ON RECP's TYPE.
5. CONSECUTIVE RECP's SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE RECP's WIDTH.
   NOTE:
   *IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE RECP's.

EROSION CONTROL BLANKET - SLOPE INSTALLATION | 3 | 1 | 3
NOT TO SCALE



NOTES:

1. FILTER SHALL BE MADE OF NON-WOVEN GEOTEXTILE MATERIAL SEWN WITH HIGH STRENGTH, DOUBLE-STITCHED "J" SEAMS. THEY SHALL BE CAPABLE OF TRAPPING PARTICLES LARGER THAN 150 MICRONS.
2. SUITABLE MEANS OF ACCESSING THE BAG WITH MACHINERY REQUIRED FOR DISPOSAL PURPOSES MUST BE PROVIDED. FILTER BAGS SHALL BE REPLACED WHEN THEY BECOME 1/2 FULL. SPARE BAGS SHALL BE KEPT AVAILABLE FOR REPLACEMENT OF THOSE THAT HAVE FAILED OR ARE FULL.
3. BAGS SHALL BE LOCATED IN WELL VEGETATED (GRASSY) AREAS, AND DISCHARGE INTO STABLE, EROSION RESISTANT AREAS. WHERE THIS IS NOT POSSIBLE, A GEOTEXTILE FLOW PATH SHALL BE PROVIDED. BAGS SHALL NOT BE PLACED ON SLOPES GREATER THAN 5%.
4. THE PUMP DISCHARGE HOSE SHALL BE INSERTED INTO THE BAGS IN THE MANNER SPECIFIED BY THE MANUFACTURER AND SECURELY CLAMPED.
5. THE PUMPING RATE SHALL BE NO GREATER THAN 750 GPM OR 1/2 THE MAXIMUM SPECIFIED BY THE MANUFACTURER, WHICHEVER IS LESS. PUMP INTAKES SHOULD BE FLOATING AND SCREENED.

PUMPED WATER FILTER BAG
NOT TO SCALE

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MARK	DATE	DESCRIPTION	BY

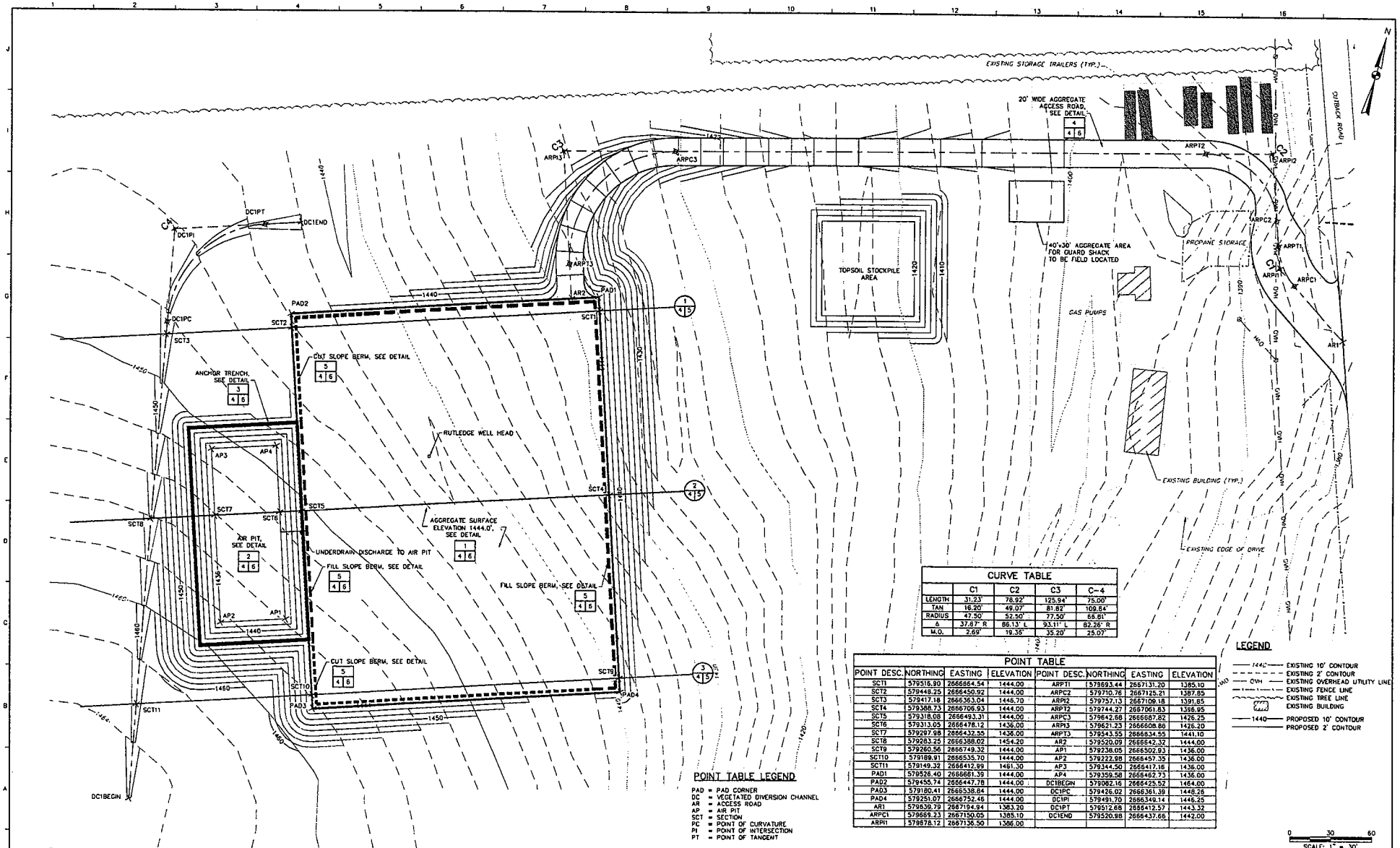
NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
EROSION & SEDIMENT CONTROL DETAILS

SCALE: AS NOTED

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	3 OF 7

C-3



CURVE TABLE				
	C1	C2	C3	C-4
LENGTH	31.23'	78.92'	125.94'	75.00'
TAN	16.20'	49.07'	81.82'	109.84'
RADIUS	47.50'	52.50'	77.50'	66.81'
Δ	37.67° R	86.13° L	93.11° L	82.26° R
M.O.	2.69'	19.38'	35.20'	25.07'

POINT TABLE							
POINT DESC.	NORTHING	EASTING	ELEVATION	POINT DESC.	NORTHING	EASTING	ELEVATION
SCT1	579516.90	2666864.54	1444.00	ARPT1	579693.44	2667131.20	1385.10
SCT2	579448.25	2666450.92	1444.00	ARPC2	579710.76	2667125.21	1387.85
SCT3	579417.18	2666363.04	1445.70	ARPI2	579757.13	2667109.18	1391.85
SCT4	579388.73	2666706.93	1444.00	ARPT2	579744.27	2667061.83	1396.95
SCT5	579318.08	2666493.31	1444.00	ARPC3	579642.66	2666687.82	1426.25
SCT6	579313.05	2666478.12	1436.00	ARPI3	579621.23	2666608.86	1426.20
SCT7	579297.98	2666432.55	1436.00	ARPT3	579543.55	2666834.55	1441.10
SCT8	579283.25	2666388.02	1454.20	AR2	579520.09	2666842.32	1444.00
SCT9	579260.56	2666749.32	1444.00	AP1	579238.05	2666502.93	1436.00
SCT10	579189.91	2666535.70	1444.00	AP2	579222.98	2666457.35	1436.00
SCT11	579149.32	2666412.99	1461.30	AP3	579344.50	2666417.16	1436.00
PAD1	579526.40	2666681.39	1444.00	AP4	579359.58	2666462.73	1436.00
PAD2	579455.74	2666447.78	1444.00	DC1BEGIN	579082.16	2666425.52	1464.00
PAD3	579180.41	2666538.84	1444.00	DC1PC	579426.02	2666361.39	1448.26
PAD4	579251.07	2666752.46	1444.00	DC1PI	579491.70	2666349.14	1446.25
AR1	579639.79	2667194.94	1383.20	DC1PT	579512.66	2666412.57	1443.32
ARPC1	579669.23	2667150.05	1385.10	DC1END	579520.98	2666437.66	1442.00
ARPI1	579878.12	2667136.50	1386.00				

POINT TABLE LEGEND

PAD = PAD CORNER
DC = VEGETATED DIVERSION CHANNEL
AR = ACCESS ROAD
AP = AIR PIT
SCT = SECTION
PC = POINT OF CURVATURE
PI = POINT OF INTERSECTION
PT = POINT OF TANGENT

LEGEND

- 1440 EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- OVH EXISTING OVERHEAD UTILITY LINE
- EXISTING FENCE LINE
- EXISTING TREE LINE
- EXISTING BUILDING
- 1440 PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR

SCALE: 1" = 30'

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MARK	DATE	DESCRIPTION	BY

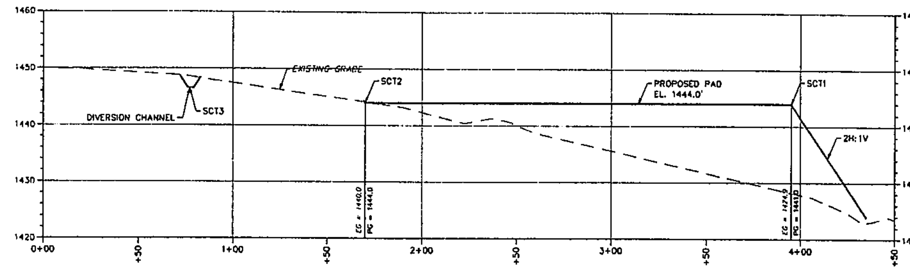
NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
STAKEOUT & SITE GEOMETRY PLAN

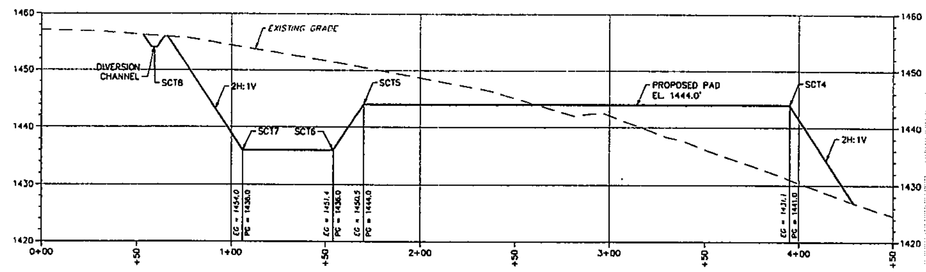
SCALE: 1" = 30'

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	4 OF 7

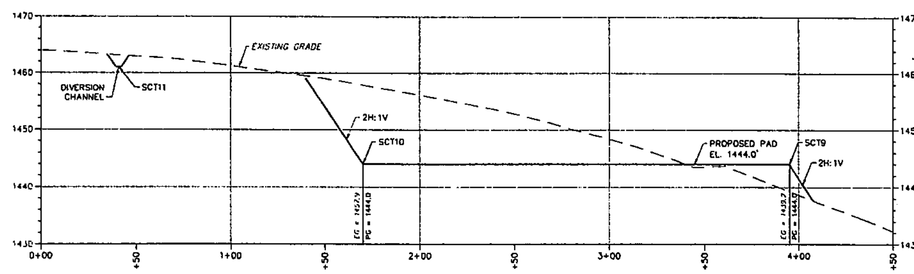
C-4



SECTION 1/4|5
SCALE: HORIZ: 1" = 30'
VERT: 1" = 10'



SECTION 2/4|5
SCALE: HORIZ: 1" = 30'
VERT: 1" = 10'



SECTION 3/4|5
SCALE: HORIZ: 1" = 30'
VERT: 1" = 10'

0 30 60
SCALE: 1" = 30'

0 10 20
SCALE: 1" = 10'

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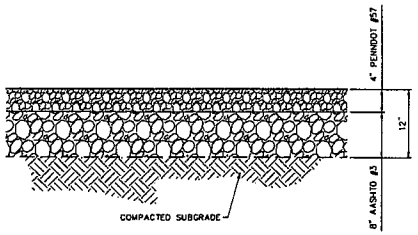
MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

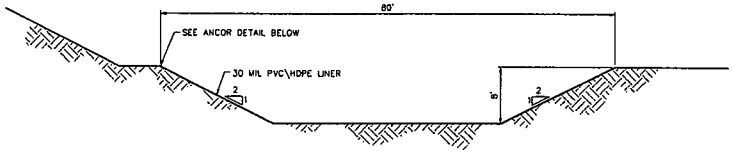
RUTLEDGE WELL PAD
SITE SECTIONS
SCALE: AS NOTED

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	5 OF 7

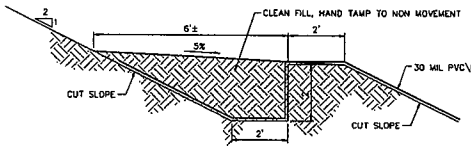
C-5



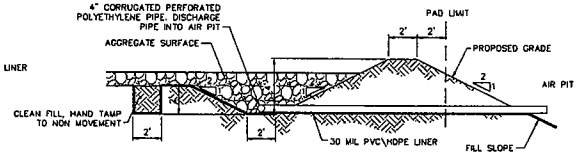
AGGREGATE SURFACE FOR WELL PAD & ACCESS ROAD 1 | 4 | 6
NOT TO SCALE



AIR PIT DETAIL 2 | 4 | 6
NOT TO SCALE

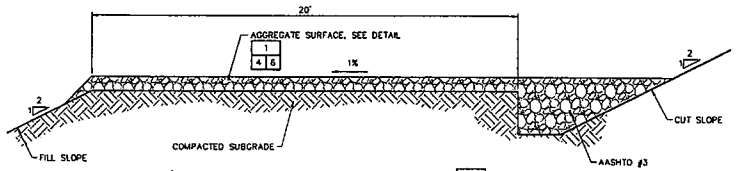


CUT SLOPE INSTALLATION

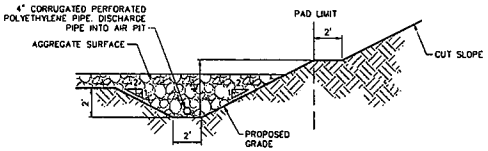


FILL SLOPE INSTALLATION

ANCHOR TRENCH DETAIL 3 | 4 | 6
NOT TO SCALE

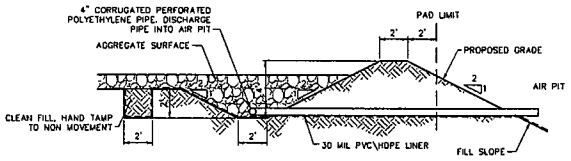


20' WIDE AGGREGATE ACCESS ROAD DETAIL 4 | 4 | 6
NOT TO SCALE



CUT SLOPE INSTALLATION

BERM DETAIL 5 | 4 | 6
NOT TO SCALE



FILL SLOPE INSTALLATION

PROJECT BID QUANTITIES

ITEM	DESCRIPTION	UNITS	QUANTITY
1	MOBILIZATION/DE-MOBILIZATION	LUMP SUM	1
2	CLEARING & GRUBBING	ACRE	4.08
3	STRIP & STOCKPILE TOPSOIL	CUBIC YARD	2,000
4	COMPOST FILTER SOCK - 12" DIAMETER	LINEAR FOOT	0
5	COMPOST FILTER SOCK - 18" DIAMETER	LINEAR FOOT	200
6	COMPOST FILTER SOCK - 24" DIAMETER	LINEAR FOOT	390
7	AGGREGATE FOR WELL PAD, ACCESS ROAD & 30'x40' GUARD SHACK AREA	CUBIC YARD	2,870
8	ROCK CONSTRUCTION ENTRANCE	EACH	1
9	EARTHWORK (INCLUDES ACCESS ROAD, WELL PAD & DIVERSION DITCHES)	CUBIC YARD	15,750
10	ROCK CUT	CUBIC YARD	N/A
11	TEMPORARY SEED, SUPPLEMENTS & MULCH	ACRE	1.11
12	RIPRAP	CUBIC YARD	10
13	EROSION CONTROL BLANKET	SQUARE YARD	5,400
14	TIRE WASH RACK	EACH	1
15	30 MIL PIT LINER	SQUARE YARD	3,000
16	4" CORRUGATED POLYETHYLENE PIPE	LINEAR FOOT	1,050
17	SITE RESTORATION - AGGREGATE REMOVAL, SPREADING TOPSOIL, PERMANENT SEEDING	LUMP SUM	N/A
18	TEMPORARY CHAIN LINK FENCE DURING CONSTRUCTION	LINEAR FOOT	N/A
19	CULVERT PIPE FOR ACCESS ROAD CROSSING	LINEAR FOOT	N/A
20	MAINTENANCE AND REPAIR OF EROSION CONTROL DEVICES	LUMP SUM	1

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
CONSTRUCTION DETAILS & BID QUANTITIES

SCALE: AS NOTED

DATE:	5/6/10
PROJECT NO.:	112C02879
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	6 OF 7

C-6

GENERAL

CONSTRUCTION ACTIVITIES WILL BE PERFORMED IN ACCORDANCE WITH PENN DOT PUBLICATION 408 SPECIFICATIONS – LATEST EDITION. THE FOLLOWING CONSTRUCTION OPERATIONS ARE INCLUDED IN THE BID PACKAGE FOR THE SITE AND ARE SUMMARIZED BELOW: SHOULD A CONFLICT BE DISCOVERED, CONTACT THE OWNER FOR A FINAL DECISION. THE OWNER IS DEFINED AS NEWFIELD APPALACHIA PA LLC.

THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS AND OR MANUFACTURERS MATERIAL CATALOG CUTS TO THE OWNER FOR REVIEW.

THE CONTRACT TERMS AND CONDITIONS SHALL BE IN ACCORDANCE WITH THE GENERAL AND SPECIAL PROVISIONS AND THE AGREEMENT AS PROVIDED BY THE OWNER.

TECHNICAL SPECIFICATIONS

1.0 CLEARING AND GRUBBING –

1.1 DESCRIPTION

REMOVAL OF TOPSOIL TO THE LIMITS OF GRADING AND STOCKPILE ON SITE AT A LOCATION DESIGNATED BY THE OWNER.

REMOVAL OF ORGANIC MATERIAL TO THE LIMITS OF GRADING AND DISPOSE OF OFF SITE

REMOVAL OF TRASH OR DEBRIS WITHIN THE GRADING LIMITS

1.2 CONSTRUCTION

INSTALL EROSION AND SEDIMENT CONTROL FEATURES PRIOR TO THE START OF CLEARING AND GRUBBING OPERATIONS

CUT TREES AND SHRUBS AND DISPOSE OF OFFSITE UNLESS DIRECTED BY THE OWNER

BURNING IS NOT PERMITTED

REMOVE STUMPS WITHIN THE GRADING AREA TO A DEPTH AT LEAST 2 FEET BELOW THE SUBGRADE ELEVATION AND OR SLOPE ELEVATIONS

DO NOT DAMAGE TREES OR AREAS BEYOND THE LIMIT OF GRADING. DAMAGES SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR.

2.0 EROSION AND SEDIMENT CONTROLS

2.1 DESCRIPTION

PROVIDE, FURNISH, INSTALL AND MAINTAIN THE EROSION AND SEDIMENT CONTROL DEVICES IN ACCORDANCE WITH THE CONTRACT DRAWINGS AND OR THE APPROVED EROSION AND SEDIMENT CONTROL PLAN

2.2 MATERIAL

COMPOST FILTER SOCKS SHALL BE COMMERCIALLY MADE USING 5 MIL CONTINUOUS HDPE FILAMENT WOVEN INTO A TUBULAR MESH NETTING WITH 3/8 INCH WOVEN OPENINGS. COMPOST FILTER SOCK DIAMETERS ARE 12 INCH, 18 INCH AND 24 INCHES.

COMPOST – SEE SHEET C-3

WOODEN STAKES – 2 INCH BY 2 INCH BY 42 INCH

ROCK CONSTRUCTION ENTRANCE

AASHTO #1 LIMESTONE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION703 – AGGREGATE

GEOTEXTILE – CLASS 4 SEPARATION IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 735

TRUCK WASH RACK

CONCRETE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 704 CEMENT CONCRETE – CLASS C.

WELDED STEEL PIPE – MINIMUM 4 INCH DIAMETER

EROSION BLANKET

100% BIODEGRADABLE EROSION CONTROL BLANKET, MACHINE-PRODUCED MAT OF 100% COCONUT FIBER WITH A FUNCTIONAL LONGEVITY OF UP TO 24 MONTHS.

THE BLANKET SHALL BE OF CONSISTENT THICKNESS WITH THE COCONUT EVENLY DISTRIBUTED OVER THE ENTIRE AREA OF THE MAT. THE BLANKET SHALL BE COVERED ON THE TOP AND BOTTOM SIDES WITH 100% BIODEGRADABLE WOVEN, NATURAL, ORGANIC FIBER NETTING. THE TOP NETTING SHALL CONSIST OF MACHINE DIRECTIONAL STRANDS FORMED FROM TWO INTERTWINED YARNS WITH CROSS DIRECTIONAL STRANDS INTERWOVEN THROUGH THE TWISTED MACHINE STRANDS TO FORM AN APPROXIMATE 0.50 X 1.00 (1.27 X 2.54 CM) MESH. THE BLANKET SHALL BE SEWN TOGETHER ON 1.50 INCH (3.81 CM) CENTERS WITH DEGRADABLE THREAD.

MATERIAL SHALL MEET REQUIREMENTS ESTABLISHED BY THE EROSION CONTROL TECHNOLOGY COUNCIL (ECTC).

MATERIAL CONTENT

MATRIX – 100 PERCENT COCONUT FIBER 0.5 LBS/YD2

NETTINGS – 100 PERCENT BIODEGRADABLE ORGANIC JUTE FIBER 9.3 LB/1000 FT2

THREAD – BIODEGRADABLE

TEMPORARY SEED AND MULCH

SEE SHEET C-2

PENNDOT PUBLICATION 408 SECTION 805 – MULCHING – HAY, STRAW OR WOOD FIBER

RIP RAP

IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 850 – ROCK LINING: R-4

2.3 CONSTRUCTION

INSTALL THE ROCK CONSTRUCTION ENTRANCE AND TIRE WASH FACILITY PRIOR TO THE START OF EARTHWORK OPERATIONS. MAINTAIN THE ROCK THICKNESS BY ADDING ROCK FROM AN ADJACENT STOCKPILE.

REMOVE SEDIMENT DEPOSITS ON A DAILY BASIS FROM THE ROCK ENTRANCE AND PUBLIC STREETS AND RETURN THE SEDIMENT TO THE CONSTRUCTION SITE.

INSTALL FILTER SOCKS AT THE LOCATIONS SHOWN ON THE CONTRACT DRAWINGS IN ACCORDANCE WITH THE DIAMETER SPECIFIED.

INSTALL 2 INCH BY 2 INCH WOODEN STAKE AT TEN FEET ON CENTER THROUGH THE FILTER SOCK.

INSTALL EROSION BLANKET UPON COMPLETION OF EARTH DISTURBANCE AND EMBANKMENT CONSTRUCTION. APPLY TEMPORARY SEED AND MULCH.

MAINTENANCE AND REPAIR:

INSPECT AND REPAIR DAMAGED OR DISLODGED EROSION AND SEDIMENT CONTROL DEVICES. INSPECT THE CONTROL DEVICES AFTER EACH RAIN EVENT AND OR AT A MINIMUM OF WEEKLY. IMMEDIATELY REPAIR, RE-STAKE, EXTEND OR REPLACE DAMAGED CONTROL DEVICES.

REMOVE SEDIMENT BUILD UP OR DEBRIS WHEN THE BUILD UP REACHES ONE HALF THE HEIGHT OF THE CONTROL DEVICE. DISPOSE OF THE SOIL MATERIAL ON SITE. DISPOSE OF TRASH AND DEBRIS OFF SITE.

INSTALL ROCK LINING AT THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

3.0 DEMOLITION

3.1 DESCRIPTION

REMOVAL OF BUILDINGS, WALLS, STRUCTURES AS INDICATED ON THE CONTRACT DRAWINGS.

3.2 CONSTRUCTION

REMOVE AND DISPOSE OF OFF SITE BUILDINGS, WALLS, STRUCTURES AS INDICATED.

ONSITE DISPOSAL IS NOT PERMITTED.

4.0 EARTHWORK – EXCAVATION AND EMBANKMENT

4.1 DESCRIPTION

EXCAVATE SOIL AND ROCK TO THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

CONSTRUCT EMBANKMENTS TO THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

4.2 CONSTRUCTION

EXCAVATE SOIL AND ROCK BY MECHANICAL MEANS.

BLASTING IS NOT PERMITTED.

PREPARED THE EMBANKMENT FOUNDATION AREA IN ACCORDANCE WITH SECTION 1.0 CLEARING AND GRUBBING.

PLACE SOIL MATERIAL IN NOT MORE THAN EIGHT INCH LOOSE LIFTS FOR THE FULL WIDTH AND COMPACT TO NOT LESS THAN 95% OF ASTM D698 STANDARD PROCTOR. THE CONTRACTOR SHALL SAMPLE, TEST AND SUBMIT THE RESULTS TO THE OWNER PRIOR TO THE START OF EMBANKMENT OPERATIONS. MAINTAIN SOIL OPTIMUM MOISTURE WITHIN PLUS OR MINUS TWO PERCENTAGE POINTS.

DO NOT PLACE SOIL MATERIAL THAT IS FROZEN, WET OR CONTAINING OBJECTIONABLE MATERIAL.

PLACE ROCK MATERIAL IN UNIFORM LAYERS. MAXIMUM ROCK SIZE PERMITTED IN THE EMBANKMENT IS EIGHT INCHES IN ANY DIMENSION.

PREPARE THE PAD SUBGRADE AND ACCESS ROAD SUBGRADE BY COMPACTING THE TOP TWO FEET OF THE EMBANKMENT OR CUT SURFACE TO 100% OF ASTM D698 STANDARD PROCTOR.

SHOULD NON RIPABLE ROCK BE ENCOUNTERED, IMMEDIATELY CONTACT THE OWNER FOR DIRECTION ON EXCAVATION.

5.0 PIT LINER

5.1 DESCRIPTION

FURNISH, PROVIDE AND INSTALL A 30 MIL PVC LINER AND ANCHOR SYSTEM IN THE PIT AREA AS INDICATED ON THE CONTRACT DRAWINGS.

5.2 MATERIAL – 30 MIL PVC

5.2.1

CERTIFIED PROPERTIES	TEST METHOD	REQUIREMENT
THICKNESS ±5%	ASTM D 5199	.030"
TENSILE – LB. FORCE/IN. WIDTH, MIN.	ASTM D 882	73
ELONGATION AT BREAK (% MIN.)	ASTM D 882	380
100% MODULUS– LB. FORCE/IN. WIDTH, MIN.	ASTM D 882	30
TEAR STRENGTH (LB./IN., MIN.)	ASTM D 1004	8
DIMENSIONAL STABILITY (% CHANGE MAX.)	ASTM D 1204	3
IMPACT COLD CRACK (°C)	ASTM D 1790	-29
INDEX PROPERTIES		
SPECIFIC GRAVITY (MIN.)	ASTM D 792	1.20
WATER EXTRACTION (%, MAX.)	ASTM D 1239	0.15
VOLATILE LOSS (%, MAX.)	ASTM D 1203(A)	0.70
RESISTANCE TO SOIL BURIAL (% CHANGE MAX.)	ASTM G 160	
1. BREAKING FACTOR		5
2. ELONGATION AT BREAK		20
3. MODULUS AT 100% ELONGATION		20
HYDROSTATIC RESISTANCE (PSI, MIN.)	ASTM D 751(A)	100
PLASTICIZER MIN. AVE. MOLECULAR WEIGHT	ASTM D 2124	400

5.3 CONSTRUCTION

INSTALL PVC LINER TO THE LINE AND GRADE OF THE PIT.

THERMAL WELD THE SEAMS.

OVERLAP THE PERIMETER AND ANCHOR THE EDGES WITH SOIL TO STABILIZE THE LINER FROM PULLING, TEARING, FLOATING AND MOVEMENT DURING FILLING OPERATIONS.

PROVIDE TO THE OWNER AN INSPECTION REPORT OF SEAM WELDS AND INTEGRITY OF THE LINER INSTALLATION.

6.1 CULVERT PIPE

6.1.1 DESCRIPTION

FURNISH, PROVIDE AND INSTALL DUCTILE IRON OR WELDED STEEL CULVERT PIPE AT ROAD CROSSINGS AT THE DIAMETER, LINE AND GRADE INDICATED ON THE CONTRACT DRAWINGS.

6.1.2 MATERIAL

WELDED STEEL CULVERT PIPE IN ACCORDANCE WITH A53, TYPE S.

DUCTILE IRON PIPE IN ACCORDANCE WITH ASTM A716

6.1.3 CONSTRUCTION

INSTALL AND MAINTAIN CULVERT PIPE DURING CONSTRUCTION. KEEP THE PIPE CLEAR OF DEBRIS AND SEDIMENT BUILDUP.

6.2 UNDERDRAIN PIPE

6.2.1 DESCRIPTION

FURNISH, PROVIDE AND INSTALL HIGH DENSITY CORRUGATED POLYETHYLENE (PE) PIPE AT LOCATIONS INDICATED ON THE CONTRACT DRAWINGS.

6.2.2 MATERIAL

HIGH DENSITY CORRUGATED POLYETHYLENE (PE) PIPE IN ACCORDANCE WITH AASHTO M 252 (PIPES 4 INCHES THROUGH 10 INCHES).

6.2.3 CONSTRUCTION

INSTALL PIPE ON A 4 INCH LAYER OF AGGREGATE AND HAND PLACE THE AGGREGATE AROUND THE PIPE.

7.0 WELL PAD AND ACCESS ROAD

7.1 DESCRIPTION

PROVIDE, FURNISH AND INSTALL AGGREGATE FOR THE WELL PAD SURFACE AND THE ACCESS ROAD SURFACE.

7.2 MATERIAL

AGGREGATE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 703 AGGREGATE

SIX INCHES OF AASHTO # 3

SIX INCHES OF PENNDOT # 57

PERFORATED CORRUGATED POLYETHYLENE CULVERT UNDERDRAIN PIPE

FOUR INCH DIAMETER IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 601 – PIPE CULVERTS

7.3 CONSTRUCTION

COMPACT AND SHAPE SUBGRADE TO THE LINES AND GRADES ON THE CONTRACT DRAWINGS.

COMPACT THE SUBGRADE TO 100% OF ASTM D698 STANDARD PROCTOR. REMOVE AND REPLACE ANY SUBGRADE THAT IS SOFT OR DISPLAYS VISUAL MOVEMENT WITH CLEAN FILL.

INSTALL THE AGGREGATE IN TWO LIFTS. COMPACT LIFTS TO NON-MOVEMENT.

INSTALL THE CORRUGATED CULVERT PIPE TO THE LINE AND GRADE SHOWN ON THE CONTRACT DRAWINGS.

8.0 SITE RESTORATION

8.1 DESCRIPTION

UPON COMPLETION OF THE WELL DRILLING AND AT THE NOTIFICATION BY THE OWNER, RETURN TO THE SITE AND REMOVE AND DISPOSE OF LOOSE AGGREGATE, COVER THE SITE WITH TOPSOIL FROM THE CURRENT STOCKPILE AND APPLY PERMANENT SEED, SUPPLEMENTS AND MULCH.

8.2 MATERIAL

TOPSOIL FROM THE EXISTING STOCKPILE

PERMANENT SEED AND SOIL SUPPLEMENTS SEE SHEET C-2

MULCH IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 805 – MULCHING – HAY, STRAW OR WOOD FIBER

8.3 CONSTRUCTION

REMOVE AND DISPOSE OF OFF SITE LOOSE AGGREGATE FROM THE WELL PAD.

SPREAD TOPSOIL EVENLY ACROSS THE WELL PAD AND APPLY PERMANENT SEED, SOIL SUPPLEMENTS AND MULCH

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
CONSTRUCTION SPECIFICATIONS

SCALE: AS NOTED

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	ARB
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	7 OF 7

C-7

M-945P (12/93)

AUDIT CONTROL NO. 711723

COMMONWEALTH OF PENNSYLVANIA

HIGHWAY OCCUPANCY PERMIT

Permit No.	04016278
Organization	046
Date Issued	090195
Permit Fees	25.00
Account No.	
County	63
Township/Boro	206

PERMITTEE: HAROLD & JEANNE RUTLEDGE

ADDRESS: R R 1 BOX 220

POST OFFICE: EQUINUNK PA ZIP CODE 18417-

County WAYNE

Township/Boro DAMASCUS

Bond/Agreement Number

ALL WORK UNDER THIS PERMIT MAY BE STARTED ON 09/01/95

AND SHALL BE COMPLETED ON OR BEFORE 09/01/96

Immediately upon completion of the work, Permittee shall notify the permit office where application was made. Subject to all the conditions, restrictions, and regulations prescribed by the Pennsylvania Department of Transportation, (see in particular 67 Pa. Code, Chapter 203, 441 and 459) and subject to the plans, special conditions, or restrictions herein set forth or attached hereto. This permit shall be located at the work site and shall be available for inspection by any police officer or department representative.

	1	2	3	4
Description	511			
State Route No.	1025			
Segment(s)	0050 0050			
Offset To Offset	1584 1584			
Township/Boro				

DESCRIPTION OF WORK

INSTALL MINIMUM USE DRIVEWAY AT
SR 1025 SEG 0050 OFFSET 1584 TO SEG 0050 OFFSET 1584
THIS PERMIT AUTHORIZES WORK ONLY IN DEPARTMENT HIGHWAY RIGHT OF WAY. SURFACE DRAINAGE MAY NOT BE DIRECTED ONTO STATE RIGHT OF WAY.
IT IS THE PERMITTEE'S RESPONSIBILITY TO KEEP VEGETATION TRIMMED IN ORDER TO MAINTAIN MINIMUM SIGHT DISTANCE. NO OBJECTS MAY BE PLACED WITHIN THE LINE OF SIGHT.
MINIMUM WORK ZONE TRAFFIC CONTROL TO BE IN ACCORDANCE WITH PUB 203 FIGURE(S) 5, 7, 10A.
PLANS DEPICTING THE HIGHWAY OCCUPANCY ARE FILED AS PUBLIC DOCUMENTS IN THE DEPARTMENT OF TRANSPORTATION, ENGINEERING DISTRICT 4-0 PERMIT OFFICE.
ALL DISTURBED AREAS OUTSIDE THE PAVEMENT OR SHOULDER SHALL BE RESTORED TO A CONDITION AT LEAST EQUAL TO THAT WHICH EXISTED BEFORE THE START OF WORK.
SHOULDERS MUST BE RESTORED IN ACCORDANCE WITH APPROPRIATE SECTION OF PUB. 408 AND ROADWAY CONSTRUCTION STANDARD RC-25.
DEPARTMENT MUST BE NOTIFIED IN WRITING UPON COMPLETION OF WORK.
X
X
X

THIS PERMIT IS NOT VALID UNTIL SIGNED BY THE DISTRICT ENGINEER OR HIS AUTHORIZED REPRESENTATIVE

FOR BRADLEY L. MALLORY, SECRETARY OF TRANSPORTATION

BY CHARLES N. MATTEI, P.E., DISTRICT ENGINEER

Acknowledgment of Completion

Permitted work has been completed

Date 9-10-96 By

RECORDING COPY/COUNTY COMPLETION REPORT

M-950A (10/93)
Central Permit Office

APPLICATION FOR MINIMUM USE DRIVEWAY

A Minimum Use Driveway Is a Residential or Other Driveway Which Is Expected to Be Used By Not More Than 25 Vehicles Per Day (i.e. 50 A.D.T)

APPL. NO. 943295

READ INSTRUCTIONS ON REVERSE

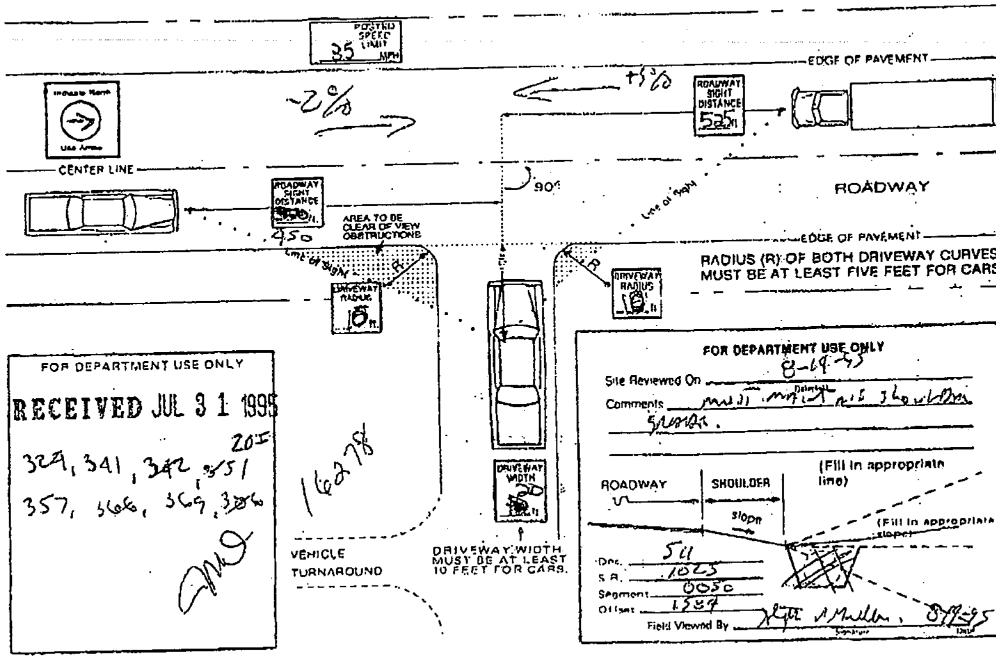
Applicant / Property Owner: Harold + Jeanne Ruttledge
Address: RR 1 Box 228 Equinunk Pa
Post Office: EQuinunk Zip Code: 18417
Phone: 224-4776 Fee: 25.00 Check No. 919

LOCATION OF PROPOSED DRIVEWAY
County: Wayne (63)
Township/Boro: Damascus (206)
Route No.: SR 1025
Name of Nearest Intersection: SR1012 / SR 1025
Distance to Nearest Intersection In Feet: 1725 FT

APPLICATION IS MADE TO
☒ CONSTRUCT A NEW DRIVEWAY ☐ ALTER AN EXISTING DRIVEWAY

DATE WORK SCHEDULED TO BEGIN: 9-95
DATE WORK SCHEDULED TO BE COMPLETED: 10-95

For the purpose of measuring sight distance, the drivers' eye height shall be 3.50 feet above the proposed access surface and highway pavement surface and the vehicles' height shall be 4.25 feet above the proposed access surface and highway pavement surface.



FOR DEPARTMENT USE ONLY
RECEIVED JUL 31 1995
205
329, 341, 342, 351
357, 366, 369, 386

FOR DEPARTMENT USE ONLY
Site Reviewed On: 8-14-95
Comments: must maintain shoulder slope.
ROADWAY | SHOULDER | (Fill in appropriate line) | Slope | (Fill in appropriate slope)
Dist. 5-0
S.R. 1025
Segment 0050
Offset 1584
Field Viewed By: [signature] 8-14-95

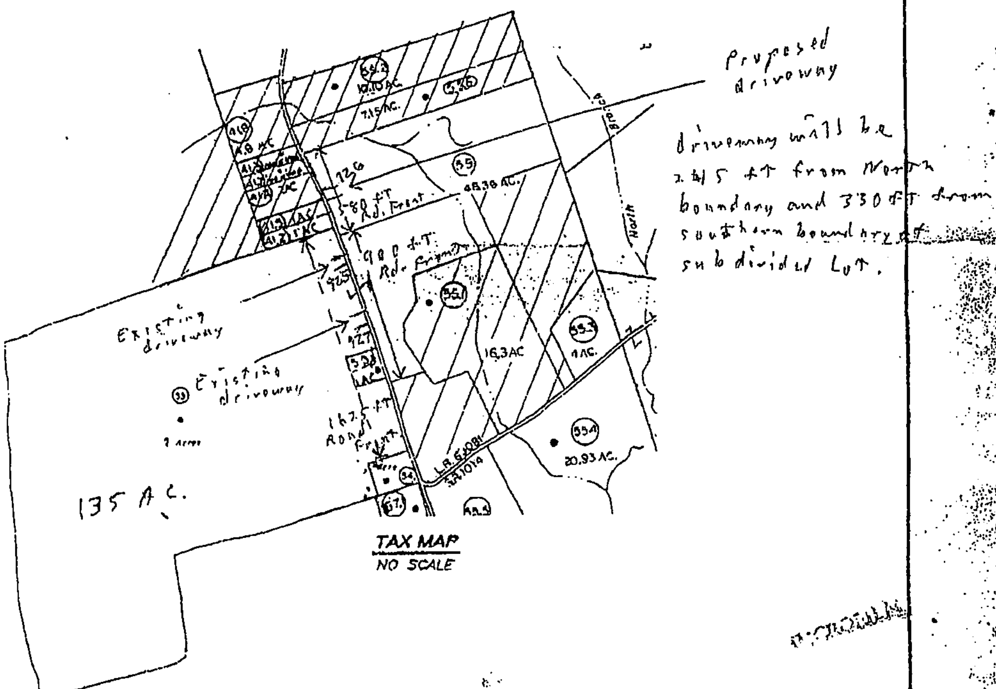
Under and subject to all the conditions, restrictions and regulations prescribed by the Pennsylvania Department of Transportation and on the issued Permit, Form M-945P.

The applicant certifies that all statements contained herein are true and correct

By X Harold R. Ruttledge Jr / Jeanne G. Ruttledge 7/25/95
SIGNATURE(S) DATE

HAVE YOU READ INSTRUCTIONS ON REVERSE?
HAVE YOU COMPLETED ALL BLANKS?

LOCATION MAP
SCALE:



TAX MAP
NO SCALE

M-946P (12/93)

AUDIT CONTROL NO. 711724

COMMONWEALTH OF PENNSYLVANIA

HIGHWAY OCCUPANCY PERMIT

Permit No.	04016279
Organization	046
Date Issued	090195
Permit Fees	25.00
Account No.	
County	63
Township/Boro	206

PERMITTEE: HAROLD & JEANNE RUTLEDGE

ADDRESS: R R 1 BOX 228

POST OFFICE: EQUINUNK PA ZIP CODE 18417-

County: WAYNE

Township/Boro: DAMASCUS

Bond/Agreement Number:

ALL WORK UNDER THIS PERMIT MAY BE STARTED ON 09/01/95

AND SHALL BE COMPLETED ON OR BEFORE 09/01/96

Immediately upon completion of the work, Permittee shall notify the permit office where application was made. Subject to all the conditions, restrictions, and regulations prescribed by the Pennsylvania Department of Transportation, (see in particular 67 Pa. Code, Chapter 203, 441 and 459) and subject to the plans, special conditions, or restrictions herein set forth or attached hereto. This permit shall be located at the work site and shall be available for inspection by any police officer or department representative.

	1	2	3	4
Description	512			
State Route No.	1025			
Segment(s)	0050			
Offset To Offset	1056	1056		
Township/Boro				

DESCRIPTION OF WORK

INSTALL MINIMUM USE DRIVEWAY WITH DRAINAGE FACILITIES AT SR 1025 SEG 0050 OFFSET 1056 TO SEG 0050 OFFSET 1056
DRAINAGE INSTALLED BY THIS PERMIT IS THE RESPONSIBILITY OF THE PERMITTEE TO CONTINUALLY MAINTAIN OR REPLACE.
THIS PERMIT AUTHORIZES WORK ONLY IN DEPARTMENT HIGHWAY RIGHT OF WAY.
IT IS THE PERMITTEE'S RESPONSIBILITY TO KEEP VEGETATION TRIMMED IN ORDER TO MAINTAIN MINIMUM SIGHT DISTANCE. NO OBJECTS MAYBE PLACED WITHIN THE LINE OF SIGHT.
MINIMUM WORK ZONE TRAFFIC CONTROL TO BE IN ACCORDANCE WITH PUB. 203 FIGURE(S) 5, 7, 10A.
PLANS DEPICTING THE HIGHWAY OCCUPANCY ARE FILED AS PUBLIC DOCUMENTS IN THE DEPARTMENT OF TRANSPORTATION, ENGINEERING DISTRICT 4-0 PERMIT OFFICE.
ALL DISTURBED AREAS OUTSIDE THE PAVEMENT OR SHOULDER SHALL BE RESTORED TO A CONDITION AT LEAST EQUAL TO THAT WHICH EXISTED BEFORE THE START OF WORK.
SHOULDERS MUST BE RESTORED IN ACCORDANCE WITH APPROPRIATE SECTION OF PUB. 408 AND ROADWAY CONSTRUCTION STANDARD RC-25.
DEPARTMENT MUST BE NOTIFIED IN WRITING UPON COMPLETION OF WORK.
X
X

THIS PERMIT IS NOT VALID UNTIL SIGNED BY THE DISTRICT ENGINEER OR HIS AUTHORIZED REPRESENTATIVE

Acknowledgment of Completion

Permitted work has been completed

Date 9-30-96 By Stephen L. Rutledge

Richard D Cook

FOR BRADLEY L. MALLORY
SECRETARY OF TRANSPORTATION

BY CHARLES M. MATTEI, P.E.
DISTRICT ENGINEER

RECORDING COPY/COUNTY COMPLETION REPORT

M-950A (10/93)
Central Permit Office

APPLICATION FOR MINIMUM USE DRIVEWAY

A Minimum Use Driveway is a Residential or Other Driveway Which Is Expected to Be Used By Not More Than 25 Vehicles Per Day (i.e. 50 A.D.T.)

APPL. NO 948297

READ INSTRUCTIONS ON REVERSE

Applicant / Property Owner: Harold + Jeanne Rutledge
Address: RR1 Box 228 Equinunk Pa
Post Office: Equinunk — Zip Code: 18417
Phone: 224-4776 — Fee: 25.00 — Check No: 919

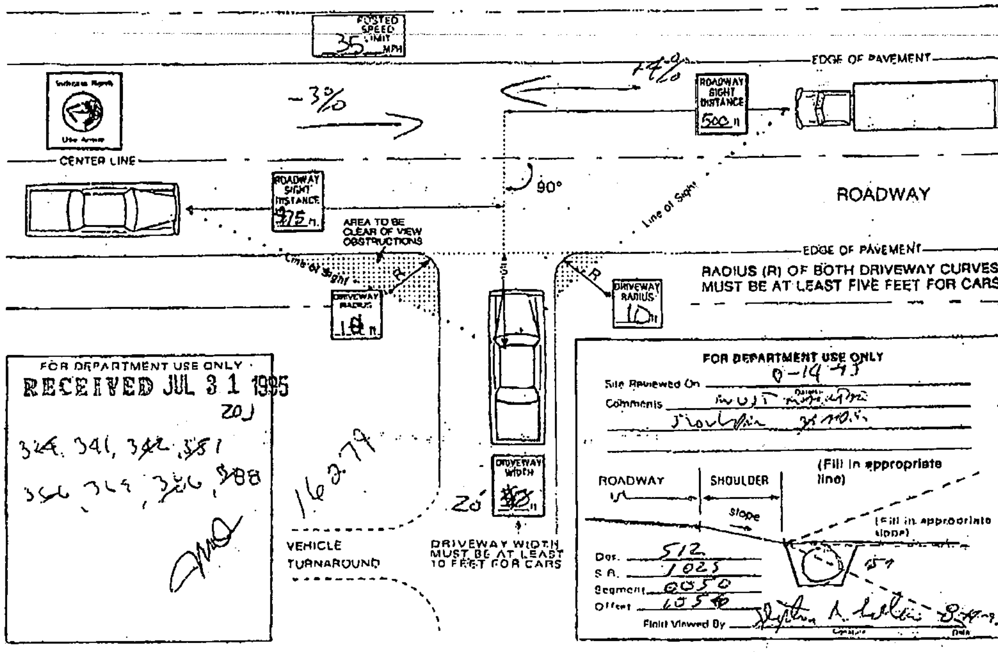
APPLICATION IS MADE TO
☐ CONSTRUCT A NEW DRIVEWAY ☐ ALTER AN EXISTING DRIVEWAY

DATE WORK SCHEDULED TO BEGIN ______
DATE WORK SCHEDULED TO BE COMPLETED ______

LOCATION OF PROPOSED DRIVEWAY

County: Wayne (63)
Township/Boro: Damascus (206)
Route No.: SR 1025
Name of Nearest Intersection: SR 1014 / SR 1025
Distance to Nearest Intersection In Feet: 925 feet

For the purpose of measuring sight distance, the drivers' eye height shall be 3.50 feet above the proposed access surface and highway pavement surface and the vehicles' height shall be 4.25 feet above the proposed access surface and highway pavement surface.



FOR DEPARTMENT USE ONLY
RECEIVED JUL 31 1995
20J
324, 341, 342, 381
356, 364, 386, 388

FOR DEPARTMENT USE ONLY
Site Reviewed On: 8-14-95
Comments: ______
(Fill in appropriate line)
ROADWAY — SHOULDER — Slope — (Fill in appropriate slope)
Dist. 512
S.R. 1025
Segment 0050
Offset 1056
Field Viewed By ______ Date ______

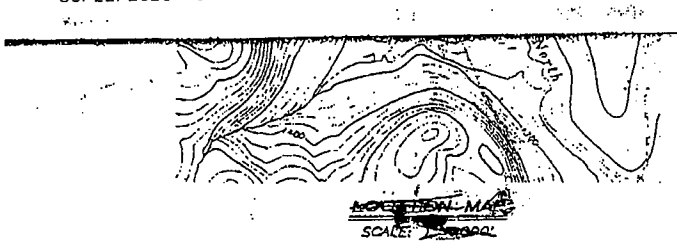
Under and subject to all the conditions, restrictions and regulations prescribed by the Pennsylvania Department of Transportation and on the issued Permit, Form M-945P.

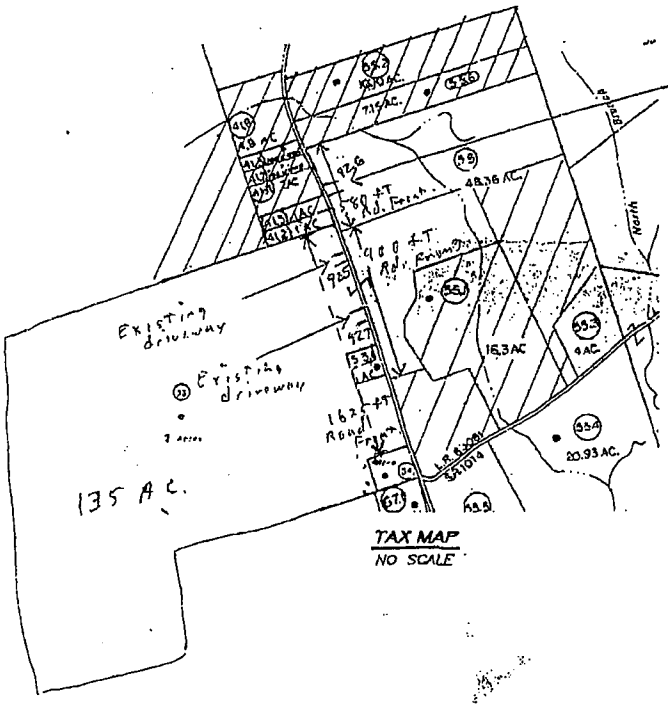
The applicant certifies that all statements contained herein are true and correct.

By X Harold R. Rutledge / Jeanne S. Rutledge — SIGNATURE(S) — 7/25/95 DATE

HAVE YOU READ INSTRUCTIONS ON REVERSE?
HAVE YOU COMPLETED ALL BLANKS?

DISTRICT PERMIT OFFICE — CENTRAL OFFICE





Proposed Driveway

Driveway will be 245 ft from North boundary and 330 ft from southern boundary of subdivided Lot.

MICROFILM

NOTES

M-946P (12/93)

AUDIT CONTROL NO. 711725

COMMONWEALTH OF PENNSYLVANIA

HIGHWAY OCCUPANCY PERMIT

Permit No.	04016280
Organization	046
Date Issued	090195
Permit Fees	25.00
Account No.	
County	63
Township/Boro	206

	(1)		(2)		(3)		(4)	
Township/Boro								
Description	511							
State Route No.	1025							
Segment(s)	0050	0050						
Offset To Offset	2000	2000						

PERMITTEE
HAROLD & JEANNE RUTLEDGE
ADDRESS
R R 1 BOX 226
POST OFFICE
EQUINUNK PA ZIP CODE 18417-

County WAYNE

Township/Boro DAMASCUS

Bond/Agreement Number

ALL WORK UNDER THIS PERMIT MAY BE STARTED ON 09/01/95

AND SHALL BE COMPLETED ON OR BEFORE 09/01/96

Immediately upon completion of the work, Permittee shall notify the permit office where application was made. Subject to all the conditions, restrictions, and regulations prescribed by the Pennsylvania Department of Transportation, (see in particular 67 Pa. Code, Chapter 203, 441 and 459) and subject to the plans, special conditions, or restrictions herein set forth or attached hereto. This permit shall be located at the work site and shall be available for inspection by any police officer or department representative.

DESCRIPTION OF WORK

INSTALL MINIMUM USE DRIVEWAY AT
SR 1025 SEG 0050 OFFSET 2000 TO SEG 0050 OFFSET 2000
THIS PERMIT AUTHORIZES WORK ONLY IN DEPARTMENT HIGHWAY
RIGHT OF WAY. SURFACE DRAINAGE MAY NOT BE DIRECTED
ONTO STATE RIGHT OF WAY.
IT IS THE PERMITTEE'S RESPONSIBILITY TO KEEP VEGETATION
TRIMMED IN ORDER TO MAINTAIN MINIMUM SIGHT DISTANCE. NO
OBJECTS MAY BE PLACED WITHIN THE LINE OF SIGHT.
MINIMUM WORK ZONE TRAFFIC CONTROL TO BE IN ACCORDANCE
WITH PUB. 203 FIGURE(S) 5, 7, 10A.
PLANS DEPICTING THE HIGHWAY OCCUPANCY ARE FILED AS
PUBLIC DOCUMENTS IN THE DEPARTMENT OF TRANSPORTATION,
ENGINEERING DISTRICT 4-0 PERMIT OFFICE.
ALL DISTURBED AREAS OUTSIDE THE PAVEMENT OR SHOULDER
SHALL BE RESTORED TO A CONDITION AT LEAST EQUAL TO THAT
WHICH EXISTED BEFORE THE START OF WORK.
SHOULDERS MUST BE RESTORED IN ACCORDANCE WITH
APPROPRIATE SECTION OF PUB. 408 AND ROADWAY
CONSTRUCTION STANDARD RC-25.
DEPARTMENT MUST BE NOTIFIED IN WRITING UPON COMPLETION
OF WORK.
X
X
X

THIS PERMIT IS NOT VALID UNTIL SIGNED BY THE DISTRICT ENGINEER OR HIS AUTHORIZED REPRESENTATIVE

Richard D. Cook

FOR BRADLEY L. MALLORY
SECRETARY OF TRANSPORTATION

BY CHARLES M. MATTEI, P.E.
DISTRICT ENGINEER

Acknowledgment of Completion

Permitted work has been completed

Date 9-3-96 By Stephen L Rutledge

RECORDING COPY/COUNTY COMPLETION REPORT

M-950A (10/93)
Central Permit Office

APPLICATION FOR MINIMUM USE DRIVEWAY

A Minimum Use Driveway Is a Residential or Other Driveway Which Is Expected to Be Used By Not More Than 25 Vehicles Per Day (i.e. 50 A.D.T.)

APPL. NO. 548296

READ INSTRUCTIONS ON REVERSE

Applicant / Property Owner: Harold + Jeanne Ruttledge

Address: RR 1 Box 228 Equinunk Pa.

Post Office: Equinunk Zip Code: 18417

Phone: 224-4776 Fee: 25.00 Check No.: 919

LOCATION OF PROPOSED DRIVEWAY

County: Wayne (64)

Township/Boro: Damascus (26)

Route No.: SR 1025

Name of Nearest Intersection: SR 1014 / SR 1025

Distance to Nearest Intersection in Feet: 1325 ft

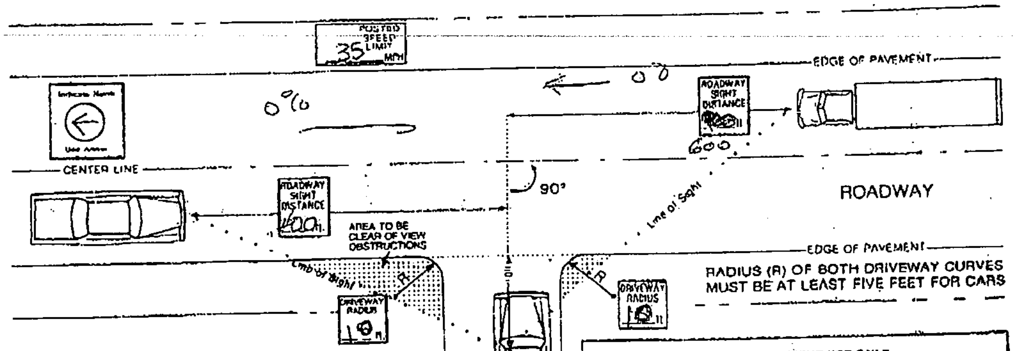
APPLICATION IS MADE TO

☐ CONSTRUCT A NEW DRIVEWAY ☐ ALTER AN EXISTING DRIVEWAY

DATE WORK SCHEDULED TO BEGIN ______

DATE WORK SCHEDULED TO BE COMPLETED ______

For the purpose of measuring sight distance, the drivers' eye height shall be 3.50 feet above the proposed access surface and highway pavement surface and the vehicles' height shall be 4.25 feet above the proposed access surface and highway pavement surface.



FOR DEPARTMENT USE ONLY

26A

RECEIVED JUL 31 1995

329, 347, 322, 351

357, 366, 369, 366

FOR DEPARTMENT USE ONLY

Site Reviewed On: 8-14-95

Comments: MUST [illegible] [illegible] shoulder [illegible]

ROADWAY | SHOULDER | (Fill in appropriate line) | Slope | (Fill in appropriate slope)

Des. 5H

S.R. 1025

Segment 0050

Offset 2000

Field Viewed By: [signature] Date: 8-14-95

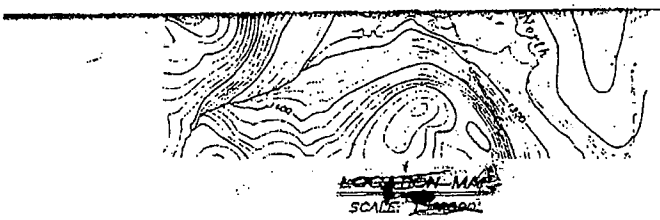
Under and subject to all the conditions, restrictions and regulations prescribed by the Pennsylvania Department of Transportation and on the issued Permit, Form M-945P.

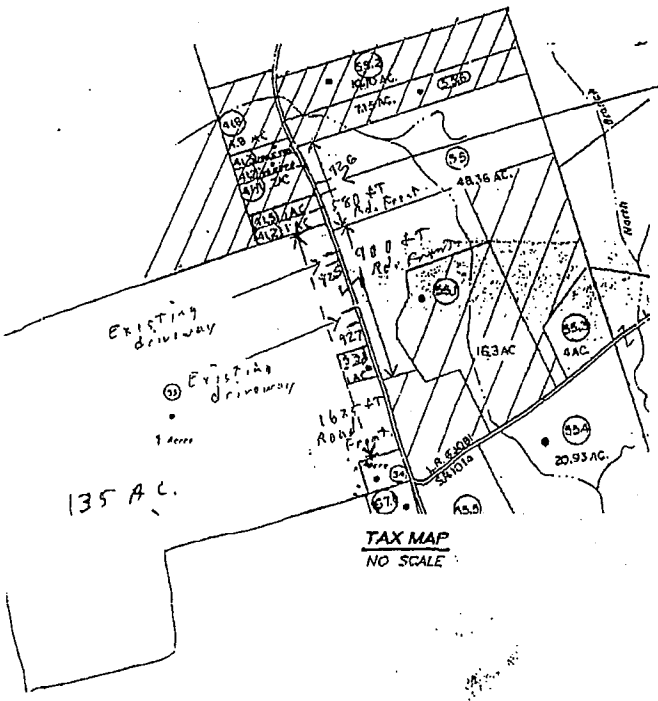
The applicant certifies that all statements contained herein are true and correct.

By X Harold L. Ruttledge / Jeanne H. Ruttledge
SIGNATURE(S)

DATE: 7/25/95

HAVE YOU READ INSTRUCTIONS ON REVERSE?
HAVE YOU COMPLETED ALL BLANKS?





Proposed driveway

driveway will be 245 ft from North boundary and 330 ft from southern boundary of subdivided Lot.

Driveway Address for the Rutledge 1-1 Well Site

Address was assigned by GIS and is on file with county Emergency Management office and 911 dispatch.

Rutledge 1-1
455 Rutledgedale Rd
Equinunk PA, 18417

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

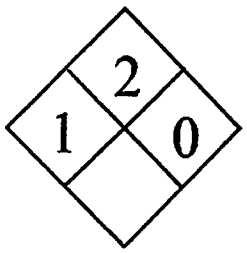
For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

INTEGRITY
INDUSTRIES INC.



****

MATERIAL SAFETY DATA SHEET

****

SECTION I - MANUFACTURER

Integrity Industries, Inc.
2710 E. Corral St.
Kingsville, Texas 78363
Emergency Phone: (361) 595-5561

Revised Date: 06/05/2008
Supercedes: new

THIS DOCUMENT IS PREPARED PURSUANT TO THE OSHA HAZARDOUS COMMUNICATION STANDARD (29 CFR 1910.1200). ALSO, OTHER SUBSTANCE NOT DEEMED "HAZARDOUS" PER THIS MSDS MAY BE LISTED.

SECTION II - MATERIAL IDENTIFICATION

Trade Name: **SYNVERT Base Oil**
Synonyms/Other Designations: Synthetic Drilling Fluid / Polymer Suspension Base
Placard: Not Applicable
Hazard(s): non-hazardous

Component	CAS Number	Weight
Paraffin/Olefin blend	Mixture	100%

SECTION III - PHYSICAL & CHEMICAL DATA

Boiling Point: IBP > 300 °F
Specific Gravity (H2O=1): 0.766
Vapor Density (Air=1): n/a
Appearance: Clear, oily liquid

Pour Point: ND
Vapor Pressure (mm Hg @ 68 °F): 0.135
Solubility in H2O: Insoluble
Viscosity (cSt @104 °F): 1.4

SECTION IV - REACTIVITY

Stability: Stable
Incompatibility: Heat, sparks, open flame. May react with strong acids/strong oxidizing agents, chlorates, nitrates, peroxides.
Hazardous Decomposition Products: Oxides of carbon. Hazardous Polymerizations: will not occur

SECTION V - FIRE & EXPLOSION DATA

Flash Point (ASTM D-93): > 200 °F
Autoignition: n/a
Extinguishing Media: Water spray, Dry Chemical, Foam, CO2
Special Fire Fighting Procedures: Respirators/eye protection and full firefighting protective gear.
Unusual Fire Hazards: Remove containers from source of heat.

SECTION VI - EMERGENCY & FIRST AID DATA

Inhalation: Move to well ventilated area; if breathing difficulties persist after 15 minutes seek medical assistance.
Eye Contact: Wash eye thoroughly for 15 minutes; if irritation persists seek medical assistance.
Skin Contact: Wash affected area with soap & water for 15 minutes; if irritation persists seek medical assistance.
Ingestion: Do not induce vomiting and seek medical advice.

SECTION VII - HEALTH HAZARDS DATA

Acute: May irritate eyes, skin, respiratory, & gastrointestinal tract. Chronic: Repeated/prolonged skin contact may irritate/redden skin, progressing to dermatitis.

SECTION VIII - SPILL & DISPOSAL DATA

Accidental Spill Procedures: Absorb in inert material and dispose of according to local, state & federal regulations. Spill into water should be contained to avoid runoff into waterways.
Handling & Storage: Keep container closed and store in cool dry place. Emptied container still contains material which may ignite with explosive violence if exposed to open flame.

SECTION IX - SPECIAL PROTECTION DATA

Respiratory Protection: Respirator in confined areas.
Ventilation: Desired Exhaust: Mechanical
Protective Gloves: Solvent/chemical resistant gloves
Eye Protection: Safety glasses, goggles.
Other Protection: As required to avoid skin contact.

SECTION X - TRANSPORT INFORMATION

The following may not apply to all shipping situations. Consult 49 CFR for more mode-specific or quantity-specific data.
DOT Proper Shipping Name: Not regulated
DOT Hazard Class or Division: Not regulated
DOT Identification Number: N/A
DOT Packaging Group: III
Type Label(s) Required. none
Placard: Not applicable
*For Limited Quantity requirements see DOT regulation 49 CFR.

SECTION XI - DISCLAIMERS

* SOME INFORMATION PROVIDED HEREIN WAS DRAWN FROM SOURCES OTHER THAN INTEGRITY INDUSTRIES.
THE INFORMATION PROVIDED HEREIN IS BELIEVED BY INTEGRITY INDUSTRIES, INC. TO BE CORRECT & RELIABLE; NO EXPRESSED OR IMPLIED WARRANTY IS PROVIDED HOWEVER.
* INTEGRITY INDUSTRIES, INC. ASSUMES NO RESPONSIBILITY AND DENIES ALL LIABILITY FOR ANY LOSS, DAMAGE, OR EXPENSE CONNECTED WITH CUSTOMERS' METHOD OF HANDLING, STORAGE, USE, AND DISPOSAL OF THIS PRODUCT.
* THE MSDS INFORMATION PROVIDED HEREIN IS APPLICABLE ONLY TO THIS PRODUCT.

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 50**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 50
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	72-112
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID®**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID®
Synonyms: None
Chemical Family: Mineral
Application: Weight Additive

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Barium sulfate	7727-43-7	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Pink to tan to gray
Odor:	Odorless
pH:	8-9-
Specific Gravity @ 20 C (Water=1):	4.2
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	100- 155
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	233.4

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact None known.

Eye Contact May cause mild eye irritation.

Ingestion May produce nervous system effects such as feeling of weakness, unsteady walk, and dilation of blood vessels. May affect the heart and cardiovascular system.

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM96: 7500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity:	TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 132.6 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LIME**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LIME
Synonyms: None
Chemical Family: Inorganic
Application: pH Control

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcium hydroxide	1305-62-0	60 - 100%	5 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye and skin burns. May cause respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes
In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion
Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Not Determined

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from acids. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	12.2
Specific Gravity @ 20 C (Water=1):	2.24
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	75
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.2
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.1

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Causes severe skin irritation. May cause skin burns on prolonged contact.
Eye Contact	Causes severe eye irritation May cause eye burns.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 7340 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 100-500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: TLM96: 478,520 ppm (Mysidopsis bahia) SPP @ 8 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Empty container completely. Transport with all closures in place. Return for reuse or dispose in a sanitary landfill according to national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **WALNUT HULLS**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: WALNUT HULLS
Synonyms: None
Chemical Family: Nut Hulls
Application: Loss Circulation Material

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Walnut hulls	Mixture	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye irritation.

4. FIRST AID MEASURES

Inhalation Under normal conditions, first aid procedures are not required.

Skin Under normal conditions, first aid procedures are not required.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Safety glasses.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.1
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 10 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

PREPAREDNESS, PREVENTION, AND CONTINGENCY PLAN
WAYNE COUNTY FIELD
WAYNE COUNTY, PENNSYLVANIA

Prepared for:

NEWFIELD APPALACHIA PA LLC
363 N. Sam Houston Pkwy E., Suite 2020
Houston, TX 77060

Prepared by:

TETRA TECH NUS INC
116 N. Washington Avenue
Scranton, PA 18503

May 2010

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LIST OF APPENDICES

1.0 DESCRIPTION OF FACILITY

1.1 DESCRIPTION OF THE INDUSTRIAL OR COMMERCIAL ACTIVITY

Newfield Appalachia PA LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will involve natural gas exploration of the Marcellus Shale formation, which will include site preparation, drilling, and well development and production activities. Wastes generated during these activities will be typical for gas drilling operations and will include drill cuttings, produced water, drilling and frac fluids, waste oil, municipal waste and trash. No hazardous waste is expected to be generated at the Newfield sites.

Newfield is currently in the exploratory phase of operations, which will require construction activities for new natural gas well pads and access roads.

This Prevention, Preparedness and Control (PPC) Plan applies to all well sites in Wayne County, Pa.

The attached map (Figure 1) in Appendix B shows the area covered under this PPC Plan Figure 2 is the required 7.5 topographic map of the specific well site. The proposed Site Plan (Figure 3) shows the site layout, the well site boundaries, material storage areas, waste storage areas, dike drains and drainage that leads away from the well site, and the entrances and exits to the well site.

During the different stages of site preparation, construction, drilling, well development and production, the site will store various fuels, oils and chemicals on-site. A chemical and container inventory for the specific well site is located in Table 1 of Appendix C.

1.2 DESCRIPTION OF EXISTING EMERGENCY RESPONSE PLANS

This is a new facility and this plan has been prepared prior to construction of the well pad. There are no previous emergency response plans.

A separate Spill Prevention Control and Countermeasure (SPCC) Plan will be prepared for each facility meeting the requirements defined in 40 CFR§112.

1.3 MATERIAL AND WASTE INVENTORY

Information in this section is used to evaluate the prevention, containment, mitigation, cleanup, and disposal measures which would be used in the event of a spill, discharge, explosion, or fire. Oils, chemicals and other hazardous materials anticipated to be used and stored at the facility during site preparation and construction, drilling, well development and production are listed in Table 1.

MSDS's will be maintained onsite for chemicals and compounds used at the facility in accordance with the Occupational Safety and Health Administration (OSHA) worker right-to-know requirements, as appropriate.

1.4 POLLUTION INCIDENT HISTORY

Newfield has not had any reportable incidents for this facility.

1.5 IMPLEMENTATION SCHEDULE FOR PLAN ELEMENTS NOT CURRENTLY IN PLACE

All plan elements are in place.

1.6 PURPOSE AND IMPLEMENTATION OF PPC PLAN

Newfield has developed and will implement this PPC Plan for effective action to minimize and abate hazards to human health and the environment from fire, explosion, and emission or discharge of pollutants to air, soil, surface water or groundwater. This plan was prepared to satisfy the requirements set forth in 25 PA Code Section 78.

The Drilling Manager serves as the Primary Emergency Coordinator and is responsible for the preparation and implementation of the PPC Plan. The PPC Plan has been prepared and implemented in general accordance with Pennsylvania Department of Environmental Protection (PADEP) guidelines, and will be submitted to PADEP for approval at such time as the PADEP may prescribe.

This PPC Plan identifies and describes any arrangements with police departments, fire departments, hospitals, contractors, and state, county, and local emergency response teams to coordinate emergency services.

The PPC Plan lists names, addresses and phone numbers of all persons identified to act as Emergency Coordinator. One person is named as the Primary Emergency Coordinator and others are listed in the order in which they will assume responsibility as alternates. The PPC Plan also includes a list of emergency equipment at the facility, the location and a physical description of emergency equipment, and a brief outline of emergency equipment capabilities.

1.7 PLAN REVISIONS

This PPC Plan will be reviewed and amended, annually, or whenever:

- Applicable PADEP regulations are revised;
- The plan fails in an emergency;
- The list of Emergency Coordinators changes;
- The list of emergency equipment changes; and
- Construction, operation, maintenance, or other circumstances change in a manner that materially increases the potential for fires, explosions, or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency.

2.0 IMPLEMENTATION OF PPC PLAN

2.1 ORGANIZATIONAL STRUCTURE OF FACILITY FOR IMPLEMENTATION

The Drilling Manager has been designated as the Primary Emergency Coordinator. The Primary Emergency Coordinator is responsible for the following:

- Coordination of spill cleanup activities;
- Notification of appropriate authorities; and
- Tank and chemical storage area inspections.

The Drilling Manager has administrative responsibility for updating, maintaining, and implementing this PPC Plan. Specifically, these responsibilities include:

- Identification of materials and wastes handled during site operation (inventory);
- Identification of potential spill sources (risk assessment);
- Establishment of spill reporting procedures;
- Coordination of the visual inspection program;
- Review of past incidents, spills, and countermeasures employed;
- Coordination and implementation of the PPC Plan goals;
- Training/educational programs and updates;
- Ensuring periodic review of the PPC Plan for adequacy and appropriateness;
- Administration and institution of appropriate changes at regular intervals;
- Review of new construction and process changes relative to the PPC Plan;
- Evaluation of PPC Plan effectiveness prior to, during and subsequent to its implementation; and
- Instituting improvements to the PPC Plan.

The Production Manager is designated as Secondary Emergency Coordinator, and, in the absence of the Drilling Manager, will assume the role of emergency coordinator for emergencies. The Secondary Emergency Coordinator will report directly to the Primary Emergency Coordinator in matters regarding this plan, and can assist with implementing the above-listed items.

2.2 LIST OF EMERGENCY COORDINATORS

As required by 25 PA Code 265.55, there will be at least one employee, either on the construction site or on call, with the responsibility for coordinating emergency response measures. The Primary and Secondary Emergency Coordinators will be thoroughly familiar with this PPC Plan, site operations and activities, the location and characteristics of materials and wastes, the location of the facility's records, and the layout of the facility. The Emergency Coordinators have the authority to commit the resources necessary to carry out the PPC Plan and for coordinating emergency response measures. In the event of a spill or release, one of the Emergency Coordinators will be immediately notified. The following individuals have been designated to act as Emergency Coordinators:

Primary Emergency Coordinator

Name: Don Sleeth
Title: Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Name: Jack Cochran
Title: Production Manager
Office: 814-437-2344
Cell: 814-671-1557

2.3 DUTIES AND RESPONSIBILITIES OF THE EMERGENCY COORDINATOR

As required by 25 PA Code 265.56 and the PPC Plan Guidance Documents, whenever there is an imminent or actual emergency situation, the Emergency Coordinator or his designee must immediately:

1. Notify all facility personnel.
2. Notify appropriate state or local agencies with designated response roles and contracted emergency response companies if additional assistance is required.
3. Identify the problem. Is it a physical emergency such as a fire, explosion, or spill? Is it a natural disaster such as a flood, tornado, or other severe weather? Is it a social emergency such as a bomb threat, riot, or vandalism?

4. Assess the health or environmental hazards and how this problem or condition will affect employees or its affect on the surrounding community.

5. Take all reasonable measures to stabilize the situation. The Emergency Coordinator will take all reasonable measures to ensure that the fire, explosion, emission, or discharge does not reoccur or spread to other materials at the site. These measures can include, when appropriate, stopping operations, collecting and containing released materials or wastes, and removing or isolating containers.

Whenever there is an emission, discharge, fire, or explosion, the Emergency Coordinator or his designee must immediately attempt to identify the character, exact source, amount, and aerial extent of emitted or discharged materials. He/she may do this by observation, by review of facility records or manifests, and, if necessary, by instrumental and chemical analysis. Concurrently, the Emergency Coordinator or his designee must assess possible hazards to human health or the environment that may result from emission, discharge, fire, or explosion. This assessment must consider both direct and indirect effects of the emission, discharge, fire, or explosion.

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion which would threaten human health or the environment (beyond the limits of the site) and if evacuation of local areas may be advisable, he/she must immediately notify the applicable local authorities (police, fire, etc.); he/she must also immediately notify the PADEP by telephone at (800) 541-2050 (24-hour number), PADEP Northeast Region at (570) 826-2511 (24-hrs), the National Response Center at (800) 424-8802, Wayne County Emergency Management Agency (EMA) at (570) 253-1622, and the Pennsylvania Emergency Management Agency at (717) 651-2001, and report the following information:

- Name of the person reporting the incident;
- Name and location of the facility;
- Telephone number where the person reporting the spill can be reached;
- Date, time, and location of the incident;
- A brief description of the incident, nature of the materials involved, extent of any injuries, and possible hazards to human health or the environment;
- The estimated quantity of the materials spilled; and
- The extent of contamination of land, water, or air, if known.

If spills or discharges of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance in greater than reportable quantities has occurred, the Emergency Coordinator must notify DEP at (800) 541-2050 and the National Response Center at (800) 424-8802 and report the above information. For an offsite release (spill or discharge) of a reportable quantity of a CERCLA hazardous substance or a Superfund Amendments and Reauthorization Act Extremely Hazardous Substance, the Emergency Coordinator must immediately notify the National Response Center at (800) 424-8802 and report the above information.

If a release occurs from a storage tank which enters a water supply or which threatens the water supply of downstream users, the Emergency Coordinator must immediately notify the Wayne County EMA (570) 253-1622, the Pennsylvania Emergency Management Agency at (717) 651-2001, and DEP at (800) 541-2050. If appropriate, the Emergency Coordinator may assist the Emergency Management Agencies in notifying the downstream water users. The priorities for notification will be by closest proximity to the release site.

During an emergency, the Emergency Coordinator will take all reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, recur, or spread to other materials at the facility. These shall include, where applicable, stopping facility operations, collecting and containing released materials, and removing or isolating containers. If the facility stops operations in response to a fire, explosion, emission, or discharge, the Emergency Coordinator must ensure that adequate monitoring is conducted for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment whenever this is appropriate.

The Emergency Coordinator will oversee and direct facility personnel in the performance of their responsibilities for addressing the emergency situation. Immediately following an emergency, the Emergency Coordinator (with PADEP approval) must provide for treating, storing, or disposing residues, contaminated soil, etc., from an emission, discharge, fire, or explosion at the construction site. The Emergency Coordinator must ensure that in the affected areas of the facility, no material incompatible with the emitted or discharged residues is processed, stored, treated, or disposed until cleanup procedures are completed and that all emergency equipment utilized in implementation of the PPC Plan is cleaned and fit for its intended use before operations are resumed. Newfield will notify PADEP and the appropriate State or local

authorities that the facility is in compliance before operations are resumed in the affected areas of the facility. Newfield will note the time, date and details of an incident that requires implementing the PPC Plan.

Within 15 days after the incident, Newfield will submit a written report on the incident to PADEP and the U.S. Environmental Protection Agency regional administrator. The report must be submitted to:

Director - Bureau of Water Quality Management
Pennsylvania Department of Environmental Protection
909 Elmerton Avenue
Harrisburg, PA 17110

Regional Administrator
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Director - PADEP Northeast Office
Pennsylvania Department of Environmental Protection
2 Public Square
Wilkes-Barre, PA 18711

The report should include the following information:

- Name, address, and telephone number of the individual filing the report;
- Name, address, and telephone number of the facility;
- Date, time, type, and location of incident;
- A brief description of the circumstances causing the incident;
- Description and estimated quantity (by weight) of materials or wastes involved;
- The extent of injuries, if any;
- An assessment of actual or potential threat to human health or the environment and assessment of contamination of land, water, or air, where applicable;
- Estimated quantity and disposition of recovered materials or wastes that resulted from the incident; and
- A description of what actions Newfield intends to take to prevent a similar occurrence in the future.

2.4 CHAIN OF COMMAND

Facility personnel must report emergency situations to the Emergency Coordinators. A Chain of Command flow chart (Table 5, Appendix C) has been developed and should be implemented during an emergency. The Emergency Response Chain of Command flow chart will be posted

next to all telephones onsite, posted in areas where potential emergency situations could arise, and placed in onsite company vehicles, as appropriate.

2.5 DISTRIBUTION OF THIS PPC PLAN

A copy of this PPC Plan and subsequent revisions will be distributed to:

- Drilling Manager (Primary Emergency Coordinator)
- Production Manager (Secondary Emergency Coordinator)

The PPC Plan will be reviewed and amended, if necessary, based on the criteria described earlier in Section 1.7.

3.0 SPILL AND LEAK PREVENTION AND RESPONSE

The site will be maintained and operated to minimize the possibility of a fire, explosion or discharge of oils, hazardous materials or their constituents to air, soil, surface water or groundwater which could threaten human health or the environment, in accordance with the requirements of 25 PA Code Section 265.31.

3.1 PRE-RELEASE PLANNING

The following sections discuss specific locations where the potential exists for accidental spills of oils and/or chemicals. The controls that are in place to minimize the potential for an uncontrolled release to the environment are also discussed. In the event that an uncontrolled spill of hazardous substances occurs, the procedures described in Section 4.0 will be followed.

To enhance spill prevention at the facility, great care will be exercised in handling oil and other materials covered in this PPC Plan. Any unusual conditions observed by any employees or contractors will be reported to one of the Emergency Response Coordinators. Management personnel whose responsibilities include involvement with the materials discussed in this document will also be familiar with this plan and the procedures recommended for spill prevention.

Spill Prevention Measures: Procedures that are to be followed to prevent and/or minimize oil spills at the Newfield facility include:

- ASTs and/or containers will be stored in secondary containment with sufficient volume;
- ASTs and regulated material containers will be visually inspected weekly for leaks;
- Special care will be taken when transferring regulated materials to prevent product loss;
- Regulated materials will be stored in a manner that minimizes the potential for contact with stormwater;
- Absorbent and spill control materials shall be maintained on-site for emergency use;

- Emergency response personnel will be familiar with procedures to follow in the case of a spill; and

- In cases where there may be leaking equipment or operations where oil or oil-related compounds are leaked, spilled, or otherwise released, containment booms or absorbent materials shall be used and equipment shall be repaired.

In the event that an uncontrolled spill of oil or a hazardous material occurs, the procedures described in Section 4.0 will be followed. Responses should be coordinated with federal, state and local agencies as appropriate.

3.2 MATERIAL COMPATIBILITY

The majority of materials received on-site in totes, drums, pails or other small containers are stored in the containers supplied by the manufacturer.

Construction materials used for the ASTs have been selected and designed to be compatible with the materials that are being stored and are typical for the natural gas industry.

3.3 INSPECTIONS AND MONITORING PROGRAM

Operating equipment will be inspected daily, and a copy of the inspection and maintenance form is included in Appendix A. Employees are responsible for detecting and reporting potential problems on the inspection and maintenance form.

Storage tank inspections will be conducted weekly and include evaluation of the following: pumps, valves, and fittings for leaks; the tank condition for evidence of corrosion; secondary containment; evidence of spilled materials; and effectiveness of housekeeping practices.

Completed inspection forms and inspection reports will be maintained in the Primary Emergency Coordinator's office. Noncompliance issues identified during the comprehensive site evaluation will be addressed in a timely manner. If additional control measures are required, implementation of the measures will generally occur within 90 days of the site evaluation. Compliance issues that require revisions to the PPC Plan (description of additional pollutant sources, measures, or controls) will be incorporated into the plan within approximately 15 days of the site evaluation.

Stormwater Management System: Stormwater inspections will include an evaluation of best management practices (BMPs), where appropriate. In accordance with the erosion and sedimentation control plan prepared for the site, erosion and sedimentation control (ESC) measures will be implemented where there is the potential for sediment or soil particles to impact stormwater quality. Repairs will be made, as necessary, following the site inspection.

Storage Tanks and Drum Storage Areas: Tanks and drum storage areas will be accessed daily. Spills or leaks that may occur will be contained by secondary containment and noted as part of routine facility operations. To enhance the daily observations, periodic inspections will be performed for the tank and drum storage areas as described in Table 2. The inspections will include observation of spill and/or leaks and observations of the condition of associated secondary containment structures. Records for the inspections will be maintained in the Primary Emergency Coordinator's office.

3.4 PREVENTIVE MAINTENANCE

Newfield will ensure that preventative maintenance of operating machinery on each construction site is performed regularly.

3.5 HOUSEKEEPING PROGRAM

The Newfield Construction Manager will be responsible for general construction site housekeeping. Specific steps taken under this program will include:

- Debris and/or sediment removal, as necessary.
- Regular refuse pickup and disposal.
- Proper filling and emptying of storage containers, tanks, and equipment to minimize spill potential.
- Periodic review of good housekeeping procedures in the employee-training program.

Once completed, the Production Manager will have overall responsibility for housekeeping at the facility. Newfield currently does not anticipate that bulk quantities of hazardous waste materials will be stored at the facility.

3.6 SECURITY

The facility is not fully fenced but is located in a remote location with limited access except via the site access road. The facility is normally manned during drilling and well development.

Flow and drain valves are locked and in the off position when in non-operational or non-standby status. The starter controls for each oil pump are locked in the off position when in non-operating or non-standby status. Master flow/drain valves are all located on the Facility and monitored by staff.

Any loading/unloading connections of facility piping is capped or blind flanged when not in service or is in standby service for an extended amount of time.

The facility has lighting sufficient for detection of spills during nighttime operations. Consideration has been given to: (a) discovery of spills occurring during hours of darkness, both by operating personnel, if present, and by non-operating personnel, and (b) prevention of spills occurring through acts of vandalism.

3.7 EXTERNAL FACTOR PLANNING

External factors are not anticipated to increase the risk of a spill or release that would impact human safety or the environment. Power outages, adverse weather conditions, or employee strikes could result in discontinuation of earth moving, drilling or well preparation activities. The Emergency Coordinator will monitor operations and initiate their orderly shutdown when necessary.

Access road conditions may be impacted by adverse weather conditions, possibly increasing the risk of a release of materials being delivered or removed. Truck drivers should report poor road conditions to the Construction or Drilling Manager. If conditions deteriorate to where they may impact safe movement of materials, the construction or Drilling Manager will review the conditions and initiate repairs or road closure as deemed necessary.

3.8 EMPLOYEE TRAINING PROGRAM

Newfield's employee training program enables employees to understand the processes and materials with which they are working, the safety and health hazards, the practices for preventing spills, and the procedures for responding properly and rapidly to spills. It also familiarizes personnel with emergency procedures.

All Newfield employees receive job specific training. Emergency Coordinators, Well Tenders, and other oil or hazardous material handling employees receive annual training on the facility's PPC and SPCC plans.

Job specific training includes preventive maintenance, inspection and monitoring activities, shut down procedures and housekeeping practices. PPC training will include spill/release recognition, initial response, initial notifications and follow-up. The training program is designed to ensure that personnel are able to respond effectively to emergencies by familiarizing them with emergency procedures, emergency equipment systems including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for automatic cut-off systems; communications and alarms systems; response to fires and explosions; site evacuation procedures; and shutdown of operations.

Annual right-to-know training for all facility employees is conducted relevant to the materials present at the facility. Employees will be given detailed instructions regarding the materials and wastes with which they are working; including safety and health hazards, handling methods, proper disposal procedures, and emergency procedures. The location of MSDS's for on-site materials will be identified to all employees.

Training records will be maintained at the facility and in the employee's personnel file.

4.0 COUNTERMEASURES

4.1 COUNTERMEASURES TO BE UNDERTAKEN BY FACILITY

The following sections present general spill response practices to be implemented at the Newfield facility, as appropriate.

4.1.1 Spill Clean-Up Procedures - General

Incidental spills should be contained and cleaned up when discovered per the employees job related training. Clean up material should be placed into a marked container and the Construction or Drilling Manager notified appropriately.

For large spills or spills of oils or hazardous materials which may reach surface water or impact the environment, the employee who first discovers the spill should contact the Emergency Coordinator. He should then work to contain and clean-up the spill.

Spill clean-up involves three steps: containment, removal, and disposal. In the event of a spill, it is very important that the material be contained to the maximum extent possible in order to minimize the effect of the spill and the cost of clean-up. **NOTE: ANY SHEEN ON A WATERBODY (STREAM, RIVER, OR WETLAND) IS A REPORTABLE RELEASE.** Once the spill is contained, the spilled material and contaminated material must be collected and physically removed from the area

4.1.2 Spill Clean-Up Procedures - Specific

The employee should do the following:

- Contain the spill to the smallest area possible using absorbent materials, earthen dikes or other diversion or containment structures. Stormwater collection structures will be either blocked or pumped.
- Block off the area to prevent traffic or employees from entering the area.
- For oils and other organic materials, apply a non-reactive sorbent material, such as Oil-Dri or Kitty Litter, to the spill.
- In the case of a spill of acids hazardous waste, check the MSDS and then neutralize with lime or soda ash if appropriate.
- If a leaking tank is involved, stop liquid flows as appropriate and dike the tank area with earth or absorbent material.

- If a leaking pail, drum or other small container is involved, place it in an over-pack container.
- Clean up spilled material and place it in a marked container.
- Work with the emergency coordinator to properly store the material and arrange for proper disposal

4.1.3 Fire or Explosion

In the case of a fire or explosion, the local fire department should be notified by calling 911. Employees may attempt to extinguish fires using handheld fire extinguishers based upon their job training.

The Emergency Coordinator will determine if evacuation per section 4.4 is required.

4.2 COUNTERMEASURES TO BE UNDERTAKEN BY CONTRACTORS

The following list shows area emergency response contractors to contact should the facility require outside help.

Company: Minuteman Spill Response, Inc.
Address: P.O. Box 10
Mifflinville, PA 18631
Telephone Number: 570-759-3658
Response Time: Approximately 2 to 3 hrs
Equipment and Services: Hazardous Materials Emergency Response

4.3 INTERNAL AND EXTERNAL COMMUNICATIONS AND ALARM SYSTEM

This section describes the internal communications or alarm used to provide immediate emergency instruction (voice or signal) to installation personnel, and the external communications or alarm system used to summon emergency assistance from local police or fire departments.

Newfield facilities in Wayne County are remote and generally do not have land-line telephone systems or alarm systems. The primary means of communication is via voice or mobile telephones. Mobile phones are provided to the Drilling and Production Managers (Primary and Secondary Emergency Coordinators).

Fire, police, and emergency service can be summoned by calling the 911 or per the numbers listed in Table 3.

4.4 EVACUATION PLAN

In the unlikely event that the site must be evacuated, the Emergency Coordinator will alert personnel to re-group at the pre-designated location for attendance taking. The Emergency Coordinator is responsible to verify that all site workers are accounted for during an evacuation. Periodic drills will be conducted, if deemed necessary, to evaluate the effectiveness of this evacuation plan.

If an emergency situation requires evacuation of personnel, the Emergency Coordinator will implement the following evacuation procedures:

1. The Emergency Coordinator will provide evacuation instructions to facility personnel via the construction site communications network, as appropriate.

2. Personnel evacuation will typically proceed as follows:

   a. If downwind of incident: Evacuate via the most accessible route perpendicular to the prevailing wind direction.
   b. If upwind of incident: Evacuate in an upwind direction.

3. Personnel will reassemble at the public road at the facility entrance as shown on Figure 3 or an alternate assembly point identified by the Emergency Coordinator, that is upwind of the incident location, and remain at this location until the Emergency Coordinator has accounted for all personnel.

4. The names of employees and the destination of employees transported to hospitals, etc. for treatment will be recorded by the Emergency Coordinator, first aid personnel or fire officials.

Once on public roadways, evacuation routes are left up to the individual.

4.5 EMERGENCY EQUIPMENT AVAILABLE FOR RESPONSE

This section provides a list of available emergency equipment, and procedures for maintenance and decontamination of emergency equipment. Newfield's emergency equipment at the facility will allow personnel to respond safely and quickly to emergency situations. Equipment will be inspected and maintained by Construction Manager to assure recommended quantities are available and its proper operation in time of emergency. After an emergency, equipment will be decontaminated, cleaned, and re-fit for its intended use before normal operations resume.

The Newfield facility will be equipped with the following emergency response equipment:

(1) Mobile telephones are provided to the Drilling and Production Mangers and are immediately available at the scene of operations for summoning emergency assistance from local police departments, fire departments or State or local emergency response teams.

(2) Portable fire extinguishers, fire control equipment, spill control equipment and decontamination equipment. This equipment is detailed in Table 4 of Appendix C.

5.0 EMERGENCY SPILL CONTROL NETWORK

5.1 ARRANGEMENTS WITH LOCAL EMERGENCY RESPONSE AGENCIES AND HOSPITALS

This section provides a list of local emergency response agencies and hospitals, and associated phone numbers. Arrangements can be made, as appropriate, to inform local emergency response agencies and hospitals concerning the type of materials handled at the Newfield facility and the potential need for services.

If appropriate, arrangements can be made to designate who will be the primary emergency response agency and who will provide support services during emergencies. Efforts can be made to familiarize police, fire departments, emergency response teams, and the Wayne County Emergency Management Agency (EMA) Coordinator with the layout of the site, the properties and dangers associated with any hazardous materials handled, places where personnel would normally be working, entrances to roads inside the site, and potential evacuation routes.

If considered appropriate by Newfield's Emergency Coordinator, agreements with hospitals and emergency response agencies can be made and included in the periodic updating or amending of the PPC Plan. The agreements and/or arrangements include efforts to familiarize area agencies and emergency responders with facility operations and potential emergency operations. The following agencies can be contacted and provided with a copy of this PPC Plan, at the discretion of the Newfield Emergency Coordinator.

- Local fire companies;
- Local county emergency response personnel;
- Local ambulance personnel; and
- Local hospital.

Table 3 lists local emergency response agencies to be contacted in the event of an emergency or reportable spill. In the unlikely event that a widespread emergency exists, the Wayne County EMA would be contacted first, and the Coordinator in turn could contact appropriate emergency response agencies through their communications network.

The Wayne County Emergency Management Agency can be contacted at (570) 253-1622. Routing of injured persons will be performed by emergency medical services personnel based on the number and type of injuries requiring treatment. The emergency medical services coordinator may be provided with a copy of this PPC Plan to assist in planning. The nearest hospitals are Catskill Regional Medical Hospital in Callicoon, New York, and Wayne County Memorial Hospital in Honesdale, Pennsylvania. The nearest fire departments are Callicoon Fire District in Callicoon, New York, Protection Engine Co No. 3 in Honesdale, Pennsylvania, and Narrowsburg Fire Department, in Narrowsburg, New York. The nearest police departments are the Honesdale Police Department, located in Honesdale, Pennsylvania, and Waymart Police Department in Honesdale Pennsylvania. All emergency response departments shall be reached through the 911 system.

5.2 NOTIFICATION LISTS

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion that could threaten human health or the environment, he will contact and report as necessary his findings to the appropriate agencies listed in Table 3. When calling any of the agencies listed in Table 3, the following information should be available for reporting to the identified agencies:

- Company name and location;
- Name of person reporting the spill, title, and telephone number;
- The type of material released;
- Estimated or exact (if known) quantity of material released (i.e., gallons, pounds, etc.);
- A brief description of the incident, including type of incident, nature of hazardous material involvement, and possible hazards to human health and the environment outside the facility;
- Probable source and location of the spill source;
- Date and time of the spill;
- Location of entry point into surface water and amount reaching the waterway (if applicable);
- The name of the receiving water and the downstream water bodies of which it is a tributary;
- Confirmation that release has been stopped or, if not, when will it be stopped;
- Mitigation/containment actions initiated;
- Direction of material movement;

- Potential population affected by the release;
- Name of person to contact on behalf of the company who will be at the scene and will be directing response measures;
- Telephone number where the on-scene coordinator can be reached; and
- The extent of injuries, if any.

A reporting form is attached in Appendix D for use by the Emergency Coordinator.

A written report including the above listed information, and other information that may be required by the applicable regulations (see 25 PA Code Section 265.56) regarding the spilled material, will need to be transmitted within 15 days to the following agencies:

U.S. Environmental Protection Agency
Region III
Spill Response Section
1650 Arch Street
Philadelphia, PA 19103

Pennsylvania Department of Environmental Protection
Bureau of Water Quality Management
2 Public Square
Wilkes-Barre, Pennsylvania 18711

6.0 WASTE DISPOSAL PRACTICES

Produced water will be removed periodically from the tanks at each well site and transported by a licensed residual waste hauler to a permitted disposal facility. Other wastes generated onsite will include used hydraulic oil that will be reclaimed from operating equipment and transported offsite for recycling. All wastes will be disposed in accordance with applicable local, state, and federal regulations.

7.0 STORMWATER MANAGEMENT PRACTICES

Newfield implements several Best Management Practices (BMPs) at each well site to reduce the potential for stormwater runoff of suspended solids and other contaminants. These BMPs include routine visual inspections, preventive maintenance, good housekeeping, and management of stormwater run-on and runoff. Routine inspection and monitoring, preventive maintenance, and good housekeeping programs are discussed in Sections 3.3, 3.4, and 3.5 of this PPC Plan. These programs prevent accidental releases of contaminants and reduce contaminant migrations via stormwater discharges. Stormwater management activities are discussed in Section 3.1 of this PPC Plan. The certification statement regarding the evaluation of discharges and confirmation that they will be comprised solely of stormwater is presented at the beginning of this Plan. Potential "significant sources of non-stormwater at the site" may include condensate, brine, hydraulic oil drums and tanks, gasoline and diesel fuel. Storage areas for these significant sources will be inspected on a daily basis.

8.0 SEDIMENT AND EROSION PREVENTION

Erosion and sedimentation controls are managed in accordance with PADEP requirements. Copies of the site E&S Plan are available at the Newfield office in Honesdale, PA and at each well site.

APPENDIX A

INSPECTION FORMS

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Facility:	Inspector Name:
Date of Inspection:	

Instructions: Indicate yes or no. If no, record observations describing the specific equipment and discrepancy.

Aboveground Storage Tanks		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
• Level gauages/alarms are operative	Yes ☐	No ☐
• Containers are labeled	Yes ☐	No ☐
Observations:		

Processing Equipment		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
Observations:		

Other Facility Equipment is Checked for: ❖ No evidence of active or past leaks ❖ Condition of equipment appears to be satisfactory (i.e., not damaged, deteriorated, or worn), and ❖ Corrosion appears to be acceptable.		
• Wellheads	Yes ☐	No ☐
• Gathering systems	Yes ☐	No ☐
• Well test stations	Yes ☐	No ☐
• Traps/Sumps	Yes ☐	No ☐
• Drainage systems and nearby ditches	Yes ☐	No ☐
• Applicable flowlines including right-of-way areas	Yes ☐	No ☐
• Containment systems	Yes ☐	No ☐
• Facility piping	Yes ☐	No ☐
Observations:		

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Secondary Containment		
• Passive containment (berm) has adequate capacity and integrity as intended	Yes ☐	No ☐
• Active containment measures are adequate	Yes ☐	No ☐
• No evidence of active or past leaks (i.e., staining, sheen)	Yes ☐	No ☐
• Any valves are closed and plugged	Yes ☐	No ☐
• Active containment is free from a significant quantity of rain/snow	Yes ☐	No ☐
Observations:		

Security		
• Lighting is adequate to observe leaks, spills, and vandalism	Yes ☐	No ☐
• Pumps, valves, nozzles are locked	Yes ☐	No ☐
Observations:		

Spill Response		
• Spill response kits are stocked and located in readily accessible areas	Yes ☐	No ☐
Observations:		

Signature:	Date:

E&S INSPECTION FORM

The E&S plan contains a maintenance program which provides for inspection of BMPs (Best Management Practices such as filter sock, vegetation, construction entrances, etc.) on a weekly basis and after each measurable rainfall event, including the repair of BMPs to ensure effective and efficient operation. The maintenance program for both the temporary and permanent erosion and sediment control BMPs, including disposal of materials removed from the BMPs or project area, has been included in the narrative. The type of maintenance, such as cleanout, repair, replacement, regrading, re-stabilizing, etc. for each of the BMPs is included in the plan. **NOTE: This inspection report must be kept up to date and onsite.**

INSPECTION DATE	INITIALS	RAINFALL OR WEEKLY?	LOCATION OF E&S CONTROL(S)	CONDITION NOTED	CORRECTIVE MEASURES TAKEN

Facility: _____ **Inspector:** _____ **Signed:** _____ **Date:** _____

Print *Signature*

Tank Truck Loading and Unloading Checklist

Date: _____ Material being loaded/unloaded: _____

Driver/Loader present during loading or unloading of material _____
(signature)

_____ Current volume in storage tank was checked prior to loading.

_____ Fill hose inspected for condition prior to loading.

_____ Wheel chocks in place prior to loading.

_____ Tanker valve(s) were inspected for leakage prior to filling and departure.

_____ The loading of the tanker was monitored.

_____ Hoses were replaced and capped after loading.

_____ No material was spilled onto the containment pad or ground.

- These forms must be completed for every tank truck shipment and must be filed in the facility PPC Plan.
- All spills should be immediately reported to at least one of the following Newfield personnel:

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Burl Eakle
Cell: 918-448-1296

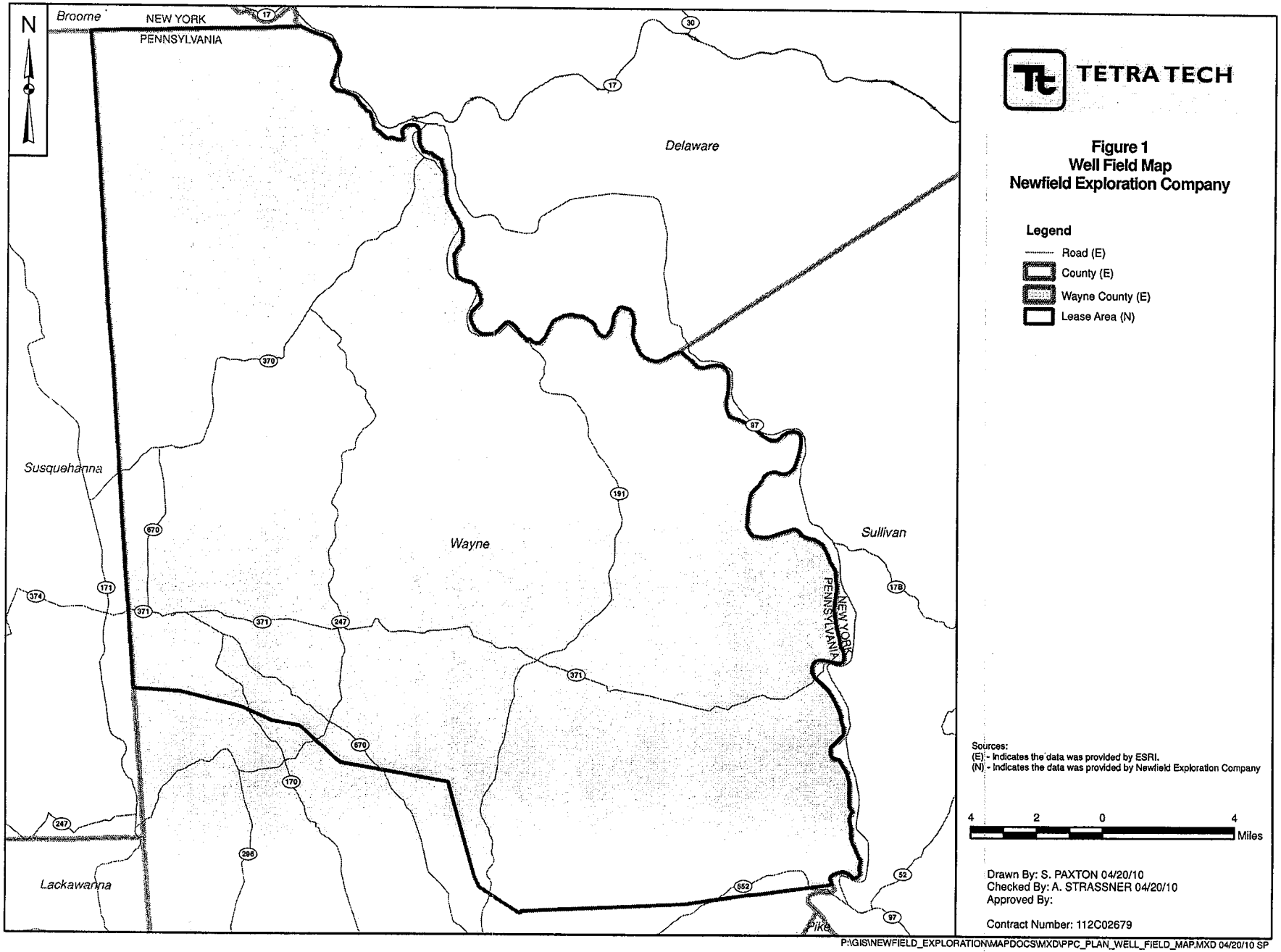
Delivery Information

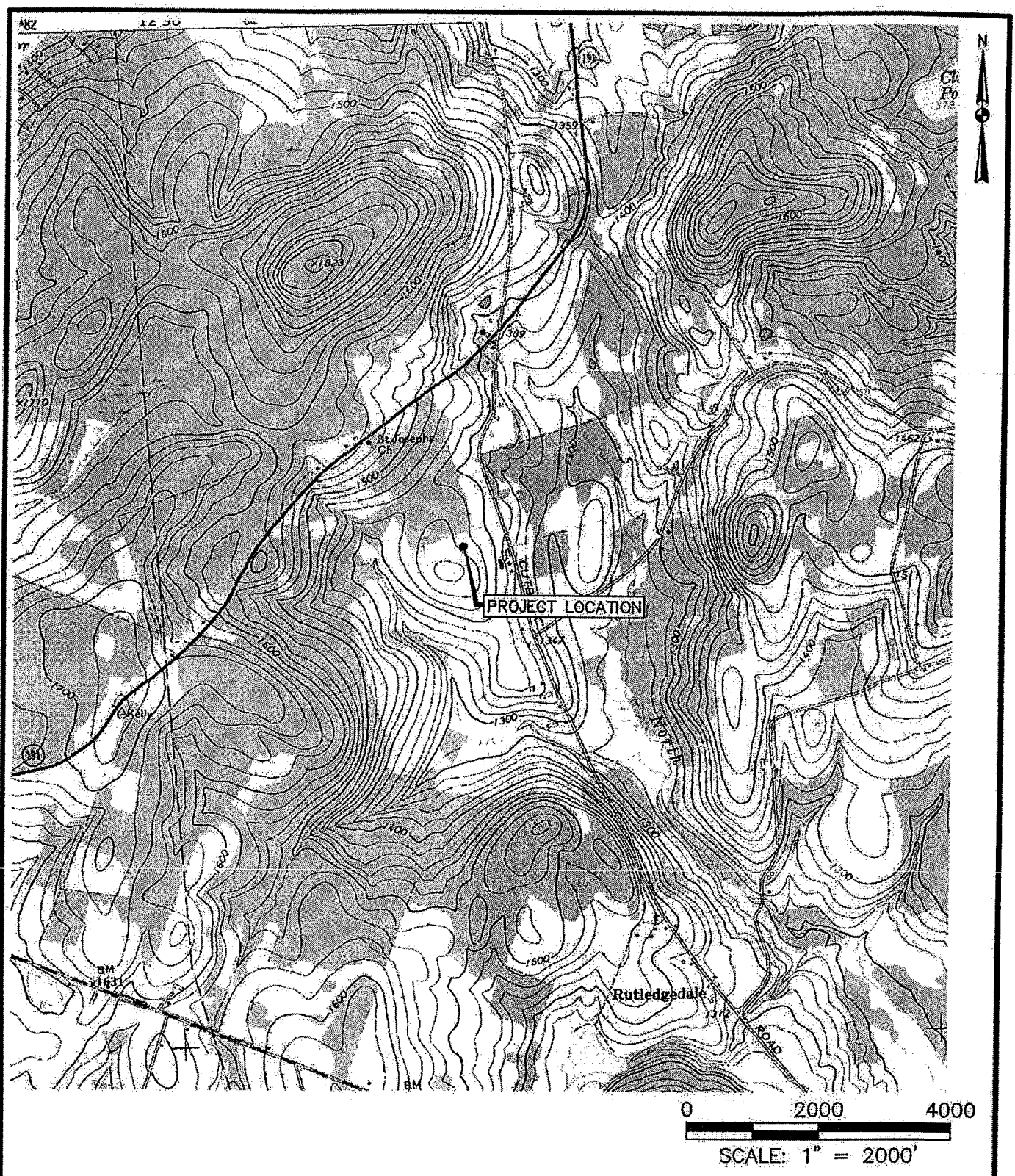
Invoice No. _____

Load No. _____

Company _____

APPENDIX B
FIGURES


N
Broome
NEW YORK
PENNSYLVANIA
Delaware
Susquehanna
Wayne
Sullivan
Lackawanna
NEW YORK
PENNSYLVANIA
TETRA TECH
Figure 1
Well Field Map
Newfield Exploration Company
Legend
Road (E)
County (E)
Wayne County (E)
Lease Area (N)
Sources:
(E) - Indicates the data was provided by ESRI.
(N) - Indicates the data was provided by Newfield Exploration Company
4 2 0 4
Miles
Drawn By: S. PAXTON 04/20/10
Checked By: A. STRASSNER 04/20/10
Approved By:
Contract Number: 112C02679
P:\GIS\NEWFIELD_EXPLORATION\MAPDOCS\MXD\PPC_PLAN_WELL_FIELD_MAP.MXD 04/20/10 SP



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TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

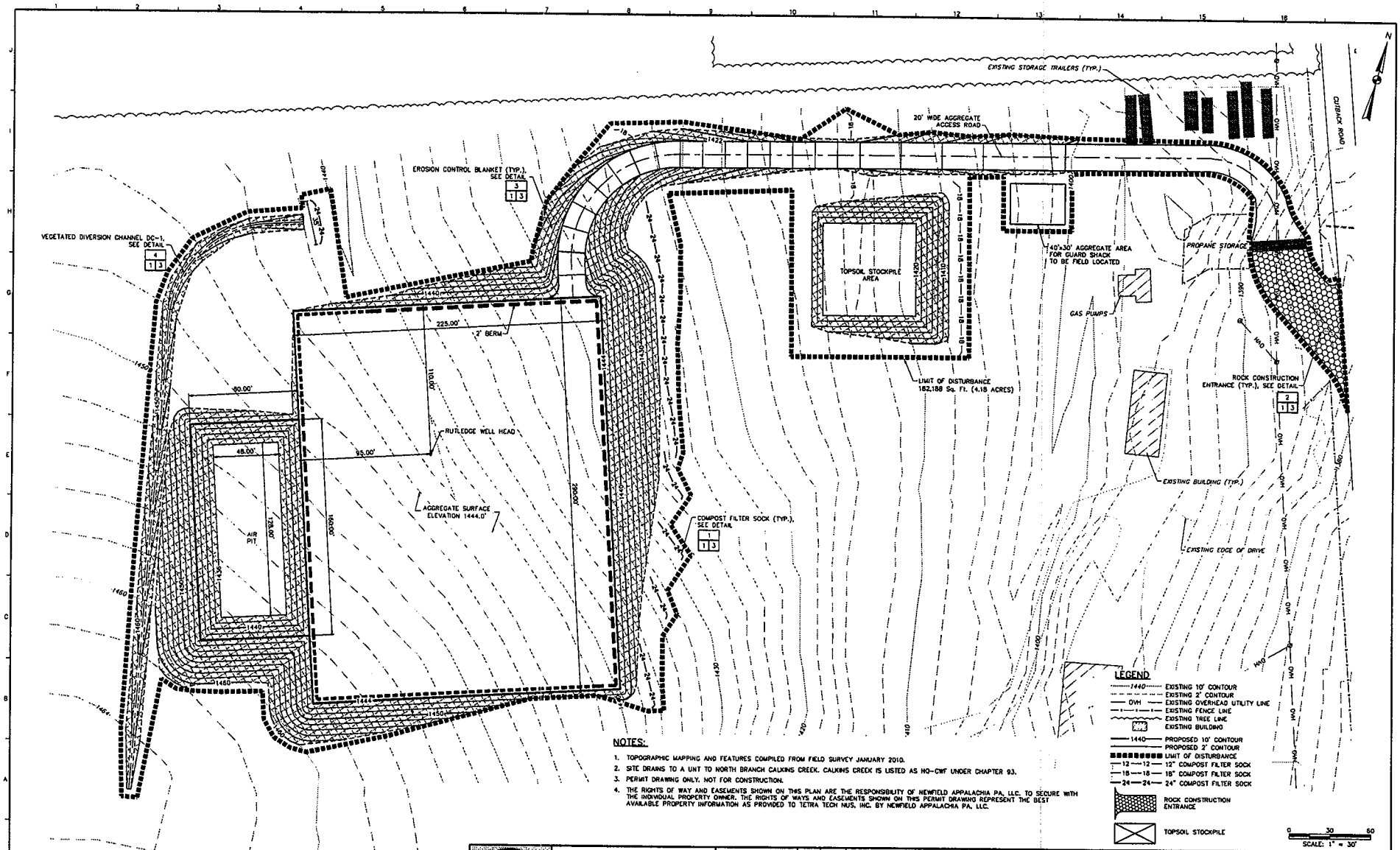
NEWFIELD APPALACHIA PA, LLC
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
LOCATION MAP

SCALE: 1" = 2000'

DATE:	3/4/10
PROJECT NO.:	112C02568
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	RAL
SHEET:	1 OF 2

FIGURE 2



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO A UNT TO NORTH BRANCH CALKINS CREEK. CALKINS CREEK IS LISTED AS HQ-CWF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

RUTLEDGE WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 30'

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	1 OF 7

FIGURE 3

APPENDIX C
TABLES

TABLE 1

LIST OF MATERIALS & WASTES

CONSTUCTION

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	250 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	180 gallons	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

DRILLING

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	2000 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	320 gallons	Well Pad	Sorbent pads; shovels/Gang box
DURATONE HT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
GELTONE V	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Lime	7,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Base Fluid	300 bbl	Well Pad	Sorbent pads; shovels/Gang box
Rig Wash	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Calcium Chloride (CaCl-)	4,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
RHEMOD L	1,770 lbs	Well Pad	Sorbent pads; shovels/Gang box
LE SUPERMUL	8,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
BARACARB 25, 50 (2 pallets each)	12,600 lbs	Well Pad	Sorbent pads; shovels/Gang box
WALNUT	2,400 lbs	Well Pad	Sorbent pads; shovels/Gang box
DRILTREAT	1,900 lbs	Well Pad	Sorbent pads; shovels/Gang box
Liquid Mud	1,500 bbl	Well Pad	Sorbent pads; shovels/Gang box
BAROID REGULAR / **BAROID BULK (barite)	125,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Drill Cuttings	100,000 lbs	Air Pit	Sorbent pads; shovels/Gang box
Cement	130,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

TABLE 2

INSPECTION AND MONITORING ACTIVITIES

Activity	Frequency
Erosion and Sedimentation Control Measures	Weekly or after a significant rain event
Aboveground Storage Tanks	Daily
Drum Storage Areas	Daily
Best Management Practices (BMPs)	Per BMP requirements
Dust Control Measures	Daily
Preparedness, Prevention, and Contingency (PPC) Plan Compliance Evaluation Inspections and Update of PPC Plan, as Appropriate	Annually

TABLE 3
AGENCY NOTIFICATION LIST

The following agencies are to be contacted, as appropriate, in the event of an emergency, accident, or chemical release.

Agency	Telephone No.
PADEP Northeast Regional Office	570-826-2511
PADEP Southcentral Office (Harrisburg)	877-333-1904
Pennsylvania Emergency Management Agency	717-651-2001
Police Department	9-1-1
Volunteer Fire Department	9-1-1
U.S. Environmental Protection Agency	215-814-5700
U.S. Coast Guard National Response Center	800-424-8802
U.S. Coast Guard (local)	570-421-1191
Pennsylvania Fish and Boat Commission	814-445-8974
Chemical Transportation Emergency Center:	
* Chemical Exposure Information	800-424-9300

LOCAL EMERGENCY RESPONSE:

Fire Department – Wayne County Company #3,13, 21, 28, 43, and 65	9-1-1
Police Department – PSP, Honesdale, Pennsylvania	9-1-1
Hospitals/Ambulances-	
Damascus Township Ambulance, Pennsylvania MT Pleasant Ambulance Northern Wayne Ambulance Mobile 504	9-1-1
Wayne County Memorial Hospital, Honesdale, Pennsylvania	570-251-6672
CMC – Trauma Center, Scranton, Pennsylvania	570-969-8128
Catskill Regional Medical Hospital in Callicoon, New York	845-887-5530
Local Emergency Management	
Wayne County EMA	570-253-1622

TABLE 4

On-Site Emergency Response Equipment

On-Site Emergency Response Equipment
Fire Extinguishers
Tyvek Suits
Nitrile Gloves
Hearing Protection
Particulate Adsorbent
Absorbent Pads
Shovels
Earth Moving Equipment
Decontamination Equipment

TABLE 5
CHAIN OF COMMAND

Primary Emergency Coordinator

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Construction Manager
Burl Eakle
Cell: 918-448-1296

Offsite Emergency Response Contractors

Company: Minuteman Spill Response, Inc.
Telephone Number: 800-905-7788

APPENDIX D
REPORTING FORM

Spill Response Notification Form

GENERAL REPORTING INFORMATION

Prepared _____
(First) (M.I.) (Last) (Position)

Daytime phone: (xxx) xxx-xxxx Evening phone: (xxx) xxx-xxxx

Newfield Appalachia PA LLC
(Company) (Address) (City) (State) (Zip)

Calling for responsible party? Yes Were materials discharged? Yes Confidential? No

Meeting Federal obligations to report: Yes

INCIDENT DESCRIPTION

Source and/or cause:

Date of Incident:Time of Incident:

Incident Location/Address

Nearest City: XXXX, PA XXXXX (XXXXXXX County)

Distance from City: In city limits Direction from City: In city limits

Facility Oil Storage Capacity: XXXXXX gallons

Container Type:Container Capacity: (gals)

Facility Latitude: xx° xx' xx" Longitude xx° xx' xx"

MATERIAL

Name (or CHRIS Code):

Discharged Quantity (Units): Discharged to Water (Units):

RESPONSE ACTION

Actions taken to correct, control or mitigate incident:

IMPACT

No. of Injuries: No. of Deaths: Other:

Evacuation (Y/N): Damage (Y/N): Amount ($):

Medium Affected: Description: Additional Information:

AGENCY NOTIFIED

NRC 800-424-8802 Date: Time: Contact:

PADEP (570) 826-2511 Date: Time: Contact:

USCG Date: Time: Contact:

Other Date: Time: Contact:

ADDITIONAL INFORMATION:

APPENDIX E
MSDS SHEETS

MATERIAL SAFETY DATA SHEET

Diesel Fuel (All Types) **MSDS No. 9909**

EMERGENCY OVERVIEW
CAUTION!
OSHA/NFPA COMBUSTIBLE LIQUID - SLIGHT TO MODERATE IRRITANT
EFFECTS CENTRAL NERVOUS SYSTEM
HARMFUL OR FATAL IF SWALLOWED
Moderate fire hazard. Avoid breathing vapors or mists. May cause dizziness and drowsiness. May cause moderate eye irritation and skin irritation (rash). Long-term, repeated exposure may cause skin cancer.
If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs).

NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER (24 hrs): **CHEMTREC (800) 424-9300**
COMPANY CONTACT (business hours): Corporate Safety (732) 750-6000
MSDS INTERNET WEBSITE: www.hess.com (See Environment, Health, Safety & Social Responsibility)

SYNONYMS: Ultra Low Sulfur Diesel (ULSD); Low Sulfur Diesel; Motor Vehicle Diesel Fuel; Diesel Fuel #2; Dyed Diesel Fuel; Non-Road, Locomotive and Marine Diesel Fuel; Tax-exempt Diesel Fuel

See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Diesel Fuel (68476-34-6)	100
Naphthalene (91-20-3)	Typically < 0.01

A complex mixture of hydrocarbons with carbon numbers in the range C9 and higher. Diesel fuel may be dyed (red) for tax purposes. May contain a multifunctional additive.

3. HAZARDS IDENTIFICATION

EYES
Contact with liquid or vapor may cause mild irritation.

SKIN
May cause skin irritation with prolonged or repeated contact. Practically non-toxic if absorbed following acute (single) exposure. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed.

INGESTION
The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION
Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY
Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. The significance of these results to human exposures has not been determined - see Section 11 Toxicological Information.

IARC classifies whole diesel fuel exhaust particulates as probably carcinogenic to humans (Group 2A). NIOSH regards whole diesel fuel exhaust particulates as a potential cause of occupational lung cancer based on animal studies and limited evidence in humans.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash).

4. FIRST AID MEASURES

EYES
In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN
Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops.

INGESTION
DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION
Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT:	> 125 °F (> 52 °C) minimum PMCC
AUTOIGNITION POINT:	494 °F (257 °C)
OSHA/NFPA FLAMMABILITY CLASS:	2 (COMBUSTIBLE)
LOWER EXPLOSIVE LIMIT (%):	0.6
UPPER EXPLOSIVE LIMIT (%):	7.5

FIRE AND EXPLOSION HAZARDS
Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA
SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES

ACTIVATE FACILITY'S SPILL CONTINGENCY OR EMERGENCY RESPONSE PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING PRECAUTIONS

Handle as a combustible liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Diesel fuel, and in particular low and ultra low sulfur diesel fuel, has the capability of accumulating a static electrical charge of sufficient energy to cause a fire/explosion in the presence of lower flashpoint products such as gasoline. The accumulation of such a static charge occurs as the diesel flows through pipelines, filters, nozzles and various work tasks such as tank/container filling, splash loading, tank cleaning; product sampling; tank gauging; cleaning, mixing, vacuum truck operations, switch loading, and product agitation. There is a greater potential for static charge accumulation in cold temperature, low humidity conditions.

Documents such as 29 CFR OSHA 1910.106 "Flammable and Combustible Liquids, NFPA 77 Recommended Practice on Static Electricity, API 2003 "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents and ASTM D4865 "Standard Guide for Generation and Dissipation of Static

Electricity in Petroleum Fuel Systems" address special precautions and design requirements involving loading rates, grounding, bonding, filter installation, conductivity additives and especially the hazards associated with "switch loading." ["Switch Loading" is when a higher flash point product (such as diesel) is loaded into tanks previously containing a low flash point product (such as gasoline) and the electrical charge generated during loading of the diesel results in a static ignition of the vapor from the previous cargo (gasoline).]

Note: When conductivity additives are used or are necessary the product should achieve 25 picosiemens/meter or greater at the handling temperature.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)	Source	Exposure Limits TWA/STEL	Note
Diesel Fuel: (68476-34-6)	OSHA	5 mg/m, as mineral oil mist	
	ACGIH	100 mg/m^3 (as totally hydrocarbon vapor) TWA	A3, skin
Naphthalene (91-20-3)	OSHA	10 ppm TWA	
	ACGIH	10 ppm TWA / 15 ppm STEL	A4, Skin

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile, neoprene, or PVC are recommended. Chemical protective clothing such as of E.I. DuPont TyChem®, Saranex® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION
A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE
Clear, straw-yellow liquid. Dyed fuel oil will be red or reddish-colored.

ODOR
Mild, petroleum distillate odor

BASIC PHYSICAL PROPERTIES

BOILING RANGE:	320 to 690 oF (160 to 366 °C)
VAPOR PRESSURE:	0.009 psia @ 70 °F (21 °C)
VAPOR DENSITY (air = 1):	> 1.0
SPECIFIC GRAVITY (H_2O = 1):	0.83 to 0.88 @ 60 °F (16 °C)
PERCENT VOLATILES:	100 %
EVAPORATION RATE:	Slow; varies with conditions
SOLUBILITY (H_2O):	Negligible

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS
Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers; Viton ®; Fluorel ®

HAZARDOUS DECOMPOSITION PRODUCTS
Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

11. TOXICOLOGICAL PROPERTIES

ACUTE TOXICITY
Acute dermal LD50 (rabbits): > 5 ml/kg
Acute oral LD50 (rats): 9 ml/kg
Primary dermal irritation: extremely irritating (rabbits)
Draize eye irritation: non-irritating (rabbits)
Guinea pig sensitization: negative

CHRONIC EFFECTS AND CARCINOGENICITY
Carcinogenic: OSHA: NO IARC: NO NTP: NO ACGIH: A3

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

MUTAGENICITY (genetic effects)
This material has been positive in a mutagenicity study.

12. ECOLOGICAL INFORMATION

Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

PROPER SHIPPING NAME:	Diesel Fuel	Placard (International Only):
HAZARD CLASS and PACKING GROUP:	3, PG III	
DOT IDENTIFICATION NUMBER:	NA 1993 (Domestic) UN 1202 (International)	
DOT SHIPPING LABEL:	None	

Use Combustible Placard if shipping in bulk domestically

15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

This product and its constituents listed herein are on the EPA TSCA Inventory. Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH	CHRONIC HEALTH	FIRE	SUDDEN RELEASE OF PRESSURE	REACTIVE
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product may contain listed chemicals below the *de minimis* levels which therefore are not subject to the supplier notification requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372. If you may be required to report releases of chemicals listed in 40 CFR 372.28, you may contact Hess Corporate Safety if you require additional information regarding this product.

CALIFORNIA PROPOSITON 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

INGREDIENT NAME (CAS NUMBER)	Date Listed
Diesel Engine Exhaust (no CAS Number listed)	10/01/1990

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 3 (Combustible Liquid) and Class D, Division 2, Subdivision B (Toxic by other means)

16. OTHER INFORMATION

NFPA® HAZARD RATING

HEALTH:	0
FIRE:	2
REACTIVITY:	0

Refer to NFPA 704 "Identification of the Fire Hazards of Materials" for further information

HMIS® HAZARD RATING

HEALTH:	1 *	* Chronic
FIRE:	2	
PHYSICAL:	0	

SUPERSEDES MSDS DATED: 02/28/2001

ABBREVIATIONS:

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute (212) 642-4900
API	American Petroleum Institute (202) 682-8000
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation [General info: (800) 467-4922]
EPA	U.S. Environmental Protection Agency
HMIS	Hazardous Materials Information System
IARC	International Agency For Research On Cancer
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association (617)770-3000
NIOSH	National Institute of Occupational Safety and Health
NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
NTP	National Toxicology Program
OPA	Oil Pollution Act of 1990
OSHA	U.S. Occupational Safety & Health Administration
PEL	Permissible Exposure Limit (OSHA)
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit (NIOSH)
SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
SCBA	Self-Contained Breathing Apparatus
SPCC	Spill Prevention, Control, and Countermeasures
STEL	Short-Term Exposure Limit (generally 15 minutes)
TLV	Threshold Limit Value (ACGIH)
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average (8 hr.)
WEEL	Workplace Environmental Exposure Level (AIHA)
WHMIS	Canadian Workplace Hazardous Materials Information System

MATERIAL SAFETY DATA SHEET

Review Date: 04/23/2007

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT: PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

MSDS NUMBER: 614348LU - 1
PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

MANUFACTURER
SOPUS Products
P.O. Box 4427
Houston, TX. 77210-4427

TELEPHONE NUMBERS
Spill Information: (877) 242-7400
Health Information: (877) 504-9351
MSDS Assistance Number: (877) 276-7285

SECTION 2 PRODUCT/INGREDIENTS

INGREDIENTS	CAS#	CONCENTRATION
Heavy Duty Motor Oil		
Highly refined petroleum oils	Mixture	90 - 99 %volume
Zinc Dialkyldithiophosphate	68649-42-3	1 - 5 %volume
Proprietary additives	Mixture	1 - 5 %volume

SECTION 3 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Appearance & Odor: Bright and clear liquid. Mild odor.
Health Hazards: No known immediate health hazards.
Physical Hazards: No known physical hazards.
NFPA Rating (Health, Fire, Reactivity): 0, 1, 0
Hazard Rating: Least - 0 Slight - 1 Moderate - 2 High - 3 Extreme - 4

Inhalation:
Inhalation of vapors (generated at high temperatures only) or oil mist may cause mild irritation of the nose, throat, and respiratory tract.

Eye Irritation:
Lubricating oils are generally considered no more than minimally irritating to the eyes.

Skin Contact:
May cause slight irritation of the skin. If irritation occurs, a temporary burning sensation and minor redness and/or swelling may result.

Ingestion:

Lubricating oils are generally no more than slightly toxic if swallowed.

Other Health Effects:
The International Agency for Research on Cancer (IARC) has determined there is sufficient evidence for the carcinogenicity in experimental animals of used gasoline motor oils. Handling procedures and safety precautions in the MSDS should be followed to minimize exposure to the used product.

Signs and Symptoms:
Irritation as noted above.

Aggravated Medical Conditions:
Pre-existing eye, skin and respiratory disorders may be aggravated by exposure to this product.

For additional health information, refer to section 11.

SECTION 4 FIRST AID MEASURES

Inhalation:
Remove victim to fresh air and provide oxygen if breathing is difficult. Get medical attention. If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.

Skin:
Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.

Eye:
Flush with water. If irritation occurs, get medical attention.

Ingestion:
Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

Note to Physician:
In general, emesis induction is unnecessary in high viscosity, low volatility products such as oils and greases.

SECTION 5 FIRE FIGHTING MEASURES

Flash Point [Method]: >400 °F/>204.44 °C [Pensky-Martens Closed Cup]

Extinguishing Media:
Material will float and can be re-ignited on surface of water. Use water fog, foam, dry chemical or carbon dioxide (CO2) to extinguish flames. Do not use a direct stream of water.

Fire Fighting Instructions:
Do not enter confined fire space without full bunker gear (helmet with face shield, bunker coats, gloves and rubber boots), including a positive pressure, NIOSH approved, self-contained breathing apparatus. This material is non-flammable.

Unusual Fire Hazards:
Material may ignite when preheated.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Protective Measures:
May burn although not readily ignitable.

Wear appropriate personal protective equipment when cleaning up spills. Refer to Section 8.

Spill Management:
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

Place in container for proper disposal. Remove contaminated soil to remove contaminated trace residues. Dispose of in same manner as material.

Reporting:
CERCLA: Product is covered by EPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) petroleum exclusion. Releases to air, land, or water are not reportable under CERCLA (Superfund).

CWA: This product is an oil as defined under Section 311 of EPA's Clean Water Act (CWA). Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 1-800-424-8802.

SECTION 7 HANDLING AND STORAGE

Precautionary Measures:
Wash with soap and water before eating, drinking, smoking, applying cosmetics, or using toilet. Launder contaminated clothing before reuse. Properly dispose of contaminated leather articles such as shoes or belts that cannot be decontaminated. Avoid heat, open flames, including pilot lights, and strong oxidizing agents. Use explosion-proof ventilation to prevent vapor accumulation. Ground all handling equipment to prevent sparking.

Storage:
Do not store in open or unlabeled containers. Store in a cool, dry place with adequate ventilation. Keep away from open flames and high temperatures.

Container Warnings:
Keep containers closed when not in use. Containers, even those that have been emptied, can contain explosive vapors. Do not cut, drill, grind, weld or perform similar operations on or near containers.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Chemical	Limit	TWA	STEL	Ceiling	Notation
Oil mist, mineral	ACGIH TLV	5 mg/m3	10 mg/m3		
Oil mist, mineral	OSHA PEL	5 mg/m3			

Exposure Controls

Provide adequate ventilation to control airborne concentrations below the exposure guidelines/limits.

Personal Protection

Personal protective equipment (PPE) selections vary based on potential exposure conditions such as handling practices, concentration and ventilation. Information on the selection of eye, skin and respiratory protection for use with this material is provided below.

Eye Protection:
Chemical Goggles, or Safety glasses with side shields

Skin Protection:
Use protective clothing which is chemically resistant to this material. Selection of protective clothing depends on potential exposure conditions and may include gloves, boots, suits and other items. The selection(s) should take into account such factors as job task, type of exposure and durability requirements.

Published literature, test data and/or glove and clothing manufacturers indicate the best protection is provided by:
Neoprene, or Nitrile Rubber

Respiratory Protection:
If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, an approved respirator must be worn. Respirator selection, use and maintenance should be in accordance with the requirements of the OSHA Respiratory Protection Standard, 29 CFR 1910.134.

Types of respirator(s) to be considered in the selection process include:
For Mist: Air Purifying, R or P style NIOSH approved respirator.
For Vapors: Air Purifying, R or P style prefilter & organic cartridge, NIOSH approved respirator. Self-contained breathing apparatus for use in environments with unknown concentrations or emergency situations.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance & Odor: Bright and clear liquid. Mild odor.
Substance Chemical Family: Petroleum Hydrocarbon

Flash Point	>400 °F [Pensky-Martens Closed Cup]	**Pour Point**	-20 °F
Solubility (in Water)	Insoluble	**Specific Gravity**	0.88 - 0.89
Stability	Stable	**Viscosity**	103 cSt @ 40 °C

SECTION 10 REACTIVITY AND STABILITY

Stability:
Material is stable under normal conditions.

Conditions to Avoid:
Avoid heat and open flames.

Materials to Avoid:
Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products:

Thermal decomposition products are highly dependent on combustion conditions. A complex mixture of airborne solids, liquids and gases will evolve when this material undergoes pyrolysis or combustion. Aldehydes, Carbon Monoxide, Carbon Dioxide, Hydrogen Sulfide, Ketones, Nitrogen Oxidesand other unidentified organic compounds may be formed upon combustion.

SECTION 11 TOXICOLOGICAL INFORMATION

Acute Toxicity

TEST	Result	OSHA Classification	Material Tested
Dermal LD50	>5.0 g/kg(Rabbit)	Non-Toxic	Based on components(s)
Oral LD50	>5.0 g/kg(Rat)	Non-Toxic	Based on components(s)

Carcinogenicity Classification

Chemical Name	NTP	IARC	ACGIH	OSHA
Heavy Duty Motor Oil	No	Not Reviewed by IARC	Not Reviewed	No

SECTION 12 ECOLOGICAL INFORMATION

Environmental Impact Summary:
There is no ecological data available for this product. However, this product is an oil. It is persistent and does not readily biodegrade. However, it does not bioaccumulate.

SECTION 13 DISPOSAL CONSIDERATIONS

RCRA Information:

Under RCRA, it is the responsibility of the user of the material to determine, at the time of the disposal, whether the material meets RCRA criteria for hazardous waste. This is because material uses, transformations, mixtures, processes, etc. may affect the classification. Refer to the latest EPA, state and local regulations regarding proper disposal.

SECTION 14 TRANSPORT INFORMATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

International Air Transport Association
Not regulated under IATA rules.

International Maritime Organization Classification
Not regulated under International Maritime Organization rules.

SECTION 15 REGULATORY INFORMATION

Federal Regulatory Status

OSHA Classification:
Under normal conditions of use or in a foreseeable emergency, this product does not meet the definition of a hazardous chemical when evaluated according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Ozone Depleting Substances (40 CFR 82 Clean Air Act):
This material does not contain nor was it directly manufactured with any Class I or Class II ozone depleting substances.

Superfund Amendment & Reauthorization Act (SARA) Title III:
There are no components in this product on the SARA 302 list.

SARA Hazard Categories (311/312):

Immediate Health	Delayed Health	Fire	Pressure	Reactivity
NO	NO	NO	NO	NO

SARA Toxic Release Inventory (TRI) (313):
Zinc compounds

Toxic Substances Control Act (TSCA) Status:
All component(s) of this material is(are) listed on the EPA/TSCA Inventory of Chemical Substances.

Other Chemical Inventories:
Component(s) of this material is (are) listed on the Australian AICS, Canadian DSL, Chinese Inventory, European EINECS, Korean Inventory, Philippines PICCS,

State Regulation

The following chemicals are specifically listed by individual states; other product specific health and safety data in other sections of the MSDS may also be applicable for state requirements. For details on your regulatory requirements you should contact the appropriate agency in your state.

SECTION 16 OTHER INFORMATION

Revision#: 1
Review Date: 04/23/2007
Revision Date: 12/19/2006
Revisions since last change (discussion): This Material Safety Data Sheet (MSDS) has been reviewed to fully comply with the guidance contained in the ANSI MSDS standard (ANSI Z400.1-2003). We encourage you to take the opportunity to read the MSDS and review the information contained therein.

SECTION 17 LABEL INFORMATION

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

ATTENTION!

PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE OIL ACNE OR DERMATITIS. USED GASOLINE ENGINE OIL HAS BEEN SHOWN TO CAUSE CANCER IN LABORATORY ANIMALS.

Precautionary Measures:
Avoid prolonged or repeated contact with eyes, skin and clothing. Avoid breathing of vapors, fumes, or mist. Use only with adequate ventilation. Wash thoroughly after handling.

FIRST AID

Inhalation: If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.
Skin Contact: Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.
Eye Contact: Flush with water. If irritation occurs, get medical attention.
Ingestion: Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

FIRE

In case of fire, Use water fog, 'alcohol foam', dry chemical or carbon dioxide (CO_2) to extinguish flames. Do not use a direct stream of water. Material will float and can be re-ignited on surface of water.

SPILL OR LEAK

Dike and contain spill.
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

CONTAINS: Highly refined petroleum oils, Mixture; Zinc Dialkyldithiophosphate, 68649-42-3; Proprietary additives, Mixture

NFPA Rating (Health, Fire, Reactivity): 0, 1, 0

TRANSPORTATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flames or heat. Keep container closed and drum bungs in place.

Name and Address

SOPUS Products
P.O. Box 4427
Houston, TX 77210-4427

ADMINISTRATIVE INFORMATION	
MANUFACTURER ADDRESS:	SOPUS Products, P.O. Box 4427, Houston, TX. 77210-4427

THE INFORMATION CONTAINED IN THIS DATA SHEET IS BASED ON THE DATA AVAILABLE TO US AT THIS TIME, AND IS BELIEVED TO BE ACCURATE BASED UPON THAT : IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT, FOR PURPOSE OF HAZARD COMMUNICATION. IT IS NOT INTENDED TO CONSTITUTE PRODUCT PERFORMANCE INFORMATION, AND NO EXPRESS OR IMPLIED WARRANTY OF ANY KIND IS MADE WITH RESPECT TO THE PRODUCT, UNDERLYING DATA OR THE INFORMATION CONTAINED HEREIN. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE, AND ARE ENCOURAGED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

TO DETERMINE THE APPLICABILITY OR EFFECT OF ANY LAW OR REGULATION WITH RESPECT TO THE PRODUCT, YOU SHOULD CONSULT WITH YOUR LEGAL ADVISOR OR THE APPROPRIATE GOVERNMENT AGENCY. WE WILL NOT PROVIDE ADVICE ON SUCH MATTERS, OR BE RESPONSIBLE FOR ANY INJURY FROM THE USE OF THE PRODUCT DESCRIBED HEREIN. THE UNDERLYING DATA, AND THE INFORMATION PROVIDED HEREIN AS A RESULT OF THAT DATA, IS THE PROPERTY OF SOPUS PRODUCTS AND IS NOT TO BE THE SUBJECT OF SALE OR EXCHANGE WITHOUT THE EXPRESS WRITTEN CONSENT OF SOPUS PRODUCTS.

44815-10737-100R-04/16/2007

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CALCIUM CHLORIDE - POWDER**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CALCIUM CHLORIDE - POWDER
Synonyms: None
Chemical Family: Inorganic Salt
Application: Accelerator

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcium chloride		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Dust proof goggles.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	10
Specific Gravity @ 20 C (Water=1):	0.83
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	51
Boiling Point/Range (F):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	42
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	147.02

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause skin irritation. May cause skin burns on prolonged contact.
Eye Contact	May cause severe eye irritation. May cause corneal injury.
Ingestion	Causes burns of the mouth, throat and stomach.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 1000 mg/kg (Rat)
Dermal Toxicity:	LD50: > 5000 mg/kg (Rabbit)
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: DRILTREAT®

Revision Date: 09-Mar-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: DRILTREAT®
Synonyms: None
Chemical Family: Lipid
Application: Oil-wetting Agent

Manufacturer/Supplier

Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Contains no hazardous substances	Mixture	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye irritation.

4. FIRST AID MEASURES

Inhalation Under normal conditions, first aid procedures are not required.

Skin Wash with soap and water.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	400
Flash Point/Range (C):	204
Flash Point Method:	PMCC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing.

Storage Information Store away from oxidizers.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally necessary.

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Amber
Odor:	Bean
pH:	6.4-7
Specific Gravity @ 20 C (Water=1):	1.03
Density @ 20 C (lbs./gallon):	8.58
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	32
Freezing Point/Range (C):	0
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Disperses
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	None known.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: 497,500 ppm (Mysidopsis bahia) SPP @ 12 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **DURATONE® HT**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: DURATONE® HT
Synonyms: None
Chemical Family: Blend
Application: Fluid Loss Additive

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Kaolin	1332-58-7	10 - 30%	2 mg/m^3	Not applicable
Nonylphenol	25154-52-3	5 - 10%	Not applicable	Not applicable
Sodium hydroxide	1310-73-2	1 - 5%	2 mg/m^3	2 mg/m^3
Quaternary ammonium compounds		10 - 30%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation — If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin — Wash with soap and water. Get medical attention if irritation persists.

Eyes — In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion — Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician — Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	608
Autoignition Temperature (C):	320
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media — Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards — Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters — Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 2, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 2*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures — Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures — Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray to black
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.8
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	31 uncompacted; 44 compacted
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	< -1 (OECD117)

9. PHYSICAL AND CHEMICAL PROPERTIES

Molecular Weight (g/mole): Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong alkalis. Strong acids. Aldehydes. Ketones. Acrylates.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause moderate skin irritation. May cause an allergic skin reaction.
Eye Contact	May cause severe eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Ames Test: Negative

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability BOD(28 Day): 9% of COD

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 30 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: EC50: 370 mg/l (Daphnia magna)

Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product contains toxic chemical(s) listed below which is(are) subject to the reporting requirements of Section 313 of Title III of SARA and 40 CFR Part 372: Aluminum Oxide//1344-28-1
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.

EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **GELTONE® V**

Revision Date: 02-Jun-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: GELTONE® V
Synonyms: None
Chemical Family: Blend
Application: Viscosifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, cristobalite	14464-46-1	0 - 1%	0.025 mg/m^3	1/2 x $\frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, tridymite	15468-32-3	0 - 1%	0.05 mg/m^3	1/2 x $\frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, quartz	14808-60-7	2-6	0.025 mg/m^3	$\frac{10\ mg/m^3}{\%SiO2 + 2}$
Isopropanol	67-63-0	1 - 5%	200 ppm	400 ppm
Modified bentonite		60 - 100%	Not applicable	Not applicable

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation — If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin — Wash with soap and water. Get medical attention if irritation persists.

Eyes — In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion — Under normal conditions, first aid procedures are not required.

Notes to Physician — Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media — All standard firefighting media.

Special Exposure Hazards — Not applicable.

Special Protective Equipment for Fire-Fighters — Not applicable.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures — Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures — None known.

Procedure for Cleaning / Absorption — Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.

Storage Information

Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.

Respiratory Protection

Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.

Hand Protection

Normal work gloves.

Skin Protection

Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection

Wear safety glasses or goggles to protect against exposure.

Other Precautions

None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	Tan
Odor:	Mild
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	35- 57
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Miscible in hydrocarbons
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.

MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LE SUPERMUL**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LE SUPERMUL
Synonyms: None
Chemical Family: Blend
Application: Emulsifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Diethylene glycol monobutyl ether	112-34-5	1 - 5%	Not applicable	Not applicable
Ethylene glycol monobutyl ether	111-76-2	1 - 5%	20 ppm	50 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview

May cause eye and skin irritation. May cause headache, dizziness, and other central nervous system effects. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin

In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes

In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion

Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration.

Notes to Physician

Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 200**Min:** > 200
Flash Point/Range (C):	> 100**Min:** > 93
Flash Point Method:	PMCC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Use water spray to cool fire exposed surfaces. Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 2, Flammability 1, Reactivity 0
HMIS Ratings: Flammability 1, Reactivity 0, Health 2

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Storage Information Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Respiratory Protection Organic vapor respirator.
In high concentrations, supplied air respirator or a self-contained breathing apparatus.

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Liquid

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	Amber
Odor:	Mild
pH:	2.6
Specific Gravity @ 20 C (Water=1):	0.924
Density @ 20 C (lbs./gallon):	7.7
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	20
Freezing Point/Range (C):	-6.6
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	280-300
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause abdominal pain, vomiting, nausea, and diarrhea. May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Lung disorders. Skin disorders.
Chronic Effects/Carcinogenicity	Prolonged or repeated exposure may cause reproductive system damage. Repeated overexposure may cause liver and kidney effects.

Other Information None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® OIL ABSORBENT**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® OIL ABSORBENT
Synonyms: None
Chemical Family: Mineral
Application: Suspending Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Magnesium silicate	1343-90-4	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	2-6	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Granules
Color:	Gray to tan
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	2.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32-38
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure

Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact

None known.

Eye Contact

May cause eye irritation.

Ingestion

May be harmful if swallowed.

Aggravated Medical Conditions

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	Product contains one or more components not listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **RHEMOD L**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: RHEMOD L
Synonyms: None
Chemical Family: Tall oil fatty acid
Application: Viscosifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fatty acids, C18-unsatd., trimers	68937-90-6	10 - 30%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and skin irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	518
Flash Point/Range (C):	270
Flash Point Method:	COC
Autoignition Temperature (F):	> 425
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 1, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Wash hands after use.
Storage Information	Store in a cool, dry location. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Dark
Odor:	Fatty acid
pH:	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	0.96
Density @ 20 C (lbs./gallon):	8
Bulk Density @ 20 C (lbs/ft3):	57.30
Boiling Point/Range (F):	> 572
Boiling Point/Range (C):	> 300
Freezing Point/Range (F):	< -4
Freezing Point/Range (C):	< 25
Vapor Pressure @ 20 C (mmHg):	< 0.001
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	0
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	1849 @ 25C
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye and skin contact.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause mild eye irritation.
Ingestion	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® RIG WASH**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® RIG WASH
Synonyms: None
Chemical Family: Blend
Application: Surfactant

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Isopropanol	67-63-0	1 - 5%	200 ppm	400 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion If swallowed dilute with 1-2 glasses of milk or water and then induce vomiting.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined**Min:** > 220
Flash Point/Range (C):	Not Determined**Min:** > 104
Flash Point Method:	COC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.
Storage Information	Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear blue
Odor:	Slight Alcohol
pH:	9.5

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	1.025
Density @ 20 C (lbs./gallon):	8.5
Bulk Density @ 20 C (lbs/ft3):	63.6
Boiling Point/Range (F):	> 212
Boiling Point/Range (C):	> 100
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product contains toxic chemical(s) listed below which is(are) subject to the reporting requirements of Section 313 of Title III of SARA and 40 CFR Part 372: Glycol Ethers//34398-01-1 Isopropanol//67-63-0
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **FWCA CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: FWCA CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polysaccharide
Application: Free Water Control Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Cellulose derivative		60 - 100%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	770
Autoignition Temperature (C):	410
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	6.5
Specific Gravity @ 20 C (Water=1):	1.39
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Forms gel
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Aldehydes. Carboxylic acids. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 322 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 322 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Blend
Application: Cement Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Sodium formate	141-53-7	1 - 5%	Not applicable	Not applicable
Cellulose derivative		10 - 30%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Red
Odor:	Odorless

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.28
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	35.2
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Partially soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 344 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 344 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polymer
Application: Fluid Loss Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modified acrylamide copolymer		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water spray, dry chemical, or foam.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 1, Reactivity 0
HMIS Ratings: Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust. Do not swallow. Avoid contact with eyes, skin, or clothing.

Storage Information Store in a cool, dry location. Store away from oxidizers. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Nitrile gloves. Polyvinylchloride gloves. Neoprene gloves. Rubber gloves. Butyl rubber gloves. Cloth gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Powder

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	White to off white
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.37
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	25-35
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	18
Freezing Point/Range (C):	-8
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide. Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Prolonged or repeated contact may cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	No adverse health effects are expected from swallowing.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	BOD(28 Day): 3% of COD
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM48: 2000 mg/l (Arcatia tonsa)
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	EC50: 3300 mg/l (Skeletonema costatum)
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-5**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-5
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Black
Odor:	Molasses
pH:	9.5-10.3
Specific Gravity @ 20 C (Water=1):	1.32

9. PHYSICAL AND CHEMICAL PROPERTIES

Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	29.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1000 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-601**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-601
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.2
Flammability Limits in Air - Upper (%):	Not Determined
Flammability Limits in Air - Upper (oz./ft3):	3.5

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 1, Reactivity 0
HMIS Ratings: Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Woody
pH:	7.8
Specific Gravity @ 20 C (Water=1):	1.08
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	30.5
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **KCL POTASSIUM CHLORIDE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: KCL POTASSIUM CHLORIDE
Synonyms: None
Chemical Family: Inorganic Salt
Application: Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Potassium chloride	7447-40-7	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid breathing vapors.

Storage Information Store in a cool, dry location. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Dust proof goggles.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White to gray
Odor:	Odorless
pH:	9.2
Specific Gravity @ 20 C (Water=1):	1.99
Density @ 20 C (lbs./gallon):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Bulk Density @ 20 C (lbs/ft3):	72.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.55

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause moderate skin irritation.
Eye Contact	May cause severe eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: 100-330 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **POZ STANDARD CEMENT 50/50**

Revision Date: 05-Jan-2009

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: POZ STANDARD CEMENT 50/50
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fly ash	68131-74-8	30 - 60%	Not applicable	Not applicable
Bentonite	1302-78-9	1 - 5%	Not applicable	Not applicable
Portland cement	65997-15-1	30 - 60%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1*, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	Not Determined
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Not Determined
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact May cause severe eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	E Corrosive Material D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CEMENT - CLASS H - PREMIUM**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CEMENT - CLASS H - PREMIUM
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Portland cement	65997-15-1	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	<3	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	3.15
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	94
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Keep away from any contact with water.
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact May cause severe eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	E Corrosive Material D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 25**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 25
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier

Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	168
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

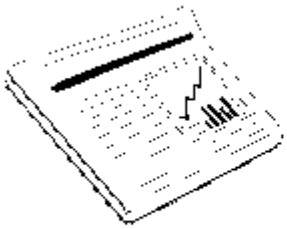
16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

Delaware River Basin Commission



News Release

For Immediate Release

May 6, 2010

DRBC WILL REVIEW NATURAL GAS WELL PAD PROJECTS AFTER ADOPTION OF NEW REGULATIONS

(WEST TRENTON, N.J.) -- The Delaware River Basin Commission (DRBC) at its May 5, 2010 public business meeting directed commission staff to draft regulations for natural gas well pad projects in shale formations in the Delaware River Basin. The commissioners will consider specific natural gas well pad applications after the new regulations are in place.

“The drafting process is already underway, so it made logical sense for the development of new regulations to move forward in advance of any individual project decisions,” DRBC Executive Director Carol R. Collier said in describing the action taken yesterday by the commissioners representing Delaware, New Jersey, New York, Pennsylvania, and the federal government. The rulemaking process will include public notice and a full opportunity for public comment before the commissioners adopt the regulations.

The DRBC has already conducted a public hearing and received over 2,000 written comments regarding a proposal previously submitted by Stone Energy Corporation for the Matoushek #1 well located in Clinton Township, Wayne County, Pa. The commissioners’ decision to rule upon this and other pending and future specific natural gas well pad project applications after the new regulations are adopted is consistent with many of the public comments submitted.

Commission review of pending or future proposed water withdrawals to be used to supply water to natural gas extraction projects, including Stone Energy’s proposed water withdrawal from the West Branch Lackawaxen River in Mount Pleasant Township, Wayne County, Pa., will proceed in accordance with existing DRBC regulations. The written comments that the DRBC received during the comment period that closed on April 12 pertained to both Stone Energy’s proposed water withdrawal project and its proposed natural gas well drilling project. The earliest that the commission could vote on the Stone Energy proposed water withdrawal project would be its next public business meeting scheduled for July 14, 2010.

The DRBC was formed by compact in 1961 through legislation signed into law by President John F. Kennedy and the governors of the four basin states with land draining to the Delaware River. The passage of this compact marked the first time in our nation's history that the federal government and a group of states joined together as equal partners in a river basin planning, development, and regulatory agency.

Additional information about the commission can be found on its web site at www.drbc.net.

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Contact: Clarke Rupert, DRBC, 609-883-9500 ext. 260, clarke.rupert@drbc.state.nj.us

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Hydrologic Info | News Releases | Next DRBC Meeting | Other Meetings | Publications | Basin Facts | Contact Info | Your Comments Welcomed

Commission Member Links: Delaware | New Jersey | Pennsylvania | New York | United States |

DRBC Home Page

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UNITED STATES OF AMERICA

Delaware River Basin Commission
25 State Police Drive
PO Box 7360
West Trenton, New Jersey
08628-0360
Phone: (609) 883-9500 Fax: (609) 883-9522
Web Site: http://www.drbc.net

Carol R. Collier
Executive Director

Robert Tudor
Deputy Executive Director

SUPPLEMENTAL DETERMINATION OF THE EXECUTIVE DIRECTOR CONCERNING NATURAL GAS EXTRACTION ACTIVITIES IN SHALE FORMATIONS WITHIN THE DRAINAGE AREA OF SPECIAL PROTECTION WATERS

This determination supplements the Executive Director's Determination of May 19, 2009 ("2009 Determination") concerning natural gas extraction activities in shale formations within the drainage area of Special Protection Waters (SPW) insofar as that determination addressed "wells intended solely for exploratory purposes."

In my Determination of May 2009, I exercised the authority conferred on the Executive Director by section 2.3.5 B.18 of the Commission's *Rules of Practice and Procedure* (RPP) by directing all sponsors of natural gas extraction projects in shale formations within the drainage area of Special Protection Waters to obtain Commission approval before commencing such projects, notwithstanding that the thresholds for review established by the RPP were not exceeded. This action was based on my recognition that as a result of water withdrawals, wastewater disposal and other activities, natural gas extraction projects in shale formations could individually or cumulatively affect the water quality of Special Protection Waters by altering their physical, biological, chemical or hydrological characteristics.

My 2009 Determination that sponsors of natural gas extraction projects in shale formations must obtain Commission approval expressly did not cover "wells intended solely for exploratory purposes." Today, subject to the reservations set forth below, I am withdrawing that exclusion and extending the provisions of my 2009 Determination to include exploratory wells. That is, by this Supplemental Determination, I am specially directing all natural gas well project sponsors, *including the sponsors of natural gas well projects intended solely for exploratory purposes*, that they may not commence any natural gas well project for the production from or exploration of shale formations within the drainage area of Special Protection Waters without first applying for and obtaining Commission approval. For the purpose of this Determination, any natural gas well drilled in or through shale is assumed to be targeting a shale formation and is subject to this Determination, unless the project sponsor proves otherwise. All other aspects of my 2009 Determination remain in effect.

My action today recognizes the risks to water resources, including ground and surface water that the land disturbance and drilling activities inherent in any shale gas well pose. In light of the Commission's May 5, 2010 decision to finalize natural gas regulations before considering project approvals, this Supplemental Determination removes any regulatory incentive for project sponsors to classify their wells as exploratory wells and install them without Commission review before the Commission's natural gas regulations are in place. It thus supports the Commission's goal that exploratory wells do not serve as a source of degradation of the Commission's Special Protection Waters.

Reservation for Existing State-Approved Projects. Where entities have invested in exploratory well projects in reliance on my May 2009 Determination and information from staff, there are countervailing considerations that favor allowing these projects to move ahead. I am informed that since May of 2009 the Pennsylvania Department of Environmental Protection (PADEP) has issued a limited number of natural gas well drilling permits within the Delaware River Basin targeting shale formations, while the New York State Department of Environmental Conservation has not issued any natural gas well permits targeting shales in the Basin since that date. In contrast to the thousands of wells projected to be installed in the Basin over the next several years, the risk to Basin waters posed by only the wells approved by PADEP since May 2009 are comparatively small. Not only are these wells subject to state regulation as to their construction and operation, but they continue to require Commission approval before they can be fractured or otherwise modified for natural gas production. In light of these existing safeguards and the investment-backed expectations of the sponsors of these projects, this Supplemental Determination does not prohibit any exploratory natural gas well project from proceeding if the applicant has obtained a state natural gas well permit for the project on or before the date of issuance set forth below.

A copy of this Supplemental Determination will be posted on the Commission's website, and additional copies will be mailed directly to those project sponsors and potential project sponsors that the Commission has identified.

Any person adversely affected by this action may request a hearing by submitting a request in writing to the Commission Secretary within thirty (30) days of the date set forth below, in accordance with the RPP.

Carol R. Collier

Carol R. Collier, Executive Director
Dated: June 14, 2010

PADEP-APPROVED NATURAL GAS WELL PROJECTS IN THE DELAWARE BASIN AS OF MID-OCTOBER 2010

	County Name	Municipality Name	Date Disposed	Appl Type Code	Other Id	Marcellus Shale Well	Horizontal Well	Well Type	Site Name	Total Depth	Operator	Status as of 10-12-10	State Code	Zip Code
1	Wayne	Damascus	04/29/2010	NEW	127-20012	N	N	GAS	**HL RUTLEDGE 1 1 OG WELL**	8350	**NEWFIELD APPALACHIA PA LLC**	**PAD CONSTRUCTED**	TX	77060-2424
2	Wayne	Damascus	04/30/2010	NEW	127-20016	N	N	TEST	**VE CRUM 1 1 OG WELL**	8350	**NEWFIELD APPALACHIA PA LLC**	**DRILLED**	TX	77060-2424
3	Wayne	Damascus	05/07/2010	NEW	127-20015	N	N	TEST	**EM SCHWEIGHOFER 1 1 OG WELL**	8350	**NEWFIELD APPALACHIA PA LLC**	**NO ACTION**	TX	77060-2424
4	Wayne	Damascus	05/27/2010	NEW	127-20017	N	N	GAS	**WOODLAND MGMT PARTNERS 1 1 OG WELL**	8350	**NEWFIELD APPALACHIA PA LLC**	**DRILLED**	TX	77060-2424
5	Wayne	Manchester	04/23/2010	NEW	127-20013	N	N	GAS	**DL TEEPLE 1 1 OG WELL**	8350	**NEWFIELD APPALACHIA PA LLC**	**DRILLED**	TX	770602424
6	Wayne	Manchester	05/25/2010	NEW	127-20018	Y	Y	GAS	**DL TEEPLE 1 2H OG WELL**	8140	**NEWFIELD APPALACHIA PA LLC**	**APPLICATION FILED W/ DRBC** (Horizontal Production Well)	TX	77060-2424
7	Wayne	Buckingham	07/22/2009	NEW	127-20011	N	N	GAS	**STOCKPORT ASSN 1**	8850	**PENNSWOOD OIL & GAS LLC** (Mr. Nowicki)	**NO ACTION**	PA	18920-9998
8	Wayne	Preston	07/29/2009	NEW	127-20010	N	N	GAS	**PRESTON 38 LLC OG WELL**	8753	**PENNSWOOD OIL & GAS LLC** (Mr. Nowicki)	**NO ACTION**	PA	18920-9998
9	Wayne	Clinton	03/14/2008	NEW	127-20006	Y	N	GAS	**MATOUSHEK 1 OG WELL**	8351	**STONE ENERGY CORP**	**DRILLED**	LA	70506
10	Wayne	Clinton	04/28/2008	NEW	127-20007	Y	N	GAS	**GEUTHER 1 OG WELL**	8150	**STONE ENERGY CORP**	**NO ACTION**	LA	70506
11	Bucks	Nockamixon	04/13/2010	REN	017-20004	N	N	GAS	**CABOT 2 OG WELL**	9500	**ARBOR OPERATING LLC**	**NO ACTION** (Counsel Withdrawn in EHB and DRBC Proceedings)	MI	49686
12	Wayne	Oregon	02/26/2009	NEW	127-20008	N	N	GAS	**ROBSON 627528 1 OG WELL**	8898	**CHESAPEAKE APPALACHIA LLC**	**DRILLED**	WV	25302
13	Wayne	Preston	03/05/2009	NEW	127-20009	Y	N	GAS	**B & E WELLS 1 OG WELL**	NULL	**SCHRADER KEVIN E**	**NO ACTION**	PA	18437
14	Wayne	Scott	7/13/2010	NEW	127-20020	Y	N	GAS	**DAVIDSON 1V WELL**	6240	**HESS CORP**	**SITE PREP UNDER WAY**	TX	77002
15	Wayne	Scott	7/20/2010	NEW	127-20022	Y	N	GAS	**HAMMOND 1V WELL**	6790	**HESS CORP**	**SITE PREP UNDER WAY**	TX	77002

Source: Except for data contained in the column headed "Status as of 10-12-10" (hereinafter, "Status Data") all data are from the spreadsheet entitled "Permits Issued by County with Location Information (Excel format containing formatting macros)," a link to which is posted on PADEP's web page at http://www.dep.state.pa.us/dep/deputate/minres/oilgas/RIG10.htm. Status Data were furnished by DRBC Project Review Section staff.

Note: Some columns are hidden to fit this spreadsheet on a single 11" x 17" page. Unhide columns by selecting Format Menu, Visibility, Hide & Unhide.

Please see the accompanying page of notes relating to this spreadsheet.

No	Authorization #	Well Name	Applicant	Auth. type	App. Type	Date Received	Status/date	Work Status	County	Watershed	Lat	Lon
1	710932	Matoushek 1V	STONE ENERGY CORP	Drill & Operate Well Permit	New	1/31/2008	Issued 03/14/2008	Drilled TAed	Wayne	DRBC	41.6851	-75.365
2	715410	Geuther 1V	STONE ENERGY CORP	Drill & Operate Well Permit	New	3/6/2008	Issued 04/28/2008	Expired	Wayne	DRBC	41.6844	-75.4356
3	720872	B& E Wells 1V	SCHRADER KEVIN E	Drill & Operate Well Permit	New	4/14/2008	Issued 03/05/2009	Expired	Wayne		Not available	
4	760352	Robson 1V	CHESAPEAKE APPALACHIA LLC	Drill & Operate Well Permit	New	1/13/2009	Issued 02/26/2009	Drilled PAed	Wayne	DRBC	41.6276	-75.2028
5	792478	Preston 38 LLC 1V	PENNSWOOD OIL & GAS LLC	Drill & Operate Well Permit	New	5/15/2009	Issued 07/29/2009	Active (Nowicki)	Wayne	DRBC	41.8031	-75.3902
6	796670	Stockport Assn 1V	PENNSWOOD OIL & GAS LLC	Drill & Operate Well Permit	New	6/15/2009	Issued 07/22/2009	Active (Nowicki)	Wayne	DRBC	41.8905	-75.2983
7	825419	HL Runtledge 1V	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	2/24/2010	Issued 04/29/2010	Active	Wayne	DRBC	41.7287	-75.1919
8	826657	Dl Teeple 1V	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	3/8/2010	Issued 04/23/2010	Drilling	Wayne	DRBC	41.8275	-75.1978
9	827012	B&E Wells 1V	SCHRADER KEVIN E	Drill & Operate Well Permit	New	3/10/2010	Issued 06/10/2010	Active (Schrader)	Wayne	DRBC	41.8458	-75.3376
10	827239	V E Crum 1V	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	3/12/2010	Issued 04/30/2010	Active	Wayne	DRBC	41.6769	-75.0821
11	827248	EM Schweighofer 1V	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	3/12/2010	Issued 05/07/2010	Active	Wayne	DRBC	41.7541	-75.1821
12	830957	Woodlands Management Ptrs 1V	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	4/12/2010	Issued 05/27/2010	Building Location	Wayne	DRBC	41.7656	-75.1086
13	830993	DL Teeple 1 2H	NEWFIELD APPALACHIA PA LLC	Drill & Operate Well Permit	New	4/13/2010	Issued 05/25/2010	Active	Wayne	DRBC	41.8228	-75.1935
14	827896	Cabot 2V	Arbor Operating LLC	Drill and Operate	New	3/11/2010	Issued 4/13/2010	Active	Bucks	DRBC		
15	836496	Davidson 1V	HESS CORP	Drill & Operate Well Permit	New	5/26/2010	Pending		Wayne	DRBC		
16	838228	Hammond 1V	HESS CORP	Drill & Operate Well Permit	New	6/4/2010	Pending		Wayne	DRBC		
17	832454	Davidson 1V	HESS CORP	Expedited ESCGP-1	New	4/26/2010	Issued 05/13/2010	Active	Wayne	DRBC		
18	833665	Hammond 1V	HESS CORP	Expedited ESCGP-1	New	5/7/2010	Issued 05/20/2010	Active	Wayne	DRBC		
19	837378	Funke 1V	HESS CORP	Expedited ESCGP-1	New	6/7/2010	Issued 06/28/2010	Active	Wayne	DRBC		
20	839543	Baker 1V	HESS CORP	Expedited ESCGP-1	New	6/28/2010	Pending		Wayne	DRBC		

Didn't pass Hess due diligence
Newfield
Hess PADEP Erosion and Sediment Control General Permits in DRBC (3 approved, 1 pending)
Hess PADEP Drilling Permit Applications (2 pending)

NOTE: The search goes back to Jan 2006

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

Delaware River Basin Commission
25 State Police Drive
PO Box 7360
West Trenton, New Jersey
08628-0360
Phone: (609) 883-9500 Fax: (609) 883-9522
Web Site: http://www.drbc.net

Carol R. Collier
Executive Director

Robert Tudor
Deputy Executive Director

AMENDMENT TO SUPPLEMENTAL DETERMINATION OF THE EXECUTIVE DIRECTOR CONCERNING NATURAL GAS EXTRACTION ACTIVITIES IN SHALE FORMATIONS WITHIN THE DRAINAGE AREA OF SPECIAL PROTECTION WATERS

On June 14, 2010 I extended to all natural gas exploratory wells, with the exception of those for which the Pennsylvania Department of Environmental Protection (PADEP) had already granted well drilling permits, my determination that the sponsors of natural gas extraction projects in shale formations within the drainage area of Special Protection Waters must obtain the Commission's approval before commencing such projects.

Following this decision, I received a request from the Hess Corporation that it be allowed to proceed with the initial phase of an exploratory drilling program planned for its lease holdings in Wayne County, Pennsylvania. Specifically, Hess requested permission to construct two vertical exploratory wells for which it had obtained Pennsylvania Erosion and Sediment Control General Permits (ESCGP-1's) prior to June 14th and for which as of that date well drilling permit applications had been filed with PADEP and were under active review. A state drilling permit for the Davidson 1V well has since been issued – PADEP Permit No. 127-20020 dated July 13, 2010 – and a PADEP permit for the Hammond 1V well is expected to be approved in July.

Hess cited as a basis for its request that by mid-June the Davidson 1V and Hammond 1V wells were in the final stages of the permitting process and represented a level of investment equivalent to that of the natural gas exploratory wells that were "grandfathered" by my decision of June 14th. Hess also urged that the scientific information to be derived from the two wells was critical to the company and to many hundreds of property owners with whom it has signed leases. Hess and its investment partner Newfield Appalachia LLC ("Newfield") have combined lease holdings of more than 100,000 acres in the Delaware Basin. Although Newfield is proceeding with an exploratory program that includes five wells in east, southeast Wayne County, no other exploratory wells have been approved in the north, northwest portion of the county, where Hess's leases are concentrated. The timing of the exploratory program is important to both entities and their lessors. Hess representatives have advised me that if the company is able to proceed with the Davidson 1V and Hammond 1V wells this summer, the two wells are expected to meet its program needs through the end of the year. Further, Hess has assured me that it supports the Commission's initiative to establish robust and responsible regulations governing natural gas development in the Delaware Basin in that timeframe.

I am convinced that the scientific information that may be derived from the two proposed exploratory wells is important in the near term, while the risk from allowing two additional exploratory wells to proceed is subject to the same balancing that I discussed in my Supplemental Determination of June 14th. Only two exploratory wells are at issue; both are

subject to PADEP well drilling permits; and in light of the erosion and sediment control permits issued before June 14th, both are included in Hess's investment-backed expectations. Hess's ESCGP-1 applications, which Hess furnished to the DRBC, provide specific information regarding siting of the two proposed wells and set forth in detail the erosion and sediment control measures to be implemented during and after their construction to protect water resources. These measures go beyond the requirements applicable to the other exploratory well projects "grandfathered" by my June 14th Determination, each of which fell below the five-acre threshold at which the requirement for an ESCGP-1 is triggered. In light of the other factors discussed above, Hess's additional sediment and erosion control demonstrations tip the balance in favor of allowing the two exploratory wells to proceed.

Accordingly, I find that allowing the Davidson 1V and Hammond 1V natural gas exploratory wells to be constructed at this time would serve multiple interests and in particular could help indicate the extent of natural gas development activity that is likely to occur in the Basin. By this Amended Supplemental Determination, I am advising the Hess Corporation that it may proceed with construction of the Davidson 1V and Hammond 1V natural gas exploratory wells. This approval is limited to the two well projects as described in Hess's letter to me of July 13, 2010 and supporting documents, including the ESCGP-1 applications and corresponding permits issued by Pennsylvania in May (collectively "letter of July 13th"). Any proposed deviation from the projects as described in Hess's letter of July 13th will invalidate this Amended Determination unless and until Hess demonstrates to my satisfaction that the proposed change does not increase the risk of harm to the basin's water resources. Any proposal to reconfigure either of the two exploratory wells for production must undergo review and approval by the Commission in accordance with my Determinations of May 19, 2009 and June 14, 2010.

Except as modified herein as to the two Hess exploratory wells, my Supplemental Determination of June 14, 2010 remains in full effect.

Any person adversely affected by this action may request a hearing by submitting a request in writing to the Commission Secretary within thirty (30) days of the date set forth below, in accordance with the Commission's *Rules of Practice and Procedure*.

Carol R. Collier

Carol R. Collier, Executive Director
Dated: July 23, 2010

FAX TRANSMISSION

COMMONWEALTH OF PENNSYLVANIA
ENVIRONMENTAL HEARING BOARD
2nd Floor, Rachel Carson State Office Bldg.
Harrisburg, PA 17105-8457
717-787-3483
Fax: 717-783-4738

To: Elizabeth Kanies Brown **Date:** 10-19-10

Fax #: 215-369-1181 **Pages:** 3, including this cover sheet.

From: Kathy

Subject: ~~210~~ 2010-066-K

COMMENTS:

IF THERE ARE ANY PROBLEMS WITH THIS TRANSMISSION PLEASE CALL _____ AT THE ABOVE TELEPHONE NUMBER.

arbor
OPERATING LLC

Department of Environmental Protection
Oil and Gas Management Program
Southwest Regional Office
400 Waterfront Dr.
Pittsburgh PA 15222

VIA CERTIFIED MAIL

Attention Mr. Alan Eichler, Regional Manager

October 14, 2010

RE: Arbor Operating Cabot #2
Permit # 37-017-2004-00

Dear Mr. Eichler,

Please allow this letter to confirm Arbor's intent to immediately withdraw the above mentioned Well Permit from the records of Pennsylvania Department of Environmental Protection.

We would also request a full release and return of our bonding mechanism.

Thank you for your immediate attention to this matter.

If you should have any questions please do not hesitate to contact our office.

ARBOR OPERATING L.L.C.

Dylan Fogelsong

Dylan Fogelsong

cc: Ms. Gail A. Myers Esquire

304 South Union Street, Traverse City, Michigan 49684
Tel 231 941 2237 Fax 231 941 2296

for mike
10-19-10

arbor
operating LLC

(10-066-K 3)

Honorable Judge Michael Krancer,

VIA FAX TO 717.783.4738

Please accept a copy of Arbor Operating's Letter to the Department of Environmental Protection, dated October 14th, 2010, as confirmation of Arbor Operating's desire to withdraw Permit # 37-017-2004-00 for the Cabot #2 well.

May we assume that this withdrawal will eliminate the need to appear on October 22nd? Please provide confirmation to Dylan Fogelsong at the number (s) below.

Thank you for your consideration.

Sincerely,

ARBOR OPERATING L.L.C.

Dylan Fogelsong

Enc.

104 South Union St.
Traverse City MI 49684

T 231.941.2237 F 231.941.2296

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 827239
Watershed Name: N. Bra Calkins Creek	Quality: HQ

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20016-	04/30/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E STE 2020	VE CRUM 1 1	
	Municipality: Damascus / County: Wayne	
HOUSTON, TX 77060-2424	7½ ' Quadrangle Name: Damascus	Map Section #: 5

Phone	Project #	Latitude	Longitude
(281) 847-6031		41-40-37.8900	-75-4-56.7400

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
904 feet	8350 feet	TE	South 11347 feet West 11136 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/30/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig [illegible]
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Site ID	Primary Fac ID: 728804
Client Id: 277879	Subfacility Id

Well Record and Completion Report

ll Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20016-		

Address	Well Farm Name & Well #	Serial #
363 N SAM HOUSTON PKWY E STE 2020,	VE CRUM 1 1	

City	State	Zip Code	County	Municipality
HOUSTON	TX	77060-2424	Wayne	Damascus

Phone	Fax	USGS 7.5 min. quadrangle map
(281) 847-6031		Damascus

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20016--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature	**DEP USE ONLY**
	Reviewed by: Date:
Title: Date:	Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728804
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879	Well API # (Permit / Reg): 37-127-20016-	
Address: 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well #: VE CRUM 1 1	Serial #:
City: HOUSTON	State: TX / Zip Code: 77060-2424	County: Wayne	Municipality: Damascus
Phone: (281) 847-6031	Fax:		

B. Land Application of Tophole Water

Date applied	pH
Volume (bbls)	Spec. cond. (µmhos/cm)

C. Off-site Waste Disposal

Type: ☐ Driling Fluid (803) **Amount:** bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: **Qty:** bbls or tons

Method of disposal or reuse

☐ Disposal Well (04) ☐ Sewage Treatment Plant (10)

☐ Landfill (05) ☐ Brine Treatment Plant (12)

☐ Other (08)

Facility Information

Name | Permit #

Hauler Information

Name

Address

City | State | Zip Code

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees | Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E. ☐ Dusting

☐ Lined pit, complete Section E. ☐ Solidification

☐ Land application, complete Section F. ☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

CRUM WELL PAD
NEWFIELD APPALACHIA PA LLC.

DAMASCUS TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

EROSION & SEDIMENT CONTROL PLAN

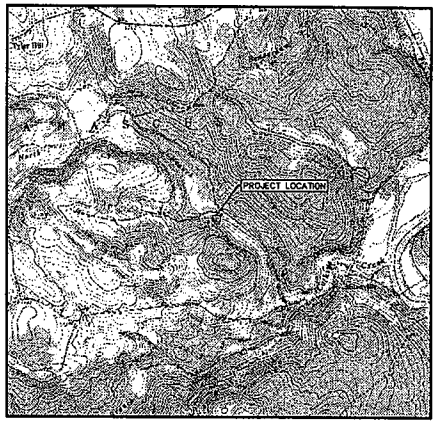
JUNE 2010

DRAWING INDEX	
No.	DRAWING TITLE
C-1	EROSION & SEDIMENT CONTROL PLAN
C-2	EROSION & SEDIMENT CONTROL NOTES
C-3	EROSION & SEDIMENT CONTROL DETAILS
C-4	STAKEOUT & SITE GEOMETRY PLAN
C-5	SITE SECTIONS
C-6	CONSTRUCTION DETAILS & BID QUANTITIES
C-7	CONSTRUCTION SPECIFICATIONS

TETRA TECH

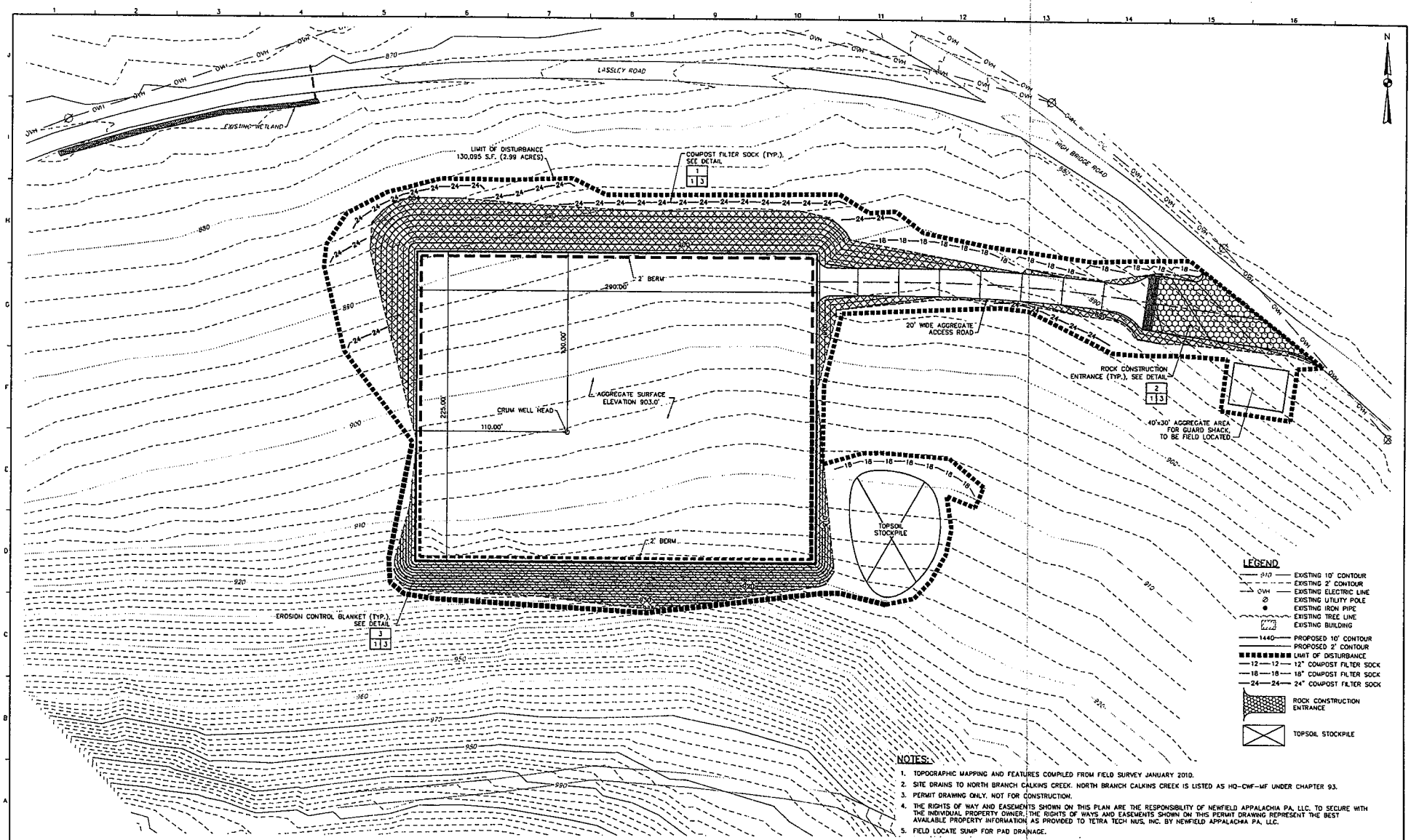
complex world | CLEAR SOLUTIONS™

661 ANDERSEN DRIVE – FOSTER PLAZA VII, PITTSBURGH, PA 15220
TEL: (412) 921-7090 | FAX: (412) 921-4040



LOCATION MAP
DAMASCUS, PA. – USGS 7.5' QUADRANGLE
CRUM WELL PAD
WAYNE COUNTY, PENNSYLVANIA
SCALE: 1" = 2000'

0 2000 4000
SCALE: 1" = 2000'



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO NORTH BRANCH CALKINS CREEK. NORTH BRANCH CALKINS CREEK IS LISTED AS HQ-CWF-MF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.
5. FIELD LOCATE SUMP FOR PAD DRAINAGE.

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 30'

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	1 OF 7

C-1

STANDARD EROSION AND SEDIMENT CONTROL PLAN NOTES

1. STOCKPILE HEIGHTS MUST NOT EXCEED 35 FEET. STOCKPILE SLOPES MUST BE 2:1 OR FLATTER.
2. THE OPERATOR SHALL ASSURE THAT THE APPROVED EROSION AND SEDIMENT CONTROL PLAN IS PROPERLY IMPLEMENTED.
3. UNTIL THE SITE ACHIEVES FINAL STABILIZATION, THE OPERATOR SHALL ASSURE THAT THE BEST MANAGEMENT PRACTICES ARE IMPLEMENTED, INSPECTED, OPERATED, AND MAINTAINED. THE OPERATOR SHALL MAINTAIN AND MAKE AVAILABLE TO DEPARTMENT OF ENVIRONMENTAL PROTECTION, WRITTEN INSPECTION LOGS. ALL MAINTENANCE WORK, INCLUDING CLEANING, REPAIR, REPLACEMENT, REGRADING, AND RESTABILIZATION SHALL BE PERFORMED IMMEDIATELY UPON DISCOVERY OF DEFICIENCY.
4. ALL PUMPING OF SEDIMENT LADEN WATER SHALL BE THROUGH A SEDIMENT CONTROL BMP, SUCH AS A PUMPED WATER FILTER BAG DISCHARGING OVER NON-DISTURBED AREAS.
5. THE CONTRACTOR SHALL REVIEW THE PROVISIONS OF THE APPENDIX 64, EROSION CONTROL RULES AND REGULATIONS, TITLE 25, PART 1, DEPARTMENT OF ENVIRONMENTAL PROTECTION, SUBPART C, PROTECTION OF NATURAL RESOURCES, ARTICLE III, WATER RESOURCES, CHAPTER 102, EROSION CONTROL.
6. A COPY OF THE EROSION AND SEDIMENT CONTROL PLAN MUST BE ON THE PROJECT SITE AT ALL TIMES.
7. EROSION AND SEDIMENT BMPS MUST BE CONSTRUCTED, STABILIZED, AND FUNCTIONAL BEFORE SITE DISTURBANCE BEGINS WITHIN THE TRIBUTARY AREAS OF THOSE BMPS.
8. AFTER FINAL SITE STABILIZATION HAS BEEN ACHIEVED, TEMPORARY EROSION AND SEDIMENT BMPS CONTROLS SHALL BE REMOVED. AREAS DISTURBED DURING REMOVAL OF THE BMPS MUST BE STABILIZED IMMEDIATELY.
9. AN AREA SHALL BE CONSIDERED TO HAVE ACHIEVED FINAL STABILIZATION WHEN IT HAS A MINIMUM UNIFORM 70% PERENNIAL VEGETATIVE COVER OR OTHER PERMANENT NON-VEGETATIVE COVER WITH A DENSITY SUFFICIENT TO RESIST ACCELERATED SURFACE EROSION AND SUBSURFACE CHARACTERISTICS SUFFICIENT TO RESIST SLIDING AND OTHER MOVEMENTS.
10. AT LEAST 3 DAYS BEFORE STARTING ANY EARTH DISTURBANCE ACTIVITIES, ALL CONTRACTORS INVOLVED IN THOSE ACTIVITIES SHALL NOTIFY THE PENNSYLVANIA ONE CALL SYSTEM AT 1-800-242-1776 FOR BURIED UTILITIES LOCATIONS.
11. IN A TIMELY MANNER AFTER EARTH DISTURBANCE ACTIVITIES CEASE, THE OPERATOR SHALL STABILIZE ANY AREAS DISTURBED BY THE ACTIVITIES. DURING NON-GERMINATING PERIODS, MULCH MUST BE APPLIED AT THE SPECIFIED RATES. DISTURBED AREAS WHICH ARE NOT AT FINISHED GRADE AND WHICH WILL BE REDISTURBED WITHIN 1 YEAR MUST BE STABILIZED IN ACCORDANCE WITH THE TEMPORARY VEGETATIVE STABILIZATION SPECIFICATIONS. DISTURBED AREAS WHICH ARE AT FINISHED GRADE OR WHICH WILL NOT BE REDISTURBED WITHIN 1 YEAR MUST BE STABILIZED IN ACCORDANCE WITH THE PERMANENT VEGETATIVE STABILIZATION SPECIFICATIONS.
12. AT STREAM CROSSINGS, 50' BUFFER AREAS SHOULD BE MAINTAINED. ON BUFFERS, CLEARING, SOD DISTURBANCES, EXCAVATION, AND EQUIPMENT TRAFFIC SHOULD BE MINIMIZED. ACTIVITIES SHOULD AS STACKING LOGS, BURNING CLEARED BRUSH, DISCHARGING RAINWATER FROM TRENCHES, WELDING PIPE SECTIONS, REFUELING AND MAINTAINING EQUIPMENT SHOULD BE ACCOMPLISHED OUTSIDE OF BUFFERS.
13. MULCH OR EROSION CONTROL BLANKETS MUST BE INSTALLED ON ALL SLOPES 3:1 AND STEEPER.
14. SEDIMENT REMOVED FROM BMPS SHALL BE DISPOSED OF IN LANDSCAPED AREAS OUTSIDE OF STEEP SLOPES, WETLANDS, FLOODPLAINS OR DRAINAGE SWALES AND IMMEDIATELY STABILIZED, OR PLACED IN TOPSOIL STOCKPILES.
15. THE OPERATOR SHALL REMOVE FROM THE SITE, RECYCLE, OR DISPOSE OF ALL BUILDING MATERIALS AND WASTES IN ACCORDANCE WITH THE DEPARTMENT'S SOLID WASTE MANAGEMENT REGULATIONS AT 25 PA. CODE 260.1 ET SEQ., 271.1 ET SEQ., AND 287.1 ET SEQ. THE CONTRACTOR SHALL NOT ILLEGALLY BURY, DUMP, OR DISCHARGE ANY BUILDING MATERIAL OR WASTES AT THE SITE.

TEMPORARY EROSION AND SEDIMENT CONTROLS INSPECTION AND MAINTENANCE SCHEDULE

BMP	INSPECTION FREQUENCY	MAINTENANCE TO BE PERFORMED
COMPOST FILTER SOCK	WEEKLY AND AFTER RAINFALL EVENTS	MAINTENANCE SHALL BE PERFORMED AS NEEDED . SEDIMENT SHALL BE REMOVED ONCE IT HAS ACCUMULATED TO ONE HALF THE ORIGINAL HEIGHT OF THE BARRIER. COMPOST FILTER SOCK SHALL BE REPLACED WHENEVER IT HAS DETERIORATED TO SUCH AN EXTENT THAT THE EFFECTIVENESS OF COMPOST FILTER SOCK IS REDUCED. COMPOST FILTER SOCKS SHALL REMAIN IN PLACE UNTIL DISTURBED AREAS HAVE BEEN PERMANENTLY STABILIZED. ALL SEDIMENT ACCUMULATION AT THE COMPOST FILTER SOCK SHALL BE REMOVED AND PROPERLY DISPOSED OF BEFORE THE COMPOST FILTER SOCK IS REMOVED.
ROCK CONSTRUCTION ENTRANCE	DAILY	CONTRACTOR SHALL MAINTAIN/REPLACE MATERIAL AS NEEDED THROUGHOUT CONSTRUCTION TO MAINTAIN MINIMUM THICKNESS DURING USE OF ACCESS ROAD. A STOCKPILE OF ROCK WILL BE MAINTAINED ON SITE FOR THIS PURPOSE
MULCH STABILIZATION PEG AND TWINE	WEEKLY AND AFTER RAINFALL EVENTS	REPLACE MULCH, PEGS AND TWINE AS REQUIRED. RESTORE SEEDING IN AFFECTED AREA IF NECESSARY.

REVEGETATION

A. TEMPORARY GRASS COVER SHALL BE ESTABLISHED IN THE FOLLOWING AREAS:

1. WHERE SOIL STOCKPILES ARE TO BE EXPOSED FOR A PERIOD GREATER THAN THIRTY (30) DAYS, THE STOCKPILE SHALL BE SEEDED.
2. WHERE VEGETATIVE FILTERS MUST BE ESTABLISHED BELOW FILTER BAGS, A MINIMUM DISTANCE OF 10 FT SHALL BE SEEDED DOWNSLOPE OF THE TRAP OUTLET. TEMPORARY COVER – SEED MIXTURE FOR TEMPORARY COVER SHALL CONSIST OF 100% ANNUAL RYEGRASS. SEED SHALL BE APPLIED AT THE RATE OF 40 LB/ACRE OR AS RECOMMENDED BY A LOCAL RECOGNIZED SEED SUPPLIER APPROVED BY THE OWNER'S REPRESENTATIVE. PRIOR TO SEEDING, APPLY 1 TON OF AGRICULTURAL GRADE LIMESTONE PER ACRE PLUS FERTILIZER AT THE RATE OF 15-30-30 LB. PER ACRE AND WORK INTO SOIL.

B. PERMANENT COVER:

RECOMMENDED PERMANENT SEED MIXTURES COOL AND WARM SEASON GRASS

MIXTURE NUMBER	SEASON	SEASON [SEEDING RATE LB/AC.]
1	COOL	TALL FESCUE*[79], OR FINE FESCUE[46], PLUS REDTOP[4], OR PERENNIAL RYEGRASS[19], PLUS BIRDSFOOT TREFOIL[8]
2	COOL	BIRDSFOOT TREFOIL[8], PLUS TALL FESCUE*[40]
3	COOL	ORCHARDGRASS[26], OR SMOOTH BROMEGRASS[33], PLUS BIRDSFOOT TREFOIL[8]
4	WARM	FLATPEA[27], PLUS TALL FESCUE*[26], OR PERENNIAL RYEGRASS[25]
5	WARM	DEERTOUNGE[21], PLUS BIRDSFOOT TREFOIL[8]
6	WARM	SWITCHGRASS[15], OR BIG BLUESTEM[15], PLUS BIRDSFOOT TREFOIL[8]

RECOMMENDED PERMANENT SEED MIXTURES FOR STABILIZING DISTURBED AREAS

SITE CONDITION	SEED MIXTURE
CUT SLOPES & FILLS (NOT MOWED)	
WELL-DRAINED	2, 4 OR 6
VARIABLE DRAINAGE	2
CUT SLOPES & FILLS (MOWED)	1
CUT SLOPES & FILLS (GRAZED/HAY)	1, 2 OR 3
GULLIES & ERODABLE AREAS	2 OR 6
EROSION CONTROL BMP'S	
CHANNELS, DRAINAGE DITCHES, TRAP EMBANKMENTS, ETC	1 OR 2
FOR HAY OR SILAGE	2 OR 3
RIGHT-OF-WAY	
WELL-DRAINED	4 OR 6
VARIABLE DRAINAGE	2
WELL-DRAINED AREAS FOR GRAZING/HAY	2 OR 3
STRIP MINED AREAS	
SPOILS, WASTE AREAS, FLY ASH, SLAG, ETC. (LIME TO SOIL TEST)	2, 4 OR 5
FOR GRAZING/HAY	2, 3 OR 6

CONSTRUCTION SEQUENCE

REFER TO THE E&SC PLAN DRAWINGS FOR THE LOCATION OF THE PROPOSED WORK AND THE ASSOCIATED BMPS. A GENERALIZED CONSTRUCTION SEQUENCE IS PROVIDED BELOW. THE CONSTRUCTION SEQUENCE IS INTENDED TO PROVIDE A GENERAL COURSE OF ACTION IN ORDER TO CONFORM TO THE APPLICABLE REGULATORY AGENCY REQUIREMENTS FOR TEMPORARY AND PERMANENT SOIL EROSION AND SEDIMENTATION CONTROL. ALL NECESSARY PARTS FOR PROPER AND COMPLETE EXECUTION OF WORK PERTAINING TO THIS PLAN, WHETHER SPECIFICALLY MENTIONED OR NOT, ARE TO BE PERFORMED BY THE CONTRACTOR. IT IS NOT INTENDED THAT THE DRAWINGS AND THIS REPORT SHOW EVERY DETAILED PIECE OF MATERIAL OR EQUIPMENT. THE CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS LISTED IN THIS SECTION. THE CONTRACTOR MAY BE REQUIRED TO ALTER CONTROLS BASED ON EFFECTIVENESS OF CONTROLS OR DIFFERING CONDITIONS ENCOUNTERED IN THE FIELD.

1. LOCATE STAGING AREAS AND ACCESS POINTS INCLUDING CONSTRUCTION ENTRANCES. INSTALL SEDIMENT BARRIERS DOWN SLOPE OF THESE AREAS.
2. INSTALL ROCK CONSTRUCTION ENTRANCE. REFER TO THE ROCK CONSTRUCTION ENTRANCE DETAIL ON DRAWINGS FOR DIMENSIONS.
3. INSTALL SEDIMENT BARRIERS ALONG THE PERIMETERS OF THE SITE AS SHOWN ON THE CONSTRUCTION DRAWINGS.
4. INSTALL EROSION CONTROL SEDIMENT BASINS, EROSION CONTROL BLANKET, TEMPORARY SLOPE PIPES, CHANNELS AND ROCK APRONS AS SHOWN ON THE EROSION CONTROL PLAN DRAWINGS.
5. CLEAR AND GRUB THE SITE.
6. STRIP AND STOCKPILE TOPSOIL. CONSTRUCT STOCKPILES AS SHOWN IN THE DETAILS ON THE CONSTRUCTION DRAWINGS.
7. MINIMIZE TOTAL AREA OF DISTURBANCE. MAINTAIN ALL TEMPORARY SOIL STOCKPILES WITHIN EXISTING SOIL EROSION AND SEDIMENT CONTROLS.
8. GRADE SURFACE TO FINISHED GRADE ELEVATIONS AS SOON AS PRACTICABLE.
9. INSTALL EROSION CONTROL BLANKET ON ALL SLOPES GREATER THAN 3:1 AS SHOWN ON THE CONSTRUCTION DRAWINGS.
10. IMMEDIATELY SEED AND MULCH DISTURBED AREAS OR PREPARE FOR AGGREGATE STABILIZATION.
11. MAINTAIN ALL EROSION AND SEDIMENTATION CONTROL DEVICES UNTIL SITE WORK IS COMPLETE AND A UNIFORM 70% PERENNIAL VEGETATIVE COVER AND AGGREGATE STABILIZATION IS ESTABLISHED.
12. REMOVE ALL SOIL AND EROSION SEDIMENT CONTROL MEASURES UPON ESTABLISHMENT OF A UNIFORM 70% VEGETATIVE COVER AND AGGREGATE STABILIZATION OVER THE DISTURBED AREA. RE-GRADE AND REVEGETATE AREAS DISTURBED DURING THE REMOVAL OF THE SOIL EROSION AND SEDIMENT CONTROLS. REMOVE ALL SOIL AND EROSION SEDIMENT CONTROL MEASURES UPON ESTABLISHMENT OF A UNIFORM 70% VEGETATIVE COVER AND AGGREGATE STABILIZATION OVER THE DISTURBED AREA. RE-GRADE AND REVEGETATE AREAS DISTURBED DURING THE REMOVAL OF THE SOIL EROSION AND SEDIMENT CONTROLS.

SITE RESTORATION

AREAS AT FINAL GRADE ARE TO BE SEEDED, MULCHED AND STABILIZED IMMEDIATELY AS SPECIFIED ABOVE. WITHIN NINE MONTHS AFTER COMPLETION OF DRILLING THE WELL, THE OIL AND GAS WELL OWNER OR OPERATOR MUST RESTORE THE LAND SURFACE WITHIN THE AREA DISTURBED IN SITING, DRILLING, COMPLETING AND PRODUCING THE WELL. THIS INCLUDES:

a. REMOVING OR FILLING THE PIT USED TO CONTAIN PRODUCED FLUIDS OR INDUSTRIAL WASTES AND DRILL CUTTINGS. PROCEDURES FOR PROPER WASTE HANDLING AND DISPOSAL SHALL BE IN ACCORDANCE WITH DEP ACCEPTED PRACTICES AND STANDARDS.

b. REMOVING ALL DRILLING SUPPLIES NOT NEEDED FOR PRODUCTION. DRILLING SUPPLIES AND EQUIPMENT NOT NEEDED FOR PRODUCTION MAY BE STORED AT THE WELL SITE IF THE EXPRESS WRITTEN CONSENT OF THE SURFACE LANDOWNER IS OBTAINED.

c. IMPLEMENT TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES TO MINIMIZE THE POTENTIAL FOR ACCELERATED EROSION AND SEDIMENTATION DUE TO EARTH DISTURBANCES NECESSARY FOR SITE RESTORATION. THESE AREAS ARE TO BE SEEDED AND MULCHED UPON COMPLETION.

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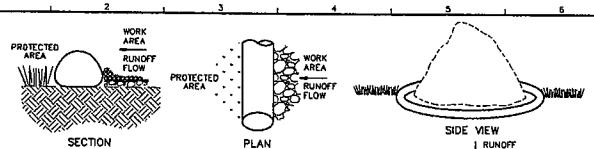
MARK	DATE	DESCRIPTION	BY

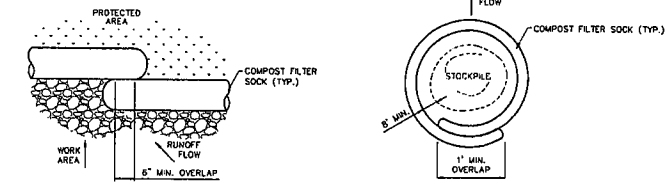
NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

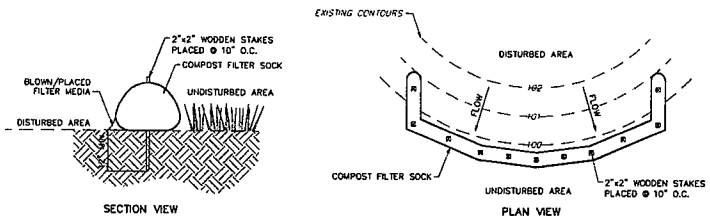
CRUM WELL PAD
EROSION & SEDIMENT CONTROL NOTES
SCALE: NOT TO SCALE

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	2 OF 7

C-2







COMPOST STANDARDS	
ORGANIC MATTER CONTENT	80%-100% (DRY WEIGHT BASIS)
ORGANIC	FIBROUS & ELONGATED
pH	5.5-8.0
MOISTURE CONTENT	35%-55%
PARTICLE SIZE	98% PASS THROUGH 1" SCREEN
SOLUBLE SALT CONCENTRATION	5.0 dS MAXIMUM

MAXIMUM SLOPE LENGTHS FOR COMPOST FILTER SOCK			
% SLOPE	12" DIAMETER	18" DIAMETER	24" DIAMETER
2 (OR LESS)	150	500	1000
5	100	250	550
10	50	150	325
15	35	100	215
20	25	70	175
25	20	55	135
30	15	45	100
35	15	40	85
40	15	35	75
45	10	30	60
50	10	25	50

COMPOST FILTER SOCK SHALL BE PLACED AT EXISTING LEVEL GRADE. BOTH ENDS OF THE SOCK SHALL BE EXTENDED AT LEAST 8 FEET UP SLOPE AT 45 DEGREES TO THE MAIN SOCK ALIGNMENT. MAXIMUM SLOPE LENGTH ABOVE ANY 18" DIAMETER SOCK SHALL NOT EXCEED THAT SHOWN ON ABOVE TABLE FOR REINFORCED SILT FENCE. MAXIMUM SLOPE LENGTH FOR A 24" DIAMETER SOCK SHALL NOT EXCEED THAT FOR SUPER SILT FENCE.

TRAFFIC SHALL NOT BE PERMITTED TO CROSS FILTER SOCKS.

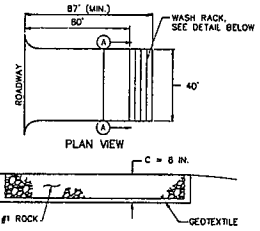
ACCUMULATED SEDIMENT SHALL BE REMOVED WHEN IT REACHES 1/2 THE ABOVE GROUND HEIGHT OF THE SOCK AND DISPOSED IN THE MANNER DESCRIBED ELSEWHERE IN THE PLAN.

SOCKS SHALL BE INSPECTED WEEKLY AND AFTER EACH RUNOFF EVENT. DAMAGED SOCKS SHALL BE REPAIRED ACCORDING TO MANUFACTURER'S SPECIFICATIONS OR REPLACED WITHIN 24 HOURS OF INSPECTION.

BIODEGRADABLE FILTER SOCK SHALL BE REPLACED AFTER 6 MONTHS; PHOTODEGRADABLE SOCKS AFTER 1 YEAR. POLYPROPYLENE SOCKS SHALL BE REPLACED ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

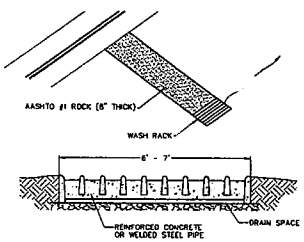
UPON STABILIZATION OF THE AREA TRIBUTARY TO THE SOCK, STAKES SHALL BE REMOVED. THE SOCK MAY BE LEFT IN PLACE AND VEGETATED OR REMOVED. IN THE LATTER CASE, THE MESH SHALL BE CUT OPEN AND THE MULCH SPREAD AS A SOIL SUPPLEMENT.

COMPOST FILTER SOCK
NOT TO SCALE
1 | 1 | 3



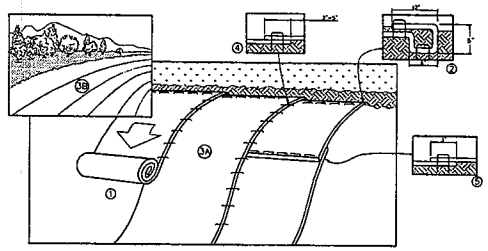
MAINTENANCE: ROCK CONSTRUCTION ENTRANCE THICKNESS SHALL BE CONSTANTLY MAINTAINED TO THE SPECIFIED DIMENSIONS BY ADDING ROCK. A STOCKPILE SHALL BE MAINTAINED ON SITE FOR THIS PURPOSE. AT THE END OF EACH CONSTRUCTION DAY, ALL SEDIMENT DEPOSITED ON PAVED ROADWAYS SHALL BE REMOVED AND RETURNED TO THE CONSTRUCTION SITE.

ROCK CONSTRUCTION ENTRANCE
NOT TO SCALE
2 | 1 | 3



MAINTENANCE:
ROCK CONSTRUCTION ENTRANCE THICKNESS SHALL BE CONSTANTLY MAINTAINED TO THE SPECIFIED DIMENSIONS BY ADDING ROCK. A STOCKPILE OF ROCK MATERIAL SHALL BE MAINTAINED ON SITE FOR THIS PURPOSE. DRAIN SPACE UNDER WASH RACK SHALL BE KEPT OPEN AT ALL TIMES. DAMAGE TO THE WASH RACK SHALL BE REPAIRED PRIOR TO FUTHER USE OF THE RACK. AT THE END OF EACH CONSTRUCTION DAY, ALL SEDIMENT DEPOSITED ON PAVED ROADWAYS SHALL BE REMOVED AND RETURNED TO THE CONSTRUCTION SITE.

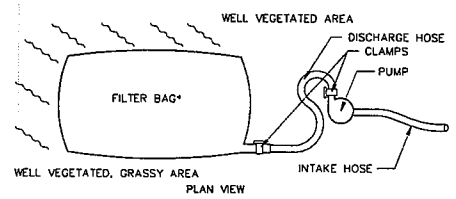
WASH RACK DETAIL
NOT TO SCALE

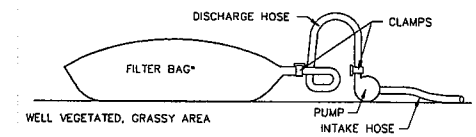


NOTES:

1. PREPARE SOIL BEFORE INSTALLING ROLLED EROSION CONTROL PRODUCTS (RECP's), INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
   NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE RECP's IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF RECP's EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE RECP's WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF RECP's BACK OVER SEED AND COMPACTED SOIL. SECURE RECP's OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE RECP's.
3. ROLL THE RECP's (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. RECP's WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL RECP's MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. THE EDGES OF PARALLEL RECP's MUST BE STAPLED WITH APPROXIMATELY 2" - 5" (5 CM - 12.5 CM) OVERLAP DEPENDING ON RECP's TYPE.
5. CONSECUTIVE RECP's SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE RECP's WIDTH.
   NOTE:
   *IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE RECP's.

EROSION CONTROL BLANKET - SLOPE INSTALLATION
NOT TO SCALE
3 | 1 | 3





NOTES:

1. FILTER SHALL BE MADE OF NON-WOVEN GEOTEXTILE MATERIAL SEWN WITH HIGH STRENGTH, DOUBLE-STITCHED "J" SEAMS. THEY SHALL BE CAPABLE OF TRAPPING PARTICLES LARGER THAN 150 MICRONS.
2. SUITABLE MEANS OF ACCESSING THE BAG WITH MACHINERY REQUIRED FOR DISPOSAL PURPOSES MUST BE PROVIDED. FILTER BAGS SHALL BE REPLACED WHEN THEY BECOME 1/2 FULL. SPARE BAGS SHALL BE KEPT AVAILABLE FOR REPLACEMENT OF THOSE THAT HAVE FAILED OR ARE FULL.
3. BAGS SHALL BE LOCATED IN WELL VEGETATED (GRASSY) AREAS, AND DISCHARGE INTO STABLE, EROSION RESISTANT AREAS. WHERE THIS IS NOT POSSIBLE, A GEOTEXTILE FLOW PATH SHALL BE PROVIDED. BAGS SHALL NOT BE PLACED ON SLOPES GREATER THAN 5%.
4. THE PUMP DISCHARGE HOSE SHALL BE INSERTED INTO THE BAGS IN THE MANNER SPECIFIED BY THE MANUFACTURER AND SECURELY CLAMPED.
5. THE PUMPING RATE SHALL BE NO GREATER THAN 750 GPM OR 1/2 THE MAXIMUM SPECIFIED BY THE MANUFACTURER, WHICHEVER IS LESS. PUMP INTAKES SHOULD BE FLOATING AND SCREENED.

PUMPED WATER FILTER BAG
NOT TO SCALE

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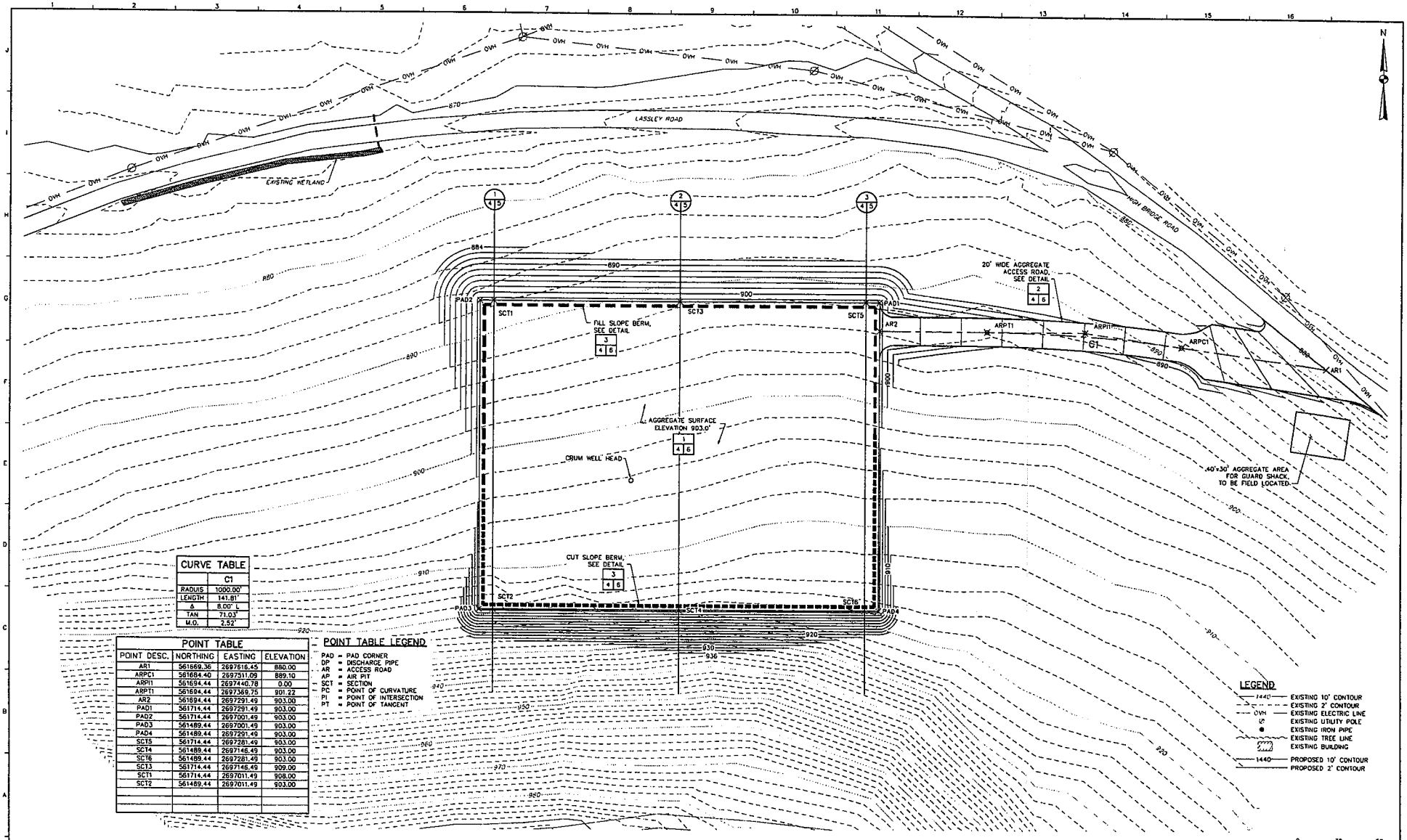
MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
EROSION & SEDIMENT CONTROL DETAILS
SCALE: AS NOTED

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	3 OF 7

C-3



CURVE TABLE	
	C1
RADIUS	1000.00'
LENGTH	141.81'
Δ	8.00°
TAN	71.03'
M.O.	2.52'

POINT TABLE			
POINT DESC.	NORTHING	EASTING	ELEVATION
AR1	561669.36	2697616.45	880.00
ARPC1	561684.40	2697511.09	889.10
ARPI1	561694.44	2697440.78	0.00
ARPT1	561694.44	2697369.75	901.22
AR2	561694.44	2697291.49	903.00
PAD1	561714.44	2697291.49	903.00
PAD2	561714.44	2697001.49	903.00
PAD3	561489.44	2697001.49	903.00
PAD4	561489.44	2697291.49	903.00
SCT5	561714.44	2697281.49	903.00
SCT4	561489.44	2697146.49	903.00
SCT6	561489.44	2697281.49	903.00
SCT3	561714.44	2697146.49	909.00
SCT1	561714.44	2697011.49	908.00
SCT2	561489.44	2697011.49	903.00

POINT TABLE LEGEND

- PAD = PAD CORNER
- DP = DISCHARGE PIPE
- AR = ACCESS ROAD
- AP = AIR PIT
- SCT = SECTION
- PC = POINT OF CURVATURE
- PI = POINT OF INTERSECTION
- PT = POINT OF TANGENT

LEGEND

- 1440 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- OVH — EXISTING ELECTRIC LINE
- EXISTING UTILITY POLE
- EXISTING IRON PIPE
- EXISTING TREE LINE
- EXISTING BUILDING
- 1440 — PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR

SCALE: 1" = 30'

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MARK	DATE	DESCRIPTION	BY

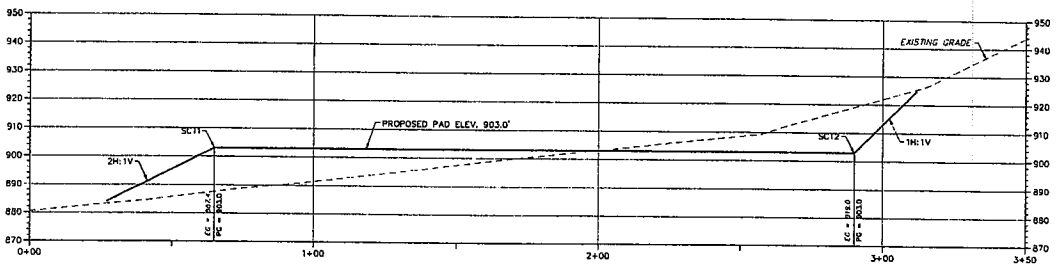
NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
STAKEOUT & SITE GEOMETRY PLAN

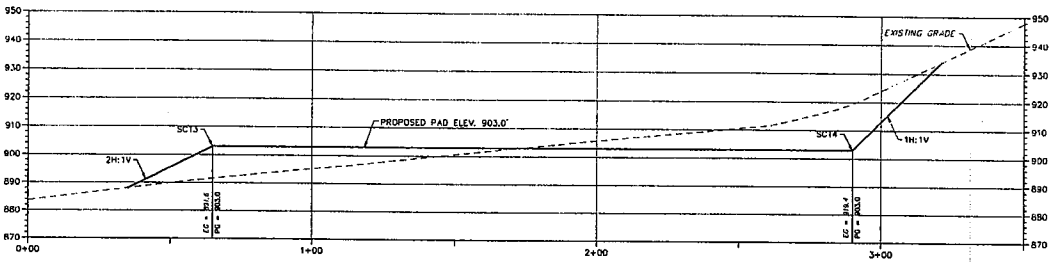
SCALE: 1" = 30'

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	4 OF 7

C-4



SECTION (1 / 4|5)
SCALE: HORIZ: 1" = 20'
VERT: 1" = 20'



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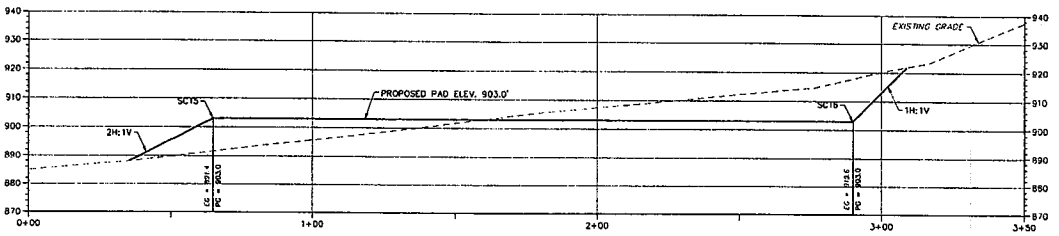
VERT: 1" = 20'



SECTION (3 / 4|5)
SCALE: HORIZ: 1" = 20'
VERT: 1" = 20'

0 20 40
SCALE: 1" = 20'

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MARK	DATE	DESCRIPTION	BY

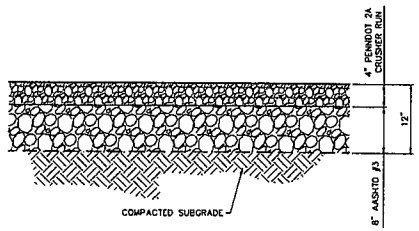
NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
SITE SECTIONS

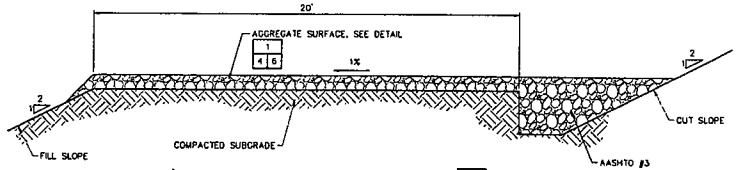
SCALE: 1" = 20'

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	5 OF 7

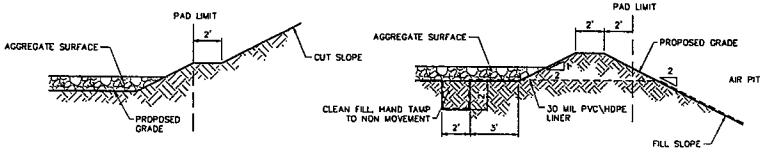
C-5



AGGREGATE SURFACE FOR WELL PAD & ACCESS ROAD [1 / 4 6]
NOT TO SCALE



20' WIDE AGGREGATE ACCESS ROAD DETAIL [2 / 4 6]
NOT TO SCALE



CUT SLOPE INSTALLATION

FILL SLOPE INSTALLATION

BERM DETAIL [3 / 4 6]
NOT TO SCALE

PROJECT BID QUANTITIES

ITEM	DESCRIPTION	UNITS	QUANTITY
1	MOBILIZATION/DE-MOBILIZATION	LUMP SUM	1
2	CLEARING & GRUBBING	ACRE	2.99
3	STRIP & STOCKPILE TOPSOIL	CUBIC YARD	2,450
4	COMPOST FILTER SOCK - 12" DIAMETER	LINEAR FOOT	0
5	COMPOST FILTER SOCK - 18" DIAMETER	LINEAR FOOT	360
6	COMPOST FILTER SOCK - 24" DIAMETER	LINEAR FOOT	580
7	AGGREGATE FOR WELL PAD, ACCESS ROAD & 30'x40' GUARD SHACK AREA	CUBIC YARD	2,800
8	ROCK CONSTRUCTION ENTRANCE	EACH	1
9	EARTHWORK (INCLUDES ACCESS ROAD, WELL PAD & DIVERSION DITCHES)	CUBIC YARD	10,700
10	ROCK CUT	CUBIC YARD	N/A
11	TEMPORARY SEED, SUPPLEMENTS & MULCH	ACRE	061
12	RIPRAP	CUBIC YARD	N/A
13	EROSION CONTROL BLANKET	SQUARE YARD	3,000
14	TIRE WASH RACK	EACH	1
15	SITE RESTORATION - AGGREGATE REMOVAL, SPREADING TOPSOIL, PERMANENT SEEDING	LUMP SUM	N/A
16	TEMPORARY CHAIN LINK FENCE DURING CONSTRUCTION	LINEAR FOOT	N/A
17	CULVERT PIPE FOR ACCESS ROAD CROSSING	LINEAR FOOT	N/A
18	MAINTENANCE AND REPAIR OF EROSION CONTROL DEVICES	LUMP SUM	1

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MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
CONSTRUCTION DETAILS & BID QUANTITIES

SCALE: AS NOTED

DATE:	6/15/10
PROJECT NO.:	112C02759
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	6 OF 7

C-6

GENERAL

CONSTRUCTION ACTIVITIES WILL BE PERFORMED IN ACCORDANCE WITH PENN DOT PUBLICATION 408 SPECIFICATIONS – LATEST EDITION. THE FOLLOWING CONSTRUCTION OPERATIONS ARE INCLUDED IN THE BID PACKAGE FOR THE SITE AND ARE SUMMARIZED BELOW: SHOULD A CONFLICT BE DISCOVERED, CONTACT THE OWNER FOR A FINAL DECISION. THE OWNER IS DEFINED AS NEWFIELD APPALACHIA PA LLC.

THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS AND OR MANUFACTURERS MATERIAL CATALOG CUTS TO THE OWNER FOR REVIEW.

THE CONTRACT TERMS AND CONDITIONS SHALL BE IN ACCORDANCE WITH THE GENERAL AND SPECIAL PROVISIONS AND THE AGREEMENT AS PROVIDED BY THE OWNER.

TECHNICAL SPECIFICATIONS

1.0 CLEARING AND GRUBBING –

1.1 DESCRIPTION

REMOVAL OF TOPSOIL TO THE LIMITS OF GRADING AND STOCKPILE ON SITE AT A LOCATION DESIGNATED BY THE OWNER.

REMOVAL OF ORGANIC MATERIAL TO THE LIMITS OF GRADING AND DISPOSE OF OFF SITE

REMOVAL OF TRASH OR DEBRIS WITHIN THE GRADING LIMITS

1.2 CONSTRUCTION

INSTALL EROSION AND SEDIMENT CONTROL FEATURES PRIOR TO THE START OF CLEARING AND GRUBBING OPERATIONS

CUT TREES AND SHRUBS AND DISPOSE OF OFFSITE UNLESS DIRECTED BY THE OWNER

BURNING IS NOT PERMITTED

REMOVE STUMPS WITHIN THE GRADING AREA TO A DEPTH AT LEAST 2 FEET BELOW THE SUBGRADE ELEVATION AND OR SLOPE ELEVATIONS

DO NOT DAMAGE TREES OR AREAS BEYOND THE LIMIT OF GRADING. DAMAGES SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR.

2.0 EROSION AND SEDIMENT CONTROLS

2.1 DESCRIPTION

PROVIDE, FURNISH, INSTALL AND MAINTAIN THE EROSION AND SEDIMENT CONTROL DEVICES IN ACCORDANCE WITH THE CONTRACT DRAWINGS AND OR THE APPROVED EROSION AND SEDIMENT CONTROL PLAN

2.2 MATERIAL

COMPOST FILTER SOCKS SHALL BE COMMERCIALLY MADE USING 5 MIL CONTINUOUS HDPE FILAMENT WOVEN INTO A TUBULAR MESH NETTING WITH 3/8 INCH WOVEN OPENINGS. COMPOST FILTER SOCK DIAMETERS ARE 12 INCH, 18 INCH AND 24 INCHES.

COMPOST – SEE SHEET C-3

WOODEN STAKES – 2 INCH BY 2 INCH BY 42 INCH

ROCK CONSTRUCTION ENTRANCE

AASHTO #1 LIMESTONE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION703 – AGGREGATE

GEOTEXTILE – CLASS 4 SEPARATION IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 735

TRUCK WASH RACK

CONCRETE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 704 CEMENT CONCRETE – CLASS C.

WELDED STEEL PIPE – MINIMUM 4 INCH DIAMETER

EROSION BLANKET

100% BIODEGRADABLE EROSION CONTROL BLANKET, MACHINE-PRODUCED MAT OF 100% COCONUT FIBER WITH A FUNCTIONAL LONGEVITY OF UP TO 24 MONTHS.

THE BLANKET SHALL BE OF CONSISTENT THICKNESS WITH THE COCONUT EVENLY DISTRIBUTED OVER THE ENTIRE AREA OF THE MAT. THE BLANKET SHALL BE COVERED ON THE TOP AND BOTTOM SIDES WITH 100% BIODEGRADABLE WOVEN, NATURAL, ORGANIC FIBER NETTING. THE TOP NETTING SHALL CONSIST OF MACHINE DIRECTIONAL STRANDS FORMED FROM TWO INTERTWINED YARNS WITH CROSS DIRECTIONAL STRANDS INTERWOVEN THROUGH THE TWISTED MACHINE STRANDS TO FORM AN APPROXIMATE 0.50 X 1.00 (1.27 X 2.54 CM) MESH. THE BLANKET SHALL BE SEWN TOGETHER ON 1.50 INCH (3.81 CM) CENTERS WITH DEGRADABLE THREAD.

MATERIAL SHALL MEET REQUIREMENTS ESTABLISHED BY THE EROSION CONTROL TECHNOLOGY COUNCIL (ECTC).

MATERIAL CONTENT

MATRIX – 100 PERCENT COCONUT FIBER 0.5 LBS/YD2

NETTINGS – 100 PERCENT BIODEGRADABLE ORGANIC JUTE FIBER 9.3 LB/1000 FT2

THREAD – BIODEGRADABLE

TEMPORARY SEED AND MULCH

SEE SHEET C-2

PENNDOT PUBLICATION 408 SECTION 805 – MULCHING – HAY, STRAW OR WOOD FIBER

RIP RAP

IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 850 – ROCK LINING: R-4

2.3 CONSTRUCTION

INSTALL THE ROCK CONSTRUCTION ENTRANCE AND TIRE WASH FACILITY PRIOR TO THE START OF EARTHWORK OPERATIONS. MAINTAIN THE ROCK THICKNESS BY ADDING ROCK FROM AN ADJACENT STOCKPILE.

REMOVE SEDIMENT DEPOSITS ON A DAILY BASIS FROM THE ROCK ENTRANCE AND PUBLIC STREETS AND RETURN THE SEDIMENT TO THE CONSTRUCTION SITE.

INSTALL FILTER SOCKS AT THE LOCATIONS SHOWN ON THE CONTRACT DRAWINGS IN ACCORDANCE WITH THE DIAMETER SPECIFIED.

INSTALL 2 INCH BY 2 INCH WOODEN STAKE AT TEN FEET ON CENTER THROUGH THE FILTER SOCK.

INSTALL EROSION BLANKET UPON COMPLETION OF EARTH DISTURBANCE AND EMBANKMENT CONSTRUCTION. APPLY TEMPORARY SEED AND MULCH.

MAINTENANCE AND REPAIR:

INSPECT AND REPAIR DAMAGED OR DISLODGED EROSION AND SEDIMENT CONTROL DEVICES. INSPECT THE CONTROL DEVICES AFTER EACH RAIN EVENT AND OR AT A MINIMUM OF WEEKLY. IMMEDIATELY REPAIR, RE-STAKE, EXTEND OR REPLACE DAMAGED CONTROL DEVICES.

REMOVE SEDIMENT BUILD UP OR DEBRIS WHEN THE BUILD UP REACHES ONE HALF THE HEIGHT OF THE CONTROL DEVICE. DISPOSE OF THE SOIL MATERIAL ON SITE. DISPOSE OF TRASH AND DEBRIS OFF SITE.

INSTALL ROCK LINING AT THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

3.0 DEMOLITION

3.1 DESCRIPTION

REMOVAL OF BUILDINGS, WALLS, STRUCTURES AS INDICATED ON THE CONTRACT DRAWINGS.

3.2 CONSTRUCTION

REMOVE AND DISPOSE OF OFF SITE BUILDINGS, WALLS, STRUCTURES AS INDICATED.

ONSITE DISPOSAL IS NOT PERMITTED.

4.0 EARTHWORK – EXCAVATION AND EMBANKMENT

4.1 DESCRIPTION

EXCAVATE SOIL AND ROCK TO THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

CONSTRUCT EMBANKMENTS TO THE LINES AND GRADES INDICATED ON THE CONTRACT DRAWINGS.

4.2 CONSTRUCTION

EXCAVATE SOIL AND ROCK BY MECHANICAL MEANS.

BLASTING IS NOT PERMITTED.

PREPARED THE EMBANKMENT FOUNDATION AREA IN ACCORDANCE WITH SECTION 1.0 CLEARING AND GRUBBING.

PLACE SOIL MATERIAL IN NOT MORE THAN EIGHT INCH LOOSE LIFTS FOR THE FULL WIDTH AND COMPACT TO NOT LESS THAN 95% OF ASTM D698 STANDARD PROCTOR. THE CONTRACTOR SHALL SAMPLE, TEST AND SUBMIT THE RESULTS TO THE OWNER PRIOR TO THE START OF EMBANKMENT OPERATIONS. MAINTAIN SOIL OPTIMUM MOISTURE WITHIN PLUS OR MINUS TWO PERCENTAGE POINTS.

DO NOT PLACE SOIL MATERIAL THAT IS FROZEN, WET OR CONTAINING OBJECTIONABLE MATERIAL.

PLACE ROCK MATERIAL IN UNIFORM LAYERS. MAXIMUM ROCK SIZE PERMITTED IN THE EMBANKMENT IS EIGHT INCHES IN ANY DIMENSION.

PREPARE THE PAD SUBGRADE AND ACCESS ROAD SUBGRADE BY COMPACTING THE TOP TWO FEET OF THE EMBANKMENT OR CUT SURFACE TO 100% OF ASTM D698 STANDARD PROCTOR.

SHOULD NON RIPABLE ROCK BE ENCOUNTERED, IMMEDIATELY CONTACT THE OWNER FOR DIRECTION ON EXCAVATION.

6.0 CULVERT PIPE

6.1.1 DESCRIPTION

FURNISH, PROVIDE AND INSTALL DUCTILE IRON OR WELDED STEEL CULVERT PIPE AT ROAD CROSSINGS AT THE DIAMETER, LINE AND GRADE INDICATED ON THE CONTRACT DRAWINGS.

6.1.2 MATERIAL

WELDED STEEL CULVERT PIPE IN ACCORDANCE WITH A53, TYPE S.

DUCTILE IRON PIPE IN ACCORDANCE WITH ASTM A716

6.1.3 CONSTRUCTION

INSTALL AND MAINTAIN CULVERT PIPE DURING CONSTRUCTION. KEEP THE PIPE CLEAR OF DEBRIS AND SEDIMENT BUILDUP.

7.0 WELL PAD AND ACCESS ROAD

7.1 DESCRIPTION

PROVIDE, FURNISH AND INSTALL AGGREGATE FOR THE WELL PAD SURFACE AND THE ACCESS ROAD SURFACE.

7.2 MATERIAL

AGGREGATE IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 703 AGGREGATE

SIX INCHES OF AASHTO # 3

SIX INCHES OF PENNDOT # 57

PERFORATED CORRUGATED POLYETHYLENE CULVERT UNDERDRAIN PIPE

FOUR INCH DIAMETER IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 601 – PIPE CULVERTS

7.3 CONSTRUCTION

COMPACT AND SHAPE SUBGRADE TO THE LINES AND GRADES ON THE CONTRACT DRAWINGS.

COMPACT THE SUBGRADE TO 100% OF ASTM D698 STANDARD PROCTOR. REMOVE AND REPLACE ANY SUBGRADE THAT IS SOFT OR DISPLAYS VISUAL MOVEMENT WITH CLEAN FILL.

INSTALL THE AGGREGATE IN TWO LIFTS. COMPACT LIFTS TO NON-MOVEMENT.

INSTALL THE CORRUGATED CULVERT PIPE TO THE LINE AND GRADE SHOWN ON THE CONTRACT DRAWINGS.

8.0 SITE RESTORATION

8.1 DESCRIPTION

UPON COMPLETION OF THE WELL DRILLING AND AT THE NOTIFICATION BY THE OWNER, RETURN TO THE SITE AND REMOVE AND DISPOSE OF LOOSE AGGREGATE. COVER THE SITE WITH TOPSOIL FROM THE CURRENT STOCKPILE AND APPLY PERMANENT SEED, SUPPLEMENTS AND MULCH.

8.2 MATERIAL

TOPSOIL FROM THE EXISTING STOCKPILE

PERMANENT SEED AND SOIL SUPPLEMENTS SEE SHEET C-2

MULCH IN ACCORDANCE WITH PENNDOT PUBLICATION 408 SECTION 805 – MULCHING – HAY, STRAW OR WOOD FIBER

8.3 CONSTRUCTION

REMOVE AND DISPOSE OF OFF SITE LOOSE AGGREGATE FROM THE WELL PAD.

SPREAD TOPSOIL EVENLY ACROSS THE WELL PAD AND APPLY PERMANENT SEED, SOIL SUPPLEMENTS AND MULCH

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MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
CONSTRUCTION SPECIFICATIONS

SCALE: AS NOTED

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	7 OF 7

C-7

DAMASCUS TOWNSHIP

WAYNE COUNTY, PENNSYLVANIA

NOTICE OF ACTIVE PERMIT

DRIVEWAY PERMIT

PERMIT NUMBER 3402

ISSUED TO **VERNON D. & ELEANOR B. CRUM**

ISSUED: **05/10/10**

FOR: **ACCESS DRIVEWAY**

PIPE: **YES** DIAM: **18 INCHES**

PIPE OFFSET FROM ROAD CENTERLINE (FT): **20+-**

LOCATION: **NO #** **HIGH BRIDGE ROAD**

CONSTRUCTION MUST BEGIN WITHIN 12 MONTHS OF DATE OF ISSUE.

THIS NOTICE MUST BE POSTED AT THE PROJECT LOCATION WHERE IT IS VISIBLE TO THE PUBLIC.

ZONING OFFICER

DAMASCUS TOWNSHIP ROAD OCCUPANCY PERMIT

DAMASCUS TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

ISSUED IN ACCORDANCE WITH ATTACHED DOCUMENTS

DATE ISSUED:	**May 10, 2010**				
ISSUED TO:	**VERNON D. & ELEANOR B. CRUM**				
ADDRESS:	**94 LASSLEY ROAD, MILANVILLE, PA 18443**				
LOCATION:	**NO #**	**HIGH BRIDGE ROAD**			**T-636**
PERMIT NO.:	**3402**				
WORK START DATE		**05/10/10**			
WORK MUST BE COMPLETED BEFORE		**05/10/11**			
PERMIT ISSUED FOR USE TYPE:		**ACCESS DRIVEWAY**			
NEAREST INTERSECTING ROAD:		**LASSLEY ROAD**			
DIST. TO NEAREST ROAD:		**250+-**	**FEET**		
DIST. TO NEAREST INTERSECTING DRIVEWAY SAME SIDE				**N/A**	**FEET**
DIST. TO NEAREST INTERSECTING DRIVEWAY OPP SIDE				**50+-**	**FEET**
TOWNSHIP ROAD R.O.W. WIDTH		**33**	**FEET**		
IMPROVED ROADWAY WIDTH		**18**	**FEET**		
APPROX. SIGHT DISTANCE LEFT		**250**	**FEET**		
APPROX. SIGHT DISTANCE RIGHT		**300**	**FEET**		
POSTED SPEED LIMIT:		**N/A**	**MPH**		
PURPOSE OF WORK:		**COMMERCIAL**			
INSTALL CULV. PIPE		**YES**			
MIN. PIPE DIAM		**18**	**INCH**		
MIN. PIPE LENGTH		**60+-**	**FEET**		
OFFSET FROM ROAD CENTER		**20+-**	**FEET MIN.**		
UTILITY OVERHEAD OR UNDERGROUND		**N/A**			
UTILITY PARALLEL OR CROSSING		**N/A**			
UTILITY OFFSET FROM RD CENTER		**N/A**	**FEET**		

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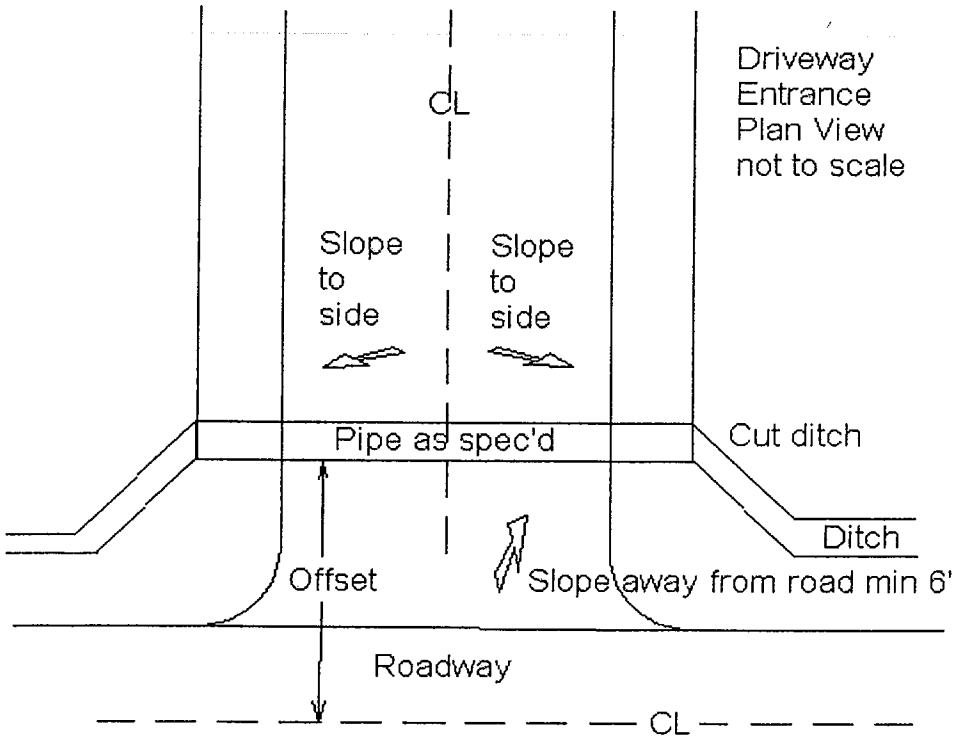
Be prepared to provide exact dig location.

1. **Under and subject to all conditions, restrictions and regulations prescribed by the Township and on the general provisions and specifications, a true copy whereof is attached and made a part hereof, with the same force and effect as if written or printed herein and subject to the special conditions, restrictions and regulations hereinafter set forth.**
2. **Property owner is responsible for clearing of brush, trees and other obstructions to enable and maintain adequate sight distance at all times.**
3. **Property owner is responsible for maintaining any drainage facilities installed to prevent water runoff from eroding or flooding the public roadway, or otherwise creating a nuisance or hazard.**
4. **No parking of any vehicles in a public roadway is allowed.**
5. **Notify Township 48 hours in advance of start of construction for inspection.**
6. **No grading or altering of stormwater drainage allowed without consulting Township.**

APPROVED BY: _____ DATE: 5/26/10

IMPORTANT: 1) The terms and conditions of this permit require the permittee to complete this work by the date specified in the permit. Where permittee fails to complete the work by the time specified the permit will become void. 2) If the permittee applies for a time extension before the epiration date of this permit a 30 day extension will be granted in the form of a supplemental permit. 3) If the work is started and not completed by specified date permittee must notify the Township prior to the expiration date of the permit. 4) The fees are applied to inspections of the site and associated filing of documents by the Township and are not refundable.

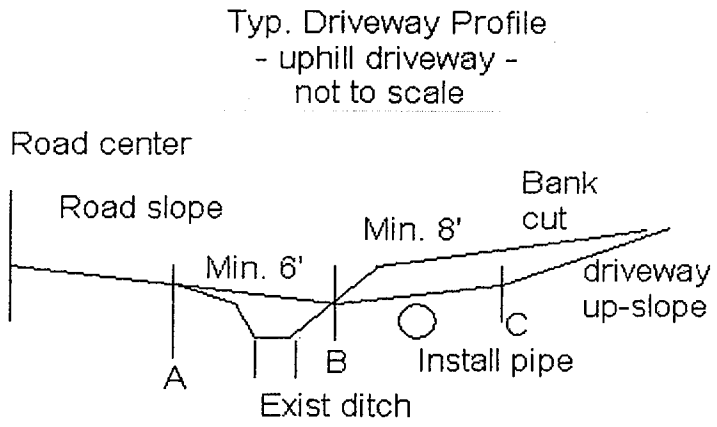
FIGURE 1 - DRIVEWAY ENTRANCE PLAN VIEW



Notes:

1. Driveway must be crowned min 4% from centerline to provide positive drainage.
2. Pipe must be set back (offset) minimum as specified in permit. Further setback to provide adequate cover over the pipe is allowable. 20+- feet from center
3. Minimum recommended pipe cover 12 inches of material.
4. Pipe size must be minimum diameter as specified in permit. 18 inches min.
5. Roadside ditch must be cut to provide flow of stormwater to and from installed pipe.
6. Grade must be downhill from roadway as specified in figure 3 or 4.
7. Runoff from driveway must not reach roadway.
8. No grading or altering of stormwater drainage allowed without consulting Township.

FIGURE 3 - DRIVEWAY PROFILE (TYP) - UPHILL ACCESS



Notes:

1. Driveway must be crowned min 4% from centerline to provide positive drainage.
2. Cut upslope to provide drainage ditch.
3. Driveway ditch must discharge to driveway pipe.
4. Fill downslope side as needed.
5. Runoff must run to sides of driveway surface
6. Runoff must not be allowed to run into township roadway.
7. No grading or altering of stormwater drainage allowed without consulting Township.
8. Minimum recommended pipe cover 12 inches of material.

Driveway Address for the Crum 1-1 Well Site

Address was assigned by GIS and is on file with county Emergency Management office and 911 dispatch.

Crum 1-1
151 High Bridge Rd
Milinville PA 18423

PREPAREDNESS, PREVENTION, AND CONTINGENCY PLAN
WAYNE COUNTY FIELD
WAYNE COUNTY, PENNSYLVANIA

Prepared for:

NEWFIELD APPALACHIA PA LLC
363 N. Sam Houston Pkwy E., Suite 2020
Houston, TX 77060

Prepared by:

TETRA TECH NUS INC
116 N. Washington Avenue
Scranton, PA 18503

May 2010

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 DESCRIPTION OF FACILITY

1.1 DESCRIPTION OF THE INDUSTRIAL OR COMMERCIAL ACTIVITY

Newfield Appalachia PA LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will involve natural gas exploration of the Marcellus Shale formation, which will include site preparation, drilling, and well development and production activities. Wastes generated during these activities will be typical for gas drilling operations and will include drill cuttings, produced water, drilling and frac fluids, waste oil, municipal waste and trash. No hazardous waste is expected to be generated at the Newfield sites.

Newfield is currently in the exploratory phase of operations, which will require construction activities for new natural gas well pads and access roads.

This Prevention, Preparedness and Control (PPC) Plan applies to all well sites in Wayne County, Pa.

The attached map (Figure 1) in Appendix B shows the area covered under this PPC Plan Figure 2 is the required 7.5 topographic map of the specific well site. The proposed Site Plan (Figure 3) shows the site layout, the well site boundaries, material storage areas, waste storage areas, dike drains and drainage that leads away from the well site, and the entrances and exits to the well site.

During the different stages of site preparation, construction, drilling, well development and production, the site will store various fuels, oils and chemicals on-site. A chemical and container inventory for the specific well site is located in Table 1 of Appendix C.

1.2 DESCRIPTION OF EXISTING EMERGENCY RESPONSE PLANS

This is a new facility and this plan has been prepared prior to construction of the well pad. There are no previous emergency response plans.

A separate Spill Prevention Control and Countermeasure (SPCC) Plan will be prepared for each facility meeting the requirements defined in 40 CFR§112.

1.3 MATERIAL AND WASTE INVENTORY

Information in this section is used to evaluate the prevention, containment, mitigation, cleanup, and disposal measures which would be used in the event of a spill, discharge, explosion, or fire. Oils, chemicals and other hazardous materials anticipated to be used and stored at the facility during site preparation and construction, drilling, well development and production are listed in Table 1.

MSDS's will be maintained onsite for chemicals and compounds used at the facility in accordance with the Occupational Safety and Health Administration (OSHA) worker right-to-know requirements, as appropriate.

1.4 POLLUTION INCIDENT HISTORY

Newfield has not had any reportable incidents for this facility.

1.5 IMPLEMENTATION SCHEDULE FOR PLAN ELEMENTS NOT CURRENTLY IN PLACE

All plan elements are in place.

1.6 PURPOSE AND IMPLEMENTATION OF PPC PLAN

Newfield has developed and will implement this PPC Plan for effective action to minimize and abate hazards to human health and the environment from fire, explosion, and emission or discharge of pollutants to air, soil, surface water or groundwater. This plan was prepared to satisfy the requirements set forth in 25 PA Code Section 78.

The Drilling Manager serves as the Primary Emergency Coordinator and is responsible for the preparation and implementation of the PPC Plan. The PPC Plan has been prepared and implemented in general accordance with Pennsylvania Department of Environmental Protection (PADEP) guidelines, and will be submitted to PADEP for approval at such time as the PADEP may prescribe.

This PPC Plan identifies and describes any arrangements with police departments, fire departments, hospitals, contractors, and state, county, and local emergency response teams to coordinate emergency services.

The PPC Plan lists names, addresses and phone numbers of all persons identified to act as Emergency Coordinator. One person is named as the Primary Emergency Coordinator and others are listed in the order in which they will assume responsibility as alternates. The PPC Plan also includes a list of emergency equipment at the facility, the location and a physical description of emergency equipment, and a brief outline of emergency equipment capabilities.

1.7 PLAN REVISIONS

This PPC Plan will be reviewed and amended, annually, or whenever:

- Applicable PADEP regulations are revised;
- The plan fails in an emergency;
- The list of Emergency Coordinators changes;
- The list of emergency equipment changes; and
- Construction, operation, maintenance, or other circumstances change in a manner that materially increases the potential for fires, explosions, or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency.

2.0 IMPLEMENTATION OF PPC PLAN

2.1 ORGANIZATIONAL STRUCTURE OF FACILITY FOR IMPLEMENTATION

The Drilling Manager has been designated as the Primary Emergency Coordinator. The Primary Emergency Coordinator is responsible for the following:

- Coordination of spill cleanup activities;
- Notification of appropriate authorities; and
- Tank and chemical storage area inspections.

The Drilling Manager has administrative responsibility for updating, maintaining, and implementing this PPC Plan. Specifically, these responsibilities include:

- Identification of materials and wastes handled during site operation (inventory);
- Identification of potential spill sources (risk assessment);
- Establishment of spill reporting procedures;
- Coordination of the visual inspection program;
- Review of past incidents, spills, and countermeasures employed;
- Coordination and implementation of the PPC Plan goals;
- Training/educational programs and updates;
- Ensuring periodic review of the PPC Plan for adequacy and appropriateness;
- Administration and institution of appropriate changes at regular intervals;
- Review of new construction and process changes relative to the PPC Plan;
- Evaluation of PPC Plan effectiveness prior to, during and subsequent to its implementation; and
- Instituting improvements to the PPC Plan.

The Production Manager is designated as Secondary Emergency Coordinator, and, in the absence of the Drilling Manager, will assume the role of emergency coordinator for emergencies. The Secondary Emergency Coordinator will report directly to the Primary Emergency Coordinator in matters regarding this plan, and can assist with implementing the above-listed items.

2.2 LIST OF EMERGENCY COORDINATORS

As required by 25 PA Code 265.55, there will be at least one employee, either on the construction site or on call, with the responsibility for coordinating emergency response measures. The Primary and Secondary Emergency Coordinators will be thoroughly familiar with this PPC Plan, site operations and activities, the location and characteristics of materials and wastes, the location of the facility's records, and the layout of the facility. The Emergency Coordinators have the authority to commit the resources necessary to carry out the PPC Plan and for coordinating emergency response measures. In the event of a spill or release, one of the Emergency Coordinators will be immediately notified. The following individuals have been designated to act as Emergency Coordinators:

Primary Emergency Coordinator

Name: Don Sleeth
Title: Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Name: Jack Cochran
Title: Production Manager
Office: 814-437-2344
Cell: 814-671-1557

2.3 DUTIES AND RESPONSIBILITIES OF THE EMERGENCY COORDINATOR

As required by 25 PA Code 265.56 and the PPC Plan Guidance Documents, whenever there is an imminent or actual emergency situation, the Emergency Coordinator or his designee must immediately:

1. Notify all facility personnel.
2. Notify appropriate state or local agencies with designated response roles and contracted emergency response companies if additional assistance is required.
3. Identify the problem. Is it a physical emergency such as a fire, explosion, or spill? Is it a natural disaster such as a flood, tornado, or other severe weather? Is it a social emergency such as a bomb threat, riot, or vandalism?

4. Assess the health or environmental hazards and how this problem or condition will affect employees or its affect on the surrounding community.

5. Take all reasonable measures to stabilize the situation. The Emergency Coordinator will take all reasonable measures to ensure that the fire, explosion, emission, or discharge does not reoccur or spread to other materials at the site. These measures can include, when appropriate, stopping operations, collecting and containing released materials or wastes, and removing or isolating containers.

Whenever there is an emission, discharge, fire, or explosion, the Emergency Coordinator or his designee must immediately attempt to identify the character, exact source, amount, and aerial extent of emitted or discharged materials. He/she may do this by observation, by review of facility records or manifests, and, if necessary, by instrumental and chemical analysis. Concurrently, the Emergency Coordinator or his designee must assess possible hazards to human health or the environment that may result from emission, discharge, fire, or explosion. This assessment must consider both direct and indirect effects of the emission, discharge, fire, or explosion.

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion which would threaten human health or the environment (beyond the limits of the site) and if evacuation of local areas may be advisable, he/she must immediately notify the applicable local authorities (police, fire, etc.); he/she must also immediately notify the PADEP by telephone at (800) 541-2050 (24-hour number), PADEP Northeast Region at (570) 826-2511 (24-hrs), the National Response Center at (800) 424-8802, Wayne County Emergency Management Agency (EMA) at (570) 253-1622, and the Pennsylvania Emergency Management Agency at (717) 651-2001, and report the following information:

- Name of the person reporting the incident;
- Name and location of the facility;
- Telephone number where the person reporting the spill can be reached;
- Date, time, and location of the incident;
- A brief description of the incident, nature of the materials involved, extent of any injuries, and possible hazards to human health or the environment;
- The estimated quantity of the materials spilled; and
- The extent of contamination of land, water, or air, if known.

If spills or discharges of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance in greater than reportable quantities has occurred, the Emergency Coordinator must notify DEP at (800) 541-2050 and the National Response Center at (800) 424-8802 and report the above information. For an offsite release (spill or discharge) of a reportable quantity of a CERCLA hazardous substance or a Superfund Amendments and Reauthorization Act Extremely Hazardous Substance, the Emergency Coordinator must immediately notify the National Response Center at (800) 424-8802 and report the above information.

If a release occurs from a storage tank which enters a water supply or which threatens the water supply of downstream users, the Emergency Coordinator must immediately notify the Wayne County EMA (570) 253-1622, the Pennsylvania Emergency Management Agency at (717) 651-2001, and DEP at (800) 541-2050. If appropriate, the Emergency Coordinator may assist the Emergency Management Agencies in notifying the downstream water users. The priorities for notification will be by closest proximity to the release site.

During an emergency, the Emergency Coordinator will take all reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, recur, or spread to other materials at the facility. These shall include, where applicable, stopping facility operations, collecting and containing released materials, and removing or isolating containers. If the facility stops operations in response to a fire, explosion, emission, or discharge, the Emergency Coordinator must ensure that adequate monitoring is conducted for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment whenever this is appropriate.

The Emergency Coordinator will oversee and direct facility personnel in the performance of their responsibilities for addressing the emergency situation. Immediately following an emergency, the Emergency Coordinator (with PADEP approval) must provide for treating, storing, or disposing residues, contaminated soil, etc., from an emission, discharge, fire, or explosion at the construction site. The Emergency Coordinator must ensure that in the affected areas of the facility, no material incompatible with the emitted or discharged residues is processed, stored, treated, or disposed until cleanup procedures are completed and that all emergency equipment utilized in implementation of the PPC Plan is cleaned and fit for its intended use before operations are resumed. Newfield will notify PADEP and the appropriate State or local

authorities that the facility is in compliance before operations are resumed in the affected areas of the facility. Newfield will note the time, date and details of an incident that requires implementing the PPC Plan.

Within 15 days after the incident, Newfield will submit a written report on the incident to PADEP and the U.S. Environmental Protection Agency regional administrator. The report must be submitted to:

Director - Bureau of Water Quality Management
Pennsylvania Department of Environmental Protection
909 Elmerton Avenue
Harrisburg, PA 17110

Regional Administrator
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Director - PADEP Northeast Office
Pennsylvania Department of Environmental Protection
2 Public Square
Wilkes-Barre, PA 18711

The report should include the following information:

- Name, address, and telephone number of the individual filing the report;
- Name, address, and telephone number of the facility;
- Date, time, type, and location of incident;
- A brief description of the circumstances causing the incident;
- Description and estimated quantity (by weight) of materials or wastes involved;
- The extent of injuries, if any;
- An assessment of actual or potential threat to human health or the environment and assessment of contamination of land, water, or air, where applicable;
- Estimated quantity and disposition of recovered materials or wastes that resulted from the incident; and
- A description of what actions Newfield intends to take to prevent a similar occurrence in the future.

2.4 CHAIN OF COMMAND

Facility personnel must report emergency situations to the Emergency Coordinators. A Chain of Command flow chart (Table 5, Appendix C) has been developed and should be implemented during an emergency. The Emergency Response Chain of Command flow chart will be posted

next to all telephones onsite, posted in areas where potential emergency situations could arise, and placed in onsite company vehicles, as appropriate.

2.5 DISTRIBUTION OF THIS PPC PLAN

A copy of this PPC Plan and subsequent revisions will be distributed to:

- Drilling Manager (Primary Emergency Coordinator)
- Production Manager (Secondary Emergency Coordinator)

The PPC Plan will be reviewed and amended, if necessary, based on the criteria described earlier in Section 1.7.

3.0 SPILL AND LEAK PREVENTION AND RESPONSE

The site will be maintained and operated to minimize the possibility of a fire, explosion or discharge of oils, hazardous materials or their constituents to air, soil, surface water or groundwater which could threaten human health or the environment, in accordance with the requirements of 25 PA Code Section 265.31.

3.1 PRE-RELEASE PLANNING

The following sections discuss specific locations where the potential exists for accidental spills of oils and/or chemicals. The controls that are in place to minimize the potential for an uncontrolled release to the environment are also discussed. In the event that an uncontrolled spill of hazardous substances occurs, the procedures described in Section 4.0 will be followed.

To enhance spill prevention at the facility, great care will be exercised in handling oil and other materials covered in this PPC Plan. Any unusual conditions observed by any employees or contractors will be reported to one of the Emergency Response Coordinators. Management personnel whose responsibilities include involvement with the materials discussed in this document will also be familiar with this plan and the procedures recommended for spill prevention.

Spill Prevention Measures: Procedures that are to be followed to prevent and/or minimize oil spills at the Newfield facility include:

- ASTs and/or containers will be stored in secondary containment with sufficient volume;
- ASTs and regulated material containers will be visually inspected weekly for leaks;
- Special care will be taken when transferring regulated materials to prevent product loss;
- Regulated materials will be stored in a manner that minimizes the potential for contact with stormwater;
- Absorbent and spill control materials shall be maintained on-site for emergency use;

- Emergency response personnel will be familiar with procedures to follow in the case of a spill; and

- In cases where there may be leaking equipment or operations where oil or oil-related compounds are leaked, spilled, or otherwise released, containment booms or absorbent materials shall be used and equipment shall be repaired.

In the event that an uncontrolled spill of oil or a hazardous material occurs, the procedures described in Section 4.0 will be followed. Responses should be coordinated with federal, state and local agencies as appropriate.

3.2 MATERIAL COMPATIBILITY

The majority of materials received on-site in totes, drums, pails or other small containers are stored in the containers supplied by the manufacturer.

Construction materials used for the ASTs have been selected and designed to be compatible with the materials that are being stored and are typical for the natural gas industry.

3.3 INSPECTIONS AND MONITORING PROGRAM

Operating equipment will be inspected daily, and a copy of the inspection and maintenance form is included in Appendix A. Employees are responsible for detecting and reporting potential problems on the inspection and maintenance form.

Storage tank inspections will be conducted weekly and include evaluation of the following: pumps, valves, and fittings for leaks; the tank condition for evidence of corrosion; secondary containment; evidence of spilled materials; and effectiveness of housekeeping practices.

Completed inspection forms and inspection reports will be maintained in the Primary Emergency Coordinator's office. Noncompliance issues identified during the comprehensive site evaluation will be addressed in a timely manner. If additional control measures are required, implementation of the measures will generally occur within 90 days of the site evaluation. Compliance issues that require revisions to the PPC Plan (description of additional pollutant sources, measures, or controls) will be incorporated into the plan within approximately 15 days of the site evaluation.

Stormwater Management System: Stormwater inspections will include an evaluation of best management practices (BMPs), where appropriate. In accordance with the erosion and sedimentation control plan prepared for the site, erosion and sedimentation control (ESC) measures will be implemented where there is the potential for sediment or soil particles to impact stormwater quality. Repairs will be made, as necessary, following the site inspection.

Storage Tanks and Drum Storage Areas: Tanks and drum storage areas will be accessed daily. Spills or leaks that may occur will be contained by secondary containment and noted as part of routine facility operations. To enhance the daily observations, periodic inspections will be performed for the tank and drum storage areas as described in Table 2. The inspections will include observation of spill and/or leaks and observations of the condition of associated secondary containment structures. Records for the inspections will be maintained in the Primary Emergency Coordinator's office.

3.4 PREVENTIVE MAINTENANCE

Newfield will ensure that preventative maintenance of operating machinery on each construction site is performed regularly.

3.5 HOUSEKEEPING PROGRAM

The Newfield Construction Manager will be responsible for general construction site housekeeping. Specific steps taken under this program will include:

- Debris and/or sediment removal, as necessary.
- Regular refuse pickup and disposal.
- Proper filling and emptying of storage containers, tanks, and equipment to minimize spill potential.
- Periodic review of good housekeeping procedures in the employee-training program.

Once completed, the Production Manager will have overall responsibility for housekeeping at the facility. Newfield currently does not anticipate that bulk quantities of hazardous waste materials will be stored at the facility.

3.6 SECURITY

The facility is not fully fenced but is located in a remote location with limited access except via the site access road. The facility is normally manned during drilling and well development.

Flow and drain valves are locked and in the off position when in non-operational or non-standby status. The starter controls for each oil pump are locked in the off position when in non-operating or non-standby status. Master flow/drain valves are all located on the Facility and monitored by staff.

Any loading/unloading connections of facility piping is capped or blind flanged when not in service or is in standby service for an extended amount of time.

The facility has lighting sufficient for detection of spills during nighttime operations. Consideration has been given to: (a) discovery of spills occurring during hours of darkness, both by operating personnel, if present, and by non-operating personnel, and (b) prevention of spills occurring through acts of vandalism.

3.7 EXTERNAL FACTOR PLANNING

External factors are not anticipated to increase the risk of a spill or release that would impact human safety or the environment. Power outages, adverse weather conditions, or employee strikes could result in discontinuation of earth moving, drilling or well preparation activities. The Emergency Coordinator will monitor operations and initiate their orderly shutdown when necessary.

Access road conditions may be impacted by adverse weather conditions, possibly increasing the risk of a release of materials being delivered or removed. Truck drivers should report poor road conditions to the Construction or Drilling Manager. If conditions deteriorate to where they may impact safe movement of materials, the construction or Drilling Manager will review the conditions and initiate repairs or road closure as deemed necessary.

3.8 EMPLOYEE TRAINING PROGRAM

Newfield's employee training program enables employees to understand the processes and materials with which they are working, the safety and health hazards, the practices for preventing spills, and the procedures for responding properly and rapidly to spills. It also familiarizes personnel with emergency procedures.

All Newfield employees receive job specific training. Emergency Coordinators, Well Tenders, and other oil or hazardous material handling employees receive annual training on the facility's PPC and SPCC plans.

Job specific training includes preventive maintenance, inspection and monitoring activities, shut down procedures and housekeeping practices. PPC training will include spill/release recognition, initial response, initial notifications and follow-up. The training program is designed to ensure that personnel are able to respond effectively to emergencies by familiarizing them with emergency procedures, emergency equipment systems including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for automatic cut-off systems; communications and alarms systems; response to fires and explosions; site evacuation procedures; and shutdown of operations.

Annual right-to-know training for all facility employees is conducted relevant to the materials present at the facility. Employees will be given detailed instructions regarding the materials and wastes with which they are working; including safety and health hazards, handling methods, proper disposal procedures, and emergency procedures. The location of MSDS's for on-site materials will be identified to all employees.

Training records will be maintained at the facility and in the employee's personnel file.

4.0 COUNTERMEASURES

4.1 COUNTERMEASURES TO BE UNDERTAKEN BY FACILITY

The following sections present general spill response practices to be implemented at the Newfield facility, as appropriate.

4.1.1 Spill Clean-Up Procedures - General

Incidental spills should be contained and cleaned up when discovered per the employees job related training. Clean up material should be placed into a marked container and the Construction or Drilling Manager notified appropriately.

For large spills or spills of oils or hazardous materials which may reach surface water or impact the environment, the employee who first discovers the spill should contact the Emergency Coordinator. He should then work to contain and clean-up the spill.

Spill clean-up involves three steps: containment, removal, and disposal. In the event of a spill, it is very important that the material be contained to the maximum extent possible in order to minimize the effect of the spill and the cost of clean-up. **NOTE: ANY SHEEN ON A WATERBODY (STREAM, RIVER, OR WETLAND) IS A REPORTABLE RELEASE.** Once the spill is contained, the spilled material and contaminated material must be collected and physically removed from the area

4.1.2 Spill Clean-Up Procedures - Specific

The employee should do the following:

- Contain the spill to the smallest area possible using absorbent materials, earthen dikes or other diversion or containment structures. Stormwater collection structures will be either blocked or pumped.
- Block off the area to prevent traffic or employees from entering the area.
- For oils and other organic materials, apply a non-reactive sorbent material, such as Oil-Dri or Kitty Litter, to the spill.
- In the case of a spill of acids hazardous waste, check the MSDS and then neutralize with lime or soda ash if appropriate.
- If a leaking tank is involved, stop liquid flows as appropriate and dike the tank area with earth or absorbent material.

- If a leaking pail, drum or other small container is involved, place it in an over-pack container.
- Clean up spilled material and place it in a marked container.
- Work with the emergency coordinator to properly store the material and arrange for proper disposal

4.1.3 Fire or Explosion

In the case of a fire or explosion, the local fire department should be notified by calling 911. Employees may attempt to extinguish fires using handheld fire extinguishers based upon their job training.

The Emergency Coordinator will determine if evacuation per section 4.4 is required.

4.2 COUNTERMEASURES TO BE UNDERTAKEN BY CONTRACTORS

The following list shows area emergency response contractors to contact should the facility require outside help.

Company: Minuteman Spill Response, Inc.
Address: P.O. Box 10
Mifflinville, PA 18631
Telephone Number: 570-759-3658
Response Time: Approximately 2 to 3 hrs
Equipment and Services: Hazardous Materials Emergency Response

4.3 INTERNAL AND EXTERNAL COMMUNICATIONS AND ALARM SYSTEM

This section describes the internal communications or alarm used to provide immediate emergency instruction (voice or signal) to installation personnel, and the external communications or alarm system used to summon emergency assistance from local police or fire departments.

Newfield facilities in Wayne County are remote and generally do not have land-line telephone systems or alarm systems. The primary means of communication is via voice or mobile telephones. Mobile phones are provided to the Drilling and Production Managers (Primary and Secondary Emergency Coordinators).

Fire, police, and emergency service can be summoned by calling the 911 or per the numbers listed in Table 3.

4.4 EVACUATION PLAN

In the unlikely event that the site must be evacuated, the Emergency Coordinator will alert personnel to re-group at the pre-designated location for attendance taking. The Emergency Coordinator is responsible to verify that all site workers are accounted for during an evacuation. Periodic drills will be conducted, if deemed necessary, to evaluate the effectiveness of this evacuation plan.

If an emergency situation requires evacuation of personnel, the Emergency Coordinator will implement the following evacuation procedures:

1. The Emergency Coordinator will provide evacuation instructions to facility personnel via the construction site communications network, as appropriate.

2. Personnel evacuation will typically proceed as follows:

   a. If downwind of incident: Evacuate via the most accessible route perpendicular to the prevailing wind direction.
   b. If upwind of incident: Evacuate in an upwind direction.

3. Personnel will reassemble at the public road at the facility entrance as shown on Figure 3 or an alternate assembly point identified by the Emergency Coordinator, that is upwind of the incident location, and remain at this location until the Emergency Coordinator has accounted for all personnel.

4. The names of employees and the destination of employees transported to hospitals, etc. for treatment will be recorded by the Emergency Coordinator, first aid personnel or fire officials.

Once on public roadways, evacuation routes are left up to the individual.

4.5 EMERGENCY EQUIPMENT AVAILABLE FOR RESPONSE

This section provides a list of available emergency equipment, and procedures for maintenance and decontamination of emergency equipment. Newfield's emergency equipment at the facility will allow personnel to respond safely and quickly to emergency situations. Equipment will be inspected and maintained by Construction Manager to assure recommended quantities are available and its proper operation in time of emergency. After an emergency, equipment will be decontaminated, cleaned, and re-fit for its intended use before normal operations resume.

The Newfield facility will be equipped with the following emergency response equipment:

(1) Mobile telephones are provided to the Drilling and Production Mangers and are immediately available at the scene of operations for summoning emergency assistance from local police departments, fire departments or State or local emergency response teams.

(2) Portable fire extinguishers, fire control equipment, spill control equipment and decontamination equipment. This equipment is detailed in Table 4 of Appendix C.

5.0 EMERGENCY SPILL CONTROL NETWORK

5.1 ARRANGEMENTS WITH LOCAL EMERGENCY RESPONSE AGENCIES AND HOSPITALS

This section provides a list of local emergency response agencies and hospitals, and associated phone numbers. Arrangements can be made, as appropriate, to inform local emergency response agencies and hospitals concerning the type of materials handled at the Newfield facility and the potential need for services.

If appropriate, arrangements can be made to designate who will be the primary emergency response agency and who will provide support services during emergencies. Efforts can be made to familiarize police, fire departments, emergency response teams, and the Wayne County Emergency Management Agency (EMA) Coordinator with the layout of the site, the properties and dangers associated with any hazardous materials handled, places where personnel would normally be working, entrances to roads inside the site, and potential evacuation routes.

If considered appropriate by Newfield's Emergency Coordinator, agreements with hospitals and emergency response agencies can be made and included in the periodic updating or amending of the PPC Plan. The agreements and/or arrangements include efforts to familiarize area agencies and emergency responders with facility operations and potential emergency operations. The following agencies can be contacted and provided with a copy of this PPC Plan, at the discretion of the Newfield Emergency Coordinator.

- Local fire companies;
- Local county emergency response personnel;
- Local ambulance personnel; and
- Local hospital.

Table 3 lists local emergency response agencies to be contacted in the event of an emergency or reportable spill. In the unlikely event that a widespread emergency exists, the Wayne County EMA would be contacted first, and the Coordinator in turn could contact appropriate emergency response agencies through their communications network.

The Wayne County Emergency Management Agency can be contacted at (570) 253-1622. Routing of injured persons will be performed by emergency medical services personnel based on the number and type of injuries requiring treatment. The emergency medical services coordinator may be provided with a copy of this PPC Plan to assist in planning. The nearest hospitals are Catskill Regional Medical Hospital in Callicoon, New York, and Wayne County Memorial Hospital in Honesdale, Pennsylvania. The nearest fire departments are Callicoon Fire District in Callicoon, New York, Protection Engine Co No. 3 in Honesdale, Pennsylvania, and Narrowsburg Fire Department, in Narrowsburg, New York. The nearest police departments are the Honesdale Police Department, located in Honesdale, Pennsylvania, and Waymart Police Department in Honesdale Pennsylvania. All emergency response departments shall be reached through the 911 system.

5.2 NOTIFICATION LISTS

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion that could threaten human health or the environment, he will contact and report as necessary his findings to the appropriate agencies listed in Table 3. When calling any of the agencies listed in Table 3, the following information should be available for reporting to the identified agencies:

- Company name and location;
- Name of person reporting the spill, title, and telephone number;
- The type of material released;
- Estimated or exact (if known) quantity of material released (i.e., gallons, pounds, etc.);
- A brief description of the incident, including type of incident, nature of hazardous material involvement, and possible hazards to human health and the environment outside the facility;
- Probable source and location of the spill source;
- Date and time of the spill;
- Location of entry point into surface water and amount reaching the waterway (if applicable);
- The name of the receiving water and the downstream water bodies of which it is a tributary;
- Confirmation that release has been stopped or, if not, when will it be stopped;
- Mitigation/containment actions initiated;
- Direction of material movement;

- Potential population affected by the release;
- Name of person to contact on behalf of the company who will be at the scene and will be directing response measures;
- Telephone number where the on-scene coordinator can be reached; and
- The extent of injuries, if any.

A reporting form is attached in Appendix D for use by the Emergency Coordinator.

A written report including the above listed information, and other information that may be required by the applicable regulations (see 25 PA Code Section 265.56) regarding the spilled material, will need to be transmitted within 15 days to the following agencies:

U.S. Environmental Protection Agency
Region III
Spill Response Section
1650 Arch Street
Philadelphia, PA 19103

Pennsylvania Department of Environmental Protection
Bureau of Water Quality Management
2 Public Square
Wilkes-Barre, Pennsylvania 18711

6.0 WASTE DISPOSAL PRACTICES

Produced water will be removed periodically from the tanks at each well site and transported by a licensed residual waste hauler to a permitted disposal facility. Other wastes generated onsite will include used hydraulic oil that will be reclaimed from operating equipment and transported offsite for recycling. All wastes will be disposed in accordance with applicable local, state, and federal regulations.

7.0 STORMWATER MANAGEMENT PRACTICES

Newfield implements several Best Management Practices (BMPs) at each well site to reduce the potential for stormwater runoff of suspended solids and other contaminants. These BMPs include routine visual inspections, preventive maintenance, good housekeeping, and management of stormwater run-on and runoff. Routine inspection and monitoring, preventive maintenance, and good housekeeping programs are discussed in Sections 3.3, 3.4, and 3.5 of this PPC Plan. These programs prevent accidental releases of contaminants and reduce contaminant migrations via stormwater discharges. Stormwater management activities are discussed in Section 3.1 of this PPC Plan. The certification statement regarding the evaluation of discharges and confirmation that they will be comprised solely of stormwater is presented at the beginning of this Plan. Potential "significant sources of non-stormwater at the site" may include condensate, brine, hydraulic oil drums and tanks, gasoline and diesel fuel. Storage areas for these significant sources will be inspected on a daily basis.

8.0 SEDIMENT AND EROSION PREVENTION

Erosion and sedimentation controls are managed in accordance with PADEP requirements. Copies of the site E&S Plan are available at the Newfield office in Honesdale, PA and at each well site.

APPENDIX A

INSPECTION FORMS

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Facility:	Inspector Name:
Date of Inspection:	

Instructions: Indicate yes or no. If no, record observations describing the specific equipment and discrepancy.

Aboveground Storage Tanks		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
• Level gauages/alarms are operative	Yes ☐	No ☐
• Containers are labeled	Yes ☐	No ☐
Observations:		

Processing Equipment		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
Observations:		

Other Facility Equipment is Checked for: ❖ No evidence of active or past leaks ❖ Condition of equipment appears to be satisfactory (i.e., not damaged, deteriorated, or worn), and ❖ Corrosion appears to be acceptable.		
• Wellheads	Yes ☐	No ☐
• Gathering systems	Yes ☐	No ☐
• Well test stations	Yes ☐	No ☐
• Traps/Sumps	Yes ☐	No ☐
• Drainage systems and nearby ditches	Yes ☐	No ☐
• Applicable flowlines including right-of-way areas	Yes ☐	No ☐
• Containment systems	Yes ☐	No ☐
• Facility piping	Yes ☐	No ☐
Observations:		

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Secondary Containment		
• Passive containment (berm) has adequate capacity and integrity as intended	Yes ☐	No ☐
• Active containment measures are adequate	Yes ☐	No ☐
• No evidence of active or past leaks (i.e., staining, sheen)	Yes ☐	No ☐
• Any valves are closed and plugged	Yes ☐	No ☐
• Active containment is free from a significant quantity of rain/snow	Yes ☐	No ☐
	Yes ☐	No ☐
Observations:		

Security		
• Lighting is adequate to observe leaks, spills, and vandalism	Yes ☐	No ☐
• Pumps, valves, nozzles are locked	Yes ☐	No ☐
Observations:		

Spill Response		
• Spill response kits are stocked and located in readily accessible areas	Yes ☐	No ☐
Observations:		

Signature:	Date:

E&S INSPECTION FORM

The E&S plan contains a maintenance program which provides for inspection of BMPs (Best Management Practices such as filter sock, vegetation, construction entrances, etc.) on a weekly basis and after each measurable rainfall event, including the repair of BMPs to ensure effective and efficient operation. The maintenance program for both the temporary and permanent erosion and sediment control BMPs, including disposal of materials removed from the BMPs or project area, has been included in the narrative. The type of maintenance, such as cleanout, repair, replacement, regrading, re-stabilizing, etc. for each of the BMPs is included in the plan. **NOTE: This inspection report must be kept up to date and onsite.**

INSPECTION DATE	INITIALS	RAINFALL OR WEEKLY?	LOCATION OF E&S CONTROL(S)	CONDITION NOTED	CORRECTIVE MEASURES TAKEN

Facility: _____ **Inspector:** _____ **Signed:** _____ **Date:** _____

Print *Signature*

Tank Truck Loading and Unloading Checklist

Date: _____ Material being loaded/unloaded: _____

Driver/Loader present during loading or unloading of material _____
(signature)

_____ Current volume in storage tank was checked prior to loading.

_____ Fill hose inspected for condition prior to loading.

_____ Wheel chocks in place prior to loading.

_____ Tanker valve(s) were inspected for leakage prior to filling and departure.

_____ The loading of the tanker was monitored.

_____ Hoses were replaced and capped after loading.

_____ No material was spilled onto the containment pad or ground.

- These forms must be completed for every tank truck shipment and must be filed in the facility PPC Plan.
- All spills should be immediately reported to at least one of the following Newfield personnel:

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Burl Eakle
Cell: 918-448-1296

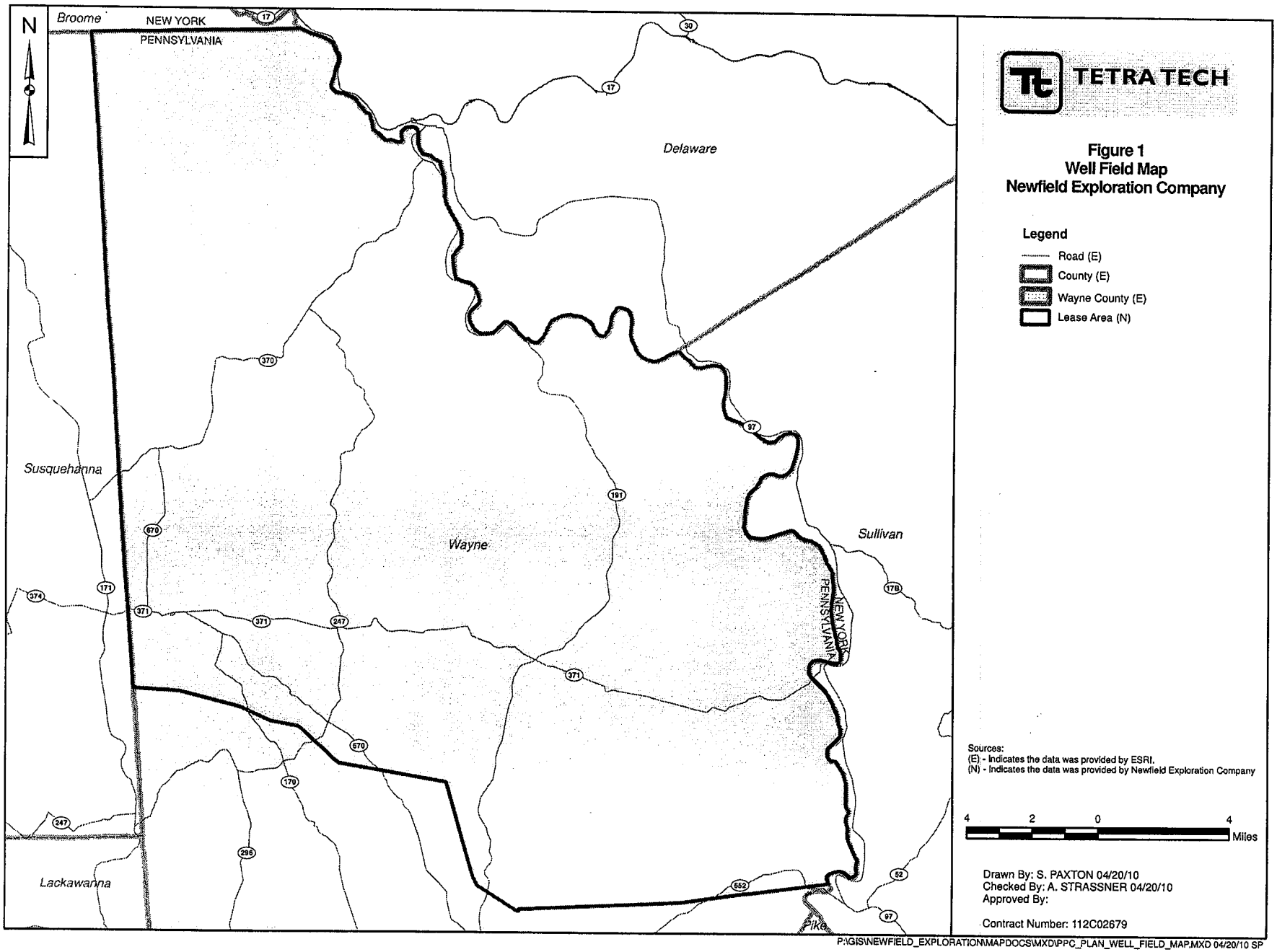
Delivery Information

Invoice No. _____

Load No. _____

Company _____

APPENDIX B
FIGURES



TETRA TECH

Figure 1
Well Field Map
Newfield Exploration Company

Legend

- Road (E)
- County (E)
- Wayne County (E)
- Lease Area (N)

Sources:
(E) - Indicates the data was provided by ESRI.
(N) - Indicates the data was provided by Newfield Exploration Company

4 2 0 4 Miles

Drawn By: S. PAXTON 04/20/10
Checked By: A. STRASSNER 04/20/10
Approved By:

Contract Number: 112C02679

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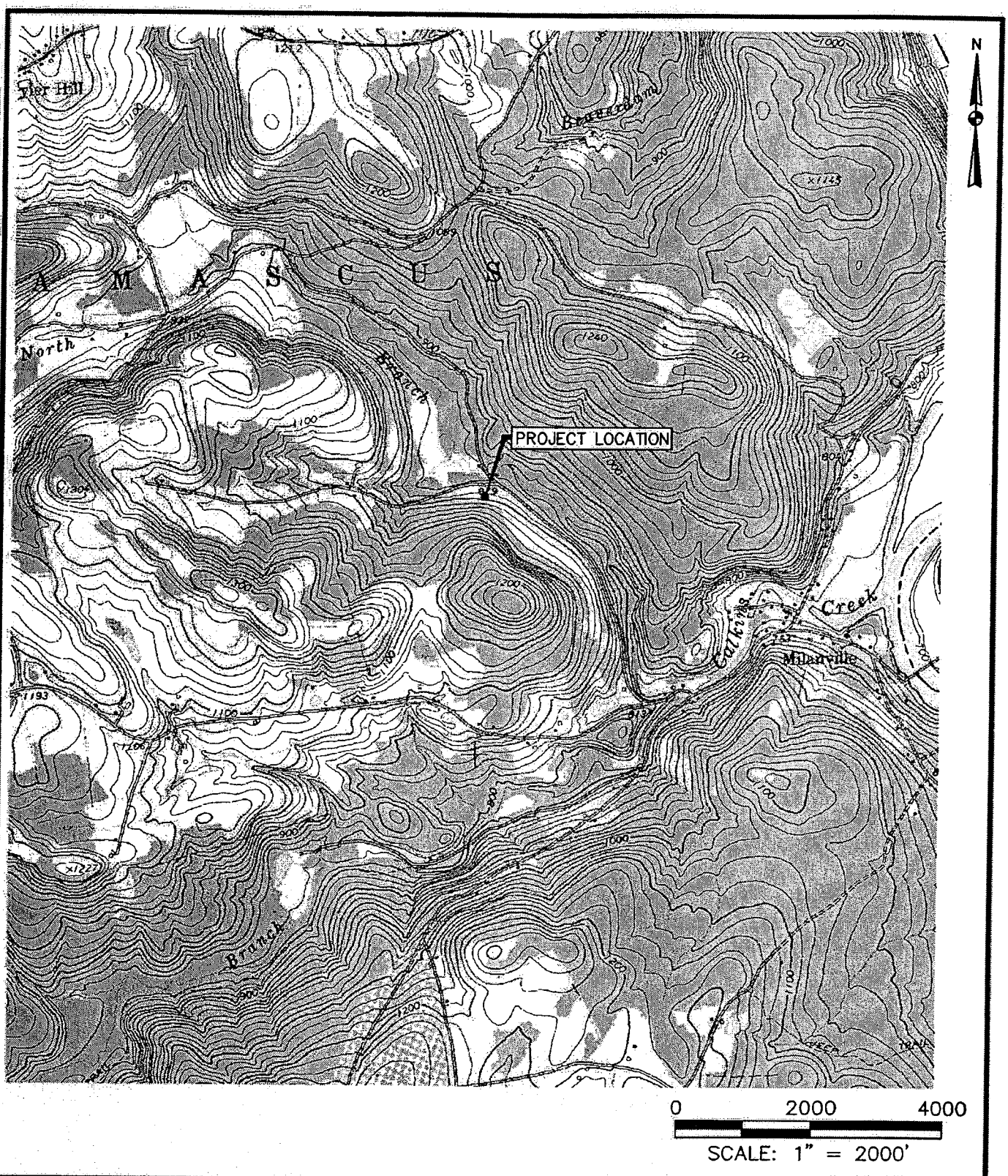

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TETRA TECH

WWW.TETRATECH.COM

661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

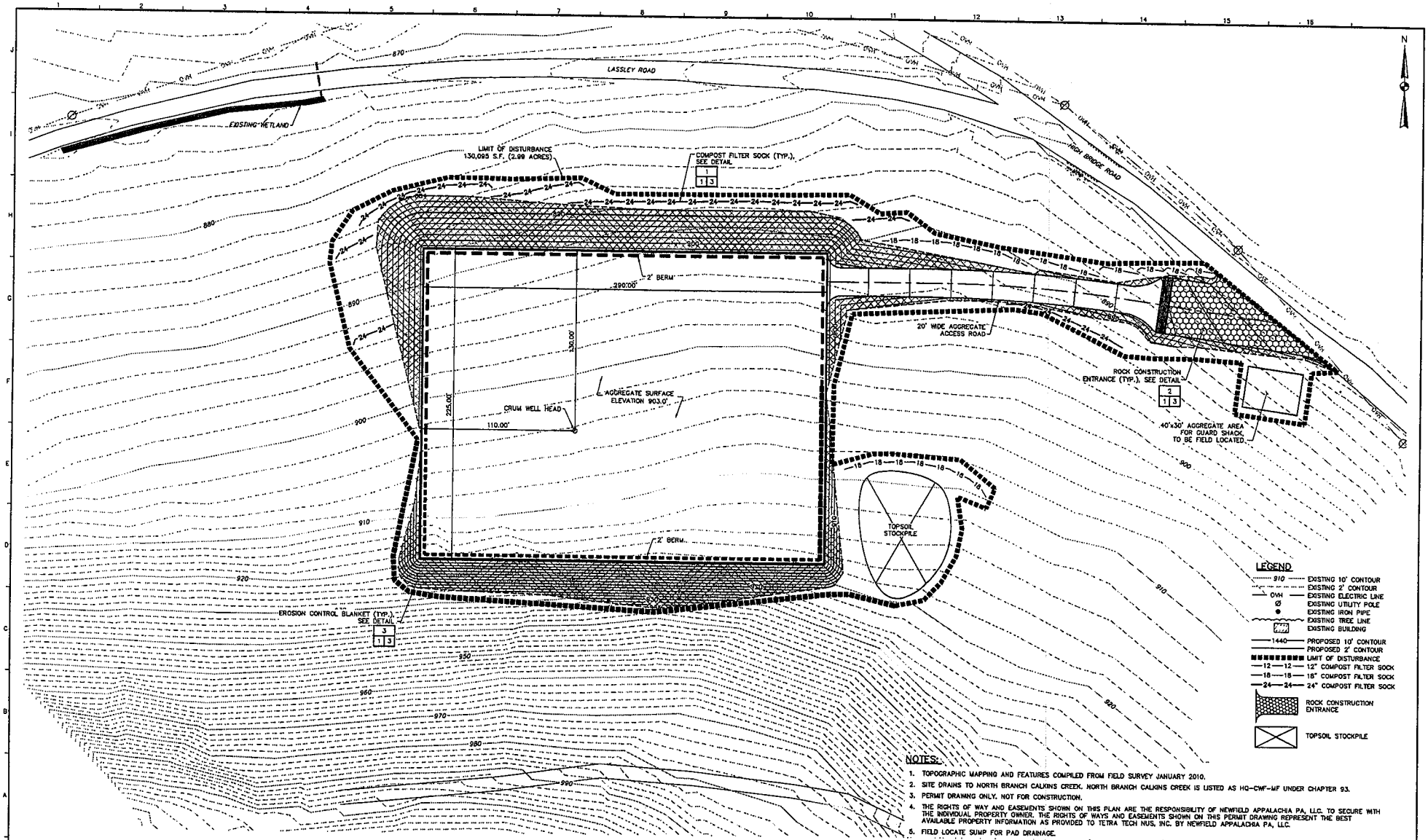
NEWFIELD EXPLORATION COMPANY
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
LOCATION MAP

SCALE: 1" = 2000'

DATE:	3/3/10
PROJECT NO.:	112C02568
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	RAL
SHEET:	1 OF 2

FIGURE 2



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO NORTH BRANCH CALKINS CREEK. NORTH BRANCH CALKINS CREEK IS LISTED AS HQ-CWF-MF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.
5. FIELD LOCATE SUMP FOR PAD DRAINAGE.

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

CRUM WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 30'

DATE:	6/15/10
PROJECT NO.:	112C02769
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	ARB
SHEET:	1 OF 7

FIGURE 3

APPENDIX C
TABLES

TABLE 1

LIST OF MATERIALS & WASTES

CONSTUCTION

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	250 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	180 gallons	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

DRILLING

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	2000 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	320 gallons	Well Pad	Sorbent pads; shovels/Gang box
DURATONE HT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
GELTONE V	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Lime	7,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Base Fluid	300 bbl	Well Pad	Sorbent pads; shovels/Gang box
Rig Wash	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Calcium Chloride (CaCl-)	4,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
RHEMOD L	1,770 lbs	Well Pad	Sorbent pads; shovels/Gang box
LE SUPERMUL	8,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
BARACARB 25, 50 (2 pallets each)	12,600 lbs	Well Pad	Sorbent pads; shovels/Gang box
WALNUT	2,400 lbs	Well Pad	Sorbent pads; shovels/Gang box
DRILTREAT	1,900 lbs	Well Pad	Sorbent pads; shovels/Gang box
Liquid Mud	1,500 bbl	Well Pad	Sorbent pads; shovels/Gang box
BAROID REGULAR / **BAROID BULK (barite)	125,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Drill Cuttings	100,000 lbs	Air Pit	Sorbent pads; shovels/Gang box
Cement	130,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

TABLE 2

INSPECTION AND MONITORING ACTIVITIES

Activity	Frequency
Erosion and Sedimentation Control Measures	Weekly or after a significant rain event
Aboveground Storage Tanks	Daily
Drum Storage Areas	Daily
Best Management Practices (BMPs)	Per BMP requirements
Dust Control Measures	Daily
Preparedness, Prevention, and Contingency (PPC) Plan Compliance Evaluation Inspections and Update of PPC Plan, as Appropriate	Annually

TABLE 3
AGENCY NOTIFICATION LIST

The following agencies are to be contacted, as appropriate, in the event of an emergency, accident, or chemical release.

Agency	Telephone No.
PADEP Northeast Regional Office	570-826-2511
PADEP Southcentral Office (Harrisburg)	877-333-1904
Pennsylvania Emergency Management Agency	717-651-2001
Police Department	9-1-1
Volunteer Fire Department	9-1-1
U.S. Environmental Protection Agency	215-814-5700
U.S. Coast Guard National Response Center	800-424-8802
U.S. Coast Guard (local)	570-421-1191
Pennsylvania Fish and Boat Commission	814-445-8974
Chemical Transportation Emergency Center:	
* Chemical Exposure Information	800-424-9300

LOCAL EMERGENCY RESPONSE:

Fire Department – Callicoon Fire District in Callicoon, New York, Protection Engine Co No. 3 in Honesdale, Pennsylvania Narrowsburg Fire Department, in Narrowsburg, New York.	9-1-1
Police Department – Honesdale Police Department, Honesdale, Pennsylvania Waymart Police Department, Honesdale Pennsylvania	9-1-1
Hospitals-Wayne County Memorial Hospital, Honesdale, Pennsylvania	570-251-6672
Catskill Regional Medical Hospital in Callicoon, New York	845-887-5530
Local Emergency Management Wayne County EMA	570-253-1622

TABLE 4

On-Site Emergency Response Equipment

On-Site Emergency Response Equipment
Fire Extinguishers
Tyvek Suits
Nitrile Gloves
Hearing Protection
Particulate Adsorbent
Absorbent Pads
Shovels
Earth Moving Equipment
Decontamination Equipment

TABLE 5
CHAIN OF COMMAND

Primary Emergency Coordinator

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Construction Manager
Burl Eakle
Cell: 918-448-1296

Offsite Emergency Response Contractors

Company: Minuteman Spill Response, Inc.
Telephone Number: 800-905-7788

APPENDIX D
REPORTING FORM

Spill Response Notification Form

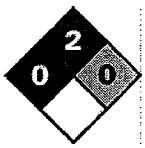
GENERAL REPORTING INFORMATION
Prepared _____ (First) (M.I.) (Last) (Position)
Daytime phone: (xxx) xxx-xxxx Evening phone: (xxx) xxx-xxxx
Newfield Appalachia PA LLC (Company) (Address) (City) (State) (Zip)
Calling for responsible party? Yes Were materials discharged? Yes Confidential? No
Meeting Federal obligations to report: Yes
INCIDENT DESCRIPTION
Source and/or cause:
Date of Incident:Time of Incident:
Incident Location/Address
Nearest City: XXXX, PA XXXXX (XXXXXXX County)
Distance from City: In city limits Direction from City: In city limits
Facility Oil Storage Capacity: XXXXXX gallons
Container Type:Container Capacity: (gals)
Facility Latitude: xx° xx' xx" Longitude xx° xx' xx"
MATERIAL
Name (or CHRIS Code):
Discharged Quantity (Units): Discharged to Water (Units):
RESPONSE ACTION
Actions taken to correct, control or mitigate incident:
IMPACT
No. of Injuries: No. of Deaths: Other:
Evacuation (Y/N): Damage (Y/N): Amount ($):
Medium Affected: Description: Additional Information:
AGENCY NOTIFIED
NRC 800-424-8802 Date: Time: Contact:
PADEP (570) 826-2511 Date: Time: Contact:
USCG Date: Time: Contact:
Other Date: Time: Contact:
ADDITIONAL INFORMATION:

APPENDIX E
MSDS SHEETS

MATERIAL SAFETY DATA SHEET

Diesel Fuel (All Types) **MSDS No. 9909**

EMERGENCY OVERVIEW
CAUTION!
OSHA/NFPA COMBUSTIBLE LIQUID - SLIGHT TO MODERATE IRRITANT
EFFECTS CENTRAL NERVOUS SYSTEM
HARMFUL OR FATAL IF SWALLOWED
Moderate fire hazard. Avoid breathing vapors or mists. May cause dizziness and drowsiness. May cause moderate eye irritation and skin irritation (rash). Long-term, repeated exposure may cause skin cancer.
If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs).



NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER (24 hrs): **CHEMTREC (800) 424-9300**
COMPANY CONTACT (business hours): Corporate Safety (732) 750-6000
MSDS INTERNET WEBSITE: www.hess.com (See Environment, Health, Safety & Social Responsibility)

SYNONYMS: Ultra Low Sulfur Diesel (ULSD); Low Sulfur Diesel; Motor Vehicle Diesel Fuel; Diesel Fuel #2; Dyed Diesel Fuel; Non-Road, Locomotive and Marine Diesel Fuel; Tax-exempt Diesel Fuel

See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Diesel Fuel (68476-34-6)	100
Naphthalene (91-20-3)	Typically < 0.01

A complex mixture of hydrocarbons with carbon numbers in the range C9 and higher. Diesel fuel may be dyed (red) for tax purposes. May contain a multifunctional additive.

3. HAZARDS IDENTIFICATION

EYES
Contact with liquid or vapor may cause mild irritation.

SKIN
May cause skin irritation with prolonged or repeated contact. Practically non-toxic if absorbed following acute (single) exposure. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed.

INGESTION
The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION
Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY
Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. The significance of these results to human exposures has not been determined - see Section 11 Toxicological Information.

IARC classifies whole diesel fuel exhaust particulates as probably carcinogenic to humans (Group 2A). NIOSH regards whole diesel fuel exhaust particulates as a potential cause of occupational lung cancer based on animal studies and limited evidence in humans.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash).

4. FIRST AID MEASURES

EYES
In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN
Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops.

INGESTION
DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION
Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT:	> 125 °F (> 52 °C) minimum PMCC
AUTOIGNITION POINT:	494 °F (257 °C)
OSHA/NFPA FLAMMABILITY CLASS:	2 (COMBUSTIBLE)
LOWER EXPLOSIVE LIMIT (%):	0.6
UPPER EXPLOSIVE LIMIT (%):	7.5

FIRE AND EXPLOSION HAZARDS
Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA
SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES

ACTIVATE FACILITY'S SPILL CONTINGENCY OR EMERGENCY RESPONSE PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING PRECAUTIONS

Handle as a combustible liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Diesel fuel, and in particular low and ultra low sulfur diesel fuel, has the capability of accumulating a static electrical charge of sufficient energy to cause a fire/explosion in the presence of lower flashpoint products such as gasoline. The accumulation of such a static charge occurs as the diesel flows through pipelines, filters, nozzles and various work tasks such as tank/container filling, splash loading, tank cleaning; product sampling; tank gauging; cleaning, mixing, vacuum truck operations, switch loading, and product agitation. There is a greater potential for static charge accumulation in cold temperature, low humidity conditions.

Documents such as 29 CFR OSHA 1910.106 "Flammable and Combustible Liquids, NFPA 77 Recommended Practice on Static Electricity, API 2003 "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents and ASTM D4865 "Standard Guide for Generation and Dissipation of Static

Electricity in Petroleum Fuel Systems" address special precautions and design requirements involving loading rates, grounding, bonding, filter installation, conductivity additives and especially the hazards associated with "switch loading." ["Switch Loading" is when a higher flash point product (such as diesel) is loaded into tanks previously containing a low flash point product (such as gasoline) and the electrical charge generated during loading of the diesel results in a static ignition of the vapor from the previous cargo (gasoline).]

Note: When conductivity additives are used or are necessary the product should achieve 25 picosiemens/meter or greater at the handling temperature.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)	Source	Exposure Limits TWA/STEL	Note
Diesel Fuel: (68476-34-6)	OSHA ACGIH	5 mg/m, as mineral oil mist 100 mg/m^3 (as totally hydrocarbon vapor) TWA	A3, skin
Naphthalene (91-20-3)	OSHA ACGIH	10 ppm TWA 10 ppm TWA / 15 ppm STEL	A4, Skin

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile, neoprene, or PVC are recommended. Chemical protective clothing such as of E.I. DuPont TyChem®, Saranex® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION

A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE

Clear, straw-yellow liquid. Dyed fuel oil will be red or reddish-colored.

ODOR

Mild, petroleum distillate odor

BASIC PHYSICAL PROPERTIES

BOILING RANGE:	320 to 690 oF (160 to 366 °C)
VAPOR PRESSURE:	0.009 psia @ 70 °F (21 °C)
VAPOR DENSITY (air = 1):	> 1.0
SPECIFIC GRAVITY (H_2O = 1):	0.83 to 0.88 @ 60 °F (16 °C)
PERCENT VOLATILES:	100 %
EVAPORATION RATE:	Slow; varies with conditions
SOLUBILITY (H_2O):	Negligible

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS

Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers; Viton ®; Fluorel ®

HAZARDOUS DECOMPOSITION PRODUCTS

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

11. TOXICOLOGICAL PROPERTIES

ACUTE TOXICITY

Acute dermal LD50 (rabbits): > 5 ml/kg
Acute oral LD50 (rats): 9 ml/kg
Primary dermal irritation: extremely irritating (rabbits)
Draize eye irritation: non-irritating (rabbits)
Guinea pig sensitization: negative

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenic: OSHA: NO IARC: NO NTP: NO ACGIH: A3

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

MUTAGENICITY (genetic effects)

This material has been positive in a mutagenicity study.

12. ECOLOGICAL INFORMATION

Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

PROPER SHIPPING NAME:	Diesel Fuel	Placard (International Only):
HAZARD CLASS and PACKING GROUP:	3, PG III	
DOT IDENTIFICATION NUMBER:	NA 1993 (Domestic) UN 1202 (International)	
DOT SHIPPING LABEL:	None	

Use Combustible Placard if shipping in bulk domestically

15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

This product and its constituents listed herein are on the EPA TSCA Inventory. Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH	CHRONIC HEALTH	FIRE	SUDDEN RELEASE OF PRESSURE	REACTIVE
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product may contain listed chemicals below the *de minimis* levels which therefore are not subject to the supplier notification requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372. If you may be required to report releases of chemicals listed in 40 CFR 372.28, you may contact Hess Corporate Safety if you require additional information regarding this product.

CALIFORNIA PROPOSITON 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

INGREDIENT NAME (CAS NUMBER)	Date Listed
Diesel Engine Exhaust (no CAS Number listed)	10/01/1990

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 3 (Combustible Liquid) and Class D, Division 2, Subdivision B (Toxic by other means)

16. OTHER INFORMATION

NFPA® HAZARD RATING

HEALTH:	0
FIRE:	2
REACTIVITY:	0

Refer to NFPA 704 "Identification of the Fire Hazards of Materials" for further information

HMIS® HAZARD RATING

HEALTH:	1 *	* Chronic
FIRE:	2	
PHYSICAL:	0	

SUPERSEDES MSDS DATED: 02/28/2001

ABBREVIATIONS:

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute (212) 642-4900
API	American Petroleum Institute (202) 682-8000
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation [General info: (800) 467-4922]
EPA	U.S. Environmental Protection Agency
HMIS	Hazardous Materials Information System
IARC	International Agency For Research On Cancer
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association (617)770-3000
NIOSH	National Institute of Occupational Safety and Health
NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
NTP	National Toxicology Program
OPA	Oil Pollution Act of 1990
OSHA	U.S. Occupational Safety & Health Administration
PEL	Permissible Exposure Limit (OSHA)
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit (NIOSH)
SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
SCBA	Self-Contained Breathing Apparatus
SPCC	Spill Prevention, Control, and Countermeasures
STEL	Short-Term Exposure Limit (generally 15 minutes)
TLV	Threshold Limit Value (ACGIH)
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average (8 hr.)
WEEL	Workplace Environmental Exposure Level (AIHA)
WHMIS	Canadian Workplace Hazardous Materials Information System

MATERIAL SAFETY DATA SHEET

Review Date: 04/23/2007

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT: PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

MSDS NUMBER: 614348LU - 1
PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

MANUFACTURER
SOPUS Products
P.O. Box 4427
Houston, TX. 77210-4427

TELEPHONE NUMBERS
Spill Information: (877) 242-7400
Health Information: (877) 504-9351
MSDS Assistance Number: (877) 276-7285

SECTION 2 PRODUCT/INGREDIENTS

INGREDIENTS	CAS#	CONCENTRATION
Heavy Duty Motor Oil		
Highly refined petroleum oils	Mixture	90 - 99 %volume
Zinc Dialkyldithiophosphate	68649-42-3	1 - 5 %volume
Proprietary additives	Mixture	1 - 5 %volume

SECTION 3 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Appearance & Odor: Bright and clear liquid. Mild odor.
Health Hazards: No known immediate health hazards.
Physical Hazards: No known physical hazards.
NFPA Rating (Health, Fire, Reactivity): 0, 1, 0
Hazard Rating: Least - 0 Slight - 1 Moderate - 2 High - 3 Extreme - 4

Inhalation:
Inhalation of vapors (generated at high temperatures only) or oil mist may cause mild irritation of the nose, throat, and respiratory tract.

Eye Irritation:
Lubricating oils are generally considered no more than minimally irritating to the eyes.

Skin Contact:
May cause slight irritation of the skin. If irritation occurs, a temporary burning sensation and minor redness and/or swelling may result.

Ingestion:

Lubricating oils are generally no more than slightly toxic if swallowed.

Other Health Effects:
The International Agency for Research on Cancer (IARC) has determined there is sufficient evidence for the carcinogenicity in experimental animals of used gasoline motor oils. Handling procedures and safety precautions in the MSDS should be followed to minimize exposure to the used product.

Signs and Symptoms:
Irritation as noted above.

Aggravated Medical Conditions:
Pre-existing eye, skin and respiratory disorders may be aggravated by exposure to this product.

For additional health information, refer to section 11.

SECTION 4 FIRST AID MEASURES

Inhalation:
Remove victim to fresh air and provide oxygen if breathing is difficult. Get medical attention. If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.

Skin:
Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.

Eye:
Flush with water. If irritation occurs, get medical attention.

Ingestion:
Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

Note to Physician:
In general, emesis induction is unnecessary in high viscosity, low volatility products such as oils and greases.

SECTION 5 FIRE FIGHTING MEASURES

Flash Point [Method]: >400 °F/>204.44 °C [Pensky-Martens Closed Cup]

Extinguishing Media:
Material will float and can be re-ignited on surface of water. Use water fog, foam, dry chemical or carbon dioxide (CO2) to extinguish flames. Do not use a direct stream of water.

Fire Fighting Instructions:
Do not enter confined fire space without full bunker gear (helmet with face shield, bunker coats, gloves and rubber boots), including a positive pressure, NIOSH approved, self-contained breathing apparatus. This material is non-flammable.

Unusual Fire Hazards:
Material may ignite when preheated.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Protective Measures:
May burn although not readily ignitable.

Wear appropriate personal protective equipment when cleaning up spills. Refer to Section 8.

Spill Management:
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

Place in container for proper disposal. Remove contaminated soil to remove contaminated trace residues. Dispose of in same manner as material.

Reporting:
CERCLA: Product is covered by EPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) petroleum exclusion. Releases to air, land, or water are not reportable under CERCLA (Superfund).

CWA: This product is an oil as defined under Section 311 of EPA's Clean Water Act (CWA). Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 1-800-424-8802.

SECTION 7 HANDLING AND STORAGE

Precautionary Measures:
Wash with soap and water before eating, drinking, smoking, applying cosmetics, or using toilet. Launder contaminated clothing before reuse. Properly dispose of contaminated leather articles such as shoes or belts that cannot be decontaminated. Avoid heat, open flames, including pilot lights, and strong oxidizing agents. Use explosion-proof ventilation to prevent vapor accumulation. Ground all handling equipment to prevent sparking.

Storage:
Do not store in open or unlabeled containers. Store in a cool, dry place with adequate ventilation. Keep away from open flames and high temperatures.

Container Warnings:
Keep containers closed when not in use. Containers, even those that have been emptied, can contain explosive vapors. Do not cut, drill, grind, weld or perform similar operations on or near containers.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Chemical	Limit	TWA	STEL	Ceiling	Notation
Oil mist, mineral	ACGIH TLV	5 mg/m3	10 mg/m3		
Oil mist, mineral	OSHA PEL	5 mg/m3			

Exposure Controls

Provide adequate ventilation to control airborne concentrations below the exposure guidelines/limits.

Personal Protection

Personal protective equipment (PPE) selections vary based on potential exposure conditions such as handling practices, concentration and ventilation. Information on the selection of eye, skin and respiratory protection for use with this material is provided below.

Eye Protection:
Chemical Goggles, or Safety glasses with side shields

Skin Protection:
Use protective clothing which is chemically resistant to this material. Selection of protective clothing depends on potential exposure conditions and may include gloves, boots, suits and other items. The selection(s) should take into account such factors as job task, type of exposure and durability requirements.

Published literature, test data and/or glove and clothing manufacturers indicate the best protection is provided by:
Neoprene, or Nitrile Rubber

Respiratory Protection:
If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, an approved respirator must be worn. Respirator selection, use and maintenance should be in accordance with the requirements of the OSHA Respiratory Protection Standard, 29 CFR 1910.134.

Types of respirator(s) to be considered in the selection process include:
For Mist: Air Purifying, R or P style NIOSH approved respirator.
For Vapors: Air Purifying, R or P style prefilter & organic cartridge, NIOSH approved respirator. Self-contained breathing apparatus for use in environments with unknown concentrations or emergency situations.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance & Odor: Bright and clear liquid. Mild odor.
Substance Chemical Family: Petroleum Hydrocarbon

Flash Point	> 400 °F [Pensky-Martens Closed Cup]	**Pour Point**	-20 °F
Solubility (in Water)	Insoluble	**Specific Gravity**	0.88 - 0.89
Stability	Stable	**Viscosity**	103 cSt @ 40 °C

SECTION 10 REACTIVITY AND STABILITY

Stability:
Material is stable under normal conditions.

Conditions to Avoid:
Avoid heat and open flames.

Materials to Avoid:
Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products:

Thermal decomposition products are highly dependent on combustion conditions. A complex mixture of airborne solids, liquids and gases will evolve when this material undergoes pyrolysis or combustion. Aldehydes, Carbon Monoxide, Carbon Dioxide, Hydrogen Sulfide, Ketones, Nitrogen Oxidesand other unidentified organic compounds may be formed upon combustion.

SECTION 11 TOXICOLOGICAL INFORMATION

Acute Toxicity

TEST	Result	OSHA Classification	Material Tested
Dermal LD50	>5.0 g/kg(Rabbit)	Non-Toxic	Based on components(s)
Oral LD50	>5.0 g/kg(Rat)	Non-Toxic	Based on components(s)

Carcinogenicity Classification

Chemical Name	NTP	IARC	ACGIH	OSHA
Heavy Duty Motor Oil	No	Not Reviewed by IARC	Not Reviewed	No

SECTION 12 ECOLOGICAL INFORMATION

Environmental Impact Summary:
There is no ecological data available for this product. However, this product is an oil. It is persistent and does not readily biodegrade. However, it does not bioaccumulate.

SECTION 13 DISPOSAL CONSIDERATIONS

RCRA Information:

Under RCRA, it is the responsibility of the user of the material to determine, at the time of the disposal, whether the material meets RCRA criteria for hazardous waste. This is because material uses, transformations, mixtures, processes, etc. may affect the classification. Refer to the latest EPA, state and local regulations regarding proper disposal.

SECTION 14 TRANSPORT INFORMATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

International Air Transport Association
Not regulated under IATA rules.

International Maritime Organization Classification
Not regulated under International Maritime Organization rules.

SECTION 15 REGULATORY INFORMATION

Federal Regulatory Status

OSHA Classification:
Under normal conditions of use or in a foreseeable emergency, this product does not meet the definition of a hazardous chemical when evaluated according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Ozone Depleting Substances (40 CFR 82 Clean Air Act):
This material does not contain nor was it directly manufactured with any Class I or Class II ozone depleting substances.

Superfund Amendment & Reauthorization Act (SARA) Title III:
There are no components in this product on the SARA 302 list.

SARA Hazard Categories (311/312):

Immediate Health	Delayed Health	Fire	Pressure	Reactivity
NO	NO	NO	NO	NO

SARA Toxic Release Inventory (TRI) (313):
Zinc compounds

Toxic Substances Control Act (TSCA) Status:
All component(s) of this material is(are) listed on the EPA/TSCA Inventory of Chemical Substances.

Other Chemical Inventories:
Component(s) of this material is (are) listed on the Australian AICS, Canadian DSL, Chinese Inventory, European EINECS, Korean Inventory, Philippines PICCS,

State Regulation

The following chemicals are specifically listed by individual states; other product specific health and safety data in other sections of the MSDS may also be applicable for state requirements. For details on your regulatory requirements you should contact the appropriate agency in your state.

SECTION 16 OTHER INFORMATION

Revision#: 1
Review Date: 04/23/2007
Revision Date: 12/19/2006
Revisions since last change (discussion): This Material Safety Data Sheet (MSDS) has been reviewed to fully comply with the guidance contained in the ANSI MSDS standard (ANSI Z400.1-2003). We encourage you to take the opportunity to read the MSDS and review the information contained therein.

SECTION 17 LABEL INFORMATION

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

ATTENTION!

PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE OIL ACNE OR DERMATITIS. USED GASOLINE ENGINE OIL HAS BEEN SHOWN TO CAUSE CANCER IN LABORATORY ANIMALS.

Precautionary Measures:
Avoid prolonged or repeated contact with eyes, skin and clothing. Avoid breathing of vapors, fumes, or mist. Use only with adequate ventilation. Wash thoroughly after handling.

FIRST AID

Inhalation: If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.
Skin Contact: Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.
Eye Contact: Flush with water. If irritation occurs, get medical attention.
Ingestion: Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

FIRE

In case of fire, Use water fog, 'alcohol foam', dry chemical or carbon dioxide (CO_2) to extinguish flames. Do not use a direct stream of water. Material will float and can be re-ignited on surface of water.

SPILL OR LEAK

Dike and contain spill.
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

CONTAINS: Highly refined petroleum oils, Mixture; Zinc Dialkyldithiophosphate, 68649-42-3; Proprietary additives, Mixture

NFPA Rating (Health, Fire, Reactivity): 0, 1, 0

TRANSPORTATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flames or heat. Keep container closed and drum bungs in place.

Name and Address

SOPUS Products
P.O. Box 4427
Houston, TX 77210-4427

ADMINISTRATIVE INFORMATION	
MANUFACTURER ADDRESS:	SOPUS Products, P.O. Box 4427, Houston, TX. 77210-4427.

THE INFORMATION CONTAINED IN THIS DATA SHEET IS BASED ON THE DATA AVAILABLE TO US AT THIS TIME, AND IS BELIEVED TO BE ACCURATE BASED UPON THAT : IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT, FOR PURPOSE OF HAZARD COMMUNICATION. IT IS NOT INTENDED TO CONSTITUTE PRODUCT PERFORMANCE INFORMATION, AND NO EXPRESS OR IMPLIED WARRANTY OF ANY KIND IS MADE WITH RESPECT TO THE PRODUCT, UNDERLYING DATA OR THE INFORMATION CONTAINED HEREIN. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE, AND ARE ENCOURAGED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

TO DETERMINE THE APPLICABILITY OR EFFECT OF ANY LAW OR REGULATION WITH RESPECT TO THE PRODUCT, YOU SHOULD CONSULT WITH YOUR LEGAL ADVISOR OR THE APPROPRIATE GOVERNMENT AGENCY. WE WILL NOT PROVIDE ADVICE ON SUCH MATTERS, OR BE RESPONSIBLE FOR ANY INJURY FROM THE USE OF THE PRODUCT DESCRIBED HEREIN. THE UNDERLYING DATA, AND THE INFORMATION PROVIDED HEREIN AS A RESULT OF THAT DATA, IS THE PROPERTY OF SOPUS PRODUCTS AND IS NOT TO BE THE SUBJECT OF SALE OR EXCHANGE WITHOUT THE EXPRESS WRITTEN CONSENT OF SOPUS PRODUCTS.

44815-10737-100R-04/16/2007

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CALCIUM CHLORIDE - POWDER**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CALCIUM CHLORIDE - POWDER
Synonyms: None
Chemical Family: Inorganic Salt
Application: Accelerator

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcium chloride		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Dust proof goggles.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	10
Specific Gravity @ 20 C (Water=1):	0.83
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	51
Boiling Point/Range (F):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	42
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	147.02

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause skin irritation. May cause skin burns on prolonged contact.
Eye Contact	May cause severe eye irritation. May cause corneal injury.
Ingestion	Causes burns of the mouth, throat and stomach.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 1000 mg/kg (Rat)
Dermal Toxicity:	LD50: > 5000 mg/kg (Rabbit)
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **DRILTREAT®**

Revision Date: 09-Mar-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: DRILTREAT®
Synonyms: None
Chemical Family: Lipid
Application: Oil-wetting Agent

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Contains no hazardous substances	Mixture	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye irritation.

4. FIRST AID MEASURES

Inhalation Under normal conditions, first aid procedures are not required.

Skin Wash with soap and water.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	400
Flash Point/Range (C):	204
Flash Point Method:	PMCC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire-fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing.

Storage Information Store away from oxidizers.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally necessary.

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Amber
Odor:	Bean
pH:	6.4-7
Specific Gravity @ 20 C (Water=1):	1.03
Density @ 20 C (lbs./gallon):	8.58
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	32
Freezing Point/Range (C):	0
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Disperses
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	None known.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Biodegradable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: TLM96: 497,500 ppm (Mysidopsis bahia) SPP @ 12 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **DURATONE® HT**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: DURATONE® HT
Synonyms: None
Chemical Family: Blend
Application: Fluid Loss Additive

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Kaolin	1332-58-7	10 - 30%	2 mg/m^3	Not applicable
Nonylphenol	25154-52-3	5 - 10%	Not applicable	Not applicable
Sodium hydroxide	1310-73-2	1 - 5%	2 mg/m^3	2 mg/m^3
Quaternary ammonium compounds		10 - 30%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation — If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin — Wash with soap and water. Get medical attention if irritation persists.

Eyes — In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion — Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician — Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	608
Autoignition Temperature (C):	320
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media — Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards — Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters — Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 2, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 2*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures — Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures — Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray to black
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.8
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	31 uncompacted; 44 compacted
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	< -1 (OECD117)

9. PHYSICAL AND CHEMICAL PROPERTIES

Molecular Weight (g/mole): Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong alkalis. Strong acids. Aldehydes. Ketones. Acrylates.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause moderate skin irritation. May cause an allergic skin reaction.
Eye Contact	May cause severe eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Ames Test: Negative

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability BOD(28 Day): 9% of COD

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 30 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: EC50: 370 mg/l (Daphnia magna)

Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product contains toxic chemical(s) listed below which is(are) subject to the reporting requirements of Section 313 of Title III of SARA and 40 CFR Part 372: Aluminum Oxide//1344-28-1
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.

EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **GELTONE® V**

Revision Date: 02-Jun-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: GELTONE® V
Synonyms: None
Chemical Family: Blend
Application: Viscosifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, cristobalite	14464-46-1	0 - 1%	0.025 mg/m^3	1/2 x $\frac{10 \text{ mg/m}^3}{\%SiO2 + 2}$
Crystalline silica, tridymite	15468-32-3	0 - 1%	0.05 mg/m^3	1/2 x $\frac{10 \text{ mg/m}^3}{\%SiO2 + 2}$
Crystalline silica, quartz	14808-60-7	2-6	0.025 mg/m^3	$\frac{10 \text{ mg/m}^3}{\%SiO2 + 2}$
Isopropanol	67-63-0	1 - 5%	200 ppm	400 ppm
Modified bentonite		60 - 100%	Not applicable	Not applicable

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.

Storage Information

Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.

Respiratory Protection

Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.

Hand Protection

Normal work gloves.

Skin Protection

Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection

Wear safety glasses or goggles to protect against exposure.

Other Precautions

None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	Tan
Odor:	Mild
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	35- 57
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Miscible in hydrocarbons
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.

MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LE SUPERMUL**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LE SUPERMUL
Synonyms: None
Chemical Family: Blend
Application: Emulsifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Diethylene glycol monobutyl ether	112-34-5	1 - 5%	Not applicable	Not applicable
Ethylene glycol monobutyl ether	111-76-2	1 - 5%	20 ppm	50 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview

May cause eye and skin irritation. May cause headache, dizziness, and other central nervous system effects. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin

In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes

In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion

Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration.

Notes to Physician

Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 200**Min:** > 200
Flash Point/Range (C):	> 100**Min:** > 93
Flash Point Method:	PMCC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Use water spray to cool fire exposed surfaces. Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 2, Flammability 1, Reactivity 0
HMIS Ratings:	Flammability 1, Reactivity 0, Health 2

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor respirator. In high concentrations, supplied air respirator or a self-contained breathing apparatus.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	Amber
Odor:	Mild
pH:	2.6
Specific Gravity @ 20 C (Water=1):	0.924
Density @ 20 C (lbs./gallon):	7.7
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	20
Freezing Point/Range (C):	-6.6
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	280-300
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause abdominal pain, vomiting, nausea, and diarrhea. May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Lung disorders. Skin disorders.
Chronic Effects/Carcinogenicity	Prolonged or repeated exposure may cause reproductive system damage. Repeated overexposure may cause liver and kidney effects.

Other Information None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® OIL ABSORBENT**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® OIL ABSORBENT
Synonyms: None
Chemical Family: Mineral
Application: Suspending Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Magnesium silicate	1343-90-4	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	2-6	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Granules
Color:	Gray to tan
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	2.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32-38
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact None known.

Eye Contact May cause eye irritation.

Ingestion May be harmful if swallowed.

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	Product contains one or more components not listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **RHEMOD L**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: RHEMOD L
Synonyms: None
Chemical Family: Tall oil fatty acid
Application: Viscosifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fatty acids, C18-unsatd., trimers	68937-90-6	10 - 30%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and skin irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	518
Flash Point/Range (C):	270
Flash Point Method:	COC
Autoignition Temperature (F):	> 425
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 1, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Wash hands after use.
Storage Information	Store in a cool, dry location. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Dark
Odor:	Fatty acid
pH:	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	0.96
Density @ 20 C (lbs./gallon):	8
Bulk Density @ 20 C (lbs/ft3):	57.30
Boiling Point/Range (F):	> 572
Boiling Point/Range (C):	> 300
Freezing Point/Range (F):	< -4
Freezing Point/Range (C):	< 25
Vapor Pressure @ 20 C (mmHg):	< 0.001
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	0
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	1849 @ 25C
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye and skin contact.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause mild eye irritation.
Ingestion	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® RIG WASH**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® RIG WASH
Synonyms: None
Chemical Family: Blend
Application: Surfactant

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Isopropanol	67-63-0	1 - 5%	200 ppm	400 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion If swallowed dilute with 1-2 glasses of milk or water and then induce vomiting.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined**Min:** > 220
Flash Point/Range (C):	Not Determined**Min:** > 104
Flash Point Method:	COC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.

Storage Information Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Respiratory Protection Organic vapor respirator.

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear blue
Odor:	Slight Alcohol
pH:	9.5

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	1.025
Density @ 20 C (lbs./gallon):	8.5
Bulk Density @ 20 C (lbs/ft3):	63.6
Boiling Point/Range (F):	> 212
Boiling Point/Range (C):	> 100
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product contains toxic chemical(s) listed below which is(are) subject to the reporting requirements of Section 313 of Title III of SARA and 40 CFR Part 372: Glycol Ethers//34398-01-1 Isopropanol//67-63-0
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **FWCA CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: FWCA CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polysaccharide
Application: Free Water Control Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Cellulose derivative		60 - 100%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	770
Autoignition Temperature (C):	410
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	6.5
Specific Gravity @ 20 C (Water=1):	1.39
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Forms gel
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Aldehydes. Carboxylic acids. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 322 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 322 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Blend
Application: Cement Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Sodium formate	141-53-7	1 - 5%	Not applicable	Not applicable
Cellulose derivative		10 - 30%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Red
Odor:	Odorless

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.28
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	35.2
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Partially soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 344 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 344 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polymer
Application: Fluid Loss Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modified acrylamide copolymer		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water spray, dry chemical, or foam.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 1, Reactivity 0
HMIS Ratings: Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust. Do not swallow. Avoid contact with eyes, skin, or clothing.

Storage Information Store in a cool, dry location. Store away from oxidizers. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Nitrile gloves. Polyvinylchloride gloves. Neoprene gloves. Rubber gloves. Butyl rubber gloves. Cloth gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Powder

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	White to off white
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.37
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	25-35
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	18
Freezing Point/Range (C):	-8
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide. Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Prolonged or repeated contact may cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	No adverse health effects are expected from swallowing.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	BOD(28 Day): 3% of COD
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM48: 2000 mg/l (Arcatia tonsa)
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	EC50: 3300 mg/l (Skeletonema costatum)
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-5**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-5
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Black
Odor:	Molasses
pH:	9.5-10.3
Specific Gravity @ 20 C (Water=1):	1.32

9. PHYSICAL AND CHEMICAL PROPERTIES

Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	29.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1000 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-601**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-601
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.2
Flammability Limits in Air - Upper (%):	Not Determined
Flammability Limits in Air - Upper (oz./ft3):	3.5

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 1, Reactivity 0
HMIS Ratings:	Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Woody
pH:	7.8
Specific Gravity @ 20 C (Water=1):	1.08
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	30.5
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **KCL POTASSIUM CHLORIDE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: KCL POTASSIUM CHLORIDE
Synonyms: None
Chemical Family: Inorganic Salt
Application: Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Potassium chloride	7447-40-7	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid breathing vapors.

Storage Information Store in a cool, dry location. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Dust proof goggles.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White to gray
Odor:	Odorless
pH:	9.2
Specific Gravity @ 20 C (Water=1):	1.99
Density @ 20 C (lbs./gallon):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Bulk Density @ 20 C (lbs/ft3):	72.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.55

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause moderate skin irritation.
Eye Contact	May cause severe eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: 100-330 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **POZ STANDARD CEMENT 50/50**

Revision Date: 05-Jan-2009

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: POZ STANDARD CEMENT 50/50
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fly ash	68131-74-8	30 - 60%	Not applicable	Not applicable
Bentonite	1302-78-9	1 - 5%	Not applicable	Not applicable
Portland cement	65997-15-1	30 - 60%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1*, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	Not Determined
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Not Determined
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact May cause severe eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	E Corrosive Material D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CEMENT - CLASS H - PREMIUM**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CEMENT - CLASS H - PREMIUM
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Portland cement	65997-15-1	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	<3	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	3.15
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	94
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Keep away from any contact with water.
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure

Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact

Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact

May cause severe eye irritation.

Ingestion

None known

Aggravated Medical Conditions

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	E Corrosive Material D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 25**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 25
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier

Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	168
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 50**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 50
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	72-112
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID®**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID®
Synonyms: None
Chemical Family: Mineral
Application: Weight Additive

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Barium sulfate	7727-43-7	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Pink to tan to gray
Odor:	Odorless
pH:	8-9-
Specific Gravity @ 20 C (Water=1):	4.2
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	100- 155
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	233.4

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact None known.

Eye Contact May cause mild eye irritation.

Ingestion May produce nervous system effects such as feeling of weakness, unsteady walk, and dilation of blood vessels. May affect the heart and cardiovascular system.

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM96: 7500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity:	TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 132.6 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LIME**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LIME
Synonyms: None
Chemical Family: Inorganic
Application: pH Control

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcium hydroxide	1305-62-0	60 - 100%	5 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye and skin burns. May cause respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes
In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion
Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Not Determined

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from acids. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	12.2
Specific Gravity @ 20 C (Water=1):	2.24
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	75
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.2
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.1

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Causes severe skin irritation. May cause skin burns on prolonged contact.
Eye Contact	Causes severe eye irritation May cause eye burns.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 7340 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 100-500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: TLM96: 478,520 ppm (Mysidopsis bahia) SPP @ 8 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Empty container completely. Transport with all closures in place. Return for reuse or dispose in a sanitary landfill according to national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **WALNUT HULLS**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: WALNUT HULLS
Synonyms: None
Chemical Family: Nut Hulls
Application: Loss Circulation Material

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Walnut hulls	Mixture	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye irritation.

4. FIRST AID MEASURES

Inhalation Under normal conditions, first aid procedures are not required.

Skin Under normal conditions, first aid procedures are not required.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Safety glasses.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.1
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 10 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

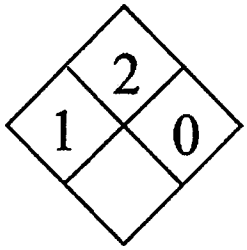
For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

INTEGRITY
INDUSTRIES INC.



****

MATERIAL SAFETY DATA SHEET

****

SECTION I - MANUFACTURER

Integrity Industries, Inc.
2710 E. Corral St.
Kingsville, Texas 78363
Emergency Phone: (361) 595-5561

Revised Date: 06/05/2008
Supercedes: new

THIS DOCUMENT IS PREPARED PURSUANT TO THE OSHA HAZARDOUS COMMUNICATION STANDARD (29 CFR 1910.1200). ALSO, OTHER SUBSTANCE NOT DEEMED "HAZARDOUS" PER THIS MSDS MAY BE LISTED.

SECTION II - MATERIAL IDENTIFICATION

Trade Name: **SYNVERT Base Oil**
Synonyms/Other Designations: Synthetic Drilling Fluid / Polymer Suspension Base
Placard: Not Applicable
Hazard(s): non-hazardous

Component	CAS Number	Weight
Paraffin/Olefin blend	Mixture	100%

SECTION III - PHYSICAL & CHEMICAL DATA

Boiling Point: IBP > 300 °F
Specific Gravity (H2O=1): 0.766
Vapor Density (Air=1): n/a
Appearance: Clear, oily liquid

Pour Point: ND
Vapor Pressure (mm Hg @ 68 °F): 0.135
Solubility in H2O: Insoluble
Viscosity (cSt @104 °F): 1.4

SECTION IV - REACTIVITY

Stability: Stable
Incompatibility: Heat, sparks, open flame. May react with strong acids/strong oxidizing agents, chlorates, nitrates, peroxides.
Hazardous Decomposition Products: Oxides of carbon. Hazardous Polymerizations: will not occur

SECTION V - FIRE & EXPLOSION DATA

Flash Point (ASTM D-93): > 200 °F
Autoignition: n/a
Extinguishing Media: Water spray, Dry Chemical, Foam, CO2
Special Fire Fighting Procedures: Respirators/eye protection and full firefighting protective gear.
Unusual Fire Hazards: Remove containers from source of heat.

SECTION VI - EMERGENCY & FIRST AID DATA

Inhalation: Move to well ventilated area; if breathing difficulties persist after 15 minutes seek medical assistance.
Eye Contact: Wash eye thoroughly for 15 minutes; if irritation persists seek medical assistance.
Skin Contact: Wash affected area with soap & water for 15 minutes; if irritation persists seek medical assistance.
Ingestion: Do not induce vomiting and seek medical advice.

SECTION VII - HEALTH HAZARDS DATA

Acute: May irritate eyes, skin, respiratory, & gastrointestinal tract. Chronic: Repeated/prolonged skin contact may irritate/redden skin, progressing to dermatitis.

SECTION VIII - SPILL & DISPOSAL DATA

Accidental Spill Procedures: Absorb in inert material and dispose of according to local, state & federal regulations. Spill into water should be contained to avoid runoff into waterways.
Handling & Storage: Keep container closed and store in cool dry place. Emptied container still contains material which may ignite with explosive violence if exposed to open flame.

SECTION IX - SPECIAL PROTECTION DATA

Respiratory Protection: Respirator in confined areas.
Ventilation: Desired Exhaust: Mechanical
Protective Gloves: Solvent/chemical resistant gloves
Eye Protection: Safety glasses, goggles.
Other Protection: As required to avoid skin contact.

SECTION X - TRANSPORT INFORMATION

The following may not apply to all shipping situations. Consult 49 CFR for more mode-specific or quantity-specific data.
DOT Proper Shipping Name: Not regulated
DOT Hazard Class or Division: Not regulated
DOT Identification Number: N/A
DOT Packaging Group: III
Type Label(s) Required. none
Placard: Not applicable
*For Limited Quantity requirements see DOT regulation 49 CFR.

SECTION XI - DISCLAIMERS

* SOME INFORMATION PROVIDED HEREIN WAS DRAWN FROM SOURCES OTHER THAN INTEGRITY INDUSTRIES.
THE INFORMATION PROVIDED HEREIN IS BELIEVED BY INTEGRITY INDUSTRIES, INC. TO BE CORRECT & RELIABLE; NO EXPRESSED OR IMPLIED WARRANTY IS PROVIDED HOWEVER.
* INTEGRITY INDUSTRIES, INC. ASSUMES NO RESPONSIBILITY AND DENIES ALL LIABILITY FOR ANY LOSS, DAMAGE, OR EXPENSE CONNECTED WITH CUSTOMERS' METHOD OF HANDLING, STORAGE, USE, AND DISPOSAL OF THIS PRODUCT.
* THE MSDS INFORMATION PROVIDED HEREIN IS APPLICABLE ONLY TO THIS PRODUCT.

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 827239
Watershed Name: N. Bra Calkins Creek	Quality: HQ

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20016-	04/30/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020		Farm Name & Well Number: VE CRUM 1 1	Well Serial #
		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½ ' Quadrangle Name: Damascus	Map Section #: 5
Phone: (281) 847-6031	Project #	Latitude: 41-40-37.8900	Longitude: -75-4-56.7400
Surf Elev at Site: 904 feet	Anticipated Total Depth: 8350 feet	Well Type: TE	Offset distances referenced to NE corner of map section. South 11347 feet West 11136 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/30/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Site ID	Primary Fac ID: 728804
Client Id: 277879	Subfacility Id

Well Record and Completion Report

ll Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20016-		

Address	Well Farm Name & Well #	Serial #
363 N SAM HOUSTON PKWY E STE 2020,	VE CRUM 1 1	

City	State	Zip Code	County	Municipality
HOUSTON	TX	77060-2424	Wayne	Damascus

Phone	Fax	USGS 7.5 min. quadrangle map
(281) 847-6031		Damascus

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20016--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728804
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879	Well API # (Permit / Reg): 37-127-20016-	
Address: 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well #: VE CRUM 1 1	Serial #:
City: HOUSTON	State: TX / Zip Code: 77060-2424	County: Wayne	Municipality: Damascus
Phone: (281) 847-6031	Fax:		

B. Land Application of Tophole Water

Date applied	pH
Volume (bbls)	Spec. cond. (µmhos/cm)

C. Off-site Waste Disposal

Type: ☐ Drilling Fluid (803) **Amount:** bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: **Qty:** bbls or tons

Method of disposal or reuse

☐ Disposal Well (04) ☐ Sewage Treatment Plant (10)

☐ Landfill (05) ☐ Brine Treatment Plant (12)

☐ Other (08)

Facility Information

Name: Permit #:

Hauler Information

Name:

Address:

City: State: Zip Code:

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E. ☐ Dusting

☐ Lined pit, complete Section E. ☐ Solidification

☐ Land application, complete Section F. ☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

5500-FM-OG0042 Rev. 8/2006

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY
DEP Client ID #
Bond Agreement #

BOND EXHIBIT A

For any wells to be covered under a Surety or Collateral Bond.

The listed well(s) are (check one):

☒ Well(s) to be drilled.

☐ Existing permitted well(s) to be bonded.

Signature

Newfield Appalachia PA, LLC
Operator Name

Donald F. Sleeth
Drilling Manager
Type or Print Name and Title

363 N. Sam Houston PkwyE.
Suite 2020
281-674-2501
Address and Telephone Number

Bond Type

☐ Collateral
Financial Institution and (Primary) Instrument ID#

☒ Surety U.S Specialty Insurance Company B005324
Company and Bond Number

Farm Name and Well Number	Permit Number (for existing wells)	FOR DEP USE ONLY
V. E. Crum 1-1		
E. M. Schweighofer 1-1		

Recycled Paper

363 N Sam Houston Pkwy E, Suite 100
Houston, Texas 77060-2421
1-866-896-4232

Newfield Appalachia LLC

REORDER 9019 - U.S. PATENT NO. 5538290, 5575508, 5641183, 5605398, 5830264, 5915008

No. 1064288

DATE 03/09/10 VENDOR NAME COMMONWEALTH OF PENNSYLVANIA VENDOR NO. 110562

INVOICE NO.	DATE	DESCRIPTION	DISCOUNT	NET AMOUNT
COMM030810A	03/08/2010	CK REQ - PERMIT APPLICATION - CRUM 1-1	0.00	1,500.00
			0.00	1,500.00

PLEASE DETACH AND RETAIN THIS STATEMENT AS YOUR RECORD OF PAYMENT. THANK YOU

THIS CHECK IS VOID WITHOUT A COLORED BORDER AND BACKGROUND PLUS A KNIGHT & FINGERPRINT WATERMARK ON THE BACK

Newfield Appalachia LLC
363 N Sam Houston Pkwy E, Suite 100
Houston, Texas 77060-2421

Wells Fargo Bank, N. A.
115 Hospital Drive
Van Wert OH 45891

No. 1064288

56-382
412

CHECK DATE	CHECK NUMBER	CHECK AMOUNT
03/09/10	1064288	$1,500.00

PAY One Thousand Five Hundred Dollars and 00/100 Cents

VOID 90 DAYS AFTER DATE OF ISSUE

TO THE ORDER OF
COMMONWEALTH OF PENNSYLVANIA
230 CHESTNUT ST
MEADVILLE, PA 16335

Second signature required over $50,000

Positive Pay Protected

⑈1064288⑈ ⑆041203824⑆9600088726⑈

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Dear Operator:

Enclosed please find well permit(s) issued for drilling or altering a well. Developing this resource in a safe and environmentally protective manner is of utmost importance. As you may be aware, there have been several recent incidences where water supplies have been affected by natural gas migration. In order to prevent future impacts to the Commonwealth's water resources and provide a mechanism for ensuring public safety, the Department is providing the following information as a reminder of the cementing requirements for oil and gas wells.

Cementing

Properly cementing the casing of a well is critical to protecting water resources, preventing gas migration, and ensuring well integrity. If the casing is improperly cemented or if insufficient cement is used, such as when cement is not returned to the surface, the operator should notify the Department pursuant to 25 Pa. Code § 78.86.

In addition, when cementing surface casing, 25 Pa. Code § 78.85 states that the cement must be allowed to set for at least 8 hours *and* until the cement attains a compressive strength of at least 350 psi. While the cement is setting, the casing must not be disturbed. This includes any activity that may cause movement or pressure changes to the casing or the cement sheath surrounding the casing. After the cement is set, care must be taken when drilling through the plug to prevent damaging the seal at the casing seat. Disturbing the casing while cement is setting or damaging the seal at the casing seat may provide a mechanism for gas and other fluids to escape from the well and contaminate groundwater and water supplies. If this occurs, the operator must notify the Department.

In addition, the Department also reminds you of the following reporting requirements for oil and gas wells.

Reporting

1. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(a) of Chapter 78 of the Oil and Gas Regulations, a **Well Record** must be submitted to the Department within thirty (30) days of cessation of drilling or altering a well.

2. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(b) of Chapter 78 of the Oil and Gas Regulations, a **Completion Report** must be submitted to the Department within thirty (30) days of completion of the well. A copy of the Well Record and Completion Report is enclosed with this letter. This is a newly revised form which requires the operator to certify that the well has been cased and cemented according to the requirements of 25 Pa. Code Chapter 78. Well Record and Completion Report forms that do not contain this certification will not be accepted by the Department. Additional copies of this form can be obtained from the Department's eLibrary at http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-9841

3. Pursuant to Section 212(a) of the Oil and Gas Act, a report specifying the well status and production on the most well-specific basis available is to be provided to the Department. Section 78.121 of Chapter 78 details the reporting time frames required for various well types, waste reporting, and the acceptable format for the **Well and Waste Production Report** submissions.

4. Also note that pursuant to Section 212(b) of the Oil and Gas Act, the Department has the authority to request and does hereby request you submit a digital copy on CD of **ALL Well Logs** (temperature, electrical, radioactive, gamma ray, neutron, induction, resistivity, multi-arm caliper, acoustic, optical, etc.) that have been run on this well.

The above records and logs are to be submitted to the Department of Environmental Protections, Oil and Gas Management, 230 Chestnut St., Meadville, Pa 16335-3481 to the attention of the Regional Oil and Gas Manager.

Thank you for your cooperation in this matter.

Sincerely,

S. Craig Lobins
Regional Manager
Oil and Gas Management

Please note that the most recent revision of the Application for Drilling or Altering a Well must be submitted with all drilling applications. Please check the website below for the most recent revisions for all forms.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/o_gforms.htm

The Erosion,Sediment& Storm water Control Module is no longer being accepted for ESCGP-1 applications. Please submit the complete ESCGP-1 application for any projects. The most recent revisions must be submitted along with the application fee of $500.00

COPY

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Permittee's eFACTS ID	Auth ID
277879	830957
Watershed Name	Quality HQ
Hollister Creek	

WELL PERMIT

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20017-00	05/27/2010
Address		Farm Name & Well Number	Well Serial #
363 N SAN HOUSTON PKWY E		WOODLAND MGMT PARTNERS 1 1	
SUITE 2020		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½' Quadrangle Name: Callicoon	Map Section #: 7
Phone: (281) 847-6031	Project #:	Latitude: 41-45-57.2000	Longitude: -75-6-33.8000
Surf Elev at Site: 1193 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 9393 feet West 7108 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires 05/27/2011 unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-PM-OG0001 Rev. 10/2009

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 1064287	Amount $ 1500

1250
200
50
$1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes	OGO # 67425	Objection Date - Do not issue before: 5/3/10	Well Permit # 127-20017
	Bond # 12382		Special Cond. A B C D E F
	C: 4/13/10 n&m > 5/3/10 JC	Date Approved: 5/11/10 Ball	Watershed Name: Hollister Creek
	INV: 5-27-10		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
Woodland Management Partners	1-1	

County	Municipality	Project # (from DEP)
WAYNE	DAMASCUS	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, *or for a well site that was previously permitted but not drilled*, check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and enter date drilled, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☒ Other (specify)

vertical test well

APPLICATION FEE Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the Oil and Gas Conservation Law? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a workable coal seam? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a workable coal seam, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the coal has been removed?	☐	☒
5. Will the well be drilled through an active (operating or projected) coalmine, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: _____ Operator: _____		
6. Will the well penetrate or be within 2,000 feet of an active gas storage reservoir boundary?	☐	☒
a. If Yes, print the names of: Storage Field: _____ Operator: _____		
7. Is the proposed well location within the permitted area of a landfill?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a stream, spring or body of water identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a wetland or in a wetland?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing building or an existing water supply?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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NORTHWEST REGIONAL OFFICE

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "Coordination of a Well Location with Public Resources" form 5500-PM-OG0076? If yes, attach a completed copy of the form.	☐	☒
12. Is the well site in a Special Protection High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an Earth Disturbance Permit for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

DEP USE ONLY — Date Stamps/Notes
Auth 530957
Site 733315
Cint 277879
APS 717958
Acct 676721
PF 729777
SF 1012951

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date 4-6-10
Donald F. Sleeth			

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Donald and Marie Hartnett	Address: 841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Name: Woodland Management Partners	Address: 308 Egypt Rd. Tafton, PA 18464	X											X
Name: Alfred Cimino	Address: 124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Name: Leon N Clouse, Sr.	Address: PO Box 241 Stanhope, NJ 07874-0241						X						X
Name:	Address:												
Name:	Address:												
Name:	Address:												

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Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☑ water supply, or ☐ building within 200 feet	Date 3/6/10
Address (of above) Leon N Clouse	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

4-27-2007

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Donald and Marie Hartnett	Address: 841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Name: Woodland Management Partners	Address: 308 Egypt Rd. Tafton, PA 18464	X											X
Name: Alfred Cimino	Address: 124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Name: Leon N Clouse, Sr.	Address: PO Box 241 Stanhope, NJ 07874-0241						X						X
Name:	Address:												
Name:	Address:												
Name:	Address:												

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Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location: WOODLAND MANAGEMENT PARTNERS LP	Date: 3/4/2010	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location: WOODLAND MGT SERVICES INC General Partner	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

Richard L. Hitchcock
PRESIDENT

1987-2001

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	
DEP Application Tracking #	
Permit #	127-20017
Project #	

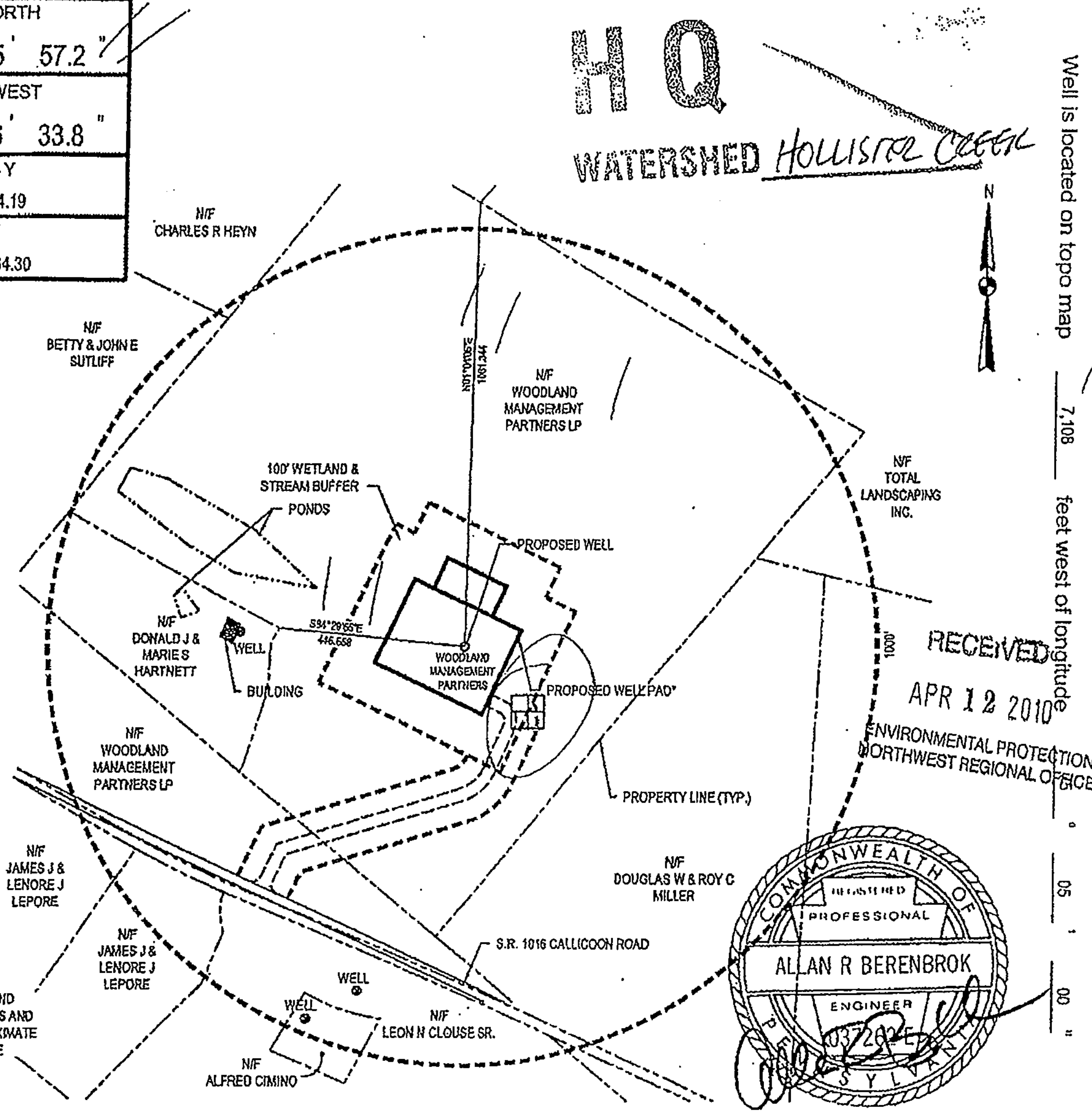
G: JL 5/3/10
C:

Denotes location of well on topo map.

Well is located on topo map 9,393 feet south of latitude 41 ° 37 ' 30 "

Well is located on topo map 7,108 feet west of longitude ° 05 ' 00 "

True Latitude: NORTH	41 ° 45 ' 57.2 "
True Longitude: WEST	75 ° 06 ' 33.8 "
WELL NORTHING - Y	593,664.19
WELL EASTING - X	2,688,764.30



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COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
037202-E

Surveyor or Engineer TETRA TECH Phone # (412) 921-8673 Dwg. # 1 Date 4/6/2010 Scale 1" = 400' Tract Acreage

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83 Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC	Well (Farm) Name: Woodland Management Partners; Well #: 1-1; Serial #:
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060	County - Code: Wayne; Municipality: Damascus; Well Type: Vertical Test
Surface Landowner / Lessor: Woodland Management Partners	USGS 7 1/2 Quadrangle Map Name: Callicoon, PA; Map Section: 7; Surface Elevation: 1193 ft.
Target Formation(s): Onondaga	Angle & Course of Deviation (Drilling): N/A; Anticipated Total Depth: TVD 8,350 ft. TMD 8,350 ft.

Surface Owner of Water Supply within 1000 ft	Approximate Course and Distance to Water Supply	Owner / Lessee / Operator of Workable Coal Seam	Name of Coal Seam Owner / Lessee / Operator
Donald and Marie Hartnett	N86d 22' 34"W 537'	N/A	N/A
Leon N. Clouse Sr.	S16d 46' 23"W 862'	N/A	N/A
Alfred Cimino	S22d 36' 51"W 965'	N/A	N/A
		N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\WMP Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/6/2010 10:54:04 AM

5500-PM-OG0002 Rev. 9/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	Auth ID #: 127-20017

Use only if you need additional space for listings.

Applicant / Well Operator Name	DEP ID#	Well (Farm) Name	Well #	Serial #

Surface Owner or Water Purveyor with a Water Supply within 1000 feet	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased or Operated

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NORTHWEST REGIONAL OFFICE

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 830957
Watershed Name: Hollister Creek	Quality HQ:

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20017-00	05/27/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAN HOUSTON PKWY E	WOODLAND MGMT PARTNERS 1 1	
SUITE 2020	Municipality: Damascus / County: Wayne	
HOUSTON, TX 77060-2424	7½' Quadrangle Name: Callicoon	Map Section #: 7

Phone	Project #	Latitude	Longitude
(281) 847-6031		41-45-57.2000	-75-6-33.8000

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1193 feet	8350 feet	GS	South 9393 feet West 7108 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires 05/27/2011 unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-PM-OG0001 Rev. 10/2009

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 10/04/289	Amount $ 1500

1250
200
50
$1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes	OGO # 67425	Objection Date - Do not issue before: 5/3/10	Well Permit # 127-20017
	Bond # 12382		Special Cond. A B C D E F
	C: 4/13/10 n Cms 5/3/10 SC	Date Approved: 5/11/10	Watershed Name: HOLLISTER CREEK
	INV: 5-27-10		Designation: (HQ) EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	
Mailing Address (Street or PO Box)	City	State	Zip +4	Country (if not USA)
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
Woodland Management Partners	1-1	
County	Municipality	Project # (from DEP)
WAYNE	DAMASCUS	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, *or for a well site that was previously permitted but not drilled,* check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and enter date drilled, if known: ______ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
☒ Drill a new well
☐ Deepen a well
☐ Redrill a well
☐ Alter a well
☐ E&S Control Module
☐ Other (specify)

TYPE OF WELL
Check one.
☐ Gas
☐ Oil
☐ Comb. (gas & oil)
☐ Injection, recovery
☐ Injection, disposal
☐ Coalbed Methane
☐ Gas Storage
☒ Other (specify)
vertical test well

APPLICATION FEE
Check applicable.
☐ Marcellus Well: Non-Vertical
☐ Marcellus Well: Vertical
☐ Non-Marcellus Well: Non-Vertical
☒ Non-Marcellus Well: Vertical
☐ $200 (Home Use Well)
☐ $500 E&S Fee
☐ $ 0 (Rehab orphan)
☒ Vertical: Length 8350 ft.
☐ Marcellus: Length ______ ft.
☐ Non-Vertical: Length ______ ft.
Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the Oil and Gas Conservation Law? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a workable coal seam? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a workable coal seam, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the coal has been removed?	☐	☒
5. Will the well be drilled through an active (operating or projected) coalmine, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: ______ Operator: ______		
6. Will the well penetrate or be within 2,000 feet of an active gas storage reservoir boundary?	☐	☒
a. If Yes, print the names of: Storage Field: ______ Operator: ______		
7. Is the proposed well location within the permitted area of a landfill?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a stream, spring or body of water identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a wetland or in a wetland?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing building or an existing water supply?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐
11. Will the well be located where it may impact a public resource as outlined in the "Coordination of a Well Location with Public Resources" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a Special Protection High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an Earth Disturbance Permit for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. ______	☐	☒

DEP USE ONLY
Date Stamps/Notes
Auth 830957
Site 733315
Clnt 277879
APS 717958
Acct 676721
PF 729777
SF 1012151

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NORTHWEST REGIONAL OFFICE

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date 4-6-10
Donald F. Sleeth			

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Donald and Marie Hartnett	Address: 841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Name: Woodland Management Partners	Address: 308 Egypt Rd. Tafton, PA 18464	X											X
Name: Alfred Cimino	Address: 124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Name: Leon N Clouse, Sr.	Address: PO Box 241 Stanhope, NJ 07874-0241						X						X
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☑ water supply, or ☐ building within 200 feet	Date: 3/6/10
Address (of above): Leon n Clouse	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

4-27-2011

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Donald and Marie Hartnett	Address: 841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Name: Woodland Management Partners	Address: 308 Egypt Rd. Tafton, PA 18464	X											X
Name: Alfred Cimino	Address: 124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Name: Leon N Clouse, Sr.	Address: PO Box 241 Stanhope, NJ 07874-0241						X						X
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location WOODLAND MANAGEMENT PARTNERS LP	Date 3/4/2010	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location WOODLAND MGT SERVICES, INC General Partner	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

President

1971-2001

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: JL 5/3/10
	Permit # 127-20017	C:
	Project #	

Denotes location of well on topo map.

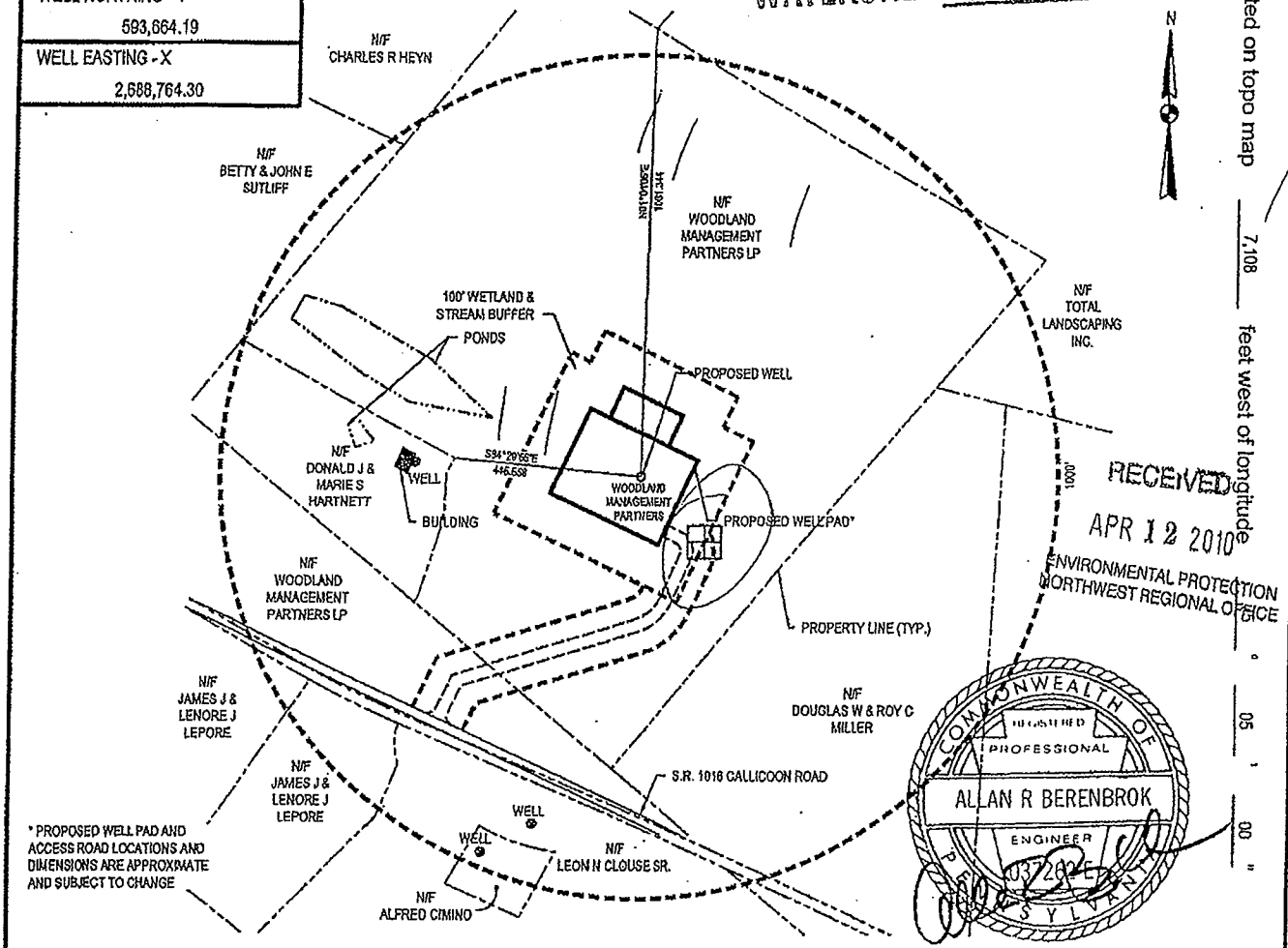
Well is located on topo map 9,393 feet south of latitude 41 ° 37 ' 30 "

True Latitude: NORTH	41 ° 45 ' 57.2 "
True Longitude: WEST	75 ° 06 ' 33.8 "
WELL NORTHING - Y	593,664.19
WELL EASTING - X	2,688,764.30

Well is located on topo map 7,108 feet west of longitude

HQ

WATERSHED HOLLISTER CREEK



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COMMONWEALTH OF REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
PENNSYLVANIA

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1 | Date: 4/6/2010 | Scale: 1" = 400' | Tract Acreage:

Lat. & Long Metadata Method: GPS	Accuracy: +/- 1 ft.	Datum: NAD83	
Elevation Metadata Method: GPS	Accuracy: +/- 1 ft.	Datum: NAD83	Survey Date: Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well (Farm) Name: Woodland Management Partners	Well #: 1-1 / Serial #:
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne	Municipality: Damascus / Well Type: Vertical Test
Surface Landowner / Lessor: Woodland Management Partners		USGS 7 1/2 Quadrangle Map Name: Callicoon, PA	Map Section: 7 / Surface Elevation: 1193 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth: TVD 8,350 ft. / TMD 8,350 ft.

Name of Water Purveyor or Surface Water Supply within 1000'	Approximate Distance from Water Source	Owner of Water Supply within 1000'	Name of Coal Seam Owned / Leased / Operated
Donald and Marie Hartnett	N86d 22' 34"W 537'	N/A	N/A
Leon N. Clouse Sr.	S16d 46' 23"W 862'	N/A	N/A
Alfred Cimino	S22d 36' 51"W 965'	N/A	N/A
		N/A	N/A

R:_Marcellus Shale Projects\Newfield\40679 - Newfield Wells\Well Plat Permits\Permit Drawings\WAP Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/6/2010 10:54:04 AM

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	Auth ID #: 127-20017

Use only if you need additional space for listings.

Applicant / Well Operator Name	DEP ID#	Well (Farm) Name	Well #	Serial #

Surface Owner or Water Purveyor with a Water Supply within 1000 feet	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased or Operated

RECEIVED
APR 12 2010
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NORTHWEST REGIONAL OFFICE

HIGHWAY OCCUPANCY PERMIT

PENNDOT

PERMIT NO.	04043824
ORGANIZATION	046
DATE ISSUED	051010
PERMIT FEES	25.00
ACCOUNT NO.	
COUNTY	63
TOWNSHIP/BORO	206

1

DESCRIPTION	512	
STATE ROUTE NO.	1016	
SEGMENT(S)	0090	0090
OFFSET TO OFFSET	0470	0470

2

DESCRIPTION		
STATE ROUTE NO.		
SEGMENT(S)		
OFFSET TO OFFSET		

3

DESCRIPTION		
STATE ROUTE NO.		
SEGMENT(S)		
OFFSET TO OFFSET		

4

TOWNSHIP/BORO		
DESCRIPTION		
STATE ROUTE NO.		
SEGMENT(S)		
OFFSET TO OFFSET		

PERMITTEE: WOODLAND MANAGEMENT PARTNERS LP

ADDRESS: 308 EGYPT ROAD

POST OFFICE: TAFTON PA ZIP CODE: 18464-

COUNTY: WAYNE

TOWNSHIP/BORO: DAMASCUS

BOND/AGREEMENT NUMBER:

ALL WORK UNDER THIS PERMIT MAY BE STARTED ON: 05/10/10

AND SHALL BE COMPLETED ON OR BEFORE: 05/10/11

Immediately upon completion of the work, Permittee shall notify the permit office where application was made. Subject to all the conditions, restrictions, and regulations prescribed by the Pennsylvania Department of Transportation, (see in particular 67 Pa. Code, Chapter 203/212, 441 and 459) and subject to the plans, special conditions, or restrictions herein set forth or attached hereto. This permit shall be located at the work site and shall be available for inspection by any police officer or department representative.

DESCRIPTION OF WORK

INSTALL MINIMUM USE DRIVEWAY WITH DRAINAGE FACILITIES AT SR 1016 SEG 0090 OFFSET 0470 TO SEG 0090 OFFSET 0470
THIS PERMIT AUTHORIZES WORK ONLY IN DEPARTMENT HIGHWAY RIGHT OF WAY.
IT IS THE PERMITTEE'S RESPONSIBILITY TO KEEP VEGETATION TRIMMED IN ORDER TO MAINTAIN MINIMUM SIGHT DISTANCE. NO OBJECTS MAY BE PLACED WITHIN THE LINE OF SIGHT.
SHOULDERS MUST BE RESTORED IN ACCORDANCE WITH APPROPRIATE SECTION OF PUB. 408 AND ROADWAY CONSTRUCTION STANDARD RC-25.
SURFACE DRAINAGE MAY NOT BE DIRECTED ONTO STATE HIGHWAY RIGHT OF WAY.
PERMITTEE MUST MAINTAIN ACCESS FROM THE PAVEMENT EDGE TO AT LEAST 20 FEET OUTSIDE THE HIGHWAY RIGHT OF WAY.
ALL DISTURBED AREAS OUTSIDE THE PAVEMENT OR SHOULDER SHALL BE RESTORED TO A CONDITION AT LEAST EQUAL TO THAT WHICH EXISTED BEFORE THE START OF WORK.
MINIMUM WORK ZONE TRAFFIC CONTROL TO BE IN ACCORDANCE WITH PUB. 213, FIGURE(S): 5, 7, & 10A. SEE PUB 213 FOR ADDITIONAL DETAILS.
DRAINAGE INSTALLED BY THIS PERMIT IS THE RESPONSIBILITY OF THE PERMITTEE TO CONTINUALLY MAINTAIN OR REPLACE.
DEPARTMENT MUST BE NOTIFIED IN WRITING UPON COMPLETION OF WORK.

THIS PERMIT IS NOT VALID UNTIL SIGNED BY THE DISTRICT ENGINEER OR HIS AUTHORIZED REPRESENTATIVE

Acknowledgement of Completion

Permitted work has been completed.

Date _____ By _____

for ALLEN D. BIEHLER, P.E. 5/3/10

Secretary of Transportation

GEORGE ROBERTS, P.E., D.E.

District Executive

PERMITTEE

APPLICATION FOR MINIMUM USE DRIVEWAY

A Minimum Use Driveway Is A Residential Or Other Driveway Which Is Expected To Be Used By Not More Than 25 Vehicles Per Day (i.e. 50 A.D.T)

APPL. NO. 075293

SEE PUBLICATION 312 GUIDE

APPLICANT/PROPERTY OWNER		
Woodlands Management Partners LP		
ADDRESS		
308 Egypt Road		
POST OFFICE		ZIP CODE
Tafton PA		18464
PHONE	FEE	CHECK NO.
570-857-1072	25.00	5049

APPLICATION IS MADE TO

☒ CONSTRUCT A NEW DRIVEWAY ☐ ALTER AN EXISTING DRIVEWAY

DATE WORK SCHEDULED TO BEGIN May 15, 2010

DATE WORK SCHEDULED TO BE COMPLETED August 31, 2010

LOCATION OF PROPOSED DRIVEWAY

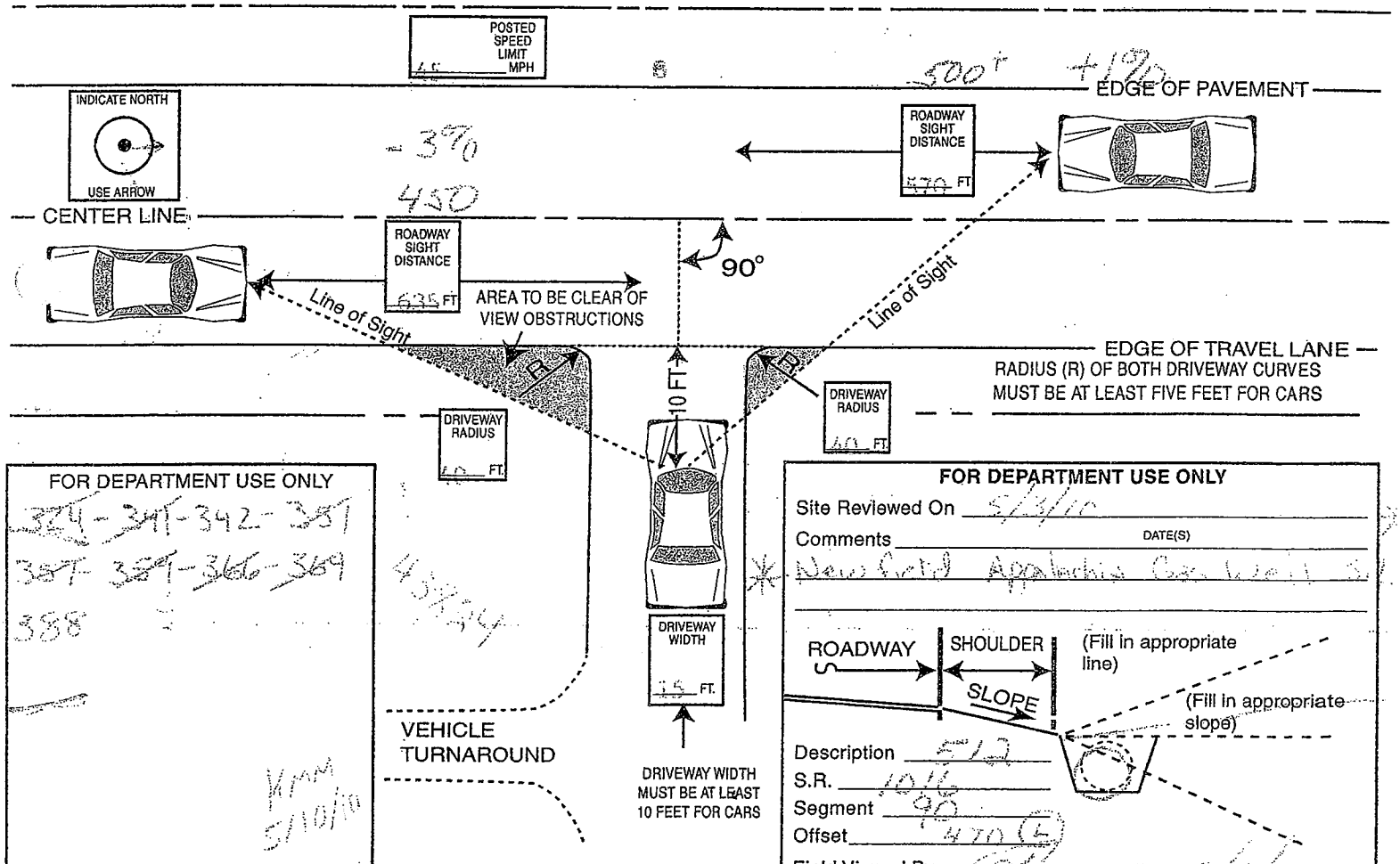
County Wayne 63

Township/Boro Damascus 206

Route No. S.R. 1016 (Callicoon Rd)

Name of Nearest Intersection Little Equinunk Creek

Distance to Nearest Intersection in Feet 3520 ft.



FOR DEPARTMENT USE ONLY

324-341-342-357
357-359-366-369
358

KMM 5/10/10

FOR DEPARTMENT USE ONLY

Site Reviewed On 5/3/10 DATE(S)

Comments New Cntd Appalachia Gas Well S

ROADWAY SHOULDER (Fill in appropriate line)

SLOPE (Fill in appropriate slope)

Description SR2

S.R. 1016

Segment 90

Offset 470 (L)

Field Viewed By SIGNATURE DATE

Is any portion of the property reserved for a person with a disability or a severely disabled veteran? ☐ YES ☒ NO

Under and subject to all the conditions, restrictions and regulations prescribed by the Pennsylvania Department of Transportation and the issued Permit, Form M-945P.

The applicant certifies that all statements contained herein are true and correct.

By X _____ 4/14/2010
SIGNATURE(S) DATE

Visit our website at: www.dot.state.pa.us

ROADWAY USE AND MAINTENANCE AGREEMENT

AND NOW THIS 21 day of June, 2010, it is agreed by and between Damascus Township, Wayne County, Pennsylvania, by and through its Board of Supervisors and New Field Exploration, a duly formed corporation with its principal place of residence at 363 Sam Houston, Houston, TX, (jointly "the Parties") to enter into this agreement regarding the use and maintenance of township roadways necessary for transportation and travel of equipment and personnel to and from oil and gas wells on various leaseholds within the Township;

WHEREAS, Damascus Township, (Hereinafter reference to as the "Township") has control and jurisdiction of various Township owned roadways with its boundaries; and

WHEREAS, the NewField (Hereinafter referred to as the "Operator"), is the owner of certain oil and gas leaseholds in Wayne County, Pennsylvania; and

WHEREAS, the Township and Operator are desirous of entering into a formal agreement for the use of Township roadways for the purposes of providing ingress, regress and egress to various leaseholds for which excess traffic and equipment transportation is necessary for the development of said oil and gas wells on said leaseholds, and

WHEREAS, the Township and Operator are desirous of addressing the excess road maintenance costs and expenditures necessary for and incurring from construction, drilling and completion stages of gas and oil operations utilizing said Township roadways.

NOW THEREFORE, in consideration of a faithful performance of each party of mutual covenants and promises hereinafter set forth, and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged as follows:

1. The Operator agrees to identify those Township roads or portions of roads to be used by its vehicles and equipment prior to the commencement of operations.

2. After receiving from the Operator a list of such roads, the Parties agree to jointly inspect the pertinent roadways promptly to determine the road structure, its condition and the existence of any buried utility lines, and to depict any surface characteristics. Operator will prepare a pre-use road inspection report documenting the road conditions and characteristics.

3. The Operator agrees to restore any affected roadways to a condition equal or better than the pre-use condition of said road(s) within 180 days of the conclusion of Operator's use, weather permitting; provided that Operator's liability shall be limited to only that portion of the cost of repair and restoration which exceeds normal and routine maintenance, costs, and which is caused by the Operator's vehicles and equipment.

4. In the event that the pre-use condition of any roadway requires or warrants repaving or improvements prior to use, the Operator shall be liable for such improvements only to the extent that the parties agree that such improvements would reduce damage caused by the Operator's use, and agree on ratably sharing the costs of such improvements.

5. In the event that the Township incurs additional costs associated with maintenance of said roadway as a direct result of the Operator's activities (including those of their agents, employees and contractors), including dust suppression needed during peak activity periods, the Township will provide prior notice of such additional maintenance needed, and if possible, obtain a cost estimate, and deliver the same to the Operator. Operator will only be liable for such maintenance costs to the extent that the parties agree that such maintenance is necessary and that the parties shall share the costs.

6. The Operator agrees to reimburse the Township for reasonable additional costs agreed upon in a reasonable and prompt period of time, but not to exceed forty-five (45) days.

7. Upon completion of all improvements called for in the final inspection report, the Operator shall submit a certification of the improvements made to the Township, and such certification shall be deemed approved unless the Township gives

written notice of objections to the certification within ten days of receipt of the certification.

8. Upon conclusion of the drilling activities anticipated by this Agreement, both parties will promptly inspect the roadways utilized and make a determination as to what, if any, improvements or maintenance need to be performed by the Operator to discharge the obligations required by this Agreement. This final report then shall be deemed to be a complete list of improvements needed to discharge this Agreement, binding upon all parties.

9. In the event that future drilling activities occur utilizing the same or part of a Township roadway(s) previously improved by virtue of this agreement, then the future contemplated activities shall cause the provisions of this agreement to resume as if said roadway(s) were being initially contemplated, with a new pre-use road inspection report, and such follow up requirements as previously herein set forth.

10. The Operator shall be given the option of having any agreed upon repair work performed by a contractor of its choice.

11. This Agreement is entered into in lieu of the Township incurring the cost and inconvenience of implementing a state compliant road bonding system and shall survive any future creation of any such system as to the Operator and remain the operative relationship between the Township and the Operator until terminated by the mutual agreement of the Township and the Operator.

12. This agreement shall be binding upon the successors and assigns of the parties hereto and shall be deemed to be a covenant running with the roads described above. This agreement shall not be transferred or assigned by the Operator without the consent in writing of the Township, which consent will not be unreasonably withheld.

IN WITNESS WHEREOF, this instrument has been executed by the undersigned the Pr Production Manage, this 21 day of June, 2010.

TOWNSHIP:

Damascus Township Supervisors

By: _____

By: _____

By: _____

OPERATOR:

New Field Exploration

(Company Name)

By: _____

Company Representative

DAMASCUS TOWNSHIP, WAYNE COUNTY, PA.

ROAD INSPECTION REPORT

PRINT NAME: _____ DATE: _____

SIGN: _____ COMPANY: _____

[ ] PRE- INSPECTION

[ ] POST INSPECTION

[ ] VIDEO RECORD: [ ] YES

[ ] NO

ROAD CONDITION: _____

_____

_____

ROAD SURFACE: ACP \ ASBC \ CRUDE \ GRAVEL:

_____

DRAINAGE [CENTERLINE, CULVERTS, APPROACHES] :

_____

_____

_____

SIGNAGE: _____

_____

EXISTING DUST CONTROL: [ ] YES

[ ] NO: _____

OTHER FACTORS EFFECTING THE ROADWAY: _____

_____

_____

WILL THE COMPANY PROVIDE A GRADER TO MAINTAIN THE DRIVING SURFACE? YES [ ] OR NO [ ]

COMMENTS: _____

_____

PREPAREDNESS, PREVENTION, AND CONTINGENCY PLAN
WAYNE COUNTY FIELD
WAYNE COUNTY, PENNSYLVANIA

Prepared for:

NEWFIELD APPALACHIA PA LLC
363 N. Sam Houston Pkwy E., Suite 2020
Houston, TX 77060

Prepared by:

TETRA TECH NUS INC
116 N. Washington Avenue
Scranton, PA 18503

May 2010

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 DESCRIPTION OF FACILITY

1.1 DESCRIPTION OF THE INDUSTRIAL OR COMMERCIAL ACTIVITY

Newfield Appalachia PA LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will involve natural gas exploration of the Marcellus Shale formation, which will include site preparation, drilling, and well development and production activities. Wastes generated during these activities will be typical for gas drilling operations and will include drill cuttings, produced water, drilling and frac fluids, waste oil, municipal waste and trash. No hazardous waste is expected to be generated at the Newfield sites.

Newfield is currently in the exploratory phase of operations, which will require construction activities for new natural gas well pads and access roads.

This Prevention, Preparedness and Control (PPC) Plan applies to all well sites in Wayne County, Pa.

The attached map (Figure 1) in Appendix B shows the area covered under this PPC Plan Figure 2 is the required 7.5 topographic map of the specific well site. The proposed Site Plan (Figure 3) shows the site layout, the well site boundaries, material storage areas, waste storage areas, dike drains and drainage that leads away from the well site, and the entrances and exits to the well site.

During the different stages of site preparation, construction, drilling, well development and production, the site will store various fuels, oils and chemicals on-site. A chemical and container inventory for the specific well site is located in Table 1 of Appendix C.

1.2 DESCRIPTION OF EXISTING EMERGENCY RESPONSE PLANS

This is a new facility and this plan has been prepared prior to construction of the well pad. There are no previous emergency response plans.

A separate Spill Prevention Control and Countermeasure (SPCC) Plan will be prepared for each facility meeting the requirements defined in 40 CFR§112.

1.3 MATERIAL AND WASTE INVENTORY

Information in this section is used to evaluate the prevention, containment, mitigation, cleanup, and disposal measures which would be used in the event of a spill, discharge, explosion, or fire. Oils, chemicals and other hazardous materials anticipated to be used and stored at the facility during site preparation and construction, drilling, well development and production are listed in Table 1.

MSDS's will be maintained onsite for chemicals and compounds used at the facility in accordance with the Occupational Safety and Health Administration (OSHA) worker right-to-know requirements, as appropriate.

1.4 POLLUTION INCIDENT HISTORY

Newfield has not had any reportable incidents for this facility.

1.5 IMPLEMENTATION SCHEDULE FOR PLAN ELEMENTS NOT CURRENTLY IN PLACE

All plan elements are in place.

1.6 PURPOSE AND IMPLEMENTATION OF PPC PLAN

Newfield has developed and will implement this PPC Plan for effective action to minimize and abate hazards to human health and the environment from fire, explosion, and emission or discharge of pollutants to air, soil, surface water or groundwater. This plan was prepared to satisfy the requirements set forth in 25 PA Code Section 78.

The Drilling Manager serves as the Primary Emergency Coordinator and is responsible for the preparation and implementation of the PPC Plan. The PPC Plan has been prepared and implemented in general accordance with Pennsylvania Department of Environmental Protection (PADEP) guidelines, and will be submitted to PADEP for approval at such time as the PADEP may prescribe.

This PPC Plan identifies and describes any arrangements with police departments, fire departments, hospitals, contractors, and state, county, and local emergency response teams to coordinate emergency services.

The PPC Plan lists names, addresses and phone numbers of all persons identified to act as Emergency Coordinator. One person is named as the Primary Emergency Coordinator and others are listed in the order in which they will assume responsibility as alternates. The PPC Plan also includes a list of emergency equipment at the facility, the location and a physical description of emergency equipment, and a brief outline of emergency equipment capabilities.

1.7 PLAN REVISIONS

This PPC Plan will be reviewed and amended, annually, or whenever:

- Applicable PADEP regulations are revised;
- The plan fails in an emergency;
- The list of Emergency Coordinators changes;
- The list of emergency equipment changes; and
- Construction, operation, maintenance, or other circumstances change in a manner that materially increases the potential for fires, explosions, or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency.

2.0 IMPLEMENTATION OF PPC PLAN

2.1 ORGANIZATIONAL STRUCTURE OF FACILITY FOR IMPLEMENTATION

The Drilling Manager has been designated as the Primary Emergency Coordinator. The Primary Emergency Coordinator is responsible for the following:

- Coordination of spill cleanup activities;
- Notification of appropriate authorities; and
- Tank and chemical storage area inspections.

The Drilling Manager has administrative responsibility for updating, maintaining, and implementing this PPC Plan. Specifically, these responsibilities include:

- Identification of materials and wastes handled during site operation (inventory);
- Identification of potential spill sources (risk assessment);
- Establishment of spill reporting procedures;
- Coordination of the visual inspection program;
- Review of past incidents, spills, and countermeasures employed;
- Coordination and implementation of the PPC Plan goals;
- Training/educational programs and updates;
- Ensuring periodic review of the PPC Plan for adequacy and appropriateness;
- Administration and institution of appropriate changes at regular intervals;
- Review of new construction and process changes relative to the PPC Plan;
- Evaluation of PPC Plan effectiveness prior to, during and subsequent to its implementation; and
- Instituting improvements to the PPC Plan.

The Production Manager is designated as Secondary Emergency Coordinator, and, in the absence of the Drilling Manager, will assume the role of emergency coordinator for emergencies. The Secondary Emergency Coordinator will report directly to the Primary Emergency Coordinator in matters regarding this plan, and can assist with implementing the above-listed items.

2.2 LIST OF EMERGENCY COORDINATORS

As required by 25 PA Code 265.55, there will be at least one employee, either on the construction site or on call, with the responsibility for coordinating emergency response measures. The Primary and Secondary Emergency Coordinators will be thoroughly familiar with this PPC Plan, site operations and activities, the location and characteristics of materials and wastes, the location of the facility's records, and the layout of the facility. The Emergency Coordinators have the authority to commit the resources necessary to carry out the PPC Plan and for coordinating emergency response measures. In the event of a spill or release, one of the Emergency Coordinators will be immediately notified. The following individuals have been designated to act as Emergency Coordinators:

Primary Emergency Coordinator

Name: Don Sleeth
Title: Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Name: Jack Cochran
Title: Production Manager
Office: 814-437-2344
Cell: 814-671-1557

2.3 DUTIES AND RESPONSIBILITIES OF THE EMERGENCY COORDINATOR

As required by 25 PA Code 265.56 and the PPC Plan Guidance Documents, whenever there is an imminent or actual emergency situation, the Emergency Coordinator or his designee must immediately:

1. Notify all facility personnel.
2. Notify appropriate state or local agencies with designated response roles and contracted emergency response companies if additional assistance is required.
3. Identify the problem. Is it a physical emergency such as a fire, explosion, or spill? Is it a natural disaster such as a flood, tornado, or other severe weather? Is it a social emergency such as a bomb threat, riot, or vandalism?

4. Assess the health or environmental hazards and how this problem or condition will affect employees or its affect on the surrounding community.

5. Take all reasonable measures to stabilize the situation. The Emergency Coordinator will take all reasonable measures to ensure that the fire, explosion, emission, or discharge does not reoccur or spread to other materials at the site. These measures can include, when appropriate, stopping operations, collecting and containing released materials or wastes, and removing or isolating containers.

Whenever there is an emission, discharge, fire, or explosion, the Emergency Coordinator or his designee must immediately attempt to identify the character, exact source, amount, and aerial extent of emitted or discharged materials. He/she may do this by observation, by review of facility records or manifests, and, if necessary, by instrumental and chemical analysis. Concurrently, the Emergency Coordinator or his designee must assess possible hazards to human health or the environment that may result from emission, discharge, fire, or explosion. This assessment must consider both direct and indirect effects of the emission, discharge, fire, or explosion.

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion which would threaten human health or the environment (beyond the limits of the site) and if evacuation of local areas may be advisable, he/she must immediately notify the applicable local authorities (police, fire, etc.); he/she must also immediately notify the PADEP by telephone at (800) 541-2050 (24-hour number), PADEP Northeast Region at (570) 826-2511 (24-hrs), the National Response Center at (800) 424-8802, Wayne County Emergency Management Agency (EMA) at (570) 253-1622, and the Pennsylvania Emergency Management Agency at (717) 651-2001, and report the following information:

- Name of the person reporting the incident;
- Name and location of the facility;
- Telephone number where the person reporting the spill can be reached;
- Date, time, and location of the incident;
- A brief description of the incident, nature of the materials involved, extent of any injuries, and possible hazards to human health or the environment;
- The estimated quantity of the materials spilled; and
- The extent of contamination of land, water, or air, if known.

If spills or discharges of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance in greater than reportable quantities has occurred, the Emergency Coordinator must notify DEP at (800) 541-2050 and the National Response Center at (800) 424-8802 and report the above information. For an offsite release (spill or discharge) of a reportable quantity of a CERCLA hazardous substance or a Superfund Amendments and Reauthorization Act Extremely Hazardous Substance, the Emergency Coordinator must immediately notify the National Response Center at (800) 424-8802 and report the above information.

If a release occurs from a storage tank which enters a water supply or which threatens the water supply of downstream users, the Emergency Coordinator must immediately notify the Wayne County EMA (570) 253-1622, the Pennsylvania Emergency Management Agency at (717) 651-2001, and DEP at (800) 541-2050. If appropriate, the Emergency Coordinator may assist the Emergency Management Agencies in notifying the downstream water users. The priorities for notification will be by closest proximity to the release site.

During an emergency, the Emergency Coordinator will take all reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, recur, or spread to other materials at the facility. These shall include, where applicable, stopping facility operations, collecting and containing released materials, and removing or isolating containers. If the facility stops operations in response to a fire, explosion, emission, or discharge, the Emergency Coordinator must ensure that adequate monitoring is conducted for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment whenever this is appropriate.

The Emergency Coordinator will oversee and direct facility personnel in the performance of their responsibilities for addressing the emergency situation. Immediately following an emergency, the Emergency Coordinator (with PADEP approval) must provide for treating, storing, or disposing residues, contaminated soil, etc., from an emission, discharge, fire, or explosion at the construction site. The Emergency Coordinator must ensure that in the affected areas of the facility, no material incompatible with the emitted or discharged residues is processed, stored, treated, or disposed until cleanup procedures are completed and that all emergency equipment utilized in implementation of the PPC Plan is cleaned and fit for its intended use before operations are resumed. Newfield will notify PADEP and the appropriate State or local

authorities that the facility is in compliance before operations are resumed in the affected areas of the facility. Newfield will note the time, date and details of an incident that requires implementing the PPC Plan.

Within 15 days after the incident, Newfield will submit a written report on the incident to PADEP and the U.S. Environmental Protection Agency regional administrator. The report must be submitted to:

Director - Bureau of Water Quality Management
Pennsylvania Department of Environmental Protection
909 Elmerton Avenue
Harrisburg, PA 17110

Regional Administrator
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Director - PADEP Northeast Office
Pennsylvania Department of Environmental Protection
2 Public Square
Wilkes-Barre, PA 18711

The report should include the following information:

- Name, address, and telephone number of the individual filing the report;
- Name, address, and telephone number of the facility;
- Date, time, type, and location of incident;
- A brief description of the circumstances causing the incident;
- Description and estimated quantity (by weight) of materials or wastes involved;
- The extent of injuries, if any;
- An assessment of actual or potential threat to human health or the environment and assessment of contamination of land, water, or air, where applicable;
- Estimated quantity and disposition of recovered materials or wastes that resulted from the incident; and
- A description of what actions Newfield intends to take to prevent a similar occurrence in the future.

2.4 CHAIN OF COMMAND

Facility personnel must report emergency situations to the Emergency Coordinators. A Chain of Command flow chart (Table 5, Appendix C) has been developed and should be implemented during an emergency. The Emergency Response Chain of Command flow chart will be posted

next to all telephones onsite, posted in areas where potential emergency situations could arise, and placed in onsite company vehicles, as appropriate.

2.5 DISTRIBUTION OF THIS PPC PLAN

A copy of this PPC Plan and subsequent revisions will be distributed to:

- Drilling Manager (Primary Emergency Coordinator)
- Production Manager (Secondary Emergency Coordinator)

The PPC Plan will be reviewed and amended, if necessary, based on the criteria described earlier in Section 1.7.

3.0 SPILL AND LEAK PREVENTION AND RESPONSE

The site will be maintained and operated to minimize the possibility of a fire, explosion or discharge of oils, hazardous materials or their constituents to air, soil, surface water or groundwater which could threaten human health or the environment, in accordance with the requirements of 25 PA Code Section 265.31.

3.1 PRE-RELEASE PLANNING

The following sections discuss specific locations where the potential exists for accidental spills of oils and/or chemicals. The controls that are in place to minimize the potential for an uncontrolled release to the environment are also discussed. In the event that an uncontrolled spill of hazardous substances occurs, the procedures described in Section 4.0 will be followed.

To enhance spill prevention at the facility, great care will be exercised in handling oil and other materials covered in this PPC Plan. Any unusual conditions observed by any employees or contractors will be reported to one of the Emergency Response Coordinators. Management personnel whose responsibilities include involvement with the materials discussed in this document will also be familiar with this plan and the procedures recommended for spill prevention.

Spill Prevention Measures: Procedures that are to be followed to prevent and/or minimize oil spills at the Newfield facility include:

- ASTs and/or containers will be stored in secondary containment with sufficient volume;
- ASTs and regulated material containers will be visually inspected weekly for leaks;
- Special care will be taken when transferring regulated materials to prevent product loss;
- Regulated materials will be stored in a manner that minimizes the potential for contact with stormwater;
- Absorbent and spill control materials shall be maintained on-site for emergency use;

- Emergency response personnel will be familiar with procedures to follow in the case of a spill; and

- In cases where there may be leaking equipment or operations where oil or oil-related compounds are leaked, spilled, or otherwise released, containment booms or absorbent materials shall be used and equipment shall be repaired.

In the event that an uncontrolled spill of oil or a hazardous material occurs, the procedures described in Section 4.0 will be followed. Responses should be coordinated with federal, state and local agencies as appropriate.

3.2 MATERIAL COMPATIBILITY

The majority of materials received on-site in totes, drums, pails or other small containers are stored in the containers supplied by the manufacturer.

Construction materials used for the ASTs have been selected and designed to be compatible with the materials that are being stored and are typical for the natural gas industry.

3.3 INSPECTIONS AND MONITORING PROGRAM

Operating equipment will be inspected daily, and a copy of the inspection and maintenance form is included in Appendix A. Employees are responsible for detecting and reporting potential problems on the inspection and maintenance form.

Storage tank inspections will be conducted weekly and include evaluation of the following: pumps, valves, and fittings for leaks; the tank condition for evidence of corrosion; secondary containment; evidence of spilled materials; and effectiveness of housekeeping practices.

Completed inspection forms and inspection reports will be maintained in the Primary Emergency Coordinator's office. Noncompliance issues identified during the comprehensive site evaluation will be addressed in a timely manner. If additional control measures are required, implementation of the measures will generally occur within 90 days of the site evaluation. Compliance issues that require revisions to the PPC Plan (description of additional pollutant sources, measures, or controls) will be incorporated into the plan within approximately 15 days of the site evaluation.

Stormwater Management System: Stormwater inspections will include an evaluation of best management practices (BMPs), where appropriate. In accordance with the erosion and sedimentation control plan prepared for the site, erosion and sedimentation control (ESC) measures will be implemented where there is the potential for sediment or soil particles to impact stormwater quality. Repairs will be made, as necessary, following the site inspection.

Storage Tanks and Drum Storage Areas: Tanks and drum storage areas will be accessed daily. Spills or leaks that may occur will be contained by secondary containment and noted as part of routine facility operations. To enhance the daily observations, periodic inspections will be performed for the tank and drum storage areas as described in Table 2. The inspections will include observation of spill and/or leaks and observations of the condition of associated secondary containment structures. Records for the inspections will be maintained in the Primary Emergency Coordinator's office.

3.4 PREVENTIVE MAINTENANCE

Newfield will ensure that preventative maintenance of operating machinery on each construction site is performed regularly.

3.5 HOUSEKEEPING PROGRAM

The Newfield Construction Manager will be responsible for general construction site housekeeping. Specific steps taken under this program will include:

- Debris and/or sediment removal, as necessary.
- Regular refuse pickup and disposal.
- Proper filling and emptying of storage containers, tanks, and equipment to minimize spill potential.
- Periodic review of good housekeeping procedures in the employee-training program.

Once completed, the Production Manager will have overall responsibility for housekeeping at the facility. Newfield currently does not anticipate that bulk quantities of hazardous waste materials will be stored at the facility.

3.6 SECURITY

The facility is not fully fenced but is located in a remote location with limited access except via the site access road. The facility is normally manned during drilling and well development.

Flow and drain valves are locked and in the off position when in non-operational or non-standby status. The starter controls for each oil pump are locked in the off position when in non-operating or non-standby status. Master flow/drain valves are all located on the Facility and monitored by staff.

Any loading/unloading connections of facility piping is capped or blind flanged when not in service or is in standby service for an extended amount of time.

The facility has lighting sufficient for detection of spills during nighttime operations. Consideration has been given to: (a) discovery of spills occurring during hours of darkness, both by operating personnel, if present, and by non-operating personnel, and (b) prevention of spills occurring through acts of vandalism.

3.7 EXTERNAL FACTOR PLANNING

External factors are not anticipated to increase the risk of a spill or release that would impact human safety or the environment. Power outages, adverse weather conditions, or employee strikes could result in discontinuation of earth moving, drilling or well preparation activities. The Emergency Coordinator will monitor operations and initiate their orderly shutdown when necessary.

Access road conditions may be impacted by adverse weather conditions, possibly increasing the risk of a release of materials being delivered or removed. Truck drivers should report poor road conditions to the Construction or Drilling Manager. If conditions deteriorate to where they may impact safe movement of materials, the construction or Drilling Manager will review the conditions and initiate repairs or road closure as deemed necessary.

3.8 EMPLOYEE TRAINING PROGRAM

Newfield's employee training program enables employees to understand the processes and materials with which they are working, the safety and health hazards, the practices for preventing spills, and the procedures for responding properly and rapidly to spills. It also familiarizes personnel with emergency procedures.

All Newfield employees receive job specific training. Emergency Coordinators, Well Tenders, and other oil or hazardous material handling employees receive annual training on the facility's PPC and SPCC plans.

Job specific training includes preventive maintenance, inspection and monitoring activities, shut down procedures and housekeeping practices. PPC training will include spill/release recognition, initial response, initial notifications and follow-up. The training program is designed to ensure that personnel are able to respond effectively to emergencies by familiarizing them with emergency procedures, emergency equipment systems including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for automatic cut-off systems; communications and alarms systems; response to fires and explosions; site evacuation procedures; and shutdown of operations.

Annual right-to-know training for all facility employees is conducted relevant to the materials present at the facility. Employees will be given detailed instructions regarding the materials and wastes with which they are working; including safety and health hazards, handling methods, proper disposal procedures, and emergency procedures. The location of MSDS's for on-site materials will be identified to all employees.

Training records will be maintained at the facility and in the employee's personnel file.

4.0 COUNTERMEASURES

4.1 COUNTERMEASURES TO BE UNDERTAKEN BY FACILITY

The following sections present general spill response practices to be implemented at the Newfield facility, as appropriate.

4.1.1 Spill Clean-Up Procedures - General

Incidental spills should be contained and cleaned up when discovered per the employees job related training. Clean up material should be placed into a marked container and the Construction or Drilling Manager notified appropriately.

For large spills or spills of oils or hazardous materials which may reach surface water or impact the environment, the employee who first discovers the spill should contact the Emergency Coordinator. He should then work to contain and clean-up the spill.

Spill clean-up involves three steps: containment, removal, and disposal. In the event of a spill, it is very important that the material be contained to the maximum extent possible in order to minimize the effect of the spill and the cost of clean-up. **NOTE: ANY SHEEN ON A WATERBODY (STREAM, RIVER, OR WETLAND) IS A REPORTABLE RELEASE.** Once the spill is contained, the spilled material and contaminated material must be collected and physically removed from the area

4.1.2 Spill Clean-Up Procedures - Specific

The employee should do the following:

- Contain the spill to the smallest area possible using absorbent materials, earthen dikes or other diversion or containment structures. Stormwater collection structures will be either blocked or pumped.
- Block off the area to prevent traffic or employees from entering the area.
- For oils and other organic materials, apply a non-reactive sorbent material, such as Oil-Dri or Kitty Litter, to the spill.
- In the case of a spill of acids hazardous waste, check the MSDS and then neutralize with lime or soda ash if appropriate.
- If a leaking tank is involved, stop liquid flows as appropriate and dike the tank area with earth or absorbent material.

- If a leaking pail, drum or other small container is involved, place it in an over-pack container.
- Clean up spilled material and place it in a marked container.
- Work with the emergency coordinator to properly store the material and arrange for proper disposal

4.1.3 Fire or Explosion

In the case of a fire or explosion, the local fire department should be notified by calling 911. Employees may attempt to extinguish fires using handheld fire extinguishers based upon their job training.

The Emergency Coordinator will determine if evacuation per section 4.4 is required.

4.2 COUNTERMEASURES TO BE UNDERTAKEN BY CONTRACTORS

The following list shows area emergency response contractors to contact should the facility require outside help.

Company: Minuteman Spill Response, Inc.
Address: P.O. Box 10
Mifflinville, PA 18631
Telephone Number: 570-759-3658
Response Time: Approximately 2 to 3 hrs
Equipment and Services: Hazardous Materials Emergency Response

4.3 INTERNAL AND EXTERNAL COMMUNICATIONS AND ALARM SYSTEM

This section describes the internal communications or alarm used to provide immediate emergency instruction (voice or signal) to installation personnel, and the external communications or alarm system used to summon emergency assistance from local police or fire departments.

Newfield facilities in Wayne County are remote and generally do not have land-line telephone systems or alarm systems. The primary means of communication is via voice or mobile telephones. Mobile phones are provided to the Drilling and Production Managers (Primary and Secondary Emergency Coordinators).

Fire, police, and emergency service can be summoned by calling the 911 or per the numbers listed in Table 3.

4.4 EVACUATION PLAN

In the unlikely event that the site must be evacuated, the Emergency Coordinator will alert personnel to re-group at the pre-designated location for attendance taking. The Emergency Coordinator is responsible to verify that all site workers are accounted for during an evacuation. Periodic drills will be conducted, if deemed necessary, to evaluate the effectiveness of this evacuation plan.

If an emergency situation requires evacuation of personnel, the Emergency Coordinator will implement the following evacuation procedures:

1. The Emergency Coordinator will provide evacuation instructions to facility personnel via the construction site communications network, as appropriate.

2. Personnel evacuation will typically proceed as follows:

   a. If downwind of incident: Evacuate via the most accessible route perpendicular to the prevailing wind direction.
   b. If upwind of incident: Evacuate in an upwind direction.

3. Personnel will reassemble at the public road at the facility entrance as shown on Figure 3 or an alternate assembly point identified by the Emergency Coordinator, that is upwind of the incident location, and remain at this location until the Emergency Coordinator has accounted for all personnel.

4. The names of employees and the destination of employees transported to hospitals, etc. for treatment will be recorded by the Emergency Coordinator, first aid personnel or fire officials.

Once on public roadways, evacuation routes are left up to the individual.

4.5 EMERGENCY EQUIPMENT AVAILABLE FOR RESPONSE

This section provides a list of available emergency equipment, and procedures for maintenance and decontamination of emergency equipment. Newfield's emergency equipment at the facility will allow personnel to respond safely and quickly to emergency situations. Equipment will be inspected and maintained by Construction Manager to assure recommended quantities are available and its proper operation in time of emergency. After an emergency, equipment will be decontaminated, cleaned, and re-fit for its intended use before normal operations resume.

The Newfield facility will be equipped with the following emergency response equipment:

(1) Mobile telephones are provided to the Drilling and Production Mangers and are immediately available at the scene of operations for summoning emergency assistance from local police departments, fire departments or State or local emergency response teams.

(2) Portable fire extinguishers, fire control equipment, spill control equipment and decontamination equipment. This equipment is detailed in Table 4 of Appendix C.

5.0 EMERGENCY SPILL CONTROL NETWORK

5.1 ARRANGEMENTS WITH LOCAL EMERGENCY RESPONSE AGENCIES AND HOSPITALS

This section provides a list of local emergency response agencies and hospitals, and associated phone numbers. Arrangements can be made, as appropriate, to inform local emergency response agencies and hospitals concerning the type of materials handled at the Newfield facility and the potential need for services.

If appropriate, arrangements can be made to designate who will be the primary emergency response agency and who will provide support services during emergencies. Efforts can be made to familiarize police, fire departments, emergency response teams, and the Wayne County Emergency Management Agency (EMA) Coordinator with the layout of the site, the properties and dangers associated with any hazardous materials handled, places where personnel would normally be working, entrances to roads inside the site, and potential evacuation routes.

If considered appropriate by Newfield's Emergency Coordinator, agreements with hospitals and emergency response agencies can be made and included in the periodic updating or amending of the PPC Plan. The agreements and/or arrangements include efforts to familiarize area agencies and emergency responders with facility operations and potential emergency operations. The following agencies can be contacted and provided with a copy of this PPC Plan, at the discretion of the Newfield Emergency Coordinator.

- Local fire companies;
- Local county emergency response personnel;
- Local ambulance personnel; and
- Local hospital.

Table 3 lists local emergency response agencies to be contacted in the event of an emergency or reportable spill. In the unlikely event that a widespread emergency exists, the Wayne County EMA would be contacted first, and the Coordinator in turn could contact appropriate emergency response agencies through their communications network.

The Wayne County Emergency Management Agency can be contacted at (570) 253-1622. Routing of injured persons will be performed by emergency medical services personnel based on the number and type of injuries requiring treatment. The emergency medical services coordinator may be provided with a copy of this PPC Plan to assist in planning. The nearest hospitals are Catskill Regional Medical Hospital in Callicoon, New York, and Wayne County Memorial Hospital in Honesdale, Pennsylvania. The nearest fire departments are Callicoon Fire District in Callicoon, New York, Protection Engine Co No. 3 in Honesdale, Pennsylvania, and Narrowsburg Fire Department, in Narrowsburg, New York. The nearest police departments are the Honesdale Police Department, located in Honesdale, Pennsylvania, and Waymart Police Department in Honesdale Pennsylvania. All emergency response departments shall be reached through the 911 system.

5.2 NOTIFICATION LISTS

If the Emergency Coordinator determines that the facility has had an emission, discharge, fire, or explosion that could threaten human health or the environment, he will contact and report as necessary his findings to the appropriate agencies listed in Table 3. When calling any of the agencies listed in Table 3, the following information should be available for reporting to the identified agencies:

- Company name and location;
- Name of person reporting the spill, title, and telephone number;
- The type of material released;
- Estimated or exact (if known) quantity of material released (i.e., gallons, pounds, etc.);
- A brief description of the incident, including type of incident, nature of hazardous material involvement, and possible hazards to human health and the environment outside the facility;
- Probable source and location of the spill source;
- Date and time of the spill;
- Location of entry point into surface water and amount reaching the waterway (if applicable);
- The name of the receiving water and the downstream water bodies of which it is a tributary;
- Confirmation that release has been stopped or, if not, when will it be stopped;
- Mitigation/containment actions initiated;
- Direction of material movement;

- Potential population affected by the release;
- Name of person to contact on behalf of the company who will be at the scene and will be directing response measures;
- Telephone number where the on-scene coordinator can be reached; and
- The extent of injuries, if any.

A reporting form is attached in Appendix D for use by the Emergency Coordinator.

A written report including the above listed information, and other information that may be required by the applicable regulations (see 25 PA Code Section 265.56) regarding the spilled material, will need to be transmitted within 15 days to the following agencies:

U.S. Environmental Protection Agency
Region III
Spill Response Section
1650 Arch Street
Philadelphia, PA 19103

Pennsylvania Department of Environmental Protection
Bureau of Water Quality Management
2 Public Square
Wilkes-Barre, Pennsylvania 18711

6.0 WASTE DISPOSAL PRACTICES

Produced water will be removed periodically from the tanks at each well site and transported by a licensed residual waste hauler to a permitted disposal facility. Other wastes generated onsite will include used hydraulic oil that will be reclaimed from operating equipment and transported offsite for recycling. All wastes will be disposed in accordance with applicable local, state, and federal regulations.

7.0 STORMWATER MANAGEMENT PRACTICES

Newfield implements several Best Management Practices (BMPs) at each well site to reduce the potential for stormwater runoff of suspended solids and other contaminants. These BMPs include routine visual inspections, preventive maintenance, good housekeeping, and management of stormwater run-on and runoff. Routine inspection and monitoring, preventive maintenance, and good housekeeping programs are discussed in Sections 3.3, 3.4, and 3.5 of this PPC Plan. These programs prevent accidental releases of contaminants and reduce contaminant migrations via stormwater discharges. Stormwater management activities are discussed in Section 3.1 of this PPC Plan. The certification statement regarding the evaluation of discharges and confirmation that they will be comprised solely of stormwater is presented at the beginning of this Plan. Potential "significant sources of non-stormwater at the site" may include condensate, brine, hydraulic oil drums and tanks, gasoline and diesel fuel. Storage areas for these significant sources will be inspected on a daily basis.

8.0 SEDIMENT AND EROSION PREVENTION

Erosion and sedimentation controls are managed in accordance with PADEP requirements. Copies of the site E&S Plan are available at the Newfield office in Honesdale, PA and at each well site.

APPENDIX A

INSPECTION FORMS

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Facility:	Inspector Name:
Date of Inspection:	

Instructions: Indicate yes or no. If no, record observations describing the specific equipment and discrepancy.

Aboveground Storage Tanks		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
• Level gauages/alarms are operative	Yes ☐	No ☐
• Containers are labeled	Yes ☐	No ☐
Observations:		

Processing Equipment		
• Equipment appears adequately supported	Yes ☐	No ☐
• No evidence of active or past leaks from equipment, piping, connections, vales, vents, etc.	Yes ☐	No ☐
• Coating condition appears satisfactory	Yes ☐	No ☐
• Corrosion appears acceptable	Yes ☐	No ☐
Observations:		

Other Facility Equipment is Checked for: ❖ No evidence of active or past leaks ❖ Condition of equipment appears to be satisfactory (i.e., not damaged, deteriorated, or worn), and ❖ Corrosion appears to be acceptable.		
• Wellheads	Yes ☐	No ☐
• Gathering systems	Yes ☐	No ☐
• Well test stations	Yes ☐	No ☐
• Traps/Sumps	Yes ☐	No ☐
• Drainage systems and nearby ditches	Yes ☐	No ☐
• Applicable flowlines including right-of-way areas	Yes ☐	No ☐
• Containment systems	Yes ☐	No ☐
• Facility piping	Yes ☐	No ☐
Observations:		

NEWFIELD APPALACHIA PA LLC
Weekly Facility Inspection Form

Secondary Containment		
• Passive containment (berm) has adequate capacity and integrity as intended	Yes ☐	No ☐
• Active containment measures are adequate	Yes ☐	No ☐
• No evidence of active or past leaks (i.e., staining, sheen)	Yes ☐	No ☐
• Any valves are closed and plugged	Yes ☐	No ☐
• Active containment is free from a significant quantity of rain/snow	Yes ☐	No ☐
Observations:		

Security		
• Lighting is adequate to observe leaks, spills, and vandalism	Yes ☐	No ☐
• Pumps, valves, nozzles are locked	Yes ☐	No ☐
Observations:		

Spill Response		
• Spill response kits are stocked and located in readily accessible areas	Yes ☐	No ☐
Observations:		

Signature:	Date:

E&S INSPECTION FORM

The E&S plan contains a maintenance program which provides for inspection of BMPs (Best Management Practices such as filter sock, vegetation, construction entrances, etc.) on a weekly basis and after each measurable rainfall event, including the repair of BMPs to ensure effective and efficient operation. The maintenance program for both the temporary and permanent erosion and sediment control BMPs, including disposal of materials removed from the BMPs or project area, has been included in the narrative. The type of maintenance, such as cleanout, repair, replacement, regrading, re-stabilizing, etc. for each of the BMPs is included in the plan. **NOTE: This inspection report must be kept up to date and onsite.**

INSPECTION DATE	INITIALS	RAINFALL OR WEEKLY?	LOCATION OF E&S CONTROL(S)	CONDITION NOTED	CORRECTIVE MEASURES TAKEN

Facility: _____ **Inspector:** _____ **Signed:** _____ **Date:** _____

Print *Signature*

Tank Truck Loading and Unloading Checklist

Date: _____ Material being loaded/unloaded: _____

Driver/Loader present during loading or unloading of material _____
(signature)

_____ Current volume in storage tank was checked prior to loading.

_____ Fill hose inspected for condition prior to loading.

_____ Wheel chocks in place prior to loading.

_____ Tanker valve(s) were inspected for leakage prior to filling and departure.

_____ The loading of the tanker was monitored.

_____ Hoses were replaced and capped after loading.

_____ No material was spilled onto the containment pad or ground.

- These forms must be completed for every tank truck shipment and must be filed in the facility PPC Plan.
- All spills should be immediately reported to at least one of the following Newfield personnel:

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Burl Eakle
Cell: 918-448-1296

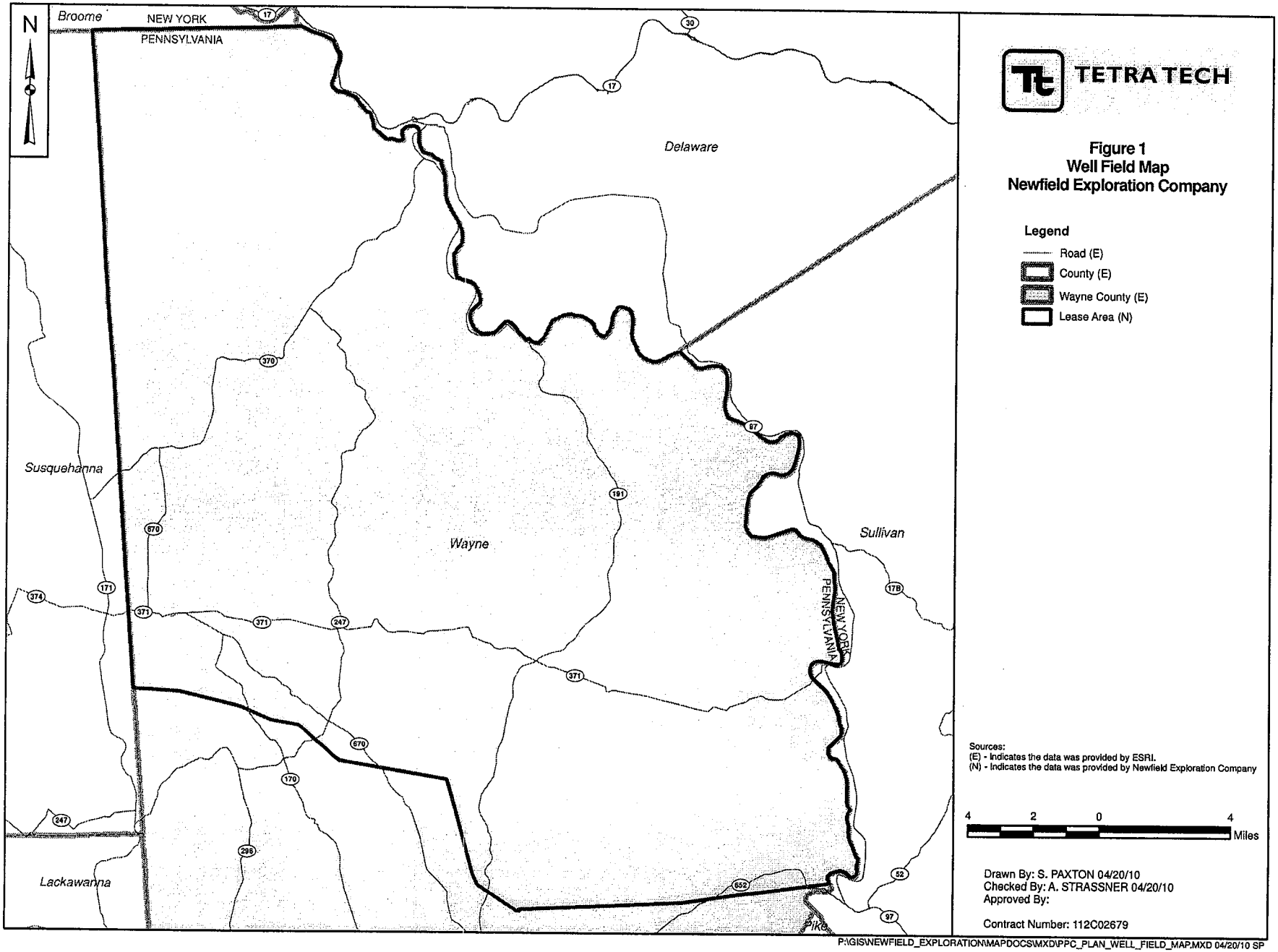
Delivery Information

Invoice No. _____

Load No. _____

Company _____

APPENDIX B
FIGURES



TETRA TECH

Figure 1
Well Field Map
Newfield Exploration Company

Legend

- Road (E)
- County (E)
- Wayne County (E)
- Lease Area (N)

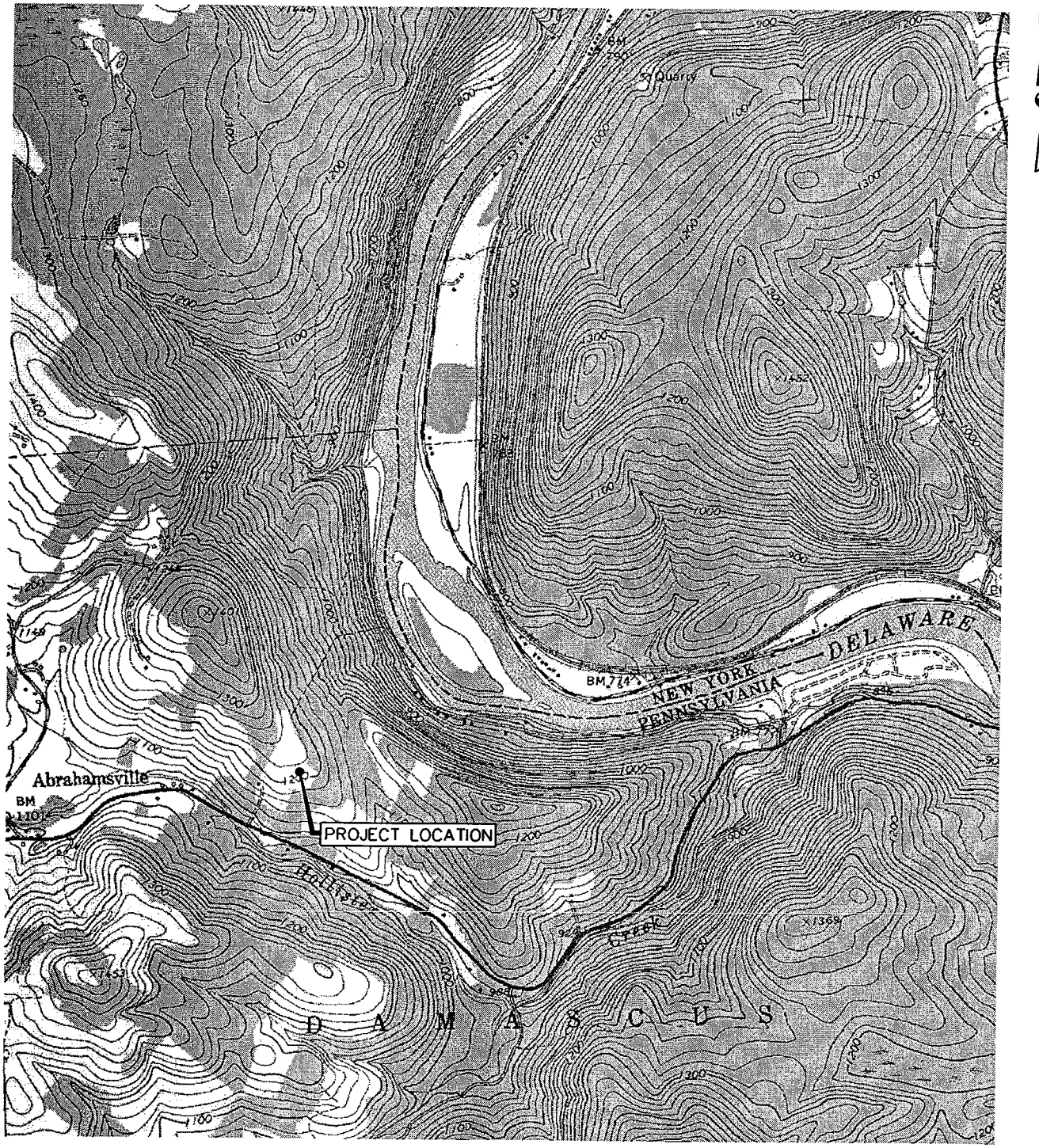
Sources:
(E) - Indicates the data was provided by ESRI.
(N) - Indicates the data was provided by Newfield Exploration Company

4 2 0 4 Miles

Drawn By: S. PAXTON 04/20/10
Checked By: A. STRASSNER 04/20/10
Approved By:

Contract Number: 112C02679

P:\GIS\NEWFIELD_EXPLORATION\MAPDOCS\MXD\PPC_PLAN_WELL_FIELD_MAP.MXD 04/20/10 SP



C:\Documents and Settings\ben.hoppe\My Documents\CAD Work\2568\Woodland Management Partners Well\Figures\2568FG001.dwg PIT BEN.HOPPE 3/3/2010 4:01:53 PM

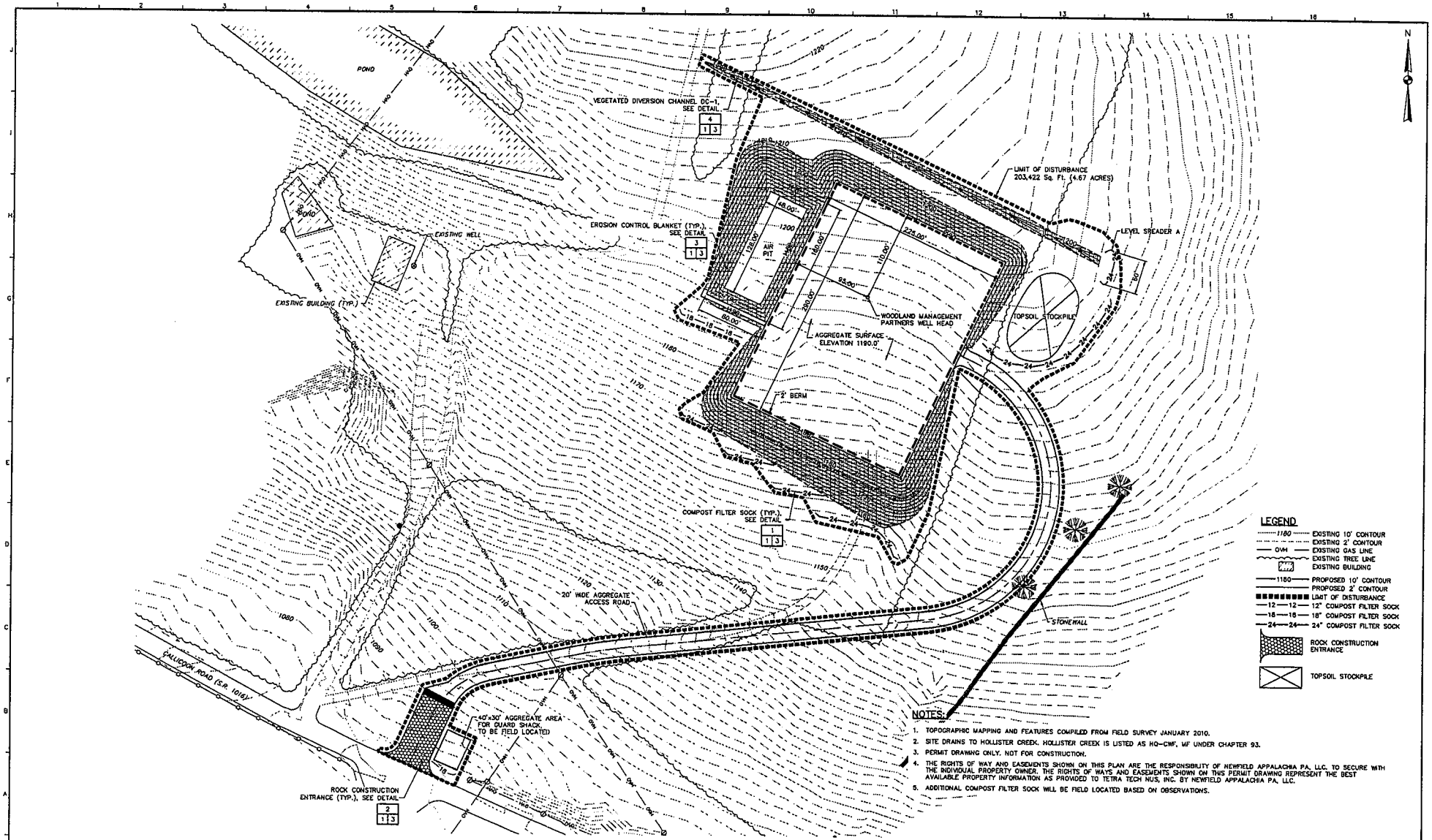
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

NEWFIELD APPALACHIA PA, LLC
WAYNE COUNTY, PENNSYLVANIA
WOODLAND MANAGEMENT PARTNERS
WELL PAD
LOCATION MAP

SCALE: 1" = 2000'

DATE:	3/4/10
PROJECT NO.:	112C02568
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	RAL
SHEET:	1 OF 2

FIGURE 2



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO HOLLISTER CREEK. HOLLISTER CREEK IS LISTED AS HQ-CWF, MF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.
5. ADDITIONAL COMPOST FILTER SOCK WILL BE FIELD LOCATED BASED ON OBSERVATIONS.

0 50 100
SCALE: 1" = 50'

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

WOODLAND MANAGEMENT PARTNERS WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 50'

DATE:	5/6/10
PROJECT NO.:	112C02679
DESIGNED BY:	RL
DRAWN BY:	BH
CHECKED BY:	RL
SHEET:	1 OF 7

FIGURE 3

APPENDIX C
TABLES

TABLE 1

LIST OF MATERIALS & WASTES

CONSTUCTION

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	250 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	180 gallons	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

DRILLING

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	2000 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	320 gallons	Well Pad	Sorbent pads; shovels/Gang box
DURATONE HT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
GELTONE V	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Lime	7,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Base Fluid	300 bbl	Well Pad	Sorbent pads; shovels/Gang box
Rig Wash	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Calcium Chloride (CaCl-)	4,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
RHEMOD L	1,770 lbs	Well Pad	Sorbent pads; shovels/Gang box
LE SUPERMUL	8,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
BARACARB 25, 50 (2 pallets each)	12,600 lbs	Well Pad	Sorbent pads; shovels/Gang box
WALNUT	2,400 lbs	Well Pad	Sorbent pads; shovels/Gang box
DRILTREAT	1,900 lbs	Well Pad	Sorbent pads; shovels/Gang box
Liquid Mud	1,500 bbl	Well Pad	Sorbent pads; shovels/Gang box
BAROID REGULAR / **BAROID BULK (barite)	125,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Drill Cuttings	100,000 lbs	Air Pit	Sorbent pads; shovels/Gang box
Cement	130,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

TABLE 2

INSPECTION AND MONITORING ACTIVITIES

Activity	Frequency
Erosion and Sedimentation Control Measures	Weekly or after a significant rain event
Aboveground Storage Tanks	Daily
Drum Storage Areas	Daily
Best Management Practices (BMPs)	Per BMP requirements
Dust Control Measures	Daily
Preparedness, Prevention, and Contingency (PPC) Plan Compliance Evaluation Inspections and Update of PPC Plan, as Appropriate	Annually

TABLE 3
AGENCY NOTIFICATION LIST

The following agencies are to be contacted, as appropriate, in the event of an emergency, accident, or chemical release.

Agency	Telephone No.
PADEP Northeast Regional Office	570-826-2511
PADEP Southcentral Office (Harrisburg)	877-333-1904
Pennsylvania Emergency Management Agency	717-651-2001
Police Department	9-1-1
Volunteer Fire Department	9-1-1
U.S. Environmental Protection Agency	215-814-5700
U.S. Coast Guard National Response Center	800-424-8802
U.S. Coast Guard (local)	570-421-1191
Pennsylvania Fish and Boat Commission	814-445-8974
Chemical Transportation Emergency Center:	
* Chemical Exposure Information	800-424-9300

LOCAL EMERGENCY RESPONSE:

Fire Department – Callicoon Fire District in Callicoon, New York, Protection Engine Co No. 3 in Honesdale, Pennsylvania Narrowsburg Fire Department, in Narrowsburg, New York.	9-1-1
Police Department – Honesdale Police Department, Honesdale, Pennsylvania Waymart Police Department, Honesdale Pennsylvania	9-1-1
Hospitals-Wayne County Memorial Hospital, Honesdale, Pennsylvania	570-251-6672
Catskill Regional Medical Hospital in Callicoon, New York	845-887-5530
Local Emergency Management Wayne County EMA	570-253-1622

TABLE 4

On-Site Emergency Response Equipment

On-Site Emergency Response Equipment
Fire Extinguishers
Tyvek Suits
Nitrile Gloves
Hearing Protection
Particulate Adsorbent
Absorbent Pads
Shovels
Earth Moving Equipment
Decontamination Equipment

TABLE 5
CHAIN OF COMMAND

Primary Emergency Coordinator

Don Sleeth
Drilling Manager
Office: 281-674-2501
Cell: 281-974-0051

Secondary Emergency Coordinator

Jack Cochran
Production Manager
Office: 814-437-2344
Cell: 814-671-1557

Construction Manager
Burl Eakle
Cell: 918-448-1296

Offsite Emergency Response Contractors

Company: Minuteman Spill Response, Inc.
Telephone Number: 800-905-7788

APPENDIX D
REPORTING FORM

Spill Response Notification Form

GENERAL REPORTING INFORMATION

Prepared _____
(First) (M.I.) (Last) (Position)

Daytime phone: (xxx) xxx-xxxx Evening phone: (xxx) xxx-xxxx

Newfield Appalachia PA LLC
(Company) (Address) (City) (State) (Zip)

Calling for responsible party? Yes Were materials discharged? Yes Confidential? No

Meeting Federal obligations to report: Yes

INCIDENT DESCRIPTION

Source and/or cause:

Date of Incident:Time of Incident:

Incident Location/Address

Nearest City: XXXX, PA XXXXX (XXXXXXX County)

Distance from City: In city limits Direction from City: In city limits

Facility Oil Storage Capacity: XXXXXX gallons

Container Type:Container Capacity: (gals)

Facility Latitude: xx° xx' xx" Longitude xx° xx' xx"

MATERIAL

Name (or CHRIS Code):

Discharged Quantity (Units): Discharged to Water (Units):

RESPONSE ACTION

Actions taken to correct, control or mitigate incident:

IMPACT

No. of Injuries: No. of Deaths: Other:

Evacuation (Y/N): Damage (Y/N): Amount ($):

Medium Affected: Description: Additional Information:

AGENCY NOTIFIED

NRC 800-424-8802 Date: Time: Contact:

PADEP (570) 826-2511 Date: Time: Contact:

USCG Date: Time: Contact:

Other Date: Time: Contact:

ADDITIONAL INFORMATION:

APPENDIX E
MSDS SHEETS

MATERIAL SAFETY DATA SHEET

Diesel Fuel (All Types)

MSDS No. 9909

EMERGENCY OVERVIEW
CAUTION!
OSHA/NFPA COMBUSTIBLE LIQUID - SLIGHT TO MODERATE IRRITANT
EFFECTS CENTRAL NERVOUS SYSTEM
HARMFUL OR FATAL IF SWALLOWED

Moderate fire hazard. Avoid breathing vapors or mists. May cause dizziness and drowsiness. May cause moderate eye irritation and skin irritation (rash). Long-term, repeated exposure may cause skin cancer. If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs).

NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER (24 hrs): **CHEMTREC (800) 424-9300**
COMPANY CONTACT (business hours): Corporate Safety (732) 750-6000
MSDS INTERNET WEBSITE: www.hess.com (See Environment, Health, Safety & Social Responsibility)

SYNONYMS: Ultra Low Sulfur Diesel (ULSD); Low Sulfur Diesel; Motor Vehicle Diesel Fuel; Diesel Fuel #2; Dyed Diesel Fuel; Non-Road, Locomotive and Marine Diesel Fuel; Tax-exempt Diesel Fuel

See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Diesel Fuel (68476-34-6)	100
Naphthalene (91-20-3)	Typically < 0.01

A complex mixture of hydrocarbons with carbon numbers in the range C9 and higher. Diesel fuel may be dyed (red) for tax purposes. May contain a multifunctional additive.

3. HAZARDS IDENTIFICATION

EYES
Contact with liquid or vapor may cause mild irritation.

SKIN
May cause skin irritation with prolonged or repeated contact. Practically non-toxic if absorbed following acute (single) exposure. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed.

INGESTION
The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION
Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY
Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. The significance of these results to human exposures has not been determined - see Section 11 Toxicological Information.

IARC classifies whole diesel fuel exhaust particulates as probably carcinogenic to humans (Group 2A). NIOSH regards whole diesel fuel exhaust particulates as a potential cause of occupational lung cancer based on animal studies and limited evidence in humans.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash).

4. FIRST AID MEASURES

EYES
In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN
Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops.

INGESTION
DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION
Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT:	> 125 °F (> 52 °C) minimum PMCC
AUTOIGNITION POINT:	494 °F (257 °C)
OSHA/NFPA FLAMMABILITY CLASS:	2 (COMBUSTIBLE)
LOWER EXPLOSIVE LIMIT (%):	0.6
UPPER EXPLOSIVE LIMIT (%):	7.5

FIRE AND EXPLOSION HAZARDS
Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA
SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES

ACTIVATE FACILITY'S SPILL CONTINGENCY OR EMERGENCY RESPONSE PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING PRECAUTIONS

Handle as a combustible liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Diesel fuel, and in particular low and ultra low sulfur diesel fuel, has the capability of accumulating a static electrical charge of sufficient energy to cause a fire/explosion in the presence of lower flashpoint products such as gasoline. The accumulation of such a static charge occurs as the diesel flows through pipelines, filters, nozzles and various work tasks such as tank/container filling, splash loading, tank cleaning; product sampling; tank gauging; cleaning, mixing, vacuum truck operations, switch loading, and product agitation. There is a greater potential for static charge accumulation in cold temperature, low humidity conditions.

Documents such as 29 CFR OSHA 1910.106 "Flammable and Combustible Liquids, NFPA 77 Recommended Practice on Static Electricity, API 2003 "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents and ASTM D4865 "Standard Guide for Generation and Dissipation of Static

Electricity in Petroleum Fuel Systems" address special precautions and design requirements involving loading rates, grounding, bonding, filter installation, conductivity additives and especially the hazards associated with "switch loading." ["Switch Loading" is when a higher flash point product (such as diesel) is loaded into tanks previously containing a low flash point product (such as gasoline) and the electrical charge generated during loading of the diesel results in a static ignition of the vapor from the previous cargo (gasoline).]

Note: When conductivity additives are used or are necessary the product should achieve 25 picosiemens/meter or greater at the handling temperature.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)	Source	Exposure Limits TWA/STEL	Note
Diesel Fuel: (68476-34-6)	OSHA	5 mg/m, as mineral oil mist	
	ACGIH	100 mg/m^3 (as totally hydrocarbon vapor) TWA	A3, skin
Naphthalene (91-20-3)	OSHA	10 ppm TWA	
	ACGIH	10 ppm TWA / 15 ppm STEL	A4, Skin

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile, neoprene, or PVC are recommended. Chemical protective clothing such as of E.I. DuPont TyChem®, Saranex® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION

A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE

Clear, straw-yellow liquid. Dyed fuel oil will be red or reddish-colored.

ODOR

Mild, petroleum distillate odor

BASIC PHYSICAL PROPERTIES

BOILING RANGE:	320 to 690 oF (160 to 366 °C)
VAPOR PRESSURE:	0.009 psia @ 70 °F (21 °C)
VAPOR DENSITY (air = 1):	> 1.0
SPECIFIC GRAVITY (H_2O = 1):	0.83 to 0.88 @ 60 °F (16 °C)
PERCENT VOLATILES:	100 %
EVAPORATION RATE:	Slow; varies with conditions
SOLUBILITY (H_2O):	Negligible

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS

Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers; Viton ®; Fluorel ®

HAZARDOUS DECOMPOSITION PRODUCTS

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

11. TOXICOLOGICAL PROPERTIES

ACUTE TOXICITY

Acute dermal LD50 (rabbits): > 5 ml/kg
Acute oral LD50 (rats): 9 ml/kg
Primary dermal irritation: extremely irritating (rabbits)
Draize eye irritation: non-irritating (rabbits)
Guinea pig sensitization: negative

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenic: OSHA: NO IARC: NO NTP: NO ACGIH: A3

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

MUTAGENICITY (genetic effects)

This material has been positive in a mutagenicity study.

12. ECOLOGICAL INFORMATION

Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

PROPER SHIPPING NAME:	Diesel Fuel	Placard (International Only):
HAZARD CLASS and PACKING GROUP:	3, PG III	
DOT IDENTIFICATION NUMBER:	NA 1993 (Domestic) UN 1202 (International)	
DOT SHIPPING LABEL:	None	

Use Combustible Placard if shipping in bulk domestically

15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

This product and its constituents listed herein are on the EPA TSCA Inventory. Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH	CHRONIC HEALTH	FIRE	SUDDEN RELEASE OF PRESSURE	REACTIVE
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product may contain listed chemicals below the *de minimis* levels which therefore are not subject to the supplier notification requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372. If you may be required to report releases of chemicals listed in 40 CFR 372.28, you may contact Hess Corporate Safety if you require additional information regarding this product.

CALIFORNIA PROPOSITON 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

INGREDIENT NAME (CAS NUMBER)	Date Listed
Diesel Engine Exhaust (no CAS Number listed)	10/01/1990

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 3 (Combustible Liquid) and Class D, Division 2, Subdivision B (Toxic by other means)

16. OTHER INFORMATION

NFPA® HAZARD RATING

HEALTH:	0
FIRE:	2
REACTIVITY:	0

Refer to NFPA 704 "Identification of the Fire Hazards of Materials" for further information

HMIS® HAZARD RATING

HEALTH:	1 *	* Chronic
FIRE:	2	
PHYSICAL:	0	

SUPERSEDES MSDS DATED: 02/28/2001

ABBREVIATIONS:

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute (212) 642-4900
API	American Petroleum Institute (202) 682-8000
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation [General info: (800) 467-4922]
EPA	U.S. Environmental Protection Agency
HMIS	Hazardous Materials Information System
IARC	International Agency For Research On Cancer
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association (617)770-3000
NIOSH	National Institute of Occupational Safety and Health
NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
NTP	National Toxicology Program
OPA	Oil Pollution Act of 1990
OSHA	U.S. Occupational Safety & Health Administration
PEL	Permissible Exposure Limit (OSHA)
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit (NIOSH)
SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
SCBA	Self-Contained Breathing Apparatus
SPCC	Spill Prevention, Control, and Countermeasures
STEL	Short-Term Exposure Limit (generally 15 minutes)
TLV	Threshold Limit Value (ACGIH)
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average (8 hr.)
WEEL	Workplace Environmental Exposure Level (AIHA)
WHMIS	Canadian Workplace Hazardous Materials Information System

MATERIAL SAFETY DATA SHEET

Review Date: 04/23/2007

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT: PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

MSDS NUMBER: 614348LU - 1
PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

MANUFACTURER
SOPUS Products
P.O. Box 4427
Houston, TX. 77210-4427

TELEPHONE NUMBERS
Spill Information: (877) 242-7400
Health Information: (877) 504-9351
MSDS Assistance Number: (877) 276-7285

SECTION 2 PRODUCT/INGREDIENTS

INGREDIENTS	CAS#	CONCENTRATION
Heavy Duty Motor Oil		
Highly refined petroleum oils	Mixture	90 - 99 %volume
Zinc Dialkyldithiophosphate	68649-42-3	1 - 5 %volume
Proprietary additives	Mixture	1 - 5 %volume

SECTION 3 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Appearance & Odor: Bright and clear liquid. Mild odor.
Health Hazards: No known immediate health hazards.
Physical Hazards: No known physical hazards.
NFPA Rating (Health, Fire, Reactivity): 0, 1, 0
Hazard Rating: Least - 0 Slight - 1 Moderate - 2 High - 3 Extreme - 4

Inhalation:
Inhalation of vapors (generated at high temperatures only) or oil mist may cause mild irritation of the nose, throat, and respiratory tract.

Eye Irritation:
Lubricating oils are generally considered no more than minimally irritating to the eyes.

Skin Contact:
May cause slight irritation of the skin. If irritation occurs, a temporary burning sensation and minor redness and/or swelling may result.

Ingestion:

Lubricating oils are generally no more than slightly toxic if swallowed.

Other Health Effects:
The International Agency for Research on Cancer (IARC) has determined there is sufficient evidence for the carcinogenicity in experimental animals of used gasoline motor oils. Handling procedures and safety precautions in the MSDS should be followed to minimize exposure to the used product.

Signs and Symptoms:
Irritation as noted above.

Aggravated Medical Conditions:
Pre-existing eye, skin and respiratory disorders may be aggravated by exposure to this product.

For additional health information, refer to section 11.

SECTION 4 FIRST AID MEASURES

Inhalation:
Remove victim to fresh air and provide oxygen if breathing is difficult. Get medical attention. If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.

Skin:
Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.

Eye:
Flush with water. If irritation occurs, get medical attention.

Ingestion:
Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

Note to Physician:
In general, emesis induction is unnecessary in high viscosity, low volatility products such as oils and greases.

SECTION 5 FIRE FIGHTING MEASURES

Flash Point [Method]: >400 °F/>204.44 °C [Pensky-Martens Closed Cup]

Extinguishing Media:
Material will float and can be re-ignited on surface of water. Use water fog, foam, dry chemical or carbon dioxide (CO2) to extinguish flames. Do not use a direct stream of water.

Fire Fighting Instructions:
Do not enter confined fire space without full bunker gear (helmet with face shield, bunker coats, gloves and rubber boots), including a positive pressure, NIOSH approved, self-contained breathing apparatus. This material is non-flammable.

Unusual Fire Hazards:
Material may ignite when preheated.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Protective Measures:
May burn although not readily ignitable.

Wear appropriate personal protective equipment when cleaning up spills. Refer to Section 8.

Spill Management:
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

Place in container for proper disposal. Remove contaminated soil to remove contaminated trace residues. Dispose of in same manner as material.

Reporting:
CERCLA: Product is covered by EPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) petroleum exclusion. Releases to air, land, or water are not reportable under CERCLA (Superfund).

CWA: This product is an oil as defined under Section 311 of EPA's Clean Water Act (CWA). Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 1-800-424-8802.

SECTION 7 HANDLING AND STORAGE

Precautionary Measures:
Wash with soap and water before eating, drinking, smoking, applying cosmetics, or using toilet. Launder contaminated clothing before reuse. Properly dispose of contaminated leather articles such as shoes or belts that cannot be decontaminated. Avoid heat, open flames, including pilot lights, and strong oxidizing agents. Use explosion-proof ventilation to prevent vapor accumulation. Ground all handling equipment to prevent sparking.

Storage:
Do not store in open or unlabeled containers. Store in a cool, dry place with adequate ventilation. Keep away from open flames and high temperatures.

Container Warnings:
Keep containers closed when not in use. Containers, even those that have been emptied, can contain explosive vapors. Do not cut, drill, grind, weld or perform similar operations on or near containers.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Chemical	Limit	TWA	STEL	Ceiling	Notation
Oil mist, mineral	ACGIH TLV	5 mg/m3	10 mg/m3		
Oil mist, mineral	OSHA PEL	5 mg/m3			

Exposure Controls

Provide adequate ventilation to control airborne concentrations below the exposure guidelines/limits.

Personal Protection

Personal protective equipment (PPE) selections vary based on potential exposure conditions such as handling practices, concentration and ventilation. Information on the selection of eye, skin and respiratory protection for use with this material is provided below.

Eye Protection:
Chemical Goggles, or Safety glasses with side shields

Skin Protection:
Use protective clothing which is chemically resistant to this material. Selection of protective clothing depends on potential exposure conditions and may include gloves, boots, suits and other items. The selection(s) should take into account such factors as job task, type of exposure and durability requirements.

Published literature, test data and/or glove and clothing manufacturers indicate the best protection is provided by:
Neoprene, or Nitrile Rubber

Respiratory Protection:
If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, an approved respirator must be worn. Respirator selection, use and maintenance should be in accordance with the requirements of the OSHA Respiratory Protection Standard, 29 CFR 1910.134.

Types of respirator(s) to be considered in the selection process include:
For Mist: Air Purifying, R or P style NIOSH approved respirator.
For Vapors: Air Purifying, R or P style prefilter & organic cartridge, NIOSH approved respirator. Self-contained breathing apparatus for use in environments with unknown concentrations or emergency situations.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance & Odor: Bright and clear liquid. Mild odor.
Substance Chemical Family: Petroleum Hydrocarbon

Flash Point	> 400 °F [Pensky-Martens Closed Cup]	**Pour Point**	-20 °F
Solubility (in Water)	Insoluble	**Specific Gravity**	0.88 - 0.89
Stability	Stable	**Viscosity**	103 cSt @ 40 °C

SECTION 10 REACTIVITY AND STABILITY

Stability:
Material is stable under normal conditions.

Conditions to Avoid:
Avoid heat and open flames.

Materials to Avoid:
Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products:

Thermal decomposition products are highly dependent on combustion conditions. A complex mixture of airborne solids, liquids and gases will evolve when this material undergoes pyrolysis or combustion. Aldehydes, Carbon Monoxide, Carbon Dioxide, Hydrogen Sulfide, Ketones, Nitrogen Oxidesand other unidentified organic compounds may be formed upon combustion.

SECTION 11 TOXICOLOGICAL INFORMATION

Acute Toxicity

TEST	Result	OSHA Classification	Material Tested
Dermal LD50	>5.0 g/kg(Rabbit)	Non-Toxic	Based on components(s)
Oral LD50	>5.0 g/kg(Rat)	Non-Toxic	Based on components(s)

Carcinogenicity Classification

Chemical Name	NTP	IARC	ACGIH	OSHA
Heavy Duty Motor Oil	No	Not Reviewed by IARC	Not Reviewed	No

SECTION 12 ECOLOGICAL INFORMATION

Environmental Impact Summary:
There is no ecological data available for this product. However, this product is an oil. It is persistent and does not readily biodegrade. However, it does not bioaccumulate.

SECTION 13 DISPOSAL CONSIDERATIONS

RCRA Information:

Under RCRA, it is the responsibility of the user of the material to determine, at the time of the disposal, whether the material meets RCRA criteria for hazardous waste. This is because material uses, transformations, mixtures, processes, etc. may affect the classification. Refer to the latest EPA, state and local regulations regarding proper disposal.

SECTION 14 TRANSPORT INFORMATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

International Air Transport Association
Not regulated under IATA rules.

International Maritime Organization Classification
Not regulated under International Maritime Organization rules.

SECTION 15 REGULATORY INFORMATION

Federal Regulatory Status

OSHA Classification:
Under normal conditions of use or in a foreseeable emergency, this product does not meet the definition of a hazardous chemical when evaluated according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Ozone Depleting Substances (40 CFR 82 Clean Air Act):
This material does not contain nor was it directly manufactured with any Class I or Class II ozone depleting substances.

Superfund Amendment & Reauthorization Act (SARA) Title III:
There are no components in this product on the SARA 302 list.

SARA Hazard Categories (311/312):

Immediate Health	Delayed Health	Fire	Pressure	Reactivity
NO	NO	NO	NO	NO

SARA Toxic Release Inventory (TRI) (313):
Zinc compounds

Toxic Substances Control Act (TSCA) Status:
All component(s) of this material is(are) listed on the EPA/TSCA Inventory of Chemical Substances.

Other Chemical Inventories:
Component(s) of this material is (are) listed on the Australian AICS, Canadian DSL, Chinese Inventory, European EINECS, Korean Inventory, Philippines PICCS,

State Regulation

The following chemicals are specifically listed by individual states; other product specific health and safety data in other sections of the MSDS may also be applicable for state requirements. For details on your regulatory requirements you should contact the appropriate agency in your state.

SECTION 16 OTHER INFORMATION

Revision#: 1
Review Date: 04/23/2007
Revision Date: 12/19/2006
Revisions since last change (discussion): This Material Safety Data Sheet (MSDS) has been reviewed to fully comply with the guidance contained in the ANSI MSDS standard (ANSI Z400.1-2003). We encourage you to take the opportunity to read the MSDS and review the information contained therein.

SECTION 17 LABEL INFORMATION

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

PRODUCT CODE(S): 5071324, 5071325, 5071326, 5071369, 5071371

PENNZOIL™ LONG-LIFE™ Motor Oil (All Grades)

ATTENTION!

PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE OIL ACNE OR DERMATITIS. USED GASOLINE ENGINE OIL HAS BEEN SHOWN TO CAUSE CANCER IN LABORATORY ANIMALS.

Precautionary Measures:
Avoid prolonged or repeated contact with eyes, skin and clothing. Avoid breathing of vapors, fumes, or mist. Use only with adequate ventilation. Wash thoroughly after handling.

FIRST AID

Inhalation: If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.
Skin Contact: Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.
Eye Contact: Flush with water. If irritation occurs, get medical attention.
Ingestion: Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention.

FIRE

In case of fire, Use water fog, 'alcohol foam', dry chemical or carbon dioxide (CO_2) to extinguish flames. Do not use a direct stream of water. Material will float and can be re-ignited on surface of water.

SPILL OR LEAK

Dike and contain spill.
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

CONTAINS: Highly refined petroleum oils, Mixture; Zinc Dialkyldithiophosphate, 68649-42-3; Proprietary additives, Mixture

NFPA Rating (Health, Fire, Reactivity): 0, 1, 0

TRANSPORTATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LE SUPERMUL**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LE SUPERMUL
Synonyms: None
Chemical Family: Blend
Application: Emulsifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Diethylene glycol monobutyl ether	112-34-5	1 - 5%	Not applicable	Not applicable
Ethylene glycol monobutyl ether	111-76-2	1 - 5%	20 ppm	50 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview

May cause eye and skin irritation. May cause headache, dizziness, and other central nervous system effects. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin

In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes

In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion

Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration.

Notes to Physician

Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	> 200**Min:** > 200
Flash Point/Range (C):	> 100**Min:** > 93
Flash Point Method:	PMCC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Use water spray to cool fire exposed surfaces. Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 2, Flammability 1, Reactivity 0
HMIS Ratings:	Flammability 1, Reactivity 0, Health 2

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor respirator. In high concentrations, supplied air respirator or a self-contained breathing apparatus.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	Amber
Odor:	Mild
pH:	2.6
Specific Gravity @ 20 C (Water=1):	0.924
Density @ 20 C (lbs./gallon):	7.7
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	20
Freezing Point/Range (C):	-6.6
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	280-300
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause abdominal pain, vomiting, nausea, and diarrhea. May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Lung disorders. Skin disorders.
Chronic Effects/Carcinogenicity	Prolonged or repeated exposure may cause reproductive system damage. Repeated overexposure may cause liver and kidney effects.

Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® OIL ABSORBENT**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® OIL ABSORBENT
Synonyms: None
Chemical Family: Mineral
Application: Suspending Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Magnesium silicate	1343-90-4	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	2-6	0.025 mg/m^3	10 mg/m^3 %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Granules
Color:	Gray to tan
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	2.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32-38
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact None known.

Eye Contact May cause eye irritation.

Ingestion May be harmful if swallowed.

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	Product contains one or more components not listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **RHEMOD L**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: RHEMOD L
Synonyms: None
Chemical Family: Tall oil fatty acid
Application: Viscosifier

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fatty acids, C18-unsatd., trimers	68937-90-6	10 - 30%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and skin irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	518
Flash Point/Range (C):	270
Flash Point Method:	COC
Autoignition Temperature (F):	> 425
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 1, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Wash hands after use.
Storage Information	Store in a cool, dry location. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Dark
Odor:	Fatty acid
pH:	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	0.96
Density @ 20 C (lbs./gallon):	8
Bulk Density @ 20 C (lbs/ft3):	57.30
Boiling Point/Range (F):	> 572
Boiling Point/Range (C):	> 300
Freezing Point/Range (F):	< -4
Freezing Point/Range (C):	< 25
Vapor Pressure @ 20 C (mmHg):	< 0.001
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	0
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	1849 @ 25C
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye and skin contact.
Inhalation	May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause mild eye irritation.
Ingestion	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID® RIG WASH**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID® RIG WASH
Synonyms: None
Chemical Family: Blend
Application: Surfactant

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Isopropanol	67-63-0	1 - 5%	200 ppm	400 ppm

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion If swallowed dilute with 1-2 glasses of milk or water and then induce vomiting.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined**Min:** > 220
Flash Point/Range (C):	Not Determined**Min:** > 104
Flash Point Method:	COC
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.
Storage Information	Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear blue
Odor:	Slight Alcohol
pH:	9.5

9. PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity @ 20 C (Water=1):	1.025
Density @ 20 C (lbs./gallon):	8.5
Bulk Density @ 20 C (lbs/ft3):	63.6
Boiling Point/Range (F):	> 212
Boiling Point/Range (C):	> 100
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product contains toxic chemical(s) listed below which is(are) subject to the reporting requirements of Section 313 of Title III of SARA and 40 CFR Part 372: Glycol Ethers//34398-01-1 Isopropanol//67-63-0
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **FWCA CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: FWCA CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polysaccharide
Application: Free Water Control Additive

Manufacturer/Supplier Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Cellulose derivative		60 - 100%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	770
Autoignition Temperature (C):	410
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage information Store away from oxidizers. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	6.5
Specific Gravity @ 20 C (Water=1):	1.39
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	32
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Forms gel
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Aldehydes. Carboxylic acids. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 322 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 322 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Blend
Application: Cement Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Sodium formate	141-53-7	1 - 5%	Not applicable	Not applicable
Cellulose derivative		10 - 30%	10 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Health 0, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Red
Odor:	Odorless

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.28
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	35.2
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Partially soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HALAD® 344 CEMENT ADDITIVE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HALAD® 344 CEMENT ADDITIVE
Synonyms: None
Chemical Family: Polymer
Application: Fluid Loss Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modified acrylamide copolymer		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water spray, dry chemical, or foam.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 1, Reactivity 0
HMIS Ratings: Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust. Do not swallow. Avoid contact with eyes, skin, or clothing.

Storage Information Store in a cool, dry location. Store away from oxidizers. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Nitrile gloves. Polyvinylchloride gloves. Neoprene gloves. Rubber gloves. Butyl rubber gloves. Cloth gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Powder

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	White to off white
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.37
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	25-35
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	18
Freezing Point/Range (C):	-8
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	<5
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	>600

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Oxides of nitrogen. Carbon monoxide and carbon dioxide. Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Prolonged or repeated contact may cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	No adverse health effects are expected from swallowing.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined

Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	BOD(28 Day): 3% of COD
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM48: 2000 mg/l (Arcatia tonsa)
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	EC50: 3300 mg/l (Skeletonema costatum)
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-5**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-5
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Black
Odor:	Molasses
pH:	9.5-10.3
Specific Gravity @ 20 C (Water=1):	1.32

9. PHYSICAL AND CHEMICAL PROPERTIES

Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	29.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1000 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HR-601**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HR-601
Synonyms: None
Chemical Family: Lignosulfonate
Application: Cement Retarder

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modifed lignosulfonate		60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.2
Flammability Limits in Air - Upper (%):	Not Determined
Flammability Limits in Air - Upper (oz./ft3):	3.5

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 1, Flammability 1, Reactivity 0
HMIS Ratings: Health 1, Flammability 1, Physical Hazard 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Woody
pH:	7.8
Specific Gravity @ 20 C (Water=1):	1.08
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	30.5
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of sulfur. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mechanical irritation to eye.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM48: > 1000 mg/l (Daphnia magna)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **KCL POTASSIUM CHLORIDE**

Revision Date: 04-Jan-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: KCL POTASSIUM CHLORIDE
Synonyms: None
Chemical Family: Inorganic Salt
Application: Additive

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Potassium chloride	7447-40-7	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid breathing vapors.
Storage Information	Store in a cool, dry location. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Dust proof goggles.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White to gray
Odor:	Odorless
pH:	9.2
Specific Gravity @ 20 C (Water=1):	1.99
Density @ 20 C (lbs./gallon):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Bulk Density @ 20 C (lbs/ft3):	72.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.55

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause moderate skin irritation.
Eye Contact	May cause severe eye irritation.
Ingestion	Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: > 5000 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: 100-330 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **POZ STANDARD CEMENT 50/50**

Revision Date: 05-Jan-2009

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: POZ STANDARD CEMENT 50/50
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Fly ash	68131-74-8	30 - 60%	Not applicable	Not applicable
Bentonite	1302-78-9	1 - 5%	Not applicable	Not applicable
Portland cement	65997-15-1	30 - 60%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Health 1*, Flammability 0, Reactivity 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	Not Determined
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Not Determined
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure

Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact

Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact

May cause severe eye irritation.

Ingestion

None known

Aggravated Medical Conditions

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory — All components listed on inventory or are exempt.

EPA SARA Title III Extremely Hazardous Substances — Not applicable

EPA SARA (311,312) Hazard Class — Acute Health Hazard
Chronic Health Hazard

EPA SARA (313) Chemicals — This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).

EPA CERCLA/Superfund Reportable Spill Quantity — Not applicable.

EPA RCRA Hazardous Waste Classification — If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.

California Proposition 65 — The California Proposition 65 regulations apply to this product.

MA Right-to-Know Law — One or more components listed.

NJ Right-to-Know Law — One or more components listed.

PA Right-to-Know Law — One or more components listed.

Canadian Regulations

Canadian DSL Inventory — All components listed on inventory.

WHMIS Hazard Class — E Corrosive Material
D2A Very Toxic Materials
Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information — For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement — This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CEMENT - CLASS H - PREMIUM**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CEMENT - CLASS H - PREMIUM
Synonyms: None
Chemical Family: Cement
Application: Cement

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Portland cement	65997-15-1	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	<3	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Gray
Odor:	Odorless
pH:	12.4
Specific Gravity @ 20 C (Water=1):	3.15
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	94
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Keep away from any contact with water.
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact Can dry skin. May cause an allergic skin reaction. May cause alkali burns with confined contact.

Eye Contact May cause severe eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	E Corrosive Material D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 25**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 25
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	168
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BARACARB® 50**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BARACARB® 50
Synonyms: None
Chemical Family: Mineral
Application: Bridging Agent

Manufacturer/Supplier

Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Limestone	1317-65-3	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	0 - 1%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store away from acids. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid Powder
Color:	White
Odor:	Odorless
pH:	8-9
Specific Gravity @ 20 C (Water=1):	2.7
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	72-112
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide. Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: LD50: > 5000 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: TLM96: >1,000,000 ppm (Mysidopsis bahia) SPP @ 178.5 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BAROID®**

Revision Date: 03-Jan-2008

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BAROID®
Synonyms: None
Chemical Family: Mineral
Application: Weight Additive

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Barium sulfate	7727-43-7	60 - 100%	10 mg/m^3	15 mg/m^3
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Pink to tan to gray
Odor:	Odorless
pH:	8-9-
Specific Gravity @ 20 C (Water=1):	4.2
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	100- 155
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	233.4

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact None known.

Eye Contact May cause mild eye irritation.

Ingestion May produce nervous system effects such as feeling of weakness, unsteady walk, and dilation of blood vessels. May affect the heart and cardiovascular system.

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 7500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 132.6 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **LIME**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: LIME
Synonyms: None
Chemical Family: Inorganic
Application: pH Control

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Calcium hydroxide	1305-62-0	60 - 100%	5 mg/m^3	15 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye and skin burns. May cause respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists. Remove contaminated clothing and launder before reuse.

Eyes
In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion
Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media All standard firefighting media.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Not Determined

NFPA Ratings: Health 1, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from acids. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (95%)

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	12.2
Specific Gravity @ 20 C (Water=1):	2.24
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	75
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	0.2
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.1

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong acids.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	Causes severe skin irritation. May cause skin burns on prolonged contact.
Eye Contact	Causes severe eye irritation May cause eye burns.
Ingestion	Irritation of the mouth, throat, and stomach.
Aggravated Medical Conditions	Skin disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 7340 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 100-500 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: TLM96: 478,520 ppm (Mysidopsis bahia) SPP @ 8 ppb
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Empty container completely. Transport with all closures in place. Return for reuse or dispose in a sanitary landfill according to national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2B Toxic Materials

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **WALNUT HULLS**

Revision Date: 02-Jan-2007

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: WALNUT HULLS
Synonyms: None
Chemical Family: Nut Hulls
Application: Loss Circulation Material

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Walnut hulls	Mixture	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye irritation.

4. FIRST AID MEASURES

Inhalation Under normal conditions, first aid procedures are not required.

Skin Under normal conditions, first aid procedures are not required.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	0.07
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0
HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Safety glasses.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Characteristic

9. PHYSICAL AND CHEMICAL PROPERTIES

pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	1.1
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined

Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 1,000,000 ppm (Mysidopsis bahia) SPP @ 10 ppb
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	None
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

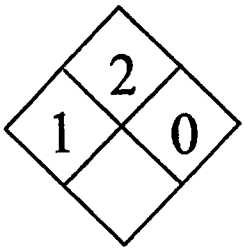
For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

INTEGRITY INDUSTRIES INC.



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MATERIAL SAFETY DATA SHEET

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SECTION I - MANUFACTURER

Integrity Industries, Inc.
2710 E. Corral St.
Kingsville, Texas 78363
Emergency Phone: (361) 595-5561

Revised Date: 06/05/2008
Supercedes: new

THIS DOCUMENT IS PREPARED PURSUANT TO THE OSHA HAZARDOUS COMMUNICATION STANDARD (29 CFR 1910.1200). ALSO, OTHER SUBSTANCE NOT DEEMED "HAZARDOUS" PER THIS MSDS MAY BE LISTED.

SECTION II - MATERIAL IDENTIFICATION

Trade Name: **SYNVERT Base Oil**
Synonyms/Other Designations: Synthetic Drilling Fluid / Polymer Suspension Base
Placard: Not Applicable
Hazard(s): non-hazardous

Component	CAS Number	Weight
Paraffin/Olefin blend	Mixture	100%

SECTION III - PHYSICAL & CHEMICAL DATA

Boiling Point: IBP > 300 °F
Specific Gravity (H2O=1): 0.766
Vapor Density (Air=1): n/a
Appearance: Clear, oily liquid

Pour Point: ND
Vapor Pressure (mm Hg @ 68 °F): 0.135
Solubility in H2O: Insoluble
Viscosity (cSt @104 °F): 1.4

SECTION IV - REACTIVITY

Stability: Stable
Incompatibility: Heat, sparks, open flame. May react with strong acids/strong oxidizing agents, chlorates, nitrates, peroxides.
Hazardous Decomposition Products: Oxides of carbon. Hazardous Polymerizations: will not occur

SECTION V - FIRE & EXPLOSION DATA

Flash Point (ASTM D-93): > 200 °F
Autoignition: n/a
Extinguishing Media: Water spray, Dry Chemical, Foam, CO2
Special Fire Fighting Procedures: Respirators/eye protection and full firefighting protective gear.
Unusual Fire Hazards: Remove containers from source of heat.

SECTION VI - EMERGENCY & FIRST AID DATA

Inhalation: Move to well ventilated area; if breathing difficulties persist after 15 minutes seek medical assistance.
Eye Contact: Wash eye thoroughly for 15 minutes; if irritation persists seek medical assistance.
Skin Contact: Wash affected area with soap & water for 15 minutes; if irritation persists seek medical assistance.
Ingestion: Do not induce vomiting and seek medical advice.

SECTION VII - HEALTH HAZARDS DATA

Acute: May irritate eyes, skin, respiratory, & gastrointestinal tract. Chronic: Repeated/prolonged skin contact may irritate/redden skin, progressing to dermatitis.

SECTION VIII - SPILL & DISPOSAL DATA

Accidental Spill Procedures: Absorb in inert material and dispose of according to local, state & federal regulations. Spill into water should be contained to avoid runoff into waterways.
Handling & Storage: Keep container closed and store in cool dry place. Emptied container still contains material which may ignite with explosive violence if exposed to open flame.

SECTION IX - SPECIAL PROTECTION DATA

Respiratory Protection: Respirator in confined areas.
Ventilation: Desired Exhaust: Mechanical
Protective Gloves: Solvent/chemical resistant gloves
Eye Protection: Safety glasses, goggles.
Other Protection: As required to avoid skin contact.

SECTION X - TRANSPORT INFORMATION

The following may not apply to all shipping situations. Consult 49 CFR for more mode-specific or quantity-specific data.
DOT Proper Shipping Name: Not regulated
DOT Hazard Class or Division: Not regulated
DOT Identification Number: N/A
DOT Packaging Group: III
Type Label(s) Required. none
Placard: Not applicable
*For Limited Quantity requirements see DOT regulation 49 CFR.

SECTION XI - DISCLAIMERS

* SOME INFORMATION PROVIDED HEREIN WAS DRAWN FROM SOURCES OTHER THAN INTEGRITY INDUSTRIES.
THE INFORMATION PROVIDED HEREIN IS BELIEVED BY INTEGRITY INDUSTRIES, INC. TO BE CORRECT & RELIABLE; NO EXPRESSED OR IMPLIED WARRANTY IS PROVIDED HOWEVER.
* INTEGRITY INDUSTRIES, INC. ASSUMES NO RESPONSIBILITY AND DENIES ALL LIABILITY FOR ANY LOSS, DAMAGE, OR EXPENSE CONNECTED WITH CUSTOMERS' METHOD OF HANDLING, STORAGE, USE, AND DISPOSAL OF THIS PRODUCT.
* THE MSDS INFORMATION PROVIDED HEREIN IS APPLICABLE ONLY TO THIS PRODUCT.

TABLE 3
AGENCY NOTIFICATION LIST

The following agencies are to be contacted, as appropriate, in the event of an emergency, accident, or chemical release.

Agency	Telephone No.
PADEP Northeast Regional Office	570-826-2511
PADEP Southcentral Office (Harrisburg)	877-333-1904
Pennsylvania Emergency Management Agency	717-651-2001
Police Department	9-1-1
Volunteer Fire Department	9-1-1
U.S. Environmental Protection Agency	215-814-5700
U.S. Coast Guard National Response Center	800-424-8802
U.S. Coast Guard (local)	570-421-1191
Pennsylvania Fish and Boat Commission	814-445-8974
Chemical Transportation Emergency Center:	
* Chemical Exposure Information	800-424-9300

LOCAL EMERGENCY RESPONSE:

Fire Department – Wayne County Company #3,13, 21, 28, 43, and 65	9-1-1
Police Department – PSP, Honesdale, Pennsylvania	9-1-1
Hospitals/Ambulances-	
Damascus Township Ambulance, Pennsylvania MT Pleasant Ambulance Northern Wayne Ambulance Mobile 504	9-1-1
Wayne County Memorial Hospital, Honesdale, Pennsylvania	570-251-6672
CMC – Trauma Center, Scranton, Pennsylvania	570-969-8128
Catskill Regional Medical Hospital in Callicoon, New York	845-887-5530
Local Emergency Management Wayne County EMA	570-253-1622

Air Quality Concerns at Woodland Management Gas Drilling Site, Damascus, PA

15 September 2010

Greg Swartz and Tannis Kowalchuk

The drilling of the Woodland Management Gas well was completed about 2 weeks ago and the drilling rig has been moved to the Crum site in Milanville, PA. Our farm and home are located 0.3 miles from the Woodland site. This past Sunday September 5, we smelled a very strong chemical sulfuric odor. We were busy picking and packing vegetables for a farmers market and we did not do anything about the odor. Monday morning the odor was again present. Here is a summary of events:

September 5	7am	Smelled chemical sulfuric odor. Lessened by afternoon.
September 6	9am	Smelled chemical sulfuric odor
	9:38am	Telephoned the DEP Emergency Response Line. Call was answered by an answering service who indicated that they would page DEP personnel. We received no call back from the DEP.
	10:20am	Called 911 to report the odor
	10:30am	Equinunk Volunteer Fire Department responded. They confirmed the odor. The Chief immediately went to the Woodland well site and inspected the pad and waste pond. Chemical odor was evident. He spoke with security personnel there who indicated that the waste water pond was to be pumped on Tuesday (9-7). Fire Department indicated that they were not concerned about the air quality and they left.
September 7	10am	Smelled chemical sulfuric odor. Heavy tanker truck activity- ostensibly emptying the waste pond.
	12:58pm	Called DEP Northeast Regional Office. They had no record of our call and referred me to Northcentral office who handles oil and gas issues.

	12:59	Called DEP Northcentral Regional Office and left a message with the person I was directed to. We called without leaving a message several more times throughout the afternoon- no one answered.
	4:15pm	Called DEP Northcentral office again and left a message. We have still not received a call back.
September 8	9:00am	Chemical sulfuric odor not present. Called DEP Northcentral Regional Director, Nels Taber. His assistant connected us with Jennifer Means, DEP Northcentral Oil and Gas Program Manager. We related the events of the past 3 days. She had no record of our initial emergency call and indicated that normally she receives the emergency calls. She indicated that she would research what went wrong and that she would be back in touch with us. We requested that an inspection be done of the well site.
	4:10pm	We received a call from Denise Brinley (DEP Deputy Secretary) and Kerry Leib (DEP Emergency Management Coordinator) who were asking for further information. They said: 1) the answering service had no record of our call and they don't know why the communication breakdown occurred. 2) Northcentral staff person who I spoke with should have handled my call on Tuesday differently because they do in fact have inspection staff in Scranton 3) They issued an order to send an inspector to the site this morning at 11am. They weren't sure when s/he would arrive. 4) They will be back in touch to respond to the lack of response from the DEP and with a report from the inspector.
September 9	4:30pm	Kelly Hefner, DEP Deputy Secretary for Field Operations left a phone a message.

September 10	9:00am	Spoke with Kelly Hefner. She offered her "sincere apology" for the troubles we have had with DEP. She confirmed that they have no record of our call. She said that an inspector was on site on Tuesday and Wednesday. We asked for: Air quality tests, water tests, soil tests, location of waste water treatment. We also asked what chemicals used in the drilling process would cause the sulfur odor. She promised results by Monday.
September 13	12:30pm	Left message for Heffner
	5:30pm	Heffner left message for us
September 14	10:00am	Left message for Heffner
	1:47pm	Left message for Heffner
	5:15pm	Heffner left a message for us saying she was in meetings and too busy to call earlier.

We are deeply concerned about the environmental and health impacts of drilling, in particular for the health of our 2 year old son. This specific case of air quality is troubling. What is even more troubling is the DEP's lack of response to our call. We don't know exactly what has been flying in the air. It may or may not be acutely toxic. It was a significant enough event that the DEP should have investigated immediately. This event highlights that the DEP is not prepared to handle the environmental risks which are part and parcel of gas drilling. We are still waiting for an official response and explanation from the DEP. We can't help but wonder what will happen when there is a catastrophic gas drilling emergency and how long it will take DEP to respond? Our volunteer fire department was here almost immediately and professionally handled the situation. However, they are not trained in air quality monitoring or any of the other potential fallout from gas drilling.

Greg Swartz and Tannis Kowlachuk
25 Stone House Rd, Damascus, PA
570-224-8013
greg@willowwisporganic.com, tannis@nacl.org

9-16-10 Email Correspondence from PADEP Acting Deputy Secretary Kelly Hefner concerning my outstanding questions about odor at the Woodland site. Attached to this correspondence were the 2 inspection reports and water test from 8-10-10 (see below).

Good Afternoon Mr. Swartz:

As we have discussed the phone side of the matter and you have taken my word that it has been addressed (thank you), I will simply add I am sorry the call was mishandled, but we have been able to make some changes that will prevent this in the future.

As we have further discussed your concerns, I have attempted to address the questions you posed when we talked on Friday and to answer the questions you posed in your Thursday morning email. I apologize that we keep missing each other.

Attached please find the answers to the questions posed at the end of last week re: the pit on the Woodland Management Site, Operated by Newfield

1. Yes, the wastewater from the pit was sampled and those results are attached.

2. The water in the pit and tanks was hauled offsite by Koberlein Environmental. They are a DEP approved waste hauler. The water went to the waste disposal facilities of Eureka Resources LLC (Williamsport, Pa.) and Waste Treatment Corporation in Warren, Pa. Manifests are on file for every load of this water hauled and disposed of.

3. Air monitoring for hydrogen sulfide (H2S) gas was not conducted. There was no air quality monitoring by DEP or the Fire Department.

4. DEP has investigated these type of pits turning septic (anaerobic digestion which generates H2S) in other parts of the Commonwealth. As of now, there is not certainty about what the food source is for the bacteria, but we suspect that it might be from drilling fluids. Some companies have added sulfide scavengers to the pits to prevent the bacterial action.

It is fairly common for H2S to be released into the environment from natural decomposition and our staff encounters it fairly regularly. Similar to what occurs at a wetland, the sludge at the bottom of an impoundment can undergo anaerobic digestion and release H2S gas. Because H2S gas has a low odor threshold, humans smell it at very low concentrations. High concentrations are highly unusual in an outdoor, well-ventilated area.

DEP was not able to have air tests done prior to the removal of the fluids on the Tuesday after Labor Day. There are limited mobile units and they are deployed in other locations in the Northern Tier doing testing but were not there on Labor day or September 7th. The odor developed in just a few days (3) due to bacteria in the pit. The H2S indeed smells bad, and is certainly irritating, but it is very, unlikely to have caused any health impacts in this circumstance. Removing the water expeditiously was the correct response.

Inspection Summary (field report attached)

NEWFIELD APPALACHIA PA LLC
WOODLAND MGMT PARTNERS 1 1
Permit 127-20017
Spud date (initiation of drilling activities) was 06/25/2010
Damascus Township, Wayne County

In response to a complaint by Mr. Greg Swartz of sulphur odors emanating from the above referenced well site, on September 8, 2010, Oil & Gas Inspector Steve Watson inspected the site and documented the following. The service contractor on-site, H&K Construction, was in the process of dewatering the reserve pit. As they pump the fluid to the frac tanks and then to the tanker trucks for transport and disposal, odors from the pit are emitted through vents on the tanks. Also, stirring up the fluid in the pit allowed odors to release to the atmosphere as well. At the time of the inspection, 95% of the fluid had already been removed from the pit. They were planning on solidifying the pit and then folding over the liner to prepare for encapsulation on Thursday, September 9, 2010. The Department intends to complete an additional inspection of the site today Friday, September 10, 2010. At the time of this e-mail, the findings of this Friday inspection have not yet been reported back to the regional office.

The Department also inspected this site on Thursday September 2, 2010, prior to the initial complaint received on either Monday or Tuesday, September 6 or 7, 2010. During this inspection it was noted that the service contractor was the only party on site. Trucks were hauling off the last pieces of the drilling rig to be moved to the next planned drilling site. Two workers were observed skimming off an oil sheen on the pit fluids, the liner was inspected showing no holes or tears. Several frac tanks are located on site for temporary storage of the fluids being removed. The only odors detected during this vist were those that would be associated with drilling fluids and/or cuttings.

Text from Thursday 9/16 email

Good Morning Ms. Heffner,
Thank you for taking the time to send the pit water test results from 8-10-10. These results are of interest to me yet they do not represent pit contents after 8-10-10. I believe that drilling activities continued past that date. You will recall from our conversation on 9-10-10 that I requested the report and test results from your inspector's visit to the Woodland site the week of 9-6. I was told that you sent an inspector on 9-7 and 9-8. I respectfully again request the following information:

1) Inspector's full reports from 9-7 and 9-8. These are attached.
2) Pit water test results from that day(s). There is no additional water test data.
3) Air quality test results from that day(s) There is no site specific air quality data. DEP's MAU (Mobile Analytical Unit) is doing multi-area samplings across the Northern Tier over the next 4 weeks. As this information is synthesized, DEP will make it available.

4) Explanation of what chemical used in the drilling process would create the odor that we and 911 responders observed

At this time DEP is still unsure of the specific "chemical" that triggers the sulfide reaction. As I mentioned previously, DEP has seen this problem in other areas of the state.

5) Health implications of said odors

H2S is primarily an eye irritant. The H2S was very smelly; it was being released in a well ventilated area and there is limited

6) Destination of waste water which has been trucked off site. See number 2 above.

I have to leave the office early today, but will be in tomorrow

Kelly Heffner

Kelly Jean Heffner | Acting Deputy Secretary
Office of Field Operations
Department of Environmental Protection
Rachel Carson State Office Building
400 Market Street | Harrisburg, PA 17101
Phone: 717.787.5028 | Fax: 717.772.3314
www.depweb.state.pa.us

5500-FM-OG0016a Rev. 5/2004

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

INSPECTION REPORT

DEP USE ONLY	Inspection Record #
Complaint Record #	Enforcement Record #

DEP Office	Scranton Phone 570-346-5511	Permit or Reg. #	127-20017
Address	101 Penn Ave Scranton PA 18503	Project #	
		Farm Name & Well #	Woodland Mgmt Partners I
Oper Name	Newfield Appalachia	County	Wayne
Address	119 Lincoln St. Honesdale PA 18431	Municipality	Damascus
		Latitude:	° ' " N
		Longitude:	° ' " W

Inspection Code:
- ☐ BDREL - Bond Release
- ☐ CEI - Compliance Evaluation
- ☐ COMPL - Complaint Inspection
- ☐ DRALT - Drilling or Alteration
- ☒ FLWUP - Follow-up
- ☐ PLUG - Plugging
- ☐ RDSPR - Road Spreading
- ☐ RESTR - Site Restoration
- ☐ RTNC - Routine

Other: ☐ Permit Expired ☐ Alt/Meth. ☐ Annulus Open ☐ Cement Returns ☐ Recommend Bond Release

Fold Line

Location	Insp.	Violation
Site ID Sign	X	
Well Tag		
Distance Restrict		
E/S Plan on Site		
E/S Controls		
Encroachments		
Site Restoration		
Drilling-Plugging		
Notification		
B.O.P.		
Casing		
Monument		
Waste Mgmt.		
Top Hole Water		
Fluids Mgmt.	X	
Impoundment/pit	X	
Pollution Prevent		
Residual Waste		

Driller's Log Information — Depth:

Fresh Water Amt / Depth	Salt Water Amt / Depth	Coal Thickness / Depth	Formations Oil / Depth	Formations Gas / Depth

Drilling / Plugging

Filling Material & Plugs	From	To

Casing & Tubing

Size	Pulled	Left

Compliance Assistance	Code	Code	Inspection Results	Code
				NOVIO

Remarks: Reponded to complaint of "Sulphur" odor coming from well site. At time of inspection construction crew on site sucking down fluid in pit. Fluid being pumped to frac tanks on site and then transported off site by tanker trucks. When pumping fluid, odor is emitted through vents in tanks. Weather conditions were windy over weekend and during inspection. Contractors planning to solidify pit tomorrow and then fold over liners on Friday. DEP will inspect pit prior to encapsulating.

Sample No.	Location / Description

DEP Rep: (signature) Stephen Watson (print name) Steve WATSON

Date: 9/8/10 Time: 14:15

☐ White – Regional File ☐ Yellow – Operator ☐ Pink – Inspector ☐ Goldenrod – Company File

5500-FM-OG0016a Rev. 5/2004

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

INSPECTION REPORT

DEP USE ONLY	Inspection Record #
Complaint Record #	Enforcement Record #

DEP Office	Scranton Phone 570 346-5534	Permit or Reg. #	127-20017
Address	101 Penn Ave	Project #	
	Scranton PA 18503	Farm Name & Well #	Woodland Mgt Partners 1
Oper Name	Newfield Appalachia	County	Wayne
Address	119 Lincoln Street	Municipality	Damascus
	Honesdale PA 18431	Latitude:	° ' " N
		Longitude:	° ' " W

Inspection Code:
- ☐ BDREL - Bond Release
- ☐ CEI - Compliance Evaluation
- ☐ COMPL - Complaint Inspection
- ☐ DRALT - Drilling or Alteration
- ☒ FLWUP - Follow-up
- ☐ PLUG - Plugging
- ☐ RDSPR - Road Spreading
- ☐ RESTR - Site Restoration
- ☐ RTNC - Routine

Other: ☐ Permit Expired ☐ Alt/Meth. ☐ Annulus Open ☐ Cement Returns ☐ Recommend Bond Release

Fold Line

Location	Insp.	Violation
Site ID Sign	X	
Well Tag		
Distance Restrict		
E/S Plan on Site		
E/S Controls		
Encroachments		
Site Restoration		
Drilling-Plugging		
Notification		
B.O.P.		
Casing		
Monument		
Waste Mgmt.		
Top Hole Water		
Fluids Mgmt.	X	
Impoundment/pit	X	
Pollution Prevent	X	
Residual Waste		

Driller's Log Information Depth:

Fresh Water Amt / Depth	Salt Water Amt / Depth	Coal Thickness / Depth	Formations Oil / Depth	Formations Gas / Depth

Drilling / Plugging

Filling Material & Plugs	From	To

Casing & Tubing

Size	Pulled	Left

Compliance Assistance	Code	Code	Inspection Results	Code
				NOV10

Remarks: Follow up inspection to determine activity on well. At time of inspection, trucks hauling off last few pieces of rig to next site (Crum). H+K contracting on site. Two workers skimming off oily sheen from reserve pit. Inspected liner - no tears were observed. Several Frac tanks on site are to be used to temporarily store fluid from pit as they pump it down. Plan to solidify and encapsulate next week sometime.

Sample No.	Location / Description

DEP Rep:
(signature) Stephen Watson
(print name) Steve WATSON

Date: 9/2/10
Time: @ 1:30

Page 1 of ____

☐ White – Regional File ☐ Yellow – Operator ☐ Pink – Inspector ☐ Goldenrod – Company File

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

TestAmerica Laboratories, Inc.

ANALYTICAL REPORT

DRBC Well Smp, Wayne County PA

Lot #: C0H110479

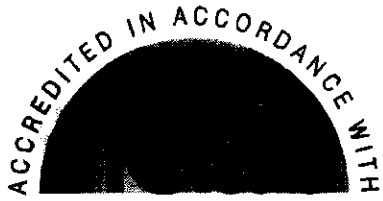
Steve Moyer

Tetra Tech NUS, Inc
116 N. Washington Avenue
Office 1G
Scranton, PA 18503

TESTAMERICA LABORATORIES, INC.

Veronica Bortot
Project Manager

August 18, 2010



NELAC REPORTING:

At the time of analysis the laboratory was in compliance with the current NELAC standards and held accreditation for all analyses performed unless noted by a qualifier. The labs accreditation numbers are listed below. The format and contents of the report meets all applicable NELAC standards except as noted in the narrative and shall not be reproduced except in full, without the written approval of the laboratory. The table below presents a summary of the certifications held by TestAmerica Pittsburgh. Our primary accreditation authority for the Non-potable water and Solid & Hazardous waste programs is Pennsylvania DEP. A more detailed parameter list is available upon request. Please ask your project manager for this information when required.

Certifying State/Program	Certificate #	Program Types	TestAmerica
DoD ELAP	ADE-1442	WW HW	X
US Dept of Agriculture	(#P330-10-00139)	Foreign Soil Import Permit	X
Arkansas	(#88-0690)	WW HW	X X
California – NELAC	04224CA	WW HW	X X
Connecticut	(#PH-0688)	WW HW	X X
Florida – NELAC	(#E871008)	WW HW	X X
Illinois – NELAC	(#002319)	WW HW	X X
Kansas – NELAC	(#E-10350)	WW HW	X X
Louisiana – NELAC	(#04041)	WW HW	X X
New Hampshire – NELAC	(#203010)	WW --	X --
New Jersey – NELAC	(PA-005)	WW HW	X X
New York – NELAC	(#11182)	WW HW	X X
North Carolina	(#434)	WW HW	X X
Pennsylvania - NELAC	(#02-00416)	WW HW	X X
South Carolina	(#89014002)	WW HW	X X
Utah – NELAC	(STLP)	WW HW	X X
West Virginia	(#142)	WW HW	X X
Wisconsin	998027800	WW HW	X X

The codes utilized for program types are described below:

HW Hazardous Waste certification
WW Non-potable Water and/or Wastewater certification
X Laboratory has some form of certification under the specific program. Many states certify laboratories for specific parameters or tests within a category. The information in the table indicates the lab is certified in a general category of testing. Please contact the laboratory if parameter specific certification information is required.

Updated: 05/19/10 N:\Reporting\NELAC NARRATIVE Pttsburgh_Updated 051910.doc

CASE NARRATIVE
TETRA TECH

Lot #: C0H110479

Sample Receiving:
TestAmerica's Pittsburgh laboratory received one sample on August 11, 2010. The cooler was received within the proper temperature range.

If project specific QC was not required for samples contained in this report, when batch QC was completed on these samples, anomalous results will be discussed below.

GC/MS Volatiles:
All non-CCC compounds that have >15% RSD were evaluated to see if a better curve could be drawn using a quadratic curve. All compounds <30% RSD will use an average response factor curve if no visible improvement is accomplished using a quadratic curve. A quadratic curve will be used for a compound where it is determined to be the "best-fit" evaluation.

Metals:
The sample and associated matrix spikes were over the instrument's linear range for sodium and strontium and was analyzed at a dilution.

The method blanks had analytes detected at concentrations between the MDL and the reporting limit. The results were flagged with a "B" qualifier. Any sample associated with a method blank that had the same analyte detected had the result flagged with a "J" qualifier.

For the matrix spike and matrix spike duplicate, potassium, sodium and strontium recoveries were not calculated due to the concentration of analyte in the sample being >4 times the concentration of spike added.

The matrix spikes recovered outside control limits for aluminum.

General Chemistry:
The test for pH is a field parameter. The laboratory pH analysis was completed at the request of the client.

Chain of Custody Record

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

TestAmerica Laboratory location: ____

Regulatory program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other ____

TestAmerica Laboratories, Inc.

COC No:

Client Contact		
Company Name: Tetra Tech NUS	Client Project Manager: Beth Witonski	Site Contact: Veronica Bortot → Lab Contact:
Address: 116 N Washington Ave	Telephone: (610) 588 6731	Telephone:
City/State/Zip: Scranton, PA, 18503		
Phone: 570-344-1148		
Project Name: SBC well Sampling Tophole	Method of Shipment/Carrier: Fedex	
Project Number: 112G05836	Shipping/Tracking No:	

TAT if different from below: ☐ 3 weeks ☐ 2 weeks ☒ 1 week ☐ 2 days ☐ 1 day

Analyses: CN, Metals, VOA, TPH

Sample Identification	Sample Date	Sample Time	Matrix / Containers & Preservatives	Analyses
WMP-Tophole 081010	8/16/10	1345	X X X X X	X X X X

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month): ☐ Return to Client ☐ Disposal By Lab ☐ Archive For ____ Months

Special Instructions/QC Requirements & Comments:
* 1 Liter sample being tested for CN is not preserved. Short hold.

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
[signature]	Tetra Tech	8/19/10; 1745			
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by: [signature]	TA-Pitt	8/19/10

TAL-0018 (1008)

METHODS SUMMARY

C0H110479

PARAMETER	ANALYTICAL METHOD	PREPARATION METHOD
pH (Electrometric)	SM20 4500-H+B	SM20 4500-H B
Biochemical Oxygen Demand 5210B	SM20 5210B	SM20 5210B
Mercury (Manual Cold Vapor Technique)	MCAWW 245.1	MCAWW 245.1
N-Hexane Ext. Material, Silica Gel Treated-1664A	CFR136A 1664A S	EPA 1664A
Total Cyanide	MCAWW 335.4	MCAWW 335.4
Total Suspended Solids SM 2540 D	SM20 2540D	SM20 2540D
Trace Inductively Coupled Plasma (ICP) Metals	MCAWW 200.7	MCAWW 200.7
Volatile Organics by GC/MS	SW846 8260B	SW846 5030B

References:

CFR136A "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

MCAWW "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.

SM20 "STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER", 20TH EDITION."

SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

SAMPLE SUMMARY

C0H110479

WO #	SAMPLE#	CLIENT SAMPLE ID	SAMPLED DATE	SAMP TIME
L5EXN	001	WMP-TOPHOLE 081010	08/10/10	13:45

NOTE(S):

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

Tetra Tech NUS, Inc

Client Sample ID: WMP-TOPHOLE 081010

GC/MS Volatiles

Lot-Sample #...: C0H110479-001 **Work Order #...:** L5EXN1A4 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10 **MS Run #.....:** 0228124
Prep Date.....: 08/16/10 **Analysis Date..:** 08/16/10
Prep Batch #...: 0228193 **Analysis Time..:** 09:28
Dilution Factor: 1

Method.....: SW846 8260B

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	ND	5.0	ug/L
Ethylbenzene	ND	5.0	ug/L
Toluene	ND	5.0	ug/L
Xylenes (total)	ND	15	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	107	(62 - 123)
Toluene-d8	96	(80 - 120)
4-Bromofluorobenzene	92	(75 - 120)
Dibromofluoromethane	104	(80 - 120)

METHOD BLANK REPORT

GC/MS Volatiles

Client Lot #...: C0H110479 **Work Order #...:** L5L921AA **Matrix.....:** WATER
MB Lot-Sample #: C0H160000-193
Prep Date.....: 08/16/10 **Analysis Time..:** 07:06
Analysis Date..: 08/16/10 **Prep Batch #...:** 0228193
Dilution Factor: 1

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD
Benzene	ND	5.0	ug/L	SW846 8260B
Ethylbenzene	ND	5.0	ug/L	SW846 8260B
Toluene	ND	5.0	ug/L	SW846 8260B
Xylenes (total)	ND	15	ug/L	SW846 8260B

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	117	(62 - 123)
Toluene-d8	94	(80 - 120)
4-Bromofluorobenzene	101	(75 - 120)
Dibromofluoromethane	97	(80 - 120)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

GC/MS Volatiles

Client Lot #...: C0H110479 **Work Order #...:** L5L921AC **Matrix.....:** WATER
LCS Lot-Sample#: C0H160000-193
Prep Date.....: 08/16/10 **Analysis Date..:** 08/16/10
Prep Batch #...: 0228193 **Analysis Time..:** 07:43
Dilution Factor: 1

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD
1,1-Dichloroethene	**82**	**(69 - 127)**	**SW846 8260B**
Trichloroethene	**98**	**(80 - 120)**	**SW846 8260B**
Chlorobenzene	**89**	**(83 - 120)**	**SW846 8260B**
Benzene	**95**	**(80 - 120)**	**SW846 8260B**
Toluene	**83**	**(80 - 124)**	**SW846 8260B**

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	112	(62 - 123)
Toluene-d8	95	(80 - 120)
4-Bromofluorobenzene	97	(75 - 120)
Dibromofluoromethane	108	(80 - 120)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Bold print denotes control parameters

MATRIX SPIKE SAMPLE EVALUATION REPORT

GC/MS Volatiles

Client Lot #...: C0H110479 **Work Order #...:** L5E0M1C7-MS **Matrix.....:** WATER
MS Lot-Sample #: C0H110483-001 L5E0M1C8-MSD
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10 **MS Run #.....:** 0228124
Prep Date.....: 08/16/10 **Analysis Date..:** 08/16/10
Prep Batch #...: 0228193 **Analysis Time..:** 08:07
Dilution Factor: 1

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD
1,1-Dichloroethene	**86**	**(69 - 127)**			**SW846 8260B**
	93	**(69 - 127)**	**8.4**	**(0-20)**	**SW846 8260B**
Trichloroethene	**98**	**(80 - 120)**			**SW846 8260B**
	110	**(80 - 120)**	**11**	**(0-20)**	**SW846 8260B**
Chlorobenzene	**99**	**(83 - 120)**			**SW846 8260B**
	98	**(83 - 120)**	**1.2**	**(0-20)**	**SW846 8260B**
Benzene	**105**	**(80 - 120)**			**SW846 8260B**
	105	**(80 - 120)**	**0.0**	**(0-20)**	**SW846 8260B**
Toluene	**90**	**(80 - 124)**			**SW846 8260B**
	89	**(80 - 124)**	**0.22**	**(0-20)**	**SW846 8260B**

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	115	(62 - 123)
	117	(62 - 123)
Toluene-d8	95	(80 - 120)
	94	(80 - 120)
4-Bromofluorobenzene	94	(75 - 120)
	94	(75 - 120)
Dibromofluoromethane	108	(80 - 120)
	115	(80 - 120)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Bold print denotes control parameters

Tetra Tech NUS, Inc

Client Sample ID: WMP-TOPHOLE 081010

TOTAL Metals

Lot-Sample #...: C0H110479-001 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 0224387						
Silver	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5EXN1AA
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Aluminum	**2420 J**	**200**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AH**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Arsenic	**11.4**	**10.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AJ**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Barium	**1830**	**200**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AK**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Beryllium	ND	4.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5EXN1AL
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Boron	**249**	**200**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AM**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Calcium	**108000 J**	**5000**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AN**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Cadmium	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5EXN1AP
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Cobalt	**1.6 B**	**50.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AQ**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Chromium	**9.6**	**5.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AR**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Copper	**10 B**	**25.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AC**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Iron	**3010**	**100**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AD**
		Dilution Factor: 1		Analysis Time..: 16:34	MS Run #.....: 0224231	

(Continued on next page)

Tetra Tech NUS, Inc

Client Sample ID: WMP-TOPHOLE 081010

TOTAL Metals

Lot-Sample #...: C0H110479-001 **Matrix.....:** WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Potassium	**249000**	**5000**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AE**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Lithium	**3190**	**50.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AF**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Magnesium	**2730 B,J**	**5000**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AG**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Manganese	**101**	**15.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/16/10**	**L5EXN1AT**
		Dilution Factor: 1		Analysis Time..: 12:07	MS Run #.....: 0224231	
Molybdenum	**89.9**	**40.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AU**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Sodium	**801000**	**25000**	**ug/L**	**MCAWW 200.7**	**08/12-08/16/10**	**L5EXN1AV**
		Dilution Factor: 5		Analysis Time..: 12:26	MS Run #.....: 0224231	
Nickel	**7.6 B**	**40.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AW**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Lead	**22.6**	**3.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1AX**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Selenium	**5.5**	**5.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1A0**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	
Strontium	**10800 J**	**250**	**ug/L**	**MCAWW 200.7**	**08/12-08/16/10**	**L5EXN1A1**
		Dilution Factor: 5		Analysis Time..: 12:26	MS Run #.....: 0224231	
Zinc	**21.3**	**20.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5EXN1A2**
		Dilution Factor: 1		Analysis Time..: 13:43	MS Run #.....: 0224231	

Prep Batch #...: 0230021

Mercury	**0.35**	**0.20**	**ug/L**	**MCAWW 245.1**	**08/18/10**	**L5EXN1A3**
		Dilution Factor: 1		Analysis Time..: 07:59	MS Run #.....: 0230010	

NOTE(S):

J Method blank contamination. The associated method blank contains the target analyte at a reportable level.

B Estimated result. Result is less than RL.

METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MB Lot-Sample #: C0H120000-387 **Prep Batch #...:** 0224387						
Aluminum	**67.6 B**	**200**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5HKP1AH**
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Arsenic	ND	10.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AJ
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Barium	ND	200	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AK
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Beryllium	**0.31 B**	**4.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5HKP1AL**
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Boron	ND	200	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AM
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Cadmium	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AP
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Calcium	**87.9 B**	**5000**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5HKP1AN**
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Chromium	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AR
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Cobalt	ND	50.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AQ
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Copper	ND	25.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AC
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Iron	ND	100	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AD
		Dilution Factor: 1				
		Analysis Time..: 16:12				

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METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Lead	ND	3.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AX
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Lithium	ND	50.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AF
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Magnesium	**54.5 B**	**5000**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5HKP1AG**
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Manganese	ND	15.0	ug/L	MCAWW 200.7	08/12-08/16/10	L5HKP1AT
		Dilution Factor: 1				
		Analysis Time..: 11:55				
Molybdenum	ND	40.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AU
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Nickel	ND	40.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AW
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Potassium	ND	5000	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AE
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Selenium	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1A0
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Silver	ND	5.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AA
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Sodium	ND	5000	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1AV
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Strontium	**0.44 B**	**50.0**	**ug/L**	**MCAWW 200.7**	**08/12-08/13/10**	**L5HKP1A1**
		Dilution Factor: 1				
		Analysis Time..: 13:26				
Zinc	ND	20.0	ug/L	MCAWW 200.7	08/12-08/13/10	L5HKP1A2
		Dilution Factor: 1				
		Analysis Time..: 13:26				

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METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MB Lot-Sample #: C0H180000-021 **Prep Batch #...:** 0230021						
Mercury	ND	0.20	ug/L	MCAWW 245.1	08/18/10	L5P4D1AA
		Dilution Factor: 1				
		Analysis Time..: 07:56				

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

B Estimated result. Result is less than RL.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
LCS Lot-Sample#: C0H120000-387 **Prep Batch #...:** 0224387					
Silver	92	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A3
		Dilution Factor: 1	Analysis Time..: 13:30		
Copper	95	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A4
		Dilution Factor: 1	Analysis Time..: 13:30		
Iron	89	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A5
		Dilution Factor: 1	Analysis Time..: 16:17		
Potassium	98	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A6
		Dilution Factor: 1	Analysis Time..: 13:30		
Lithium	96	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A7
		Dilution Factor: 1	Analysis Time..: 13:30		
Magnesium	97	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A8
		Dilution Factor: 1	Analysis Time..: 13:30		
Aluminum	100	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1A9
		Dilution Factor: 1	Analysis Time..: 13:30		
Arsenic	101	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CA
		Dilution Factor: 1	Analysis Time..: 13:30		
Barium	96	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CC
		Dilution Factor: 1	Analysis Time..: 13:30		
Beryllium	96	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CD
		Dilution Factor: 1	Analysis Time..: 13:30		
Boron	101	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CE
		Dilution Factor: 1	Analysis Time..: 13:30		
Calcium	99	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CF
		Dilution Factor: 1	Analysis Time..: 13:30		
Cadmium	95	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CG
		Dilution Factor: 1	Analysis Time..: 13:30		
Cobalt	99	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CH
		Dilution Factor: 1	Analysis Time..: 13:30		

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LABORATORY CONTROL SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Chromium	95	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CJ
		Dilution Factor: 1	Analysis Time..: 13:30		
Manganese	95	(85 - 115)	MCAWW 200.7	08/12-08/16/10	L5HKP1CK
		Dilution Factor: 1	Analysis Time..: 11:59		
Molybdenum	95	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CL
		Dilution Factor: 1	Analysis Time..: 13:30		
Sodium	97	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CM
		Dilution Factor: 1	Analysis Time..: 13:30		
Nickel	98	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CN
		Dilution Factor: 1	Analysis Time..: 13:30		
Lead	98	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CP
		Dilution Factor: 1	Analysis Time..: 13:30		
Selenium	104	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CQ
		Dilution Factor: 1	Analysis Time..: 13:30		
Strontium	96	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CR
		Dilution Factor: 1	Analysis Time..: 13:30		
Zinc	96	(85 - 115)	MCAWW 200.7	08/12-08/13/10	L5HKP1CT
		Dilution Factor: 1	Analysis Time..: 13:30		

LCS Lot-Sample#: C0H180000-021 **Prep Batch #...:** 0230021

Mercury	100	(85 - 115)	MCAWW 245.1	08/18/10	L5P4D1AC
		Dilution Factor: 1	Analysis Time..: 07:57		

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MS Lot-Sample #: C0H110479-001 **Prep Batch #...:** 0224387							
Aluminum	153 N	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CQ
	147 N	(70 - 130)	2.3	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CR
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Arsenic	114	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CT
	111	(70 - 130)	2.0	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CU
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Barium	106	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CV
	102	(70 - 130)	2.1	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CW
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Beryllium	101	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CX
	97	(70 - 130)	3.8	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1C0
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Boron	101	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1C1
	99	(70 - 130)	2.0	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1C2
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Cadmium	98	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1C5
	95	(70 - 130)	3.4	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1C6
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Calcium	101	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1C3
	94	(70 - 130)	2.1	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1C4
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					

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MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Chromium	100	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1C9
	98	(70 - 130)	2.0	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DA
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Cobalt	111	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1C7
	107	(70 - 130)	3.5	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1C8
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Copper	103	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CE
	99	(70 - 130)	3.6	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CF
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Iron	116	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CG
	117	(70 - 130)	0.33	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CH
		Dilution Factor: 1					
		Analysis Time..: 16:45					
		MS Run #.....: 0224231					
Lead	105	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1DL
	101	(70 - 130)	3.2	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DM
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Lithium	111	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CL
	104	(70 - 130)	1.6	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CM
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Magnesium	100	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CN
	96	(70 - 130)	3.7	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CP
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					

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MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Manganese	101	(70 - 130)			MCAWW 200.7	08/12-08/16/10	L5EXN1DC
	99	(70 - 130)	1.8	(0-20)	MCAWW 200.7	08/12-08/16/10	L5EXN1DD
		Dilution Factor: 1					
		Analysis Time..: 12:16					
		MS Run #.....: 0224231					
Molybdenum	100	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1DE
	97	(70 - 130)	2.4	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DF
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Nickel	109	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1DJ
	105	(70 - 130)	3.3	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DK
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Potassium	NC	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CJ
	NC	(70 - 130)		(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CK
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Selenium	115	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1DN
	111	(70 - 130)	3.6	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DP
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Silver	102	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1CC
	100	(70 - 130)	2.2	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1CD
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					
Sodium	NC	(70 - 130)			MCAWW 200.7	08/12-08/16/10	L5EXN1DG
	NC	(70 - 130)		(0-20)	MCAWW 200.7	08/12-08/16/10	L5EXN1DH
		Dilution Factor: 5					
		Analysis Time..: 12:35					
		MS Run #.....: 0224231					

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MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Strontium	NC	(70 - 130)			MCAWW 200.7	08/12-08/16/10	L5EXN1DQ
	NC	(70 - 130)		(0-20)	MCAWW 200.7	08/12-08/16/10	L5EXN1DR
		Dilution Factor: 5					
		Analysis Time..: 12:35					
		MS Run #.....: 0224231					
Zinc	100	(70 - 130)			MCAWW 200.7	08/12-08/13/10	L5EXN1DT
	98	(70 - 130)	2.2	(0-20)	MCAWW 200.7	08/12-08/13/10	L5EXN1DU
		Dilution Factor: 1					
		Analysis Time..: 13:52					
		MS Run #.....: 0224231					

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

N Spiked analyte recovery is outside stated control limits.

NC The recovery and/or RPD were not calculated.

MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MS Lot-Sample #: C0H110483-001 **Prep Batch #...:** 0230021							
Mercury	95	(70 - 130)			MCAWW 245.1	08/18/10	L5E0M1DG
	87	(70 - 130)	7.6	(0-20)	MCAWW 245.1	08/18/10	L5E0M1DH

Dilution Factor: 1
Analysis Time..: 08:02
MS Run #.....: 0230010

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Tetra Tech NUS, Inc

Client Sample ID: WMP-TOPHOLE 081010

General Chemistry

Lot-Sample #...: C0H110479-001 **Work Order #...:** L5EXN **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
pH	**8.2**	--	--	**SM20 4500-H+B**	**08/16/10**	**0228263**
		Dilution Factor: 1		Analysis Time..: 14:06	MS Run #.....: 0228171	
Biochemical Oxygen Demand (BOD)	**436**	**2.0**	**mg/L**	**SM20 5210B**	**08/12-08/17/10**	**0224155**
		Dilution Factor: 1		Analysis Time..: 12:25	MS Run #.....: 0224080	
Total Cyanide	ND	0.010	mg/L	MCAWW 335.4	08/13/10	0225143
		Dilution Factor: 1		Analysis Time..: 10:56	MS Run #.....: 0225056	
Total Suspended Solids	**238**	**4.0**	**mg/L**	**SM20 2540D**	**08/16-08/17/10**	**0228259**
		Dilution Factor: 1		Analysis Time..: 07:30	MS Run #.....: 0228163	
TPH (SGT-HEM)	ND	5.8	mg/L	CFR136A 1664A SGT	08/12/10	0224136
		Dilution Factor: 1.15		Analysis Time..: 09:01	MS Run #.....:	

METHOD BLANK REPORT

General Chemistry

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Biochemical Oxygen Demand (BOD)		Work Order #: L5GAD1AA		MB Lot-Sample #:	C0H120000-155	
	ND	2.0	mg/L	SM20 5210B	08/12-08/17/10	0224155
		Dilution Factor: 1				
		Analysis Time..: 12:25				
Total Cyanide		Work Order #: L5H171AA		MB Lot-Sample #:	C0H130000-143	
	ND	0.010	mg/L	MCAWW 335.4	08/13/10	0225143
		Dilution Factor: 1				
		Analysis Time..: 10:56				
Total Suspended Solids		Work Order #: L5MFX1AA		MB Lot-Sample #:	C0H160000-259	
	ND	4.0	mg/L	SM20 2540D	08/16-08/17/10	0228259
		Dilution Factor: 1				
		Analysis Time..: 07:30				
TPH (SGT-HEM)		Work Order #: L5F871AA		MB Lot-Sample #:	C0H120000-136	
	ND	5.0	mg/L	CFR136A 1664A SGT	08/12/10	0224136
		Dilution Factor: 1				
		Analysis Time..: 09:01				

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

General Chemistry

Lot-Sample #...: C0H110479 **Matrix.....:** WATER

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Biochemical Oxygen Demand (BOD)	WO#:L5GAD1AC-LCS/L5GAD1AD-LCSD					LCS Lot-Sample#: C0H120000-155	
	92	(85 - 115)			SM20 5210B	08/12-08/17/10	0224155
	91	(85 - 115)	0.55	(0-20)	SM20 5210B	08/12-08/17/10	0224155
	Dilution Factor: 1				Analysis Time..: 12:25		
TPH (SGT-HEM)	WO#:L5F871AC-LCS/L5F871AD-LCSD					LCS Lot-Sample#: C0H120000-136	
	89	(64 - 132)			CFR136A 1664A SGT	08/12/10	0224136
	86	(64 - 132)	2.8	(0-34)	CFR136A 1664A SGT	08/12/10	0224136
	Dilution Factor: 1				Analysis Time..: 09:01		

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

General Chemistry

Client Lot #...: C0H110479 **Matrix.....:** WATER

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
pH		Work Order #: L5MG11AA	LCS Lot-Sample#: C0H160000-263		
	100	(99 - 101)	SM20 4500-H+B	08/16/10	0228263
		Dilution Factor: 1	Analysis Time..: 14:04		
Total Cyanide		Work Order #: L5H171AC	LCS Lot-Sample#: C0H130000-143		
	103	(90 - 110)	MCAWW 335.4	08/13/10	0225143
		Dilution Factor: 1	Analysis Time..: 10:56		
Total Suspended Solids		Work Order #: L5MFX1AC	LCS Lot-Sample#: C0H160000-259		
	83	(80 - 120)	SM20 2540D	08/16-08/17/10	0228259
		Dilution Factor: 1	Analysis Time..: 07:30		

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

MATRIX SPIKE SAMPLE EVALUATION REPORT

General Chemistry

Client Lot #...: C0H110479 **Matrix.....:** WATER
Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Total Cyanide		WO#: L5EXN1DV-MS/L5EXN1DW-MSD				MS Lot-Sample #: C0H110479-001	
	105	(90 - 110)			MCAWW 335.4	08/13/10	0225143
	100	(90 - 110)	4.6	(0-20)	MCAWW 335.4	08/13/10	0225143

Dilution Factor: 1
Analysis Time..: 10:56
MS Run #.....: 0225056

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

SAMPLE DUPLICATE EVALUATION REPORT

General Chemistry

Client Lot #...: C0H110479 **Work Order #...:** L5EKJ-SMP L5EKJ-DUP **Matrix.....:** WATER

Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAM	RESULT	DUPLICATE RESULT	UNITS	RPD	RPD LIMIT	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Total Suspended Solids						SD Lot-Sample #: C0H110430-001		
	75.0	73.0	mg/L	2.7	(0-20)	SM20 2540D	08/16-08/17/10	0228259

Dilution Factor: 1 Analysis Time..: 07:30 MS Run Number..: 0228163

SAMPLE DUPLICATE EVALUATION REPORT

General Chemistry

Client Lot #...: C0H110479 **Work Order #...:** L5EXN-SMP L5EXN-DUP **Matrix.....:** WATER

Date Sampled...: 08/10/10 **Date Received..:** 08/11/10

PARAM	RESULT	DUPLICATE RESULT	UNITS	RPD	RPD LIMIT	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
pH						SD Lot-Sample #: C0H110479-001		
	8.2	8.2	--	0.12	(0-2.0)	SM20 4500-H+B	08/16/10	0228263
			Dilution Factor: 1			Analysis Time..: 14:06	MS Run Number..: 0228171	
Biochemical Oxygen Demand (BOD)						SD Lot-Sample #: C0H110479-001		
	436	490	mg/L	12	(0-20)	SM20 5210B	08/12-08/17/10	0224155
			Dilution Factor: 1			Analysis Time..: 12:25	MS Run Number..: 0224080	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 826657
Watershed Name: Shehawken Rattlesnake Creek	Quality: HQ

Permittee: NEWFIELD APPALACHIA PA LLC	OGO.#: OGO-67425		Permit Number: 37-127-20013-	Date Issued: 04/23/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020			Farm Name & Well Number: DL TEEPLE 1 1	Well Serial #
			Municipality: Manchester	County: Wayne
HOUSTON, TX 770602424			7½ ' Quadrangle Name: Long Eddy	Map Section #: 1
Phone: (281) 847-6031	Project #		Latitude: 41-49-39.9000	Longitude: -75-11-53.3300
Surf Elev at Site: 1516 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 2304 feet West 8580 feet	

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/23/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Staci Gustafson for S. Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 106345	Amount $ 1500.00

$1250 + 250 = $1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes			
Vertical Test Well	OGO # 67425	Objection Date - Do not issue before: 4/5/10	Well Permit # 127-20013
	Bond # 12382	Date Approved: 4/20/10 JS	Special Cond. A B C D E F
	C: 3/11/10 Del G: 4/5/10 JCO		Watershed Name: Shehawken Rattlesnake Creek
	INV: 4-22-10		Designation: (HQ) EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address.
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	☐
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
D.L. Teeple	1-1	

County	Municipality	Project # (from DEP)
WAYNE	MANCHESTER	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled**, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storege
- ☒ Other (specify)

vertical test well

APPLICATION FEE
Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☒	☐
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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NORTHWEST REGIONAL OFFICE

DEP USE ONLY
Date Stamps/Notes
Auth 826651
Site 731937
Clnt 277879
APS 715262
Acct 674710

PF 728625
SF 101026

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the **"Coordination of a Well Location with Public Resources"** form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	*(Print or Type)*	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date
Donald F. Sleeth III			3-5-10

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 — Record of Notification / Written Consent

127-20013

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Lookout Veterans Home Corp	Address: 3785 Hancock Hwy Equinunk, PA 18417						X						X
Name: Carl Keesler	Address: 12 Legion Road, Equinunk, PA 18417						X			2-18-10	2-22-10		
Name: Dale L & Ella E Teeple	Address: 13 Teeple Rd Equinunk, PA 18417-3514	X					X						X
Name: Alan W & Mary E Hazen	Address: 7 Legion Rd Equinunk, PA 18417-3325						X						X
Name: Henry and Rita Hazen	Address: 9 Legion Rd Equinunk, PA 18417-3325						X						X
Name: Diane Day	Address: 3542 Hancock Hwy Equinunk, PA 18417						X						X
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Dale L Teeple Ella E. Teeple	Date 2-8-10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft. Allan Hazen Mary Hazen	Date 2/8/10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft. Rita Hazen	Date 2/8/10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft. Ronald E Lange	Date 2-17-10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location Dale L Teeple	Date 2-8-10	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location Ella E. Teeple	Date 2-8-10	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

127-20013

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

Name	Address	Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Lookout Veterans Home Corp	3785 Hancock Hwy Equinunk, PA 18417						X						X
Carl Keesler	12 Legion Road,Equinunk, PA 18417						X			2-18-10	2-22-10		
Dale L & Ella E Teeple	13 Teeple Rd Equinunk, PA 18417-3514	X					X						X
Alan W & Mary E Hazen	7 Legion Rd Equinunk, PA 18417-3325						X						X
Henry and Rita Hazen	9 Legion Rd Equinunk, PA 18417-3325						X						X
Diane Day	3542 Hancock Hwy Equinunk, PA 18417						X						X

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☒ Landowner with water supply within 1,000 ft.	Date 3/17/10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

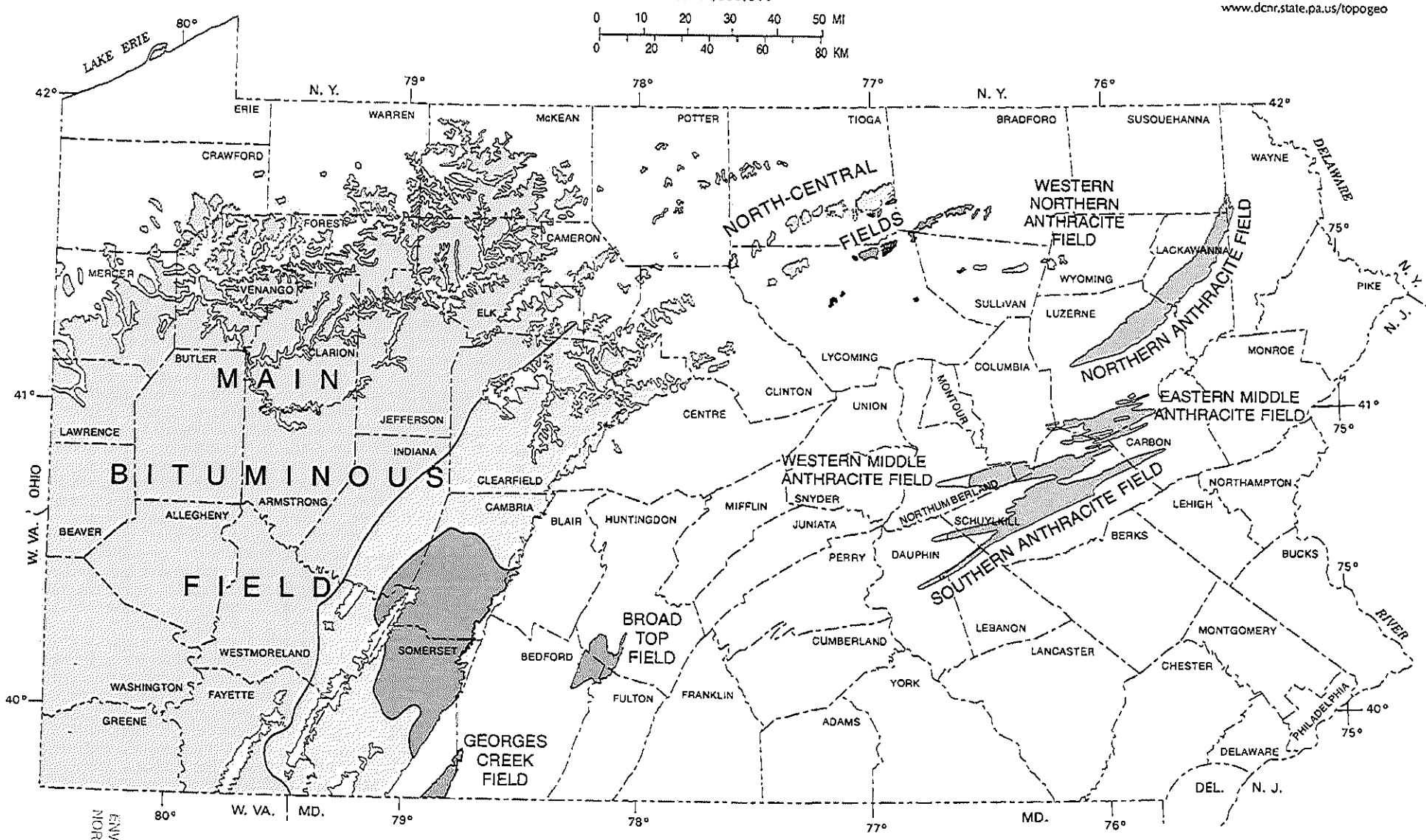
MAP 11

DISTRIBUTION OF PENNSYLVANIA COALS

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF
CONSERVATION AND NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
www.dcnr.state.pa.us/topogeo

SCALE 1:2,000,000

0 10 20 30 40 50 MI
0 20 40 60 80 KM



EXPLANATION

BITUMINOUS FIELDS

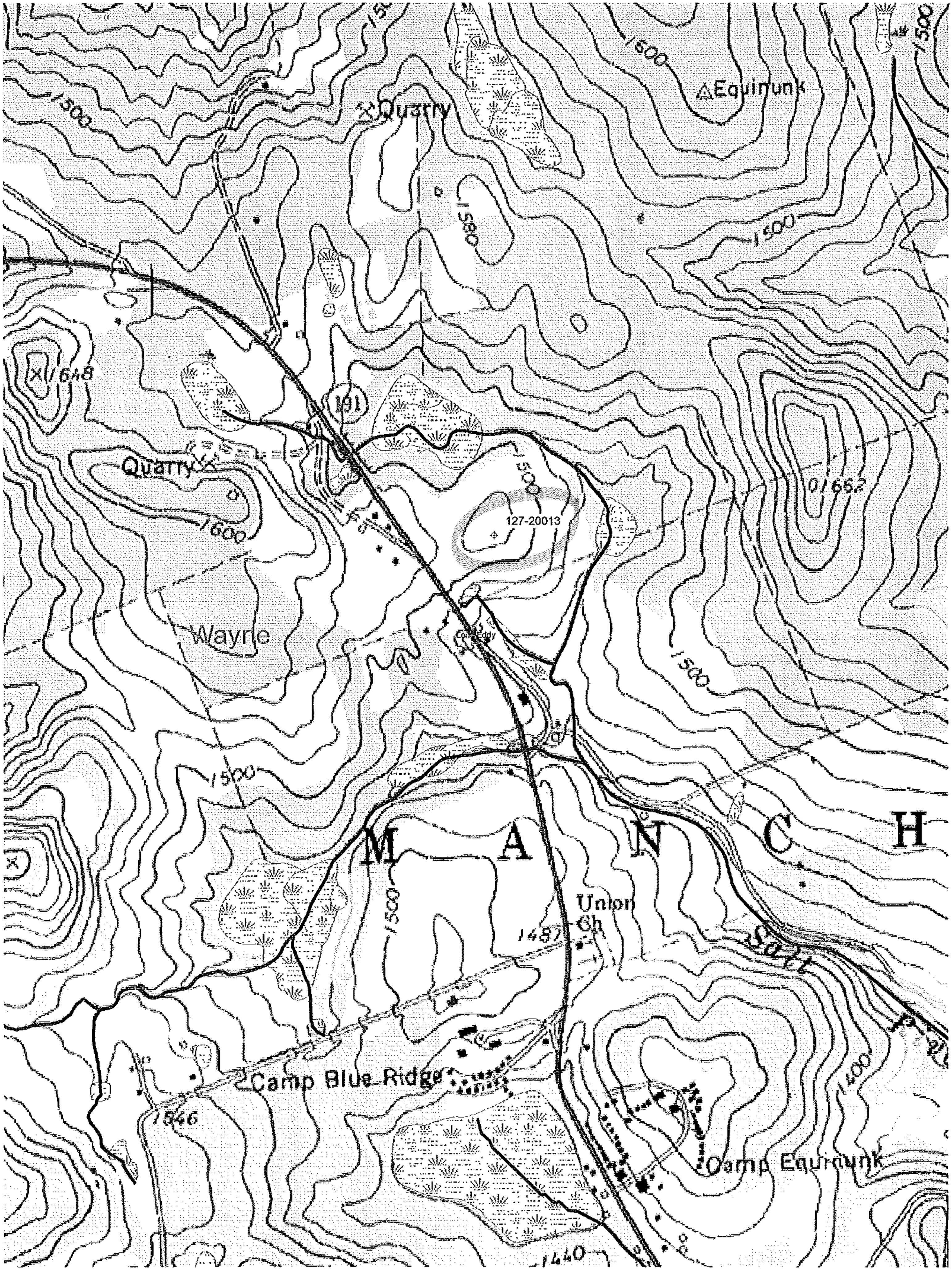
- High-volatile bituminous coal
- Medium-volatile bituminous coal
- Low-volatile bituminous coal

ANTHRACITE FIELDS

- Semi-anthracite
- Anthracite

Prepared by Bureau of Topographic and Geologic Survey.
Third Edition, Revised, 2000; Third Printing, 2008.

2200-MP-DCNR0855
Printed on Recycled Paper

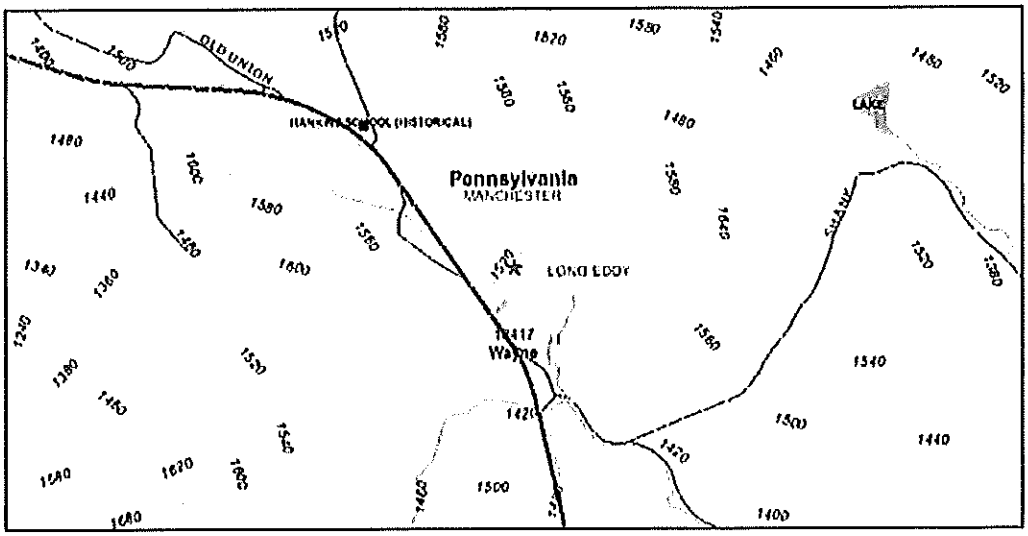


Equinunk
Quarry
1500
1600
1580
1648
191
Quarry
1600
127-20013
1662
Wayne
1500
1500
M A N C H
Union
Ch
1487
1500
Camp Blue Ridge
1546
Camp Equinunk
1400
1440

PNDI Project Environmental Review Receipt Project Search ID: 20100202227314

1. PROJECT INFORMATION

Project Name: **Newfield-1-Teeple**
Date of review: **2/2/2010 2:27:54 PM**
Project Category: **Mining,Oil or Gas (including roads and pipelines),New Well**
Project Area: **N/A**
County: **Wayne** Township/Municipality: **Manchester**
Quadrangle Name: **LONG EDDY**
ZIP Code: **18417**
Decimal Degrees: **41.82775 N, --75.198147 W**
Degrees Minutes Seconds: **41° 49' 39.90" N, -75° 11' 53.33" W**



2. SEARCH RESULTS

Agency	Results	Response
PA Game Commission	No Known Impact	No Further Review Required
PA Department of Conservation and Natural Resources	No Known Impact	No Further Review Required
PA Fish and Boat Commission	No Known Impact	No Further Review Required
U.S. Fish and Wildlife Service	No Known Impact	No Further Review Required

As summarized above, Pennsylvania Natural Diversity Inventory (PNDI) records indicate no known impacts to threatened and endangered species and/or special concern species and resources within the project area. Therefore, based on the information you provided, no further coordination is required with the jurisdictional agencies. This response does not reflect potential agency concerns regarding impacts to other ecological resources, such as wetlands.

3. AGENCY COMMENTS

Regardless of whether a DEP permit is necessary for this proposed project, any potential impacts to threatened and endangered species and/or special concern species and resources must be resolved with the appropriate jurisdictional agency. In some cases, a permit or authorization from the jurisdictional agency may be needed if adverse impacts to these species and habitats cannot be avoided.

These agency determinations and responses are **valid for one year** (from the date of the review), and are based on the project information that was provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the following change: 1) project location, 2) project size or configuration, 3) project type, or 4) responses to the questions that were asked during the online review, the results of this review are not valid, and the review must be searched again via the PNDI Environmental Review Tool and resubmitted to the jurisdictional agencies. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt.

PA Game Commission

RESPONSE: No impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Department of Conservation and Natural Resources

RESPONSE: No impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Fish and Boat Commission

RESPONSE: No impact is anticipated to threatened and endangered species and/or special concern species and resources.

U.S. Fish and Wildlife Service

RESPONSE: No impacts to federally listed or proposed species are anticipated. Therefore, no further consultation/coordination under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* is required. Because no take of federally listed species is anticipated, none is authorized. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

4. DEP INFORMATION

The Pa Department of Environmental Protection (DEP) requires that a signed copy of this receipt, along with any required documentation from jurisdictional agencies concerning resolution of potential impacts, be submitted with applications for permits requiring PNDI review. For cases where a "Potential Impact" to threatened and endangered species has been identified before the application has been submitted to DEP, the application should not be submitted until the impact has been resolved. For cases where "Potential Impact" to special concern species and resources has been identified before the application has been submitted, the application should be submitted to DEP along with the PNDI receipt, a completed PNDI form and a USGS 7.5 minute quadrangle map with the project boundaries delineated on the map. The PNDI Receipt should also be submitted to the appropriate agency according to directions on the PNDI Receipt. DEP and the jurisdictional agency will work together to resolve the potential impact(s). See the DEP PNDI policy at

http://www.naturalheritage.state.pa.us.

5. ADDITIONAL INFORMATION

The PNDI environmental review website is a **preliminary** screening tool. There are often delays in updating species status classifications. Because the proposed status represents the best available information regarding the conservation status of the species, state jurisdictional agency staff give the proposed statuses at least the same consideration as the current legal status. If surveys or further information reveal that a threatened and endangered and/or special concern species and resources exist in your project area, contact the appropriate jurisdictional agency/agencies immediately to identify and resolve any impacts.

For a list of species known to occur in the county where your project is located, please see the species lists by county found on the PA Natural Heritage Program (PNHP) home page (www.naturalheritage.state.pa.us). Also note that the PNDI Environmental Review Tool only contains information about species occurrences that have actually been reported to the PNHP.

6. AGENCY CONTACT INFORMATION

PA Department of Conservation and Natural Resources
Bureau of Forestry, Ecological Services Section
400 Market Street, PO Box 8552, Harrisburg, PA. 17105-8552
Fax:(717) 772-0271

U.S. Fish and Wildlife Service
Endangered Species Section
315 South Allen Street, Suite 322, State College, PA. 16801-4851
NO Faxes Please.

PA Fish and Boat Commission
Division of Environmental Services
450 Robinson Lane, Bellefonte, PA. 16823-7437
NO Faxes Please

PA Game Commission
Bureau of Wildlife Habitat Management
Division of Environmental Planning and Habitat Protection
2001 Elmerton Avenue, Harrisburg, PA. 17110-9797
Fax:(717) 787-6957

7. PROJECT CONTACT INFORMATION

Name: Stephen Moyer
Company/Business Name: Tetra Tech NUS
Address: 661 Anderson Drive Foster Plaza 7
City, State, Zip: Pittsburgh, PA 15220
Phone:(570) 344-1140 Fax:( )
Email: Steve.Moyer@tetratech.com

8. CERTIFICATION

I certify that ALL of the project information contained in this receipt (including project location, project size/configuration, project type, answers to questions) is true, accurate and complete. In addition, if the project type, location, size or configuration changes, or if the answers to any questions that were asked during this online review change, I agree to re-do the online environmental review.

applicant/project proponent signature

2/2/10
date

USPS

Confirmation Services

Package ID: 9171082133393775231599
Destination ZIP Code: 77584
Customer Reference:
Recipient: BILLY W COCKRELL
Address: 17214 HARKEY RD COUNTY RD 103
PEARLAND, TX 77584

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 17 2010 12:46P

D. FINLEY

Confirmation Services

Package ID: 9171082133393775231605
Destination ZIP Code: 77584
Customer Reference:
Recipient: BILLY W. COCKRELL
Address: 17214 HARKEY RD COUNTY RD 103
PEARLAND, TX 77584

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 17 2010 12:46P

RECEIVED
MAR 08 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

D. FINLEY

Confirmation Services

Package ID: 9171082133393775231612
Destination ZIP Code: 78245
Customer Reference:
Recipient: LATOYA ALEXANDER
Address: 1231 OLD FORREST ST.
SAN ANTONIO, TX 78245

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 17 2010 12:46P

D. Finley

Confirmation Services

Package ID: 9171082133393775231629
Destination ZIP Code: 90043
Customer Reference:
Recipient: Jeannie Alexander
Address: 6321 7th Avenue
Los Angeles, CA 90043

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 18 2010 4:10P

Amie Faul

Confirmation Services

Package ID: 9171082133393775231636
Destination ZIP Code: 18417
Customer Reference:
Recipient: Mr. Carl Keesler
Address: 12 Legion Road
Equinunk, PA 18417

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 19 2010 12:27P

Confirmation Services

Confirmation Services

Confirmation Services

Confirmation Services

Confirmation Services

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Carl Keesler
12 Legion Road
Equinunk, PA 18417

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) John Zona Jr. C. Date of Delivery 2-22-10

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☒ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service lat 91 7108 2133 3937 7523 1636

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: ACO 4/19/10
	Permit # 127-20013	C:
	Project #	

Denotes location of well on topo map.

Well is located on topo map 2,034 feet south of latitude 41 ° 50 ' 00 "

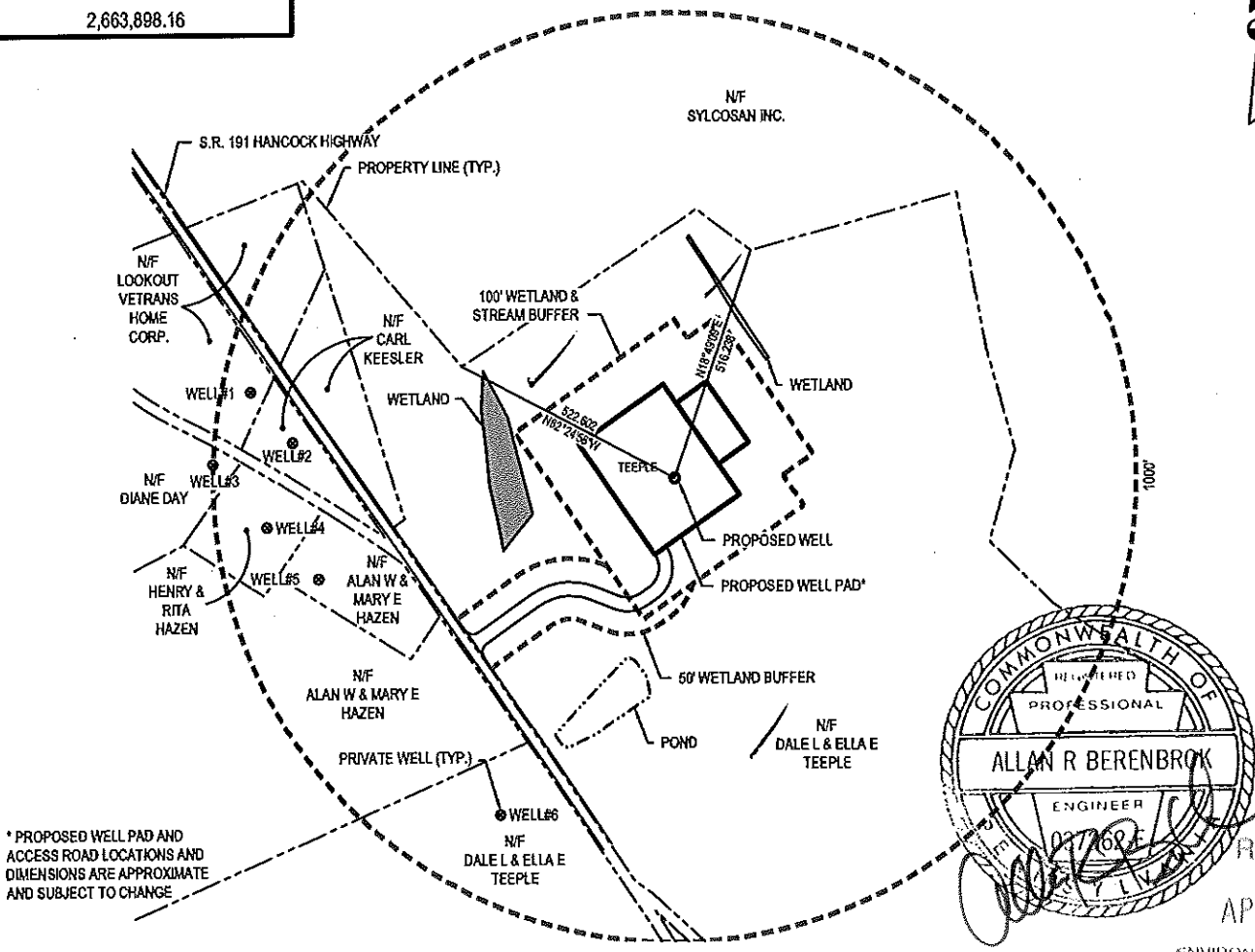
Well is located on topo map 8,580 feet west of longitude 75 ° 10 ' 00

True Latitude: NORTH	True Longitude: WEST	WELL NORTHING - Y	WELL EASTING - X
41 ° 49 ' 39.90 "	75 ° 11 ' 53.33 "	615,470.64	2,663,898.16

HQ WATERSHED

She hawken

Rattlesnake Creek



COMMONWEALTH OF PENNSYLVANIA REGISTERED PROFESSIONAL ALLAN R BERENBROK ENGINEER 027768E

RECEIVED
APR 19 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8673 | Dwg. #: 1 | Date: 4/16/2010 | Scale: 1" = 400' | Total Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83

Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83 Survey Date Jan. 2010

Applicant / Well Operator Name: Newfield Appalachia PA LLC

Well(Farm) Name: D.L. Teeple | Well # 1-1 | Serial #

Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060

County - Code: Wayne | Municipality: Manchester | Well Type: Vertical Test

Surface Landowner / Lessor: Dale and Ella Teeple

USGS 7 1/2 Quadrangle Map Name: Long Eddy, NY 0444 | Map Section: 5 | Surface Elevation: 1516 ft.

Target Formation(s): Onondaga

Angle & Course of Deviation (Drilling): N/A | Anticipated Total Depth: TVD 8,350 TMD 8,350

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp.	N78d 20' 44"W 938'	N/A	N/A
Carl Keesler	N84d 27' 43"W 832'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 816'	N/A	N/A
Alan W Mary E Hazen	S74d 33' 6"W 802'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\12679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/16/2010 12:43:02 PM

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	DEP Application Tracking #	G: 4/19/10
	Permit # 127-20013	C:
	Project #	

Use only if you need additional space for listings.

Applicant / Well Operator Name	Well(Farm) Name	Well #	Serial #
Newfield Appalachia PA LLC	D.L. Teeple	1-1	

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Henry and Rita Hazen ✓	S83d 23' 28"W 890'	N/A	N/A
Diane Day ✓	N88d 2' 27"W 1000'	N/A	N/A

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APR 19 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

R:_Marcellus Shale Projects\Newfield\02679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit C.dwg PIT SCOTT.CALTON 4/9/2010 12:05:06 PM

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G:
	Permit #	
	Project #	C:

Denotes location of well on topo map.

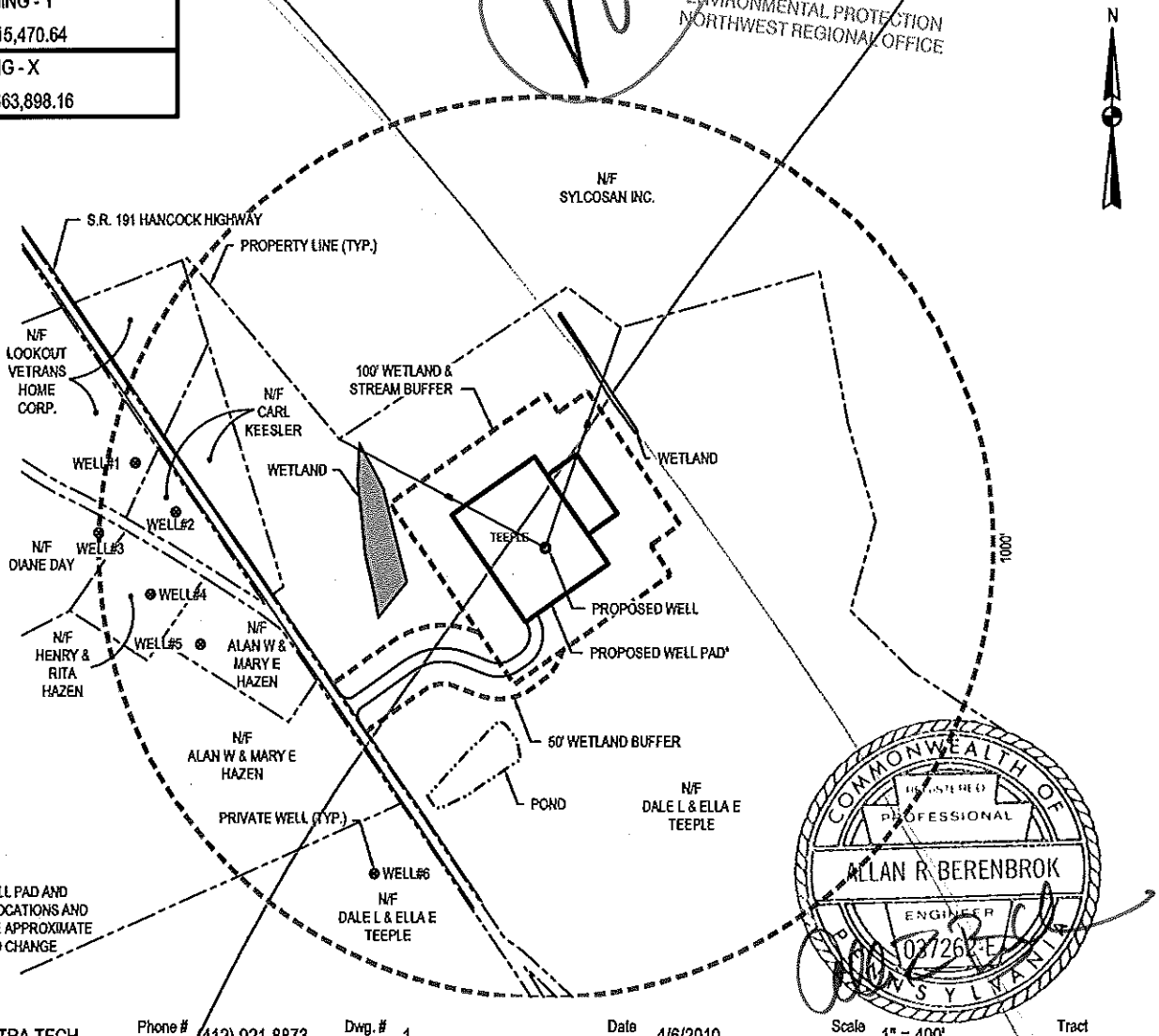
Well is located on topo map 2,034 feet south of latitude 41 ° 50 ' 00 "

Well is located on topo map 8,580 feet west of longitude 75 ° 10 ' 00 "

True Latitude: NORTH	True Longitude: WEST	WELL NORTHING - Y	WELL EASTING - X
41 ° 49 ' 39.90 "	75 ° 11 ' 53.33 "	615,470.64	2,663,898.16

VOID

RECEIVED
APR 12 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE



Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1 | Date: 4/6/2010 | Scale: 1" = 400' | Tract Acreage:

Lat. & Long Metadata			Elevation Metadata			Survey Date
Method GPS	Accuracy +/- 1	ft. Datum NAD83	Method GPS	Accuracy +/- 1	ft. Datum NAD83	Jan. 2010

Applicant / Well Operator Name	Well(Farm) Name	Well #	Serial #
Newfield Appalachia PA LLC	D.L. Teeple	1-1	

Address	County - Code	Municipality	Well Type
363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060	Wayne	Manchester	Vertical Test

Surface Landowner / Lessor	USGS 7 1/2 Quadrangle Map Name	Map Section	Surface Elevation
Dale and Ella Teeple	Long Eddy, NY	5	1516 ft.

Target Formation(s)	Angle & Course of Deviation (Drilling)	Anticipated Total Depth
Onondaga	N/A	TVD 8,350 TMD 8,350

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp.	N78d 20' 44"W 938'	N/A	N/A
Carl Keesler	N84d 27' 43"W 832'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 818'	N/A	N/A
Alan W Mary E Hazen	S74d 33' 6"W 802'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit A.dwg PIT SCOTT.CALTON 4/9/2010 12:07:34 PM

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G:
	Permit #	
	Project #	C:

Denotes location of well on topo map.

True Latitude: NORTH
41 ° 49 ' 39.90 "

True Longitude: WEST
75 ° 11 ' 53.33 "

WELL NORTHING - Y
615,470.64

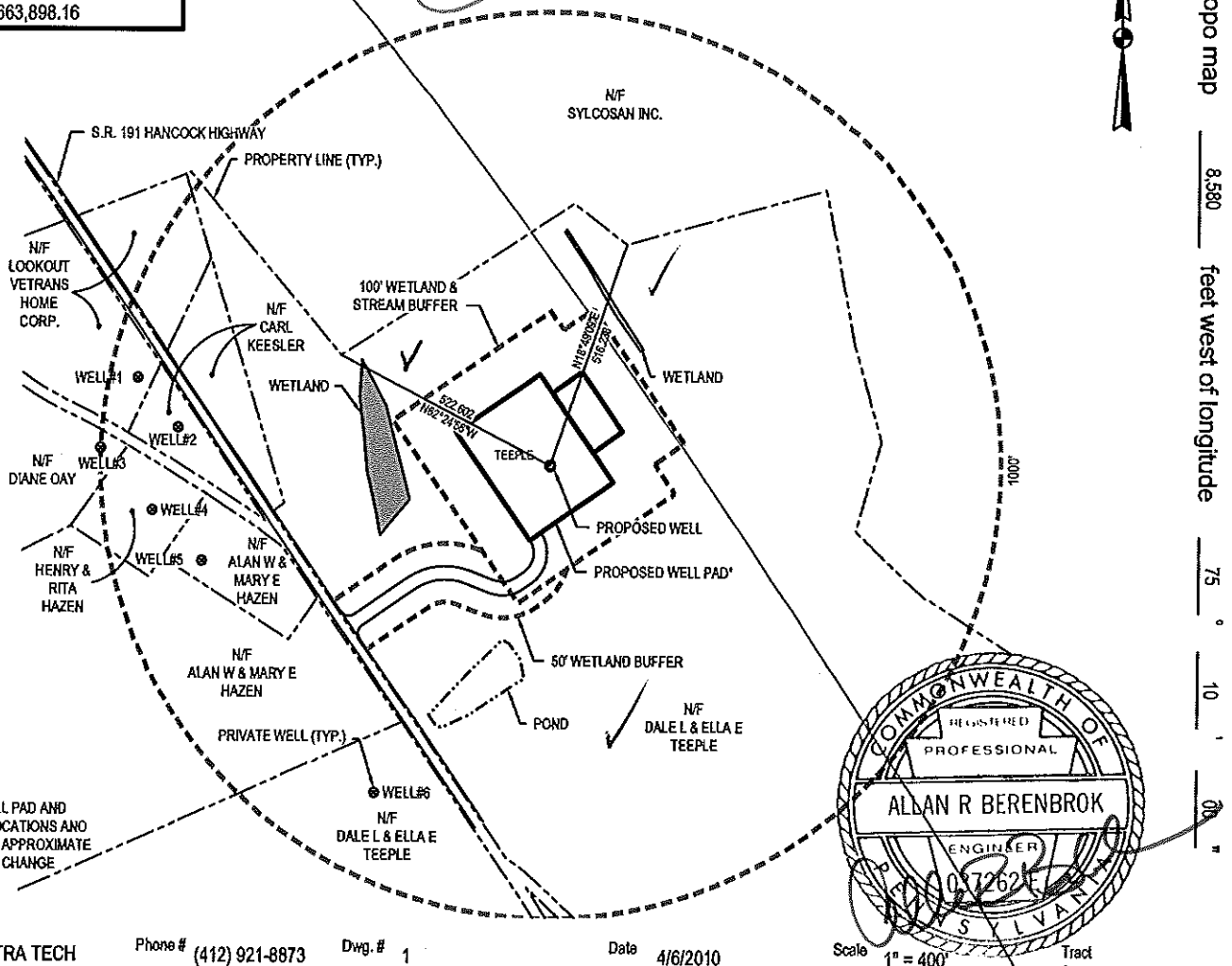
WELL EASTING - X
2,663,898.16

Well is located on topo map 2,034 feet south of latitude 41 ° 50 ' 00 "

Well is located on topo map 8,580 feet west of longitude 75 ° 10 ' 00 "

RECEIVED
APR 0 9 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

VOID



COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
PE 037262E

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1 | Date: 4/6/2010 | Scale: 1" = 400' | Tract Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well(Farm) Name: D.L. Teeple	Well # 1-1 / Serial #
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne	Municipality: Manchester / Well Type: Vertical Test
Surface Landowner / Lessor: Dale and Ella Teeple		USGS 7 1/2 Quadrangle Map Name: Long Eddy, NY	Map Section: 1 / Surface Elevation: 1516 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth: TVD 8,350 TMD 8,350

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp.	N78d 20' 44"W 852'	N/A	N/A
Carl Keester	N84d 27' 43"W 757'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 882'	N/A	N/A
Alan W Mary E Hazen	S74d 33' 6"W 769'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/8/2010 10:50:31 AM

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	
	Permit #: 127-20013	
	Project #:	

100 G 4/5/10 C:

Denotes location of well on topo map.

Well is located on topo map 2,304 feet south of latitude 41° 50' 00"

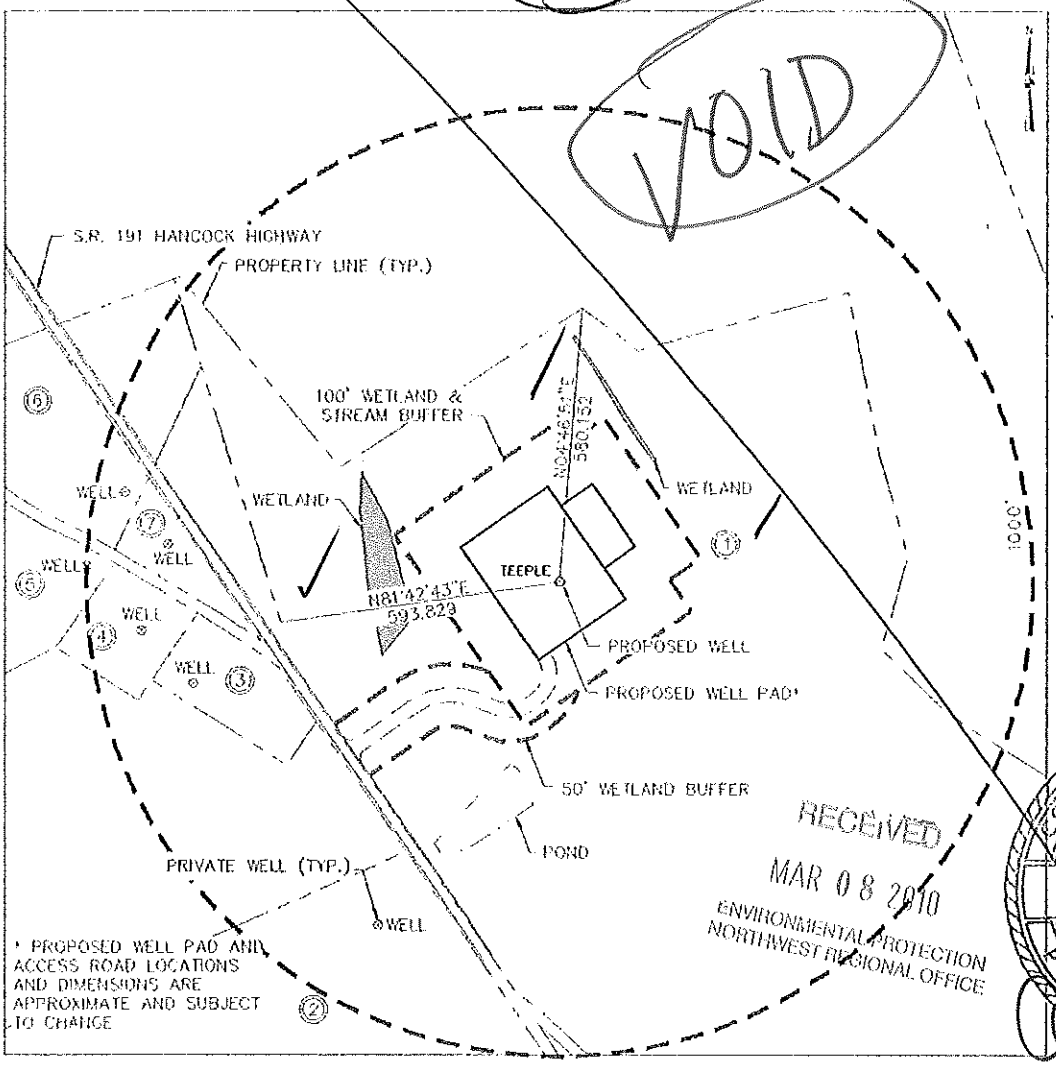
True Latitude: NORTH
41°49' 39.90"

True Longitude: WEST
75° 11' 53.33"

Well Northing – Y
615470.64

Well Easting – X
2663898.16

VOID



1. N/F DALE L & ELLA E TEEPLE 022555 65.462067
2. N/F DALE L & ELLA E TEEPLE 022556 43.559532
3. N/F ALAN W & MARY E HAZEN 022553 1.222088
4. N/F HENRY & RITA HAZEN 022552 1.041061
5. N/F DIANE DAY 022549 4.389164
6. N/F LOOKOUT VETERANS HOME CORP. 021002 2.885954
7. N/F CARL KEESLER 022548 0.688145

RECEIVED
MAR 08 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
037262-E

Well is located on topo map 8,580 feet west of longitude 75° 10' 00"

Surveyor or Engineer: Tetra Tech | Phone #: 412-921-8873 | Dwg #: 1 | Date: 02-02-2010 | Scale: 400 | Tract Acreage:

Lat & Long Metadata — Method GPS | Accuracy +/- 1 ft. | Datum NAD83
Elevation Metadata — Method GPS | Accuracy +/- 1 ft. | Datum NAD83 | Survey Date Jan 2010

Applicant / Well Operator Name: Newfield Appalachia PA LLC	DEP ID#: 277879	Well (Farm) Name: D.L. TEEPLE	Well #: 1-1 / Serial #:
Address: 363 N. Sam Houston Pkwy E. Suite 2020, Houston, TX, 77060	County: WAYNE	Municipality: MANCHESTER	Well Type: Vertical Test
Surface Landowner / Lessor: Dale and Ella Teeple	USGS 7½' Quadrangle Map Name: LONG EDDY, NY 0444	Map Section: 1	Surface Elevation: 1516 ft.
Target Formation(s): Onondaga	Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth ft.: TVD 8350 ft.	TMD 8350 ft.

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp	N78d 20' 44"W 852'	N/A	N/A
Carl Keesler	N84d 27' 43"W 757'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 882'	N/A	N/A

Tetra Tech NUS

Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745
Tel: (412) 921-7090
Fax: (412) 921-4040

LETTER OF TRANSMITTAL

DATE: 16 April 2010	JOB NO.: 112C02679
ATTENTION: Aaron O'Hara	
RE: Newfield – Teeple 1-1 and Schweighofer Well Plat	

TO

Pa DEP Northwest Regional Office

230 Chestnut Street

Meadville, Pa 16335

814-332-6870

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
1			Teeple Well Plat 1-1 – sealed original
1			Schweighofer Well Plat – sealed original

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ___ copies for approval

[x] For your use [ ] Approved as noted [ ] Submit ____copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return ____ corrected prints

[ ] For review and comment [ ] For Your Signature

[ ] **FOR BIDS DUE** _____ **19** ___ [ ] **PRINTS RETURNED AFTER LOAN TO US**

REMARKS:

Attached is the revised original Teeple and Schweighofer well plat with the revisions based upon our telephone conversation on 16 April 2010. Should you require any additional information, please contact me (412) -921-8873 at any time.

SIGNED _____

Allan R. Berenbrok, P.E.

CC: file (w/a)
Andrew Strassner (w/a)
Don Sleeth (w/a)

Tetra Tech NUS
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745
Tel: (412) 921-7090
Fax: (412) 921-4040

LETTER OF TRANSMITTAL

DATE: 9 April 2010	JOB NO.: 112C02679
ATTENTION: Aaron O'Hara	
RE: Newfield – Teeple 1-1 Well Plat	

TO

Pa DEP Northwest Regional Office

230 Chestnut Street

Meadville, Pa 16335

814-332-6870

WE ARE SENDING YOU [*X*] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
1			Teeple Well Plat 1-1 – sealed original

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ___ copies for approval

[x] For your use [ ] Approved as noted [ ] Submit ____copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return ____ corrected prints

[ ] For review and comment [ ] For Your Signature

[ ] **FOR BIDS DUE** _____ **19** ___ [ ] **PRINTS RETURNED AFTER LOAN TO US**

REMARKS:

Attached is the revised original Teeple well plat with the revisions based upon our telephone conversation on 9 April 2010. Should you require any additional information, please contact me (412) -921-8873 at any time.

SIGNED _____

Allan R. Berenbrok, P.E.

CC: file (w/a)
Andrew Strassner (w/a)
Don Sleeth (w/a)

Tetra Tech NUS

Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745
Tel: (412) 921-7090
Fax: (412) 921-4040

LETTER OF TRANSMITTAL

DATE: 8 April 2010	JOB NO.: 112C02679
ATTENTION: Aaron O'Hara	
RE: Newfield – Teeple 1-1 Well Plat	

TO

Pa DEP Northwest Regional Office

230 Chestnut Street

Meadville, Pa 16335

814-332-6870

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
1			Teeple Well Plat 1-1 – sealed original

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ___ copies for approval

[x] For your use [ ] Approved as noted [ ] Submit ____copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return ____ corrected prints

[ ] For review and comment [ ] For Your Signature

[ ] **FOR BIDS DUE** _____ **19** ___ [ ] **PRINTS RETURNED AFTER LOAN TO US**

REMARKS:

Attached is the revised original Teeple well plat with the revisions based upon our telephone conversation on 6 April 2010. Should you require any additional information, please contact me (412) -921-8873 at any time.

SIGNED _____

Allan R. Berenbrok, P.E.

CC: file (w/a)
Andrew Strassner (w/a)
Don Sleeth (w/a)

Phone Contact Log

Date/Time: 4/5/10 **Permit Number(s):** 127-2013

Company: Tetratech

Contact: Betsy Collins

Phone: 412-921-8250

Deficiencies Addressed:

Plat offsets, topo mark, course and distance to water supplies

Map section, new plats will be sent in

Map section, topo, water supplies

4/12/10 New plats received - Course and distance to well

left message Allen Berenbrok

4/19/10 New plats Received

Denial Date:

NEWFIELD

April 1, 2010

PADEP Oil & Gas Management
230 Chestnut St.
Meadville, PA 16335

RECEIVED
APR 02 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Subject: Newfield Appalachia PA LLC – DEP ID# 277879
D.L. Teeple Well #1-1

To Whom It May Concern:

Please include this letter of clarification as part of our permit application associated with the above captioned well.

This permit is to develop a well which is intended solely for exploratory purposes. A core is to be taken from several formations throughout the drilling process of this well and additional scientific study is to be performed on multiple formations including, but not limited to, geophysical logs, micro-seismic studies and fluid sampling. As permitted and configured, this well is not to be completed for production, not to be hydraulically fractured and is not to produce gas. In the future, this wellbore will either be plugged and abandoned per PADEP regulations, converted to inactive status and utilized as a monitoring well, or reconfigured and converted to a production well. Prior to either plugging and abandonment, conversion to inactive status or reconfiguration and conversion to production, we acknowledge that additional permitting will be necessary with approvals from the PADEP and other regulatory bodies with jurisdiction.

Sincerely,

Donald F. Sleeth
Drilling Manager

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 826657
Watershed Name: Shehawken Rattlesnake Creek	Quality HQ:

Permittee: NEWFIELD APPALACHIA PA LLC	OGO #: OGO-67425	Permit Number: 37-127-20013-	Date Issued: 04/23/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020		Farm Name & Well Number: DL TEEPLE 1 1	Well Serial #
		Municipality: Manchester	County: Wayne
HOUSTON, TX 770602424		7½' Quadrangle Name: Long Eddy	Map Section #: 1
Phone: (281) 847-6031	Project #	Latitude: 41-49-39.9000	Longitude: -75-11-53.3300
Surf Elev at Site: 1516 feet	Anticipated Total Depth: 8350 feet / Well Type: GS	Offset distances referenced to NE corner of map section.	South 2304 feet West 8580 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires 04/23/2011 unless drilling is commenced on or before that date and prosecuted with due diligence.

Stacie Gustafson for S. Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Site ID	Primary Fac ID 728625
Client Id 277879	Subfacility Id

Well Record and Completion Report

ll Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20013-		
Address		Well Farm Name & Well #		Serial #
363 N SAM HOUSTON PKWY E STE 2020,		DL TEEPLE 1 1		
City	**State**	**Zip Code**	**County**	**Municipality**
HOUSTON	TX	770602424	Wayne	Manchester
Phone	**Fax**		USGS 7.5 min. quadrangle map	
(281) 847-6031			Long Eddy	

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20013--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728625
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC
DEP ID#: 277879
Address: 363 N SAM HOUSTON PKWY E STE 2020,
City: HOUSTON
State: TX
Zip Code: 770602424
Phone: (281) 847-6031
Fax:

Well API # (Permit / Reg): 37-127-20013-
Well Farm Name & Well #: DL TEEPLE 1 1
Serial #:
County: Wayne
Municipality: Manchester

B. Land Application of Tophole Water

Date applied:
pH:
Volume (bbls):
Spec. cond. (µmhos/cm):

C. Off-site Waste Disposal

Type: ☐ Drilling Fluid (803) Amount: bbls
☐ Fracing Fluid (804) bbls
☐ Other, specify: Qty: bbls or tons

Method of disposal or reuse

☐ Disposal Well (04)
☐ Landfill (05)
☐ Sewage Treatment Plant (10)
☐ Brine Treatment Plant (12)
☐ Other (08)

Facility Information

Name:
Permit #:

Hauler Information

Name:
Address:
City:
State:
Zip Code:

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees
Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E.
☐ Lined pit, complete Section E.
☐ Land application, complete Section F.
☐ Dusting
☐ Solidification
☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches
Pit liner, material: Thickness: mils
Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

Please note that the most recent revision of the Application for Drilling or Altering a Well must be submitted with all drilling applications. Please check the website below for the most recent revisions for all forms.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/o_gforms.htm

The Erosion, Sediment& Storm water Control Module is no longer being accepted for ESCGP-1 applications. Please submit the complete ESCGP-1 application for any projects. The most recent revisions must be submitted along with the application fee of $500.00

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Dear Operator:

Enclosed please find well permit(s) issued for drilling or altering a well. Developing this resource in a safe and environmentally protective manner is of utmost importance. As you may be aware, there have been several recent incidences where water supplies have been affected by natural gas migration. In order to prevent future impacts to the Commonwealth's water resources and provide a mechanism for ensuring public safety, the Department is providing the following information as a reminder of the cementing requirements for oil and gas wells.

Cementing

Properly cementing the casing of a well is critical to protecting water resources, preventing gas migration, and ensuring well integrity. If the casing is improperly cemented or if insufficient cement is used, such as when cement is not returned to the surface, the operator should notify the Department pursuant to 25 Pa. Code § 78.86.

In addition, when cementing surface casing, 25 Pa. Code § 78.85 states that the cement must be allowed to set for at least 8 hours *and* until the cement attains a compressive strength of at least 350 psi. While the cement is setting, the casing must not be disturbed. This includes any activity that may cause movement or pressure changes to the casing or the cement sheath surrounding the casing. After the cement is set, care must be taken when drilling through the plug to prevent damaging the seal at the casing seat. Disturbing the casing while cement is setting or damaging the seal at the casing seat may provide a mechanism for gas and other fluids to escape from the well and contaminate groundwater and water supplies. If this occurs, the operator must notify the Department.

In addition, the Department also reminds you of the following reporting requirements for oil and gas wells.

Reporting

1. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(a) of Chapter 78 of the Oil and Gas Regulations, a **Well Record** must be submitted to the Department within thirty (30) days of cessation of drilling or altering a well.

2. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(b) of Chapter 78 of the Oil and Gas Regulations, a **Completion Report** must be submitted to the Department within thirty (30) days of completion of the well. A copy of the Well Record and Completion Report is enclosed with this letter. This is a newly revised form which requires the operator to certify that the well has been cased and cemented according to the requirements of 25 Pa. Code Chapter 78. Well Record and Completion Report forms that do not contain this certification will not be accepted by the Department. Additional copies of this form can be obtained from the Department's eLibrary at http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-9841

3. Pursuant to Section 212(a) of the Oil and Gas Act, a report specifying the well status and production on the most well-specific basis available is to be provided to the Department. Section 78.121 of Chapter 78 details the reporting time frames required for various well types, waste reporting, and the acceptable format for the **Well and Waste Production Report** submissions.

4. Also note that pursuant to Section 212(b) of the Oil and Gas Act, the Department has the authority to request and docs hereby request you submit a digital copy on CD of **ALL Well Logs** (temperature, electrical, radioactive, gamma ray, neutron, induction, resistivity, multi-arm caliper, acoustic, optical, etc.) that have been run on this well.

The above records and logs are to be submitted to the Department of Environmental Protections, Oil and Gas Management, 230 Chestnut St., Meadville, Pa 16335-3481 to the attention of the Regional Oil and Gas Manager.

Thank you for your cooperation in this matter.

Sincerely,

S. Craig Lobins
Regional Manager
Oil and Gas Management

http://www.ahs2.dep.state.pa.us/eFACTSWeb/searchResults_singleViol.aspx?InspectionID=1890758

Violation Details for Inspection ID: 1890758

Facility: DL TEEPLE 1 1 (728625)
Program: Oil & Gas

Disclaimer: The dollar amounts listed below are for the entire related enforcement, and may encompass many sites/facilities. The *Total Amount Collected* may or may not be related to the *Penalty Amount Assessed*, depending on how your program or regional office records payments in eFACTS. Questions regarding payments or penalties should be directed to the eFACTS Help Desk at:

(717) 705−3768 or mailto:ra-epefactshelp@state.pa.us

Violation ID	Date	Violation Description
589311	05/26/2010	Improperly lined pit
		Resolution:
		PA Code Legal Citation: 25 Pa. Code 78.56(a)(4); 78.57(c)(2);91.35(a) : PA Code Website
		Violation Type: Administrative
		Enforcement Type: No Enforcement Data

Violation ID	Date	Violation Description
589310	05/26/2010	Failure to minimize accelerated erosion, implement E&S plan, maintain E&S controls. Failure to stabilize site until total site restoration under OGA Sec 206(c)(d)
		Resolution:
		PA Code Legal Citation: 25 Pa. Code 102.4 : PA Code Website
		Violation Type: Environmental Health & Safety
		Enforcement Type: No Enforcement Data

Report on Selected Environmental Impacts of Exploratory Gas Drilling in the Delaware River Watershed

Prepared by:

Emmet M. Owens, P.E.
Senior Research Engineer
Upstate Freshwater Institute
Syracuse, New York 13214

Prepared for:

Delaware Riverkeeper Network
300 Pond Street, Bristol, PA 19007

and

Damascus Citizens for Sustainability
P.O. Box 147, Milanville, PA 18443

November 18, 2010

Executive Summary

This report is concerned with the construction and operation of exploratory vertical gas wells in the Special Protection Waters portion of the Delaware River watershed.

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of exploratory well drilling. Regulators should proceed with caution in evaluating the impact of exploratory gas wells on surrounding surface waters. Current regulations in Pennsylvania do not require analysis of surrounding surface waters and there is no evidence that the well operators will perform or have performed any surface water analysis prior to, during or after drilling of these wells.

Stream buffer strips have proven to be an effective means of reducing the effect of land development on surface waters, both in general land development and in the particular case of drilling for oil and gas exploration and extraction. Pennsylvania regulations only require a 100 foot separation distance between a gas well and a surface water body. This is wholly inadequate as a stream buffer and will not provide needed protection to the Special Protection Waters of the Delaware River.

The loss of intact forest land and the increase of forest fragmentation associated with oil and gas development is well documented. In this Special Protection Waters area, development that results in such changes to the land should be carefully evaluated. Where such development is approved, mitigating steps or measures should be implemented in order to preserve water quality. Pennsylvania regulations do not provide adequate protection of forest and does not prevent or reduce forest fragmentation leading to inadequate protection of forest cover required to protect the Special protection Waters of the Delaware River Basin.

At issue here is the impact of multiple exploratory wells. It is important that, in evaluating the environmental impact of these wells, the evaluation consider not only the impact of each individual well site, but also of the cumulative impact of all sites operating together and simultaneously. When viewed in this manner, the impact of the exploratory wells in question is amplified. There is no evidence that any cumulative impact analysis of the potential impacts of and risks posed by the multiple exploratory wells on receiving water bodies, particularly the main stem Delaware River, has been done.

It has been found (The Nature Conservancy and Pennsylvania Audubon, 2010) (Exhibit 1) that, with proper planning in advance of well construction, integration of conservation features into the development of well sites can lead to significantly reduced impacts on surface waters. However, there is no evidence that such planning has occurred in the development of the exploratory well sites that are of interest here. As a result, it is prudent that the procedures used in selecting the sites for the exploratory sites, and the activities on these sites, be carefully reviewed. This is particularly important given the Special Protection Waters status of the watershed.

The opinions provided in this report are stated to a reasonable degree of scientific and professional certainty

Introduction

Exploratory gas wells have been or are permitted to be drilled in northeastern Pennsylvania as a part of a project to extract natural gas from the Marcellus shale formation. This gas extraction will use the process of hydraulic fracturing in the future to extract the gas from this deep geologic formation. The portions of the Delaware River watershed where the exploratory wells grandfathered under the Supplemental Executive Director Determination (SEDD) at issue in this hearing are located have been designated as Special Protection Waters (SPW) by the Delaware River Basin Commission (DRBC). Waters receiving this designation have been found to have exceptionally high scenic, recreational, ecological and/or water supply values. The regulations establishing SPW significantly restrict new and increased discharges of wastewater directly to the designated waterways by prohibiting discharges that create any measurable change in water quality.

Groundwater Contamination

An important issue in evaluating potential pollution pathways from exploratory gas wells is groundwater contamination from poorly constructed water wells. Generally, drinking water wells are shallower than natural gas wells, and their casing may not extend their entire depth. This is particularly the case for domestic water wells that may not be subject to the same level of oversight and scrutiny as municipal or privately owned water supply facilities. This is particularly true for older water wells and for spring wells, which are used in the regions of the Delaware River watershed that are underlain by Marcellus shale, including Wayne County, and the local areas immediately adjacent or quite close to where these grandfathered exploratory wells are located. A water well that is not cased from the surface, or is not constructed and cased properly, might allow contaminated water to flow from the ground surface and enter the water well, possibly compromising the quality of drinking water in the well, as well as the drinking water aquifer itself.

In such instances, and particularly where natural gas drilling activities are nearby, leaky surface impoundments or careless surface disposal of drilling fluids at the natural gas operation could increase the risk of contaminating the nearby water well. While the quantity of chemicals used in the installation of exploratory wells may be less than for production wells, the potential for this type of contamination is significant. The grandfathered wells under the SEDD are each located close to groundwater wells or springs providing potable water to residents in, adjacent to, and downgradient from these exploratory well sites.

Surface Water Impacts of Well Drilling

The Pennsylvania Academy of Natural Sciences has called for a comprehensive research plan that would result in guidelines and an assessment tool for regulators and managers in order to minimize the environmental impact of Marcellus Shale gas drilling. Dr. David Velinsky Testimony (Exhibit 2) (available at http://www.ansp.org/about/news/marcellus-shale.php)

The research described by Dr. Velinsky found that there is very little information available as to the impacts of long-term exposure of a watershed to Marcellus Shale drilling activities. It is unknown if there is a cumulative impact of drilling activity on a small watershed. Initial research by Academy scientists shows the environmental impact of drilling may be directly related to the density of drilling in a specific area. This research has pointed out that a question that needs to be addressed is whether there is a threshold point past which a certain amount of drilling activity has an impact on the ecological health and services of the watershed, regardless of how carefully drilling is conducted. This is very important in regards to the exploratory wells that are being drilled in the Basin under the grandfathered wells provision of the SEDD. Three of the grandfathered wells in southern Wayne County drain over a short distance to a relatively small stretch of the Delaware River that influences vulnerable species such as dwarf wedge mussel, a federally listed endangered species, and other fish, wildlife and aquatic species that are sensitive to water quality and flow changes.

The Academy scientists examined small watersheds in northeastern Pennsylvania—three in which there had been no drilling, three in which there had been some drilling and three in which there had been a high density of drilling. At each site, they tested the water, the abundance of certain sensitive insects, and the abundance of salamanders. The presence of salamanders is particularly important because amphibians are especially vulnerable to changes in the environment. The absence of amphibians is often an ecological early-warning system. For each of the measures, there was a significant difference between high-density drilling locations and locations with no drilling or less drilling. The studies showed that water conductivity (which indicates the level of contamination) was almost twice as high in the high density sites as the other sites, and the number of both sensitive insects and salamanders were reduced by 25 percent.

Site preparation on the surface at the well site is likely to cause increased erosion and runoff into surrounding streams. For both exploratory and production wells, the wellbore acts as a conduit between adjoining geologic formations, which can allow contaminants to flow into shallow groundwater or surface waters.

It has been reported (DRBC 2009) that wastewater generated during the drilling of the Matoushek well (which was completed as a future production well but has not gone into production and therefore is similar to an exploratory well) was stored on site and then trucked to a municipal wastewater treatment plant in Athens, PA. It is known that the wastewater treatment processes used at municipal treatment plants, including the plant at Athens, are not capable of removing the industrial pollutants (organic chemicals, heavy metals, etc.) that are present in the wastewater that is generated by well drilling operations. As a result, it is likely that these pollutants were discharged into either surface or groundwater without treatment. The

grandfathered exploratory wells at issue here either have already generated wastewaters or will generate them when they are drilled and such wastewaters will most likely be transported from the well site to another treatment or disposal location that has not been identified by DRBC because it is not exercising any regulatory control over these wells.

Land Disturbance - General

Drill sites involve land disturbance, making sites susceptible to runoff during storm events that can cause pollution of streams, lakes, ponds, etc. downstream from the site. Construction of drill pads as a surface for operations and storage of large equipment/containers is completed prior to the commencement of drilling and can be as large as five acres. Roads may also need to be built for access to the site. Phase II Stormwater Regulations require that construction activities disturbing one or more acres of land must have a stormwater discharge permit. In New York such permits are issued by NYS DEC under its State Pollutant Discharge Elimination System (SPDES) General Permit for construction activities. As part of this permit, a Stormwater Pollution and Prevention Plan (SWPPP) would be required, with NYS DEC charged with ensuring the SWPPP is met. Apparently no such permitting of this type is required in Pennsylvania for oil and gas projects less than 5 acres. Stormwater runoff from the grandfathered exploratory well sites is a source of pollutants to the Special Protection Waters.

With regard to land disturbance, the grandfathered exploratory wells that are at issue here are generally the same as production wells. This includes disturbance on the well site itself, placement of well facilities such as the well pad and pit, and in the construction of access roads to the site, and traffic on such roads.

It should be noted that the Marcellus shale formation underlies a significant portion of the watershed of the New York City water supply system in southeastern New York State and the watershed for water supply to Philadelphia, central and southern New Jersey, and all of the communities along the Delaware River. The New York City public water supply is unusual in that there is no filtration applied to the water diverted from the Delaware River Basin before delivery to the public. New York City has been granted a waiver from federal regulations that require such filtration. The granting of this waiver is dependent on enforcement of various regulations in the watershed that are designed to maintain water quality. The goals and associated requirements of the Special Protection Waters status of the portion of the Delaware River watershed where the grandfathered exploratory wells are located are applicable to protect the downstream water users and are similar in many ways to the requirements that exist in the watershed of the New York City water supply system.

The entire New York City watershed located west of the Hudson River (the Catskill and Delaware portions of the watershed) is underlain by Marcellus shale, and gas development has been proposed in this area. In response to this potential gas development, the New York City Dept. of Environmental Protection completed a study to evaluate the impact of gas development on general water quality in the watershed, and specifically on the risk to the federal filtration waiver (Hazen and Sawyer 2009)(Exhibit 3).

While this study was concerned with both gas exploration and production, many of the findings and recommendations apply to the grandfathered exploratory wells in question here, because, as reported by Dr. Rubin in recent comments to the U.S. Environmental Protection Agency (Exhibit 4), the geology of the Delaware River Basin watershed below the New York City reservoirs is the same as the geology of the areas of New York state addressed by Hazen and Sawyer. Among other conclusions, the Hazen and Sawyer study found that land disturbance associated with gas exploration and development would lead to increased risk to the water supply. With regard to land disturbance, these conclusions also apply to the Special Protection Waters of the Delaware River watershed. The Hazen and Sawyer study more generally documented the problems that may be associated with well drilling (exploratory or production), such as migration of drilling muds, hydrocarbons, and naturally occurring radioactive compounds into surface and groundwater.

Projects that involve only exploratory wells have been found to result in problems affecting surrounding land and water resources (U.S. Forest Service, 2005). Monitoring of the Gunnison Energy Exploratory Gas Drilling Project in the Grand Mesa/Uncompahgre/Gunnison (GMUG) National Forest and the Willsource Exploratory Project in the White River National Forest demonstrated unexpected negative environmental impacts after exploration began. Gunnison Energy Corp., the developer at the GMUG National Forest, experienced the movement of significant quantities of sediment from well sites into nearby streams. Measures that were designed to prevent an increase in runoff from well sites were found to not be effective. At the Willsource Exploratory Project, sediment from access roads was deposited in nearby stream channels, and runoff from well sites was not properly controlled. The grandfathered well sites at issue here present similar runoff pollution risks.

Land Disturbance - Buffer Zones

A riparian forest buffer is a streamside forest composed of native trees, shrubs and herbaceous plants (Lee et al. 2004). Use of such buffer areas provides various benefits. Buffers are natural filters. Leaf litter on the forest floor traps sediments before they can enter the stream. In addition, the presence of trees and shrubs along a stream's banks minimizes erosion and the effects of flooding. Buffers also encourage groundwater infiltration. Trees convert the excess nutrients in stormwater runoff into a form that actually sustains the growth of the forest. In addition, buffers provide shade necessary to maintain cool water temperatures and higher dissolved oxygen levels. Native trout, for example, require water temperatures below 68^{o}F to survive, and forested streams are as much as 10 degrees cooler than streams that flow through meadows (Lee et al. 2004). In addition, insects, the primary food for trout, are abundant both above and in wooded streams and cannot survive in water temperatures that exceed 68^{o}F.

The results demonstrate the positive impact of forest buffer zones in reducing the influence of agricultural nutrients and chemicals on surface stream waters (Anbumozhi et al. 2005). Some of the adverse effects of impervious surfaces (such as paved roads, parking lots, and manmade structures) and agricultural areas can be mitigated by tree cover and streamside vegetation buffers, which reduce the force of overland flows, uptake excess nutrients, maintain stream bank integrity, and provide shade that reduces solar warming of waterways (Goetz et al.

2004). In addition, it has been found that forest cover provides more optimal land cover for protecting water quality than many of the potential uses to which that land may be converted (Hall et al. 2008).

There is solid evidence that providing riparian buffers of sufficient width protects and improves water quality by intercepting nonpoint source pollution (NPSP) in surface and shallow subsurface water flow (Lowrance et al. 1984; Pinay and Decamps 1988). The spatial placement of buffer strips within a watershed can have profound effects on water quality. Riparian buffers in headwater streams (i.e., those adjacent to first-, second-, and third-order systems) have much greater influences on overall water quality within a watershed than those buffers occurring in downstream reaches. Downstream buffers have proportionally less impact on polluted water already in the stream (Fischer and Fischenich, 2000).

The areas that have been or will be disturbed by the construction of the grandfathered well sites at issue here include forested and other land areas that will be or have been disturbed. This will compromise buffer zones to streams and creeks in close proximity to the well sites. These streams and creeks are mostly classified as high value or exceptional value streams and provide spawning habitat for native trout, among other important aquatic species.

It has been found that species richness was positively correlated with wetland area, forest cover, and the amount of wetlands on adjacent lands and negatively correlated with road density (Houlahan and Findlay, 2003). Lowrance et al. (1997) found that riparian forest buffers retain 50%–90% of the total loading of nitrate in shallow groundwater, sediment in surface runoff, and total nitrogen in both surface runoff and groundwater, thereby reducing the loading of these nutrients to downstream waters.

In a study of Pennsylvania streams by Brenner et al. (1991), riparian woodlands were effective in reducing fecal coliform, suspended solids, and total phosphorus. The establishment and maintenance of wetlands and riparian vegetation were determined to be a cost effective means of non-point source pollution abatement. Stormwater treatment strategies that focus on infiltration and take advantage of trees and intact forest buffers can counter the unhealthy effects of development. The areas surrounding the grandfathered well sites generally provide all or most of these land features.

Pennsylvania's Independent Regulatory Review Commission (IRRC) recently passed two new regulations that provide protections for water resources and for drinking water and watersheds from the impacts of natural gas drilling pollution as well as other new development projects. The rules fall under Title 25, in the PA code, Chapter 95, Wastewater Treatment Requirements, and Chapter 102, Erosion and Sedimentation Control. Changes to Chapter 102 state regulations approved by the IRRC will require some developers to maintain or create a 150-foot natural vegetative buffer beside Pennsylvania's best rivers and streams. These rules affect so-called E&S permitting or Erosion and Sedimentation Control measures implemented with construction projects to reduce impact on streams and rivers. Streams in the top 20% statewide for water quality will be subject to the increased protections. This would presumably include streams designated as Special Protection Waters. Unfortunately, natural gas projects are exempted from the additional buffer width requirements that are being adopted for Pennsylvania's best streams.

The subject exploratory wells will not employ these extra buffer protections, exposing the high and exceptional water quality of the tributaries and main stem Delaware River in the Wayne County region to degradation in proximity to the places where the grandfathered wells have been or will be located.

Streamside buffers are widely considered to be the best and most effective long-term solution for protection water quality. Buffers help filter water, reduce the impacts of flooding, shade and reduce water temperatures creating better habitat for fish and aquatic species. Over 200 municipalities within Pennsylvania require streamside buffers for such development projects. Again, no natural gas well, exploratory or production well, will be required to follow this rule to which all other development projects are now subject.

Land Disturbance - Intact Forest Land Cover and Forest Fragmentation

Ecosystem fragmentation generally causes large changes in the physical environment as well as biogeographic changes (Saunders et al. 1991). The exchange of solar radiation, water, and nutrients across the land surface and landscape are altered significantly. These in turn can have important influences on the biota within remnant areas, especially at or near the edge of the remnant. It has generally been found that intact forests that have not been subject to fragmentation by construction of roads and pipelines support more diverse and healthier ecosystems (Spellerberg 1998).

Areas of high ecological integrity that may serve as core refugia include: intact old growth forests, native forest ecosystems operating within the bounds of historic disturbance regimes, intact watersheds and large roadless areas (DellaSala et al. 2003). Intact natural vegetation helps to reduce or control floods and retain moisture in the soils (O'Neill et al. 1997; Hunsaker and Levine. 1995). Construction of logging and other roads in forested areas has been correlated with decrease in the acreage of intact forest (Heilman et al. 2002).

For gas well drilling in forested areas, trees and vegetation are removed for the well pad, access roads, and pipelines (Woodring 2009). This habitat destruction and forest fragmentation has the potential to seriously disrupt and endanger flora and fauna. Furthermore, noise from traffic could have a negative effect on local wildlife and clearings for pipelines may present an opportunity for increased traffic from off-road vehicles (Woodring 2009). Indirect impacts include road-building and pipeline development, which may result in habitat fragmentation and increased access to remote areas. While larger intact forest ecosystems may withstand the impacts of mining and oil development, smaller fragments are likely to be particularly sensitive to clearing (Mooney et al. 1995). Several of the sites where grandfathered wells have been or will be located will suffer forest fragmentation from the construction of these well sites.

General decline in the diversity of animal populations has been observed as a result of forest fragmentation in Pennsylvania (Yahner 1996). One potential repercussion of forest fragmentation is a decline in migratory bird populations, which become more vulnerable without continuous forest cover (Robinson et al. 1995). It has been found that maintenance of intact forests encourages the vitality of bird populations in Pennsylvania (Porneluzi et al. 1993). Food

supply for various bird species in Pennsylvania has been found to be reduced as a result of forest fragmentation (Robinson 1998).

Forest fragmentation has been found to increase the susceptibility of forests to damage from unusual weather events. For example, in the first autumn after fragmentation, a period with high winds caused severe blowdown and other forest damage in all five fragments of a previously intact forest. Total tree mortality after 67 months showed a steep increase with decreasing area of contiguous forest areas (Esseen 1994). Because the Executive Director of the Delaware River Basin Commission decided in the SEDD not to exercise the Commission's review jurisdiction over the grandfathered sites, there is no assessment from the Commission staff whether the cumulative effect of these grandfathered projects could result in similar forest fragmentation and its consequences.

Conclusions

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of drilling the grandfathered exploratory wells.
The loss of intact forest land and the increase of forest fragmentation associated with grandfathered exploratory gas wells can be expected to have measurable impact in the Special Protection Waters area. Mitigating steps or measures, such as the provision of stream buffers, will not be required by the Commission because it is not exercising jurisdiction over the grandfathered wells. Such mitigation measure should be taken in order to preserve water quality.

The multiple exploratory wells that are at issue here should not only be reviewed as to the individual impact of each site, but also the cumulative impact of all exploratory sites in the Special Protection Waters. The surface waters of the Delaware River Basin, in particular the Special Protection Waters are at significant risk of degradation associated with construction and operation of exploratory gas wells. These waters are not protected adequately by present regulations.

The opinions expressed herein are stated to a reasonable degree of scientific and professional certainty.

Signature: 

Emmet M. Owens

Date: November 18, 2010

References

Alberts, S. Reduction of total suspended sediment concentration in agricultural runoff by a vegetative buffer strip in Chester County, Pennsylvania. M.S. Thesis, West Chester University, 2000.

Anbumozhi, V., Radhakrishnan, J., and E. Yamaji, 2005. Impact of riparian buffer zones on water quality and associated management considerations. *Ecological Engineering* Volume 24, Issue 5, 30 May 2005, pp. 517-523.

Angermeier, P.L., A.P. Wheeler, and A.E. Rosenberger, 2004. A Conceptual Framework for Assessing Impacts of Roads on Aquatic Biota. *Fisheries* Volume 29, pp. 19-29.

Booth, D.B., D. Hartley, and R.Jackson, 2002. Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. *Journal of the American Water Resources Association*, Volume 38, Number 3, pp. 835–845.

Brenner, F.J., Mondok, J.J., and McDonald, R.J., 1991. Impact of Riparian Areas and Land Use on Four Non-Point Source Pollution Parameters in Pennsylvania *Journal of the Pennsylvania Academy of Science*, Volume 65, Number 2, pp. 65-78.

Castelle, A. J., A. W. Johnson, and C. Conolly, 1994. Wetland and Stream Buffer Size Requirements – A Review. *Journal of Environmental Quality* Volume 23, pp.878-882.

Delaware River Basin Commission , 2008. Admininstrative Manual Part III, Water Quality Regulations, with Amendments through July 16, 2008, 18 CFR Part 410.

Delaware River Basin Commission, 2009. DOCKET NO. D-2009-18-1, Special Protection Waters, Stone Energy Corporation, Matoushek 1 Well Site, Shale Gas Exploration and Development Project, Clinton Township, Wayne County, Pennsylvania

DellaSala, D.A., A. Martin, R. Spivak, T. Schulke, B. Bird, M. Criley, C. van Daalen, J. Kreilick, R. Brown, and G. Aplet, 2003. A Citizen's Call for Ecological Forest Restoration: Forest Restoration Principles and Criteria. *Ecological Restoration* Volume 21, Number 1, pp.14-23. Quote: Relatively intact natural areas and core refugia that have high ecological integrity and little need for restoration should be protected and maintained.

Doyle, R. C., Stanton, G. C., and Wolf, D. C. (1977). "Effectiveness of forest and grass buffer strips in improving the water quality of manure polluted runoff," American Society of Agricultural Engineers, Paper 77-2501, St. Joseph, MI.

Esseen, P.-A., 1994. Tree mortality patterns after experimental fragmentation of an old-growth conifer forest. *Biological Conservation* Volume 68, Issue 1, pp. 19-28.

Fischer, R. A., Martin, C. O., Barry, D. Q., Hoffman, K., Dickson, K. L., Zimmerman, E. G., and Elrod, D. A., 1999. "Corridors and vegetated buffer zones: A preliminary assessment and study design," *Technical Report EL-99-3*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fischer, R.A. and J.C. Fischenich, 2000. "Design Recommendations for Riparian Corridors and Vegetated Buffer Strips". *EMRRP Technical Note* (ERDC TN-EMRRP-SR-24), US Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

Goetz, S.J. and C.A. Jantz, S.D. Prince, A.J. Smith, D. Varlyguin, and R.K. Wright, 2004. Integrated Analysis of Ecosystem Interactions With Land Use Change: The Chesapeake Bay Watershed. In: R. S. DeFries, G. P. Asner, and R. A. Houghton (Eds.), Ecosystems and land use change (pp. 263–275). American Geophysical Union.

Hall, M., R. Germain, M. Tyrrell, and N. Sampson, 2008. Predicting Future Water Quality from Land Use Change Projections in the Catskill-Delaware Watersheds. Joint Report by The State University of New York College of Environmental Science and Forestry and The Global Institute of Sustainable Forestry, Yale University School of Forestry and Environmental Studies.

Hazen and Sawyer, Environmental Engineers and Scientists, 2009. Final Impact Assessment Report, Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed. Report prepared for the New York City Dept. of Environmental Protection.

Heilman, G.E., J.R. Strittholt, N.C. Slosser, and D.A. DellaSala. 2002. Forest fragmentation of the conterminous United States: Assessing forest intactness through road density and spatial characteristics. *BioScience* Volume 52, Number 5, pp. 411-422.

Houlahan, J.E., and C.S. Findlay, 2003. The effects of adjacent land use on wetland amphibian species richness and community composition. *Canadian Journal Fisheries and Aquatic Science* Volume 60, Number 9, pp. 1078–1094.

Hunsaker, C.T. and D.A. Levine. 1995. Hierarchical Approaches to the Study of Water Quality in Rivers. *BioScience.* Volume 45, Number 3, Ecology of Large Rivers, pp. 193-203.

Kargbo, D.M., R.G. Wilhelm, and D.J. Campbell, 2010. Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities *Environmental Science and Technoogy*, Volume 44, Number 15, pp 5679–5684.

Keister, T., 2009. Marcellus gas well water supply and wastewater disposal, treatment, and recycle technology. Web site:
http://www.prochemtech.com/Literature/TAB/PDF_TAB_Marcellus_
Gas_Well_Water_Recycle.pdf.

Kogelmann, W.J., H. Lin, and R.B. Bryant, 2002. A Statewide Assessment of the Impacts of P-Index Implementation in Pennsylvania, Phase 1 Report, Pennsylvania State Conservation Commission, Pennsylvania Department of Agriculture, Harrisburg, PA.

Lee, P., C. Smyth, and S. Boutin. 2004. Quantitative review of riparian buffer width guidelines from Canada and the United States. *Journal of Environmental Management* Volume 70, pp.165-180.

Lowrance,R., L.S. Altier, J. D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J. W. Gilliam, J.L. Robinson and R.B. Brinsfield. 1997. Water Quality Functions of Riparian Forest Buffers in Chesapeake Bay Watersheds. *Environmental Management* Volume 21, Number 5, pp. 687-712.

Lowrance, R. R., Todd, R. C., Fail, J., Hendrickson, O., Leonard, R. A., and Asmussen, L. E., 1984. "Riparian forests as nutrient filters in agricultural watersheds," *BioScience* Volume 34, pp. 374-77.

Mehaffey, M.H., Nash, M.S., Wade, T.G., Edmonds, C.M., Ebert, D.W., Jones, K.B., 2002. A Landscape Assessment of the Catskill/Delaware Watershed 1975-1998: New York City's Water Supply Watersheds. United States Environmental Protection Agency Report, EPA/600/R-01/075.

Mooney, H.A. et al., 1995. "Biodiversity and Ecosystem Functioning: Ecosystem Analyses," In V.H. Heywood and R.T. Watson, *Global Biodiversity Assessment.* Cambridge University Press, London.

National Park Service, 1999. Comprehensive Interpretive Plan, Upper Delaware Scenic and Recreational River, U.S. Department of the Interior, October, 1999.

O'Neill, R.V., C.T. Hunsaker, K. B. Jones, K.H. Riitters, J.D. Wickham, P.M. Schwartz, I.A. Goodman, B.L. Jackson and W.S. Baillargeon, 1997. Monitoring Environmental Quality at the Landscape Scale. *BioScience* Volume 47, No. 8, pp. 513-519.

Pinay, G., and H. Decamps, 1988. "The role of riparian woods in regulating nitrogen fluxes between the alluvial aquifer and surface water: A conceptual model," *Regulated Rivers: Research and Management.* Volume 2, pp.507-516.

Porneluzi, P., Bednarz, J. C., Goodrich, L. J., Zawada, N. and Hoover, J., 1993. Reproductive Performance of Territorial Ovenbirds Occupying Forest Fragments and a Contiguous Forest in Pennsylvania. *Conservation Biology* Volume 7, pp. 618–622.

Robinson, S.K., F.R. Thompson III, T.M. Donovan, D.R. Whitehead, and J. Faaborg. 1995. Regional Forest Fragmentation and the Nesting Success of Migratory Birds. *Science* Volume 267, pp. 1987-1990.

Robinson, S. K., 1998. Another Threat Posed by Forest Fragmentation: Reduced Food Supply. *The Awk, A Quarterly Journal of Ornithology*. Volume 115, Number 1, pp. 1-3.

Spellerberg, I., 1998. Ecological effects of roads and traffic: a literature review. *Global Ecology and Biogeography*, Volume 7, pp. 317–333.

The Nature Conservancy, and Audubon Pennsylvania, 2010. Pennsylvania Energy Impacts Assessment, Report 1: Marcellus Shale Natural Gas and Wind, November 15, 2010.

U.S. Forest Service, 2005. Methodology for Project Data Collection and Results of Review, Oil & Gas Exploration and Development Categorical Exclusion, Forest Service Research and Development, U.S. Forest Service, Washington, D.C., December 12, 2005.

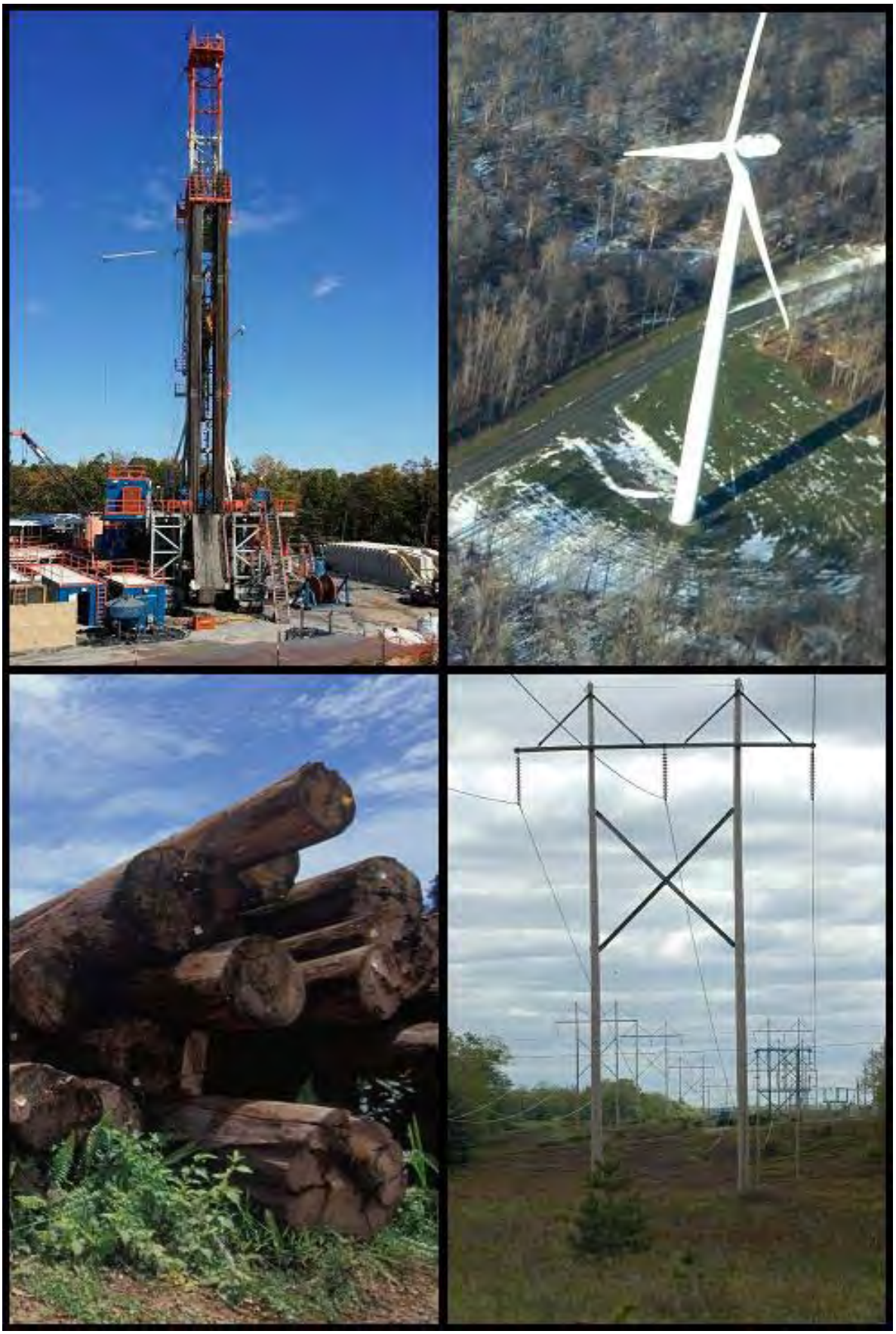
Velinsky, D. 2010. Testimony on the economic and environmental impacts of hydraulic drilling of Marcellus shale on Philadelphia and the surrounding region. Before the Joint Committees on the Environment and Transportation & Public Utilities of the Council of the City of Philadelphia. September 28, 2010. Available at http://www.ansp.org/about/news/marcellus-shale.php

Woodring, D. 2009. Natural Gas Pipelines and Forest Fragmentation: Challenges for the Forest Landowner. *Forest Leaves*, School of Forest Resources, The Pennsylvania State University Volume 18, pp.1-2.

Yahner, R.H., 1996. Forest Fragmentation, Artificial Nest Studies, and Predator Abundance *Conservation Biology*, Volume 10, Number 2, pp. 672-673.

Pennsylvania Energy Impacts Assessment

Report 1: Marcellus Shale Natural Gas and Wind



Pennsylvania Energy Impacts Assessment

Report 1: Marcellus Shale Natural Gas and Wind

November 15, 2010

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1. The Nature Conservancy – Pennsylvania Chapter
2. Western Pennsylvania Conservancy – Pennsylvania Natural Heritage Program
3. Audubon Pennsylvania

Cover photo: Marcellus gas drilling rig in Clinton County © George C. Gress / TNC

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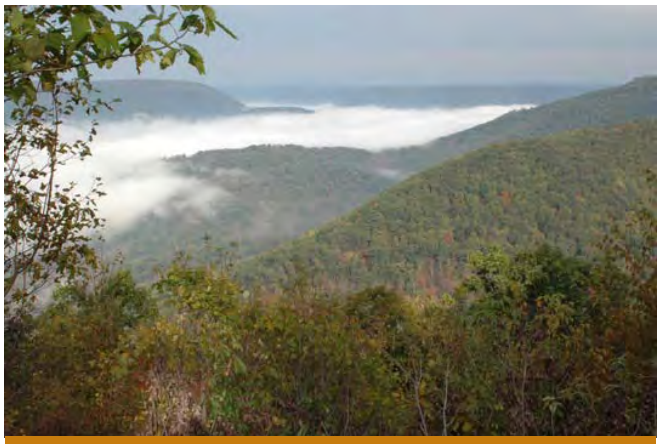
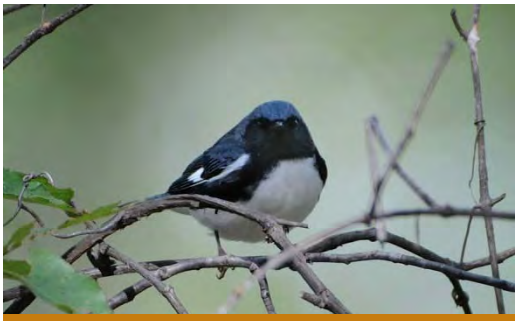
Executive Summary



Forest landscape along the West Branch Susquehanna River, Clinton County. © George C. Gress / TNC

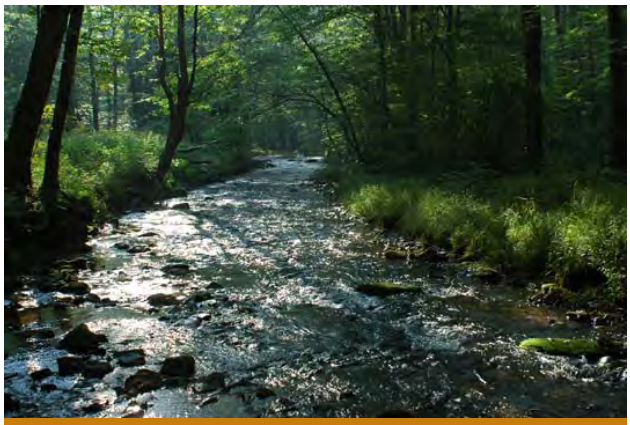
Within a few weeks during the summer of 2000, eight towers rose two hundred feet above an agricultural field on a low ridge top along the Pennsylvania Turnpike. Not long after, large blades began sweeping the Somerset County sky as Pennsylvania's first industrial wind facility went on line. Several years later and an hour drive to the west, an unusual natural gas well was drilled over a mile down and pumped full of water. That well in Washington County yielded a surprising amount of gas flowing from fractures in a shale formation that geologists had long suspected held plenty of gas but has been too expensive to develop. Meanwhile, a Canadian company bought a small sawmill in Mifflintown and started producing wood pellets for stoves, boilers, and electric plants. It soon became one of the region's largest producers of wood biomass energy supplies. In the decade since, these three new energy technologies have expanded rapidly across the state. By the end of this year, 500 wind turbines will be turning on Pennsylvania ridgelines, nearly 1,800 Marcellus natural gas wells will be scattered across rolling fields and forests, and over 50 facilities will be producing wood pellets or burning wood for energy. Thousands of miles of pipelines and powerlines already crisscross the state to get energy supplies to major markets in the Northeast.



Black-throated blue warblers and other interior forest species could be impacted by forest fragmentation caused by energy development. © Gary Irwin

Each of these energy sources carries both promise and risk for people and nature. The promise is that wind, natural gas, and wood biomass energy can replace coal and oil and their higher greenhouse gas emissions, generate jobs, and increase energy security. The risk is that extensive land use change and loss of natural habitats could accompany new energy development and transmission lines. Impacts to priority conservation habitats across the state have been modest thus far. For example, aerial photo analysis indicates Marcellus gas development has so far cleared just 3,500 acres of forest (about 1,000 acres for wind turbines). An additional 8,500 acres of forest is now within 300 feet of new fragmenting edges created by well pads, and associated roads and infrastructure (5,000 acres for wind turbines). This fragmentation deprives "interior" forest species, such as black-throated blue warblers, northern goshawks, salamanders, and many woodland flowers, of the shade, humidity and tree canopy protection that only deep forest environments can provide.

By all accounts, each of these energy types is likely to grow substantially in Pennsylvania during the next two decades. The Marcellus shale formation, which underlies two-thirds of the state, is now believed to be one of the largest unconventional shale gas reserves in the world. The Pennsylvania Alternative Energy Portfolio Standards Act of 2004, along with state and federal incentives, will likely boost expansion of wind, wood biomass, and other alternative energy types over the next two decades. But, how much of each energy type might be developed? What transmission infrastructure will be needed to get more electric power and natural gas to consumers? And, where are these energy types most likely to be developed? How does the likely scale and location of future energy development overlap with priority conservation areas? The Pennsylvania Energy Impacts Assessment seeks answers to these questions so that conservationists can work more effectively with energy companies and government agencies to avoid, minimize or mitigate habitat impacts in the future.



Nine Mile Run Creek in PA's North Central Highlands
© George C. Gress / TNC.

Assessment Goal: Develop credible energy development projections and assess how they might affect high priority conservation areas across Pennsylvania. Marcellus natural gas, wind, wood biomass, and associated electric and gas transmission lines were chosen as the focus since these energy types have the most potential to cause land-use change in the state over the next two decades. The conservation impacts focus is on forest, freshwater, and rare species habitats. The assessment **does not** address other potential environmental impacts, including water withdrawal, water quality, air quality and migratory pathways for birds and bats.

Key Assumptions: Any assessment of future trends must include certain assumptions. Among the most important assumptions of the Pennsylvania Energy Impacts Assessment are the following:

- A 20-year time period is used to assess potential cumulative habitat impacts from energy development;
- Given uncertainties about how energy prices could change, it was assumed that prices and capital investment (and policy and social conditions) will be sufficient to promote steady development growth for each energy type during the next two decades;
- Given uncertainty about how technology changes could affect spatial footprints, it was assumed that spatial footprints per well pad, turbine, and mile of transmission line will not change significantly during the next two decades;
- Given the proprietary nature of data on leases, Marcellus Shale porosity, fine resolution wind power, etc., all projections are based on publicly available information;
- It was assumed that recent trends and patterns of energy development will continue for the next two decades absent significant changes in government policies and industry practices;

Energy projections contained in this assessment are informed scenarios – **not predictions** – for how much energy development might take place and where it is more and less probable. Projected impacts, however, are based on measurements of actual spatial footprints measured for hundreds of well pads and wind turbines.

Analytical Steps: Key analytical steps for the Pennsylvania Energy Assessment included:

1) *Data collection* – Over 50 spatial data layers on energy resources, development permits, road and transmission infrastructure, physical features, and conservation priorities were compiled for the assessment;

2) *Spatial footprint analysis* – Spatial footprints for Marcellus gas well and wind turbine pads, associated roads, associated pipelines, associated electric transmission lines, and associated other clearings (*e.g.*, gas containment pits, equipment staging areas, electrical substations) were digitized using aerial photos of sites before and after construction;

3) *Scale projections* – Low, medium, and high scenarios for ***how much*** Marcellus Shale natural gas, wind, wood biomass, and transmission line development might occur were based as much as possible on existing projections and data from credible sources.

4) *Geographic projections* – Projections of ***where*** new Marcellus natural gas and wind energy development is more and less likely to occur were based on modeling the probability of a map pixel's land-use change to energy production based on sets of drivers and constraints developed for each energy type. Geographic projections for wood biomass and energy transmission were not modeled due to a lack of data. Conclusions about regional patterns of wood biomass and transmission development and potential conservation impacts will be presented in Report 2 of the Pennsylvania Energy Impacts Assessment.

5) *Conservation impacts analysis* – The potential impacts of future energy development were assessed for forest and freshwater habitats across the state. In addition, sites recognized as important for species of conservation concern were assessed. Conservation datasets for these assessments included, among others, large forest patches from The Nature Conservancy and the Western Pennsylvania Conservancy, habitat areas for rare species from the Pennsylvania Natural Heritage Program, densities for interior forest nesting bird species from the 2nd Pennsylvania Breeding Bird Atlas, and intact watersheds for native brook trout populations from the Eastern Brook Trout Joint Venture.

6) *Review* – A dozen energy experts in government, industry, and research organizations provided technical review of the energy projections.

Energy Projections: The Pennsylvania Energy Impacts Assessment developed low, medium and high scenarios for the amount of energy development that might take place in Pennsylvania by 2030. The projections include:

- *Marcellus Shale* – Sixty thousand wells could be drilled on between 6,000 and 15,000 new well pads (there are currently about 1,000) , depending on how many wells are placed on each pad. Gas development will occur in at least half of the state's counties, with the densest development likely in 15 counties in southwest, north central, and northeast Pennsylvania.

- *Wind* – Between 750 and 2,900 additional wind turbines could be built (there are currently about 500), depending on the wind share of electric generation by 2030. Most turbines would be built along the Allegheny Front in western Pennsylvania and on high Appalachian ridgetops in the central and northeastern parts of the state.

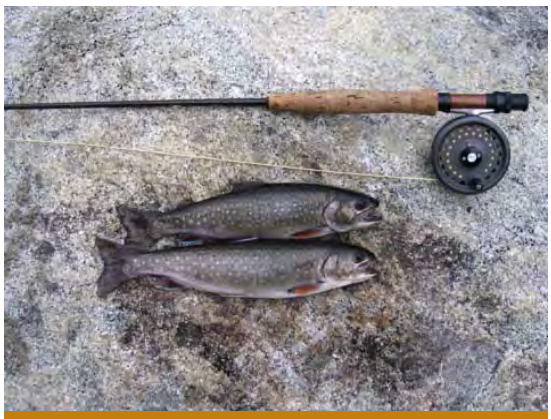
- *Wood Biomass* – Wood biomass energy demand could double or even triple today's wood energy use, depending on whether and how many coal power plants co-fire with wood biomass. Wood biomass energy development is likely to be widespread across the state in all three scenarios.

- *Transmission Lines* – Preliminary findings indicate between 10,000 and 15,000 thousand miles of new high-voltage power lines and gas pipelines (especially gathering lines) could be built during the next twenty years. There is considerable uncertainty about exactly where these lines will be built but recently proposed electric and gas transmission lines provide insights into potential habitat impacts.

Conservation Impacts: This first Pennsylvania Energy Impacts Assessment report focuses on the overlap between likely Marcellus gas and wind development areas and Pennsylvania's most important natural habitats. A second report will focus on the potential for additional impacts from new wood biomass energy plants, electric power lines, and natural gas pipelines. Key findings for impacts from Marcellus natural gas and for wind development include:

Forests. By 2030, a range of between 34,000 to 82,000 acres of forest cover could be cleared by new Marcellus gas development in the state. Forest clearing for the wind development scenarios is much smaller, ranging from 1,000 to 4,500 acres. Such clearings would create new forest edges where the risk of predation, changes in light and humidity levels, and expanded presence of invasive species could threaten forest interior species in 85,000 to 190,000 forest acres adjacent to Marcellus development and 5,400 to 27,000 forest acres adjacent to wind development. Forest impacts will be concentrated in the north central and southwest parts of the state where many of the state's largest and most intact forest patches could be fragmented into smaller patches by well pads, roads, and other infrastructure. Impacts to forest interior species will vary depending on their geographic distribution and density. Some species, such as the black-throated blue warbler, could see widespread impacts to their relatively restricted breeding habitats in the state while widely distributed species, such as the Scarlet Tanager, would be relatively less affected. Locating energy infrastructure in open areas or toward the outer edges of large patches can significantly reduce impacts to important forest areas.

Freshwater. Aquatic habitats are at risk too. Once widespread, healthy populations of native eastern brook trout in Pennsylvania are now largely confined to small mountain watersheds. Nearly 80 percent of the state's most intact brook trout watersheds could see at least some Marcellus gas and wind development during the next twenty years. Strongholds for brook trout are concentrated in north central Pennsylvania, where Marcellus development is projected to be relatively intensive in over half of the state's best brook trout watersheds. Exceptional Value streams – the Department of Environmental Protection's highest quality designation – could see hundreds of well pads (perhaps 300 - 750) and dozens of wind turbines (perhaps 50 – 200) located within one-half mile under the projections. Because many intact brook trout



Brook trout © TNC

and EV streams are in steep terrain, rigorous sediment controls, and possibly additional setback measures, are needed to help conserve these sensitive habitats.

Rare Species. Nearly 40 percent of Pennsylvania's globally rare and Pennsylvania threatened species can be found in areas with high potential for Marcellus gas development. These species tend to be associated with riparian areas, streams, and wetlands, while others are concentrated in unusually diverse areas such as the Youghiogheny Gorge. A handful of rare species have most or all of their known locations in high potential areas for Marcellus gas development. For example, three-fourths of all known snow trillium populations are in high potential Marcellus development areas as are all known populations for the green salamander. A much smaller number of known locations for globally and state rare species overlap with high potential wind development sites and they tend to be associated with rocky outcrops and ridgetop barrens habitats. Species with the greatest overlaps include timber rattlesnakes, Allegheny woodrats, and northern long-eared Myotis bats. More intensive surveys for globally rare and state critically endangered species in high potential Marcellus and wind development areas could help to minimize impacts before development begins. The Pennsylvania Game Commission is working with wind companies and other researchers to assess impacts to migratory pathways for birds and bats.

Recreation. Extensive overlaps are projected between Marcellus development and state forests, state parks, and state game lands. Just over ten percent of Pennsylvania's public lands are legally protected from gas development, most of it within State Wild and Natural Areas or in state parks where the Commonwealth owns the mineral rights. The state does not own mineral rights for 80% of State Park and State Game Lands, nearly 700,000 acres of State Forests have already been leased, and only about 300,000 acres of the remaining State Forest Lands are legally off-limits to future leases. Projections indicate between 900 and 2,200 well pads could be developed across all state lands, with most going on State Forest Lands, followed by State Game Lands, and State Parks. Wind development was not projected on state lands, though some facilities are projected near highly visited sites, including natural vistas.

Clearly, the heart of some of Pennsylvania's best natural habitats lie directly in the path of future energy development. Integrating information on conservation priorities into energy planning, operations, and policy by energy companies and government agencies sooner rather than later could dramatically reduce these impacts. Many factors – including energy prices, economic benefits, greenhouse gas reductions, and energy independence – will go into final decisions about where and how to proceed with energy development. Information about Pennsylvania's most important natural habitats should be an important part of the calculus about trade-offs and optimization as energy development proceeds. Would Pennsylvania's conservation pioneers, including Gifford Pinchot, Maurice Goddard, and Rachel Carson, expect anything less?

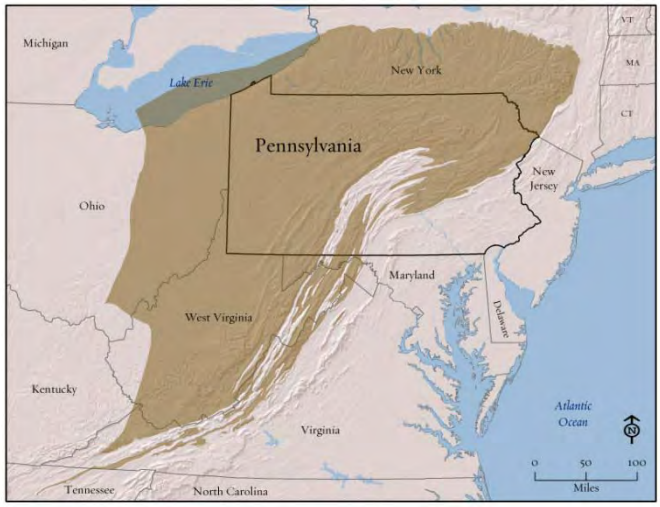
Marcellus Shale Natural Gas

Once thought to be inaccessible, deep shale formations with tightly held natural gas have become the most rapidly growing source of energy in North America. New technologies and methods have allowed companies to drill 6,000 to 10,000 feet down to reach the Marcellus shale, turn the well horizontally to follow the shale layer for a mile or more, and then pump in millions of gallons of water to fracture the shale and release the natural gas. Pennsylvania is at the epicenter of the Marcellus formation, one of the world's largest unconventional shale natural gas reserves. Situated right next door to huge markets in the Mid-Atlantic and Northeastern states, Marcellus gas development has expanded at a furious pace since the first wells were drilled just few years ago in Washington County. There are now nearly 2,000 drilled wells, most of them concentrated in the southwestern and northeastern parts of the state.

The Marcellus boom is bringing rapid economic growth to many rural communities that have been in economic decline for decades. Natural gas is also displacing higher carbon coal and oil supplies thus slowing the rise in greenhouse gas emissions. These benefits are real but not without costs. Large amounts of water must be withdrawn to frac each well (about 5 million gallons). The return flow water that comes back up from the well contains varying levels of chemicals, heavy metals, and even radioactive materials, and must be handled carefully to avoid spills when recycled or disposed. Heavy trucks and compressor stations rumble constantly in gas development areas putting heavy strains on roads, bridges and air quality. Because of known and perceived risks to environmental quality and human health, water use, air emissions and transportation demands are receiving growing attention from government agencies, researchers and energy companies. Thus far, relatively little attention, however, has been focused on Marcellus gas development impacts to natural habitats across the state.

What is Marcellus Shale Natural Gas?

The Marcellus is the largest gas-bearing shale formation in North America in both area and potential gas volume. It spans over 150,000 square miles across 5 states including the southern tier of New York, the northern and western half of Pennsylvania, the eastern third of Ohio, most of West Virginia, and a small slice of western Virginia. Estimates of the potential recoverable volume have increased steadily. The latest estimates by the U.S. Department of Energy are nearly 300 trillion cubic feet – enough to supply all natural gas demand in the United States for at least 10 years.



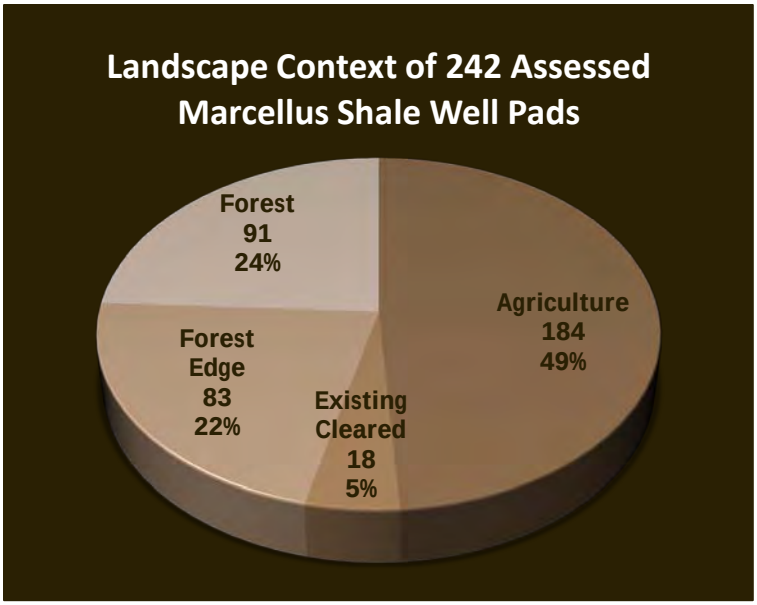
Map showing the extent of the Marcellus Shale formation. Data source: United States Geological Survey.

Geologists have long known the Marcellus formation is an organically-rich shale with potentially large amounts of natural gas, but it was too deep, too thin, and too dense to exploit. In 2005, Range Resources drilled the first production Marcellus well using horizontal drilling and hydraulic fracturing methods. The horizontal drilling is necessary because the shale is typically thin and vertical wells will only intercept a small part of the formation. Hydraulic fracturing (or "fracing") is a process that uses large volumes of water, sand, lubricants, and other chemicals to create small fissures in the shale rock. Hydro-fracing is necessary to release the gas which is tightly held in the dense black shale. These methods, first perfected for deep shale gas in the Barnett formation of Texas, unlocked the tremendous gas reserves in the Marcellus and other "unconventional" shale formations previously thought to be out of economic reach.

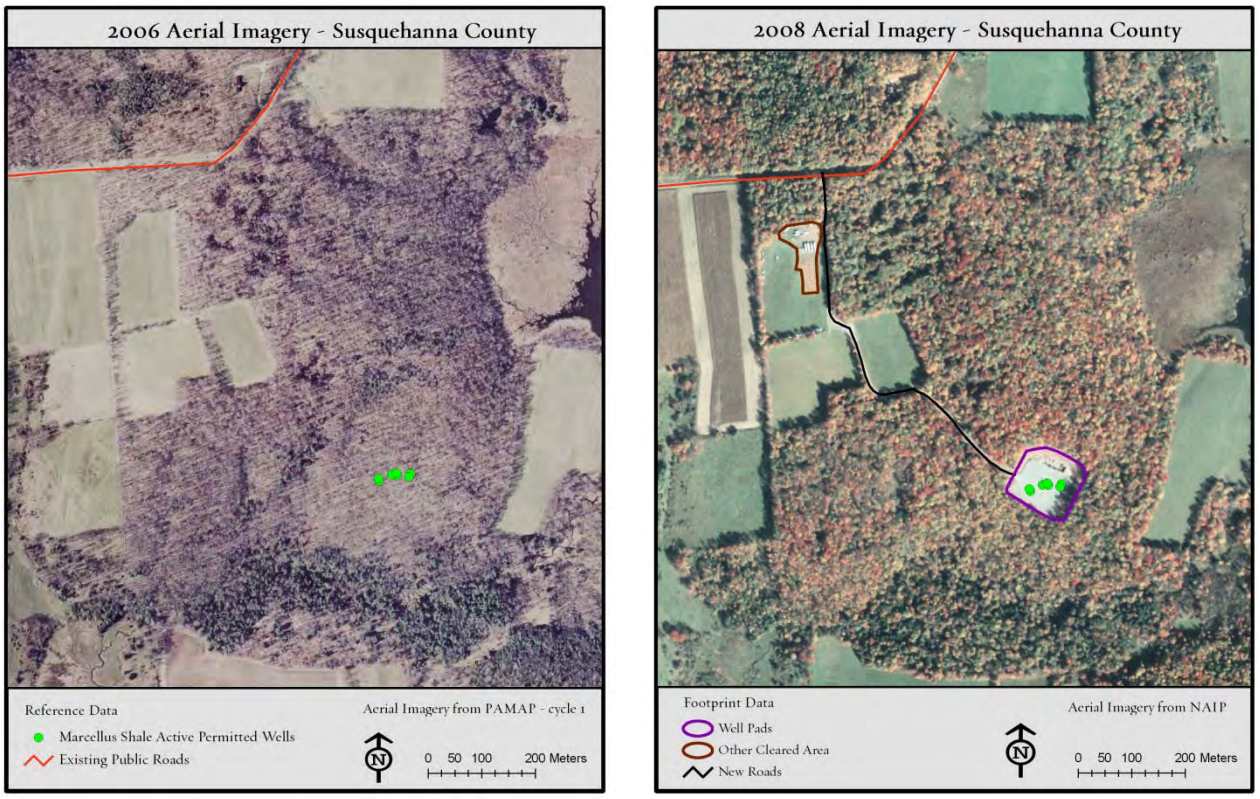
In contrast to shallow gas deposits in western Pennsylvania, the Marcellus is developed with multiple horizontal wells that can reach out 5,000 feet or more from one well pad. Everything about Marcellus development is bigger than conventional shallow gas plays. The well pads are more expansive (averaging just over 3 acres compared to a small fraction of an acre), the water used to frac wells is much greater (5 million gallons versus a hundred thousand gallons), and the supporting infrastructure is much larger in scale (24" diameter pipelines to gather gas from wells versus 2" or 4" pipelines in shallow fields). Individual wells are also vastly more productive (5 – 10 million cubic feet per day versus less than 100,000 cubic feet in peak early production). While the larger pad, greater water use, and more extensive infrastructure pose more challenges for conservation than shallow gas, the area "drained" by wells on each Marcellus pad is much larger than from shallow gas pads (500-1,000 acres versus 10-80 acres) since there are typically multiple lateral wells on a Marcellus pad versus a single vertical well on a shallow gas pad. The lateral reach of Marcellus wells means there is more flexibility in where pads and infrastructure can be placed relative to shallow gas. This increased flexibility in placing Marcellus infrastructure can be used to avoid or minimize impacts to natural habitats in comparison to more densely-spaced shallow gas fields.

Current and Projected Marcellus Shale Natural Gas Development

Projections of future Marcellus gas development impacts depend on robust spatial measurements for existing Marcellus well pads and infrastructure. We have been able to precisely document the spatial foot print for 242 Marcellus well sites across the state by comparing aerial photos of Pennsylvania Department of Environmental Protection (DEP) Marcellus well permit locations taken before and after development. The ground excavated for wells and associated infrastructure is the most obvious spatial impact.



For each well site, the area for the well pad, new or expanded roads, gathering pipelines, and water impoundments were digitized and measured.



Aerial photos before and after development of a Marcellus gas well pad site in Susquehanna County, PA. To assess the impacts of this type of energy development, we have digitized the spatial footprint of 242 gas well pad sites and associated infrastructure.

Average Spatial Disturbance for Marcellus Shale Well Pads in Forested Context (acres)		
Forest cleared for Marcellus Shale well pad	**3.1**	**8.8**
Forest cleared for associated infrastructure (roads, pipelines, water impoundments, etc.)	**5.7**	
Indirect forest impact from new edges	**21.2**	
TOTAL DIRECT AND INDIRECT IMPACTS	**30**	

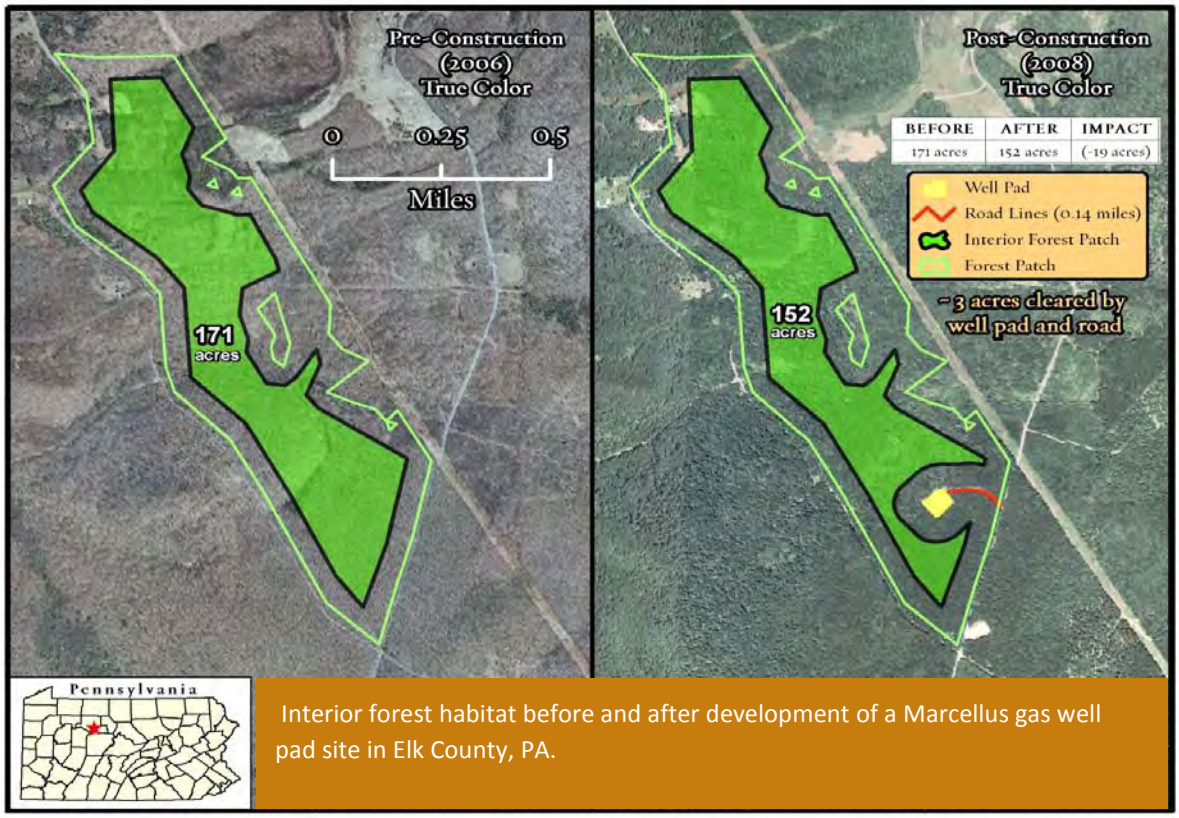
Well pads occupy 3.1 acres on average while the associated infrastructure (roads, water impoundments, pipelines) takes up an additional 5.7 acres, or a total of nearly 9 acres per well pad.

Adjacent lands can also be impacted, even if they are not directly cleared. This is most notable in forest settings where clearings fragment contiguous forest patches,

create new edges, and change habitat conditions for sensitive wildlife and plant species that depend on “interior” forest conditions.

Forest ecologists call this the “edge effect.” While the effect is somewhat different for each species, research has shown measurable impacts often extend at least 330 feet (100 meters) forest adjacent to an edge. Interior forest species avoid edges for different reasons. Black-throated blue warblers and other interior forest nesting birds, for example, avoid areas near edges because of the increased risk of predation. Tree frogs, flying squirrels and certain woodland flowers are sensitive to forest fragmentation because of changes in canopy cover, humidity and light levels. Some species, especially common species such as whitetail deer and cowbirds, are attracted to forest edges – often resulting in increased competition, predation, parasitism, and herbivory. Invasive plant species, such as tree of heaven, stilt grass, and Japanese barberry, often thrive on forest edges and can displace native forest species. As large forest patches become progressively cut into smaller patches, populations of forest interior species decline.

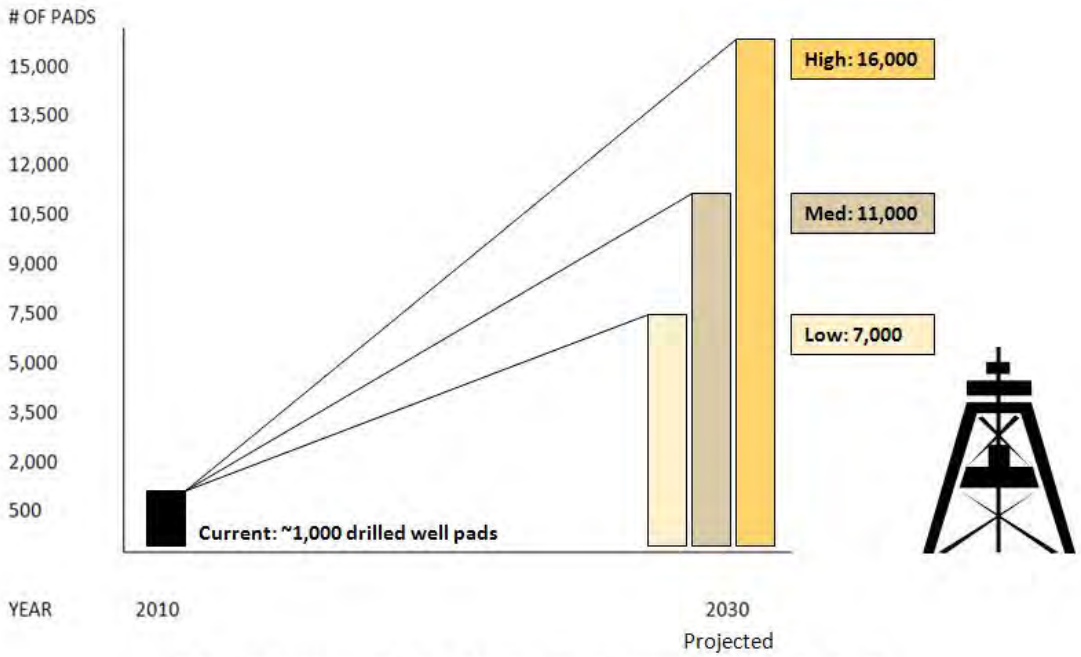
To assess the potential interior forest habitat impact, we created a 100 meter buffer into forest patches from new edges created by well pad and associated infrastructure development. For those well sites developed in forest areas (about half of the 242 total sites), an average area of 21 acres of interior forest habitat was lost.



Interior forest habitat before and after development of a Marcellus gas well pad site in Elk County, PA.

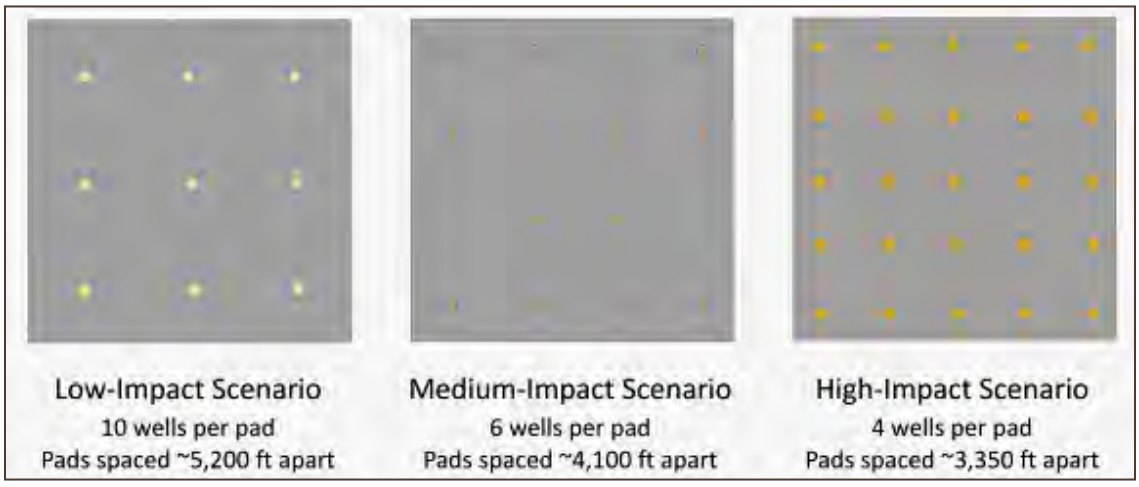
The number of Marcellus wells drilled in Pennsylvania during the next two decades will expand steadily. Just how many wells are drilled will be driven by various factors including natural gas prices, technological improvements, human resources, regulatory changes in Pennsylvania and beyond (e.g., end of New York drilling moratorium), and social preferences. Assessing how these factors will change over the next two decades is very difficult; therefore

our projections assume economic, policy, and social conditions remain stable enough to promote steady expansion of Marcellus gas development in the state. The first key variable in our projection is the number of drilling rigs that will be operating in Pennsylvania. By October 2010, the industry had moved just over 100 rigs into Pennsylvania to drill Marcellus wells according to the Baker-Hughes weekly rig count. Given the high productivity of the Marcellus and its proximity to major northeastern markets, most industry observers expect this number to continue growing steadily. The number of horizontal drill rigs operating in the Barnett Shale has peaked at about 200, but the



Key drivers: number of rigs, number of wells per pad.

We project 60,000 Marcellus wells will be drilled during the next twenty years based on company investor presentations and academic assessments of gas development potential. Depending on how many wells on average are placed on the same pad site (see illustration below), we project between 7,000 and 16,000 new well pad sites will be developed in Pennsylvania by 2030.



Marcellus Shale is much larger and could reach 300 rigs in Pennsylvania alone. We chose a conservative estimate of 250 maximum horizontal drill rigs for each scale projection scenario. Assuming that each rig can drill one well per month, 3,000 wells are estimated to be drilled annually. At that rate, 60,000 new wells would be drilled by the year 2030.

The second key variable, especially for determining land-use and habitat impacts, is the number of wells on each pad. Because each horizontal well can drain gas from 80 to 170 acres (depending on the lateral well length), more wells per pad translates to less disturbance and infrastructure on the landscape. It's technically possible to put a dozen or more Marcellus wells on one pad So far, the average in Pennsylvania is two wells per pad as companies quickly move on to drill other leases to test productivity and to secure as many potentially productive leases as possible (leases typically expire after 5 years if there is no drilling activity). In many cases, the gas company will return to these pads later and drill additional wells. The low scenario (6,000 well pads) assumes that each pad on average will have ten wells. Because many leases are irregularly shaped, in mixed ownership, or the topography and geology impose constraints, it is unlikely this scenario will develop. It would take relatively consolidated leaseholds and few logistical constraints for this scenario to occur. The medium scenario for well pads assumes 6 wells on average will be drilled from each pad, or 10,000 well pads across the state. Industry staff generally agree that six is the most likely number of wells they will be developing per pad for most of their leaseholds, at least where lease patterns facilitate drilling units of 600 acres or larger. The high scenario assumes each pad will have 4 wells drilled on average, or 15,000 well pads across the state. This scenario is more likely if there is relatively little consolidation of lease holds between companies in the next several years.

The number of well pads is less important than where they are located, at least from a habitat conservation perspective. To understand which areas within Pennsylvania's Marcellus formation are more and less likely to be developed, we used a machine-based learning modeling approach known as maximum entropy (Maxent 3.3.3a, Princeton University). Maximum entropy was used to find relationships between 1,461 existing and permitted well pad locations and variables that might be relevant to a company's decision to drill a Marcellus well. Such variables were chosen based on data availability and included Marcellus Shale depth, thickness and thermal maturity as well as percent slope, distance to pipelines, and distance to roads. The model produces a raster surface that represents the probability of an area to potentially support future gas well development. An additional 487 existing and permitted wells were used to test the validity of the model's probability surface and the model was found to be 80% accurate in predicting existing and permitted wells from randomly sampled undeveloped areas. The resulting probability map indicates wide variation across the Marcellus formation in terms of the likelihood of future gas well development.

To get a better sense of where gas development is most likely, we searched for the highest probability areas where well pads in each scenario might be located. The probability raster was re-sampled to a resolution that reflects the minimum separation distance between well pads for each of the three impact scenarios (low – 5,217 ft; medium – 4,134 ft; high – 3,346 ft). The minimum separation distance represents the drainage area for gas extraction and is dependent upon the number of wells per pad, which differs among the three impact scenarios. Using this method, each pixel of the raster represents the combined area of a well pad plus the minimum separation distance. The highest probable pixels were then selected until the threshold for each impact scenario was reached (low – 6,000 well pads; medium – 10,000 well pads; high – 15,000 well pads). Areas incompatible for future gas exploration (existing drilled Marcellus Shale wells, Wild and Natural Areas, and water bodies) were excluded from being selected as probable pixels. The highest probable pixels were then converted into points for map display purposes.

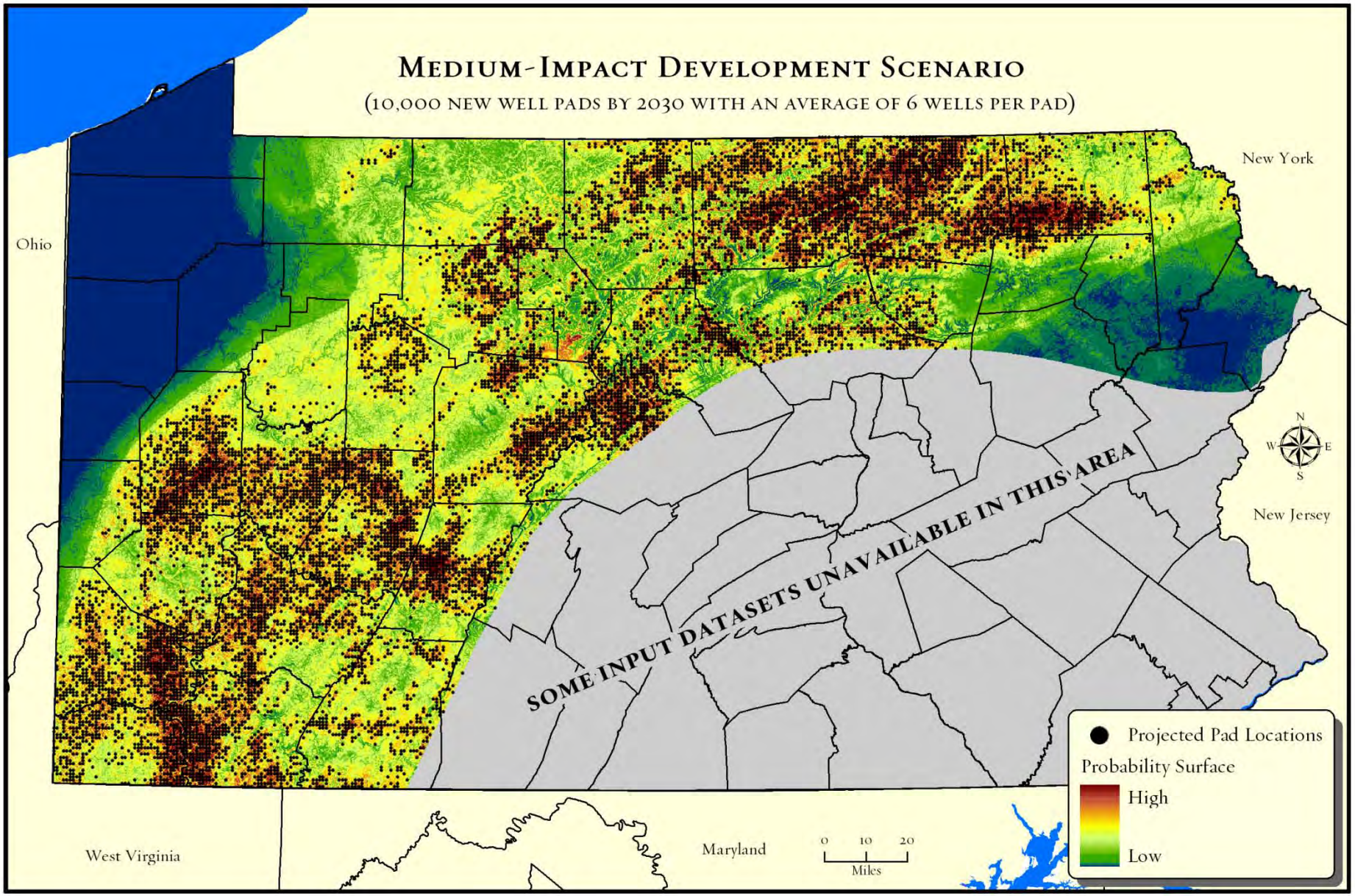
While the geographic area with projected well pads expands from low to high scenarios, the overall geographic pattern is not cumulative due to the differences in minimum separation distance between the three scenarios. Overall, hotspots for future gas development can be seen in half a dozen counties in southwestern Pennsylvania and half a dozen counties in north central and northeastern parts of the state.

These geographic projections of future Marcellus gas development are spatial representations of possible scenarios. They are not predictions. We faced several constraints in developing the geographic scenarios:

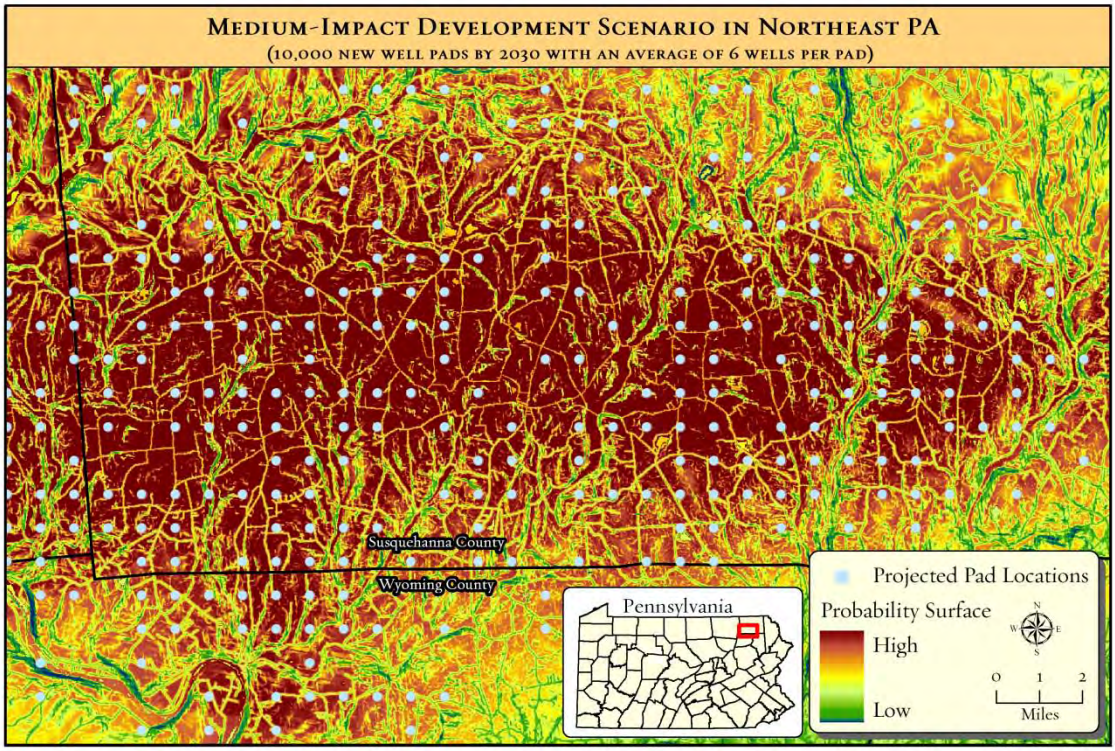
- We do not have access to proprietary seismic and test well geologic data that natural gas companies have. Shale porosity, for example, is a key factor but there are no publicly available data for this.

- We do not have the detailed location of gas company leases. Each company is looking for the highest probability locations across their lease holds while our model looks for the highest probability sites across the entire Marcellus formation in the state. Because there have only been a few Marcellus test wells and permits in the Delaware watershed, we believe the projections for new well pads are probably significantly underestimated in Wayne County.

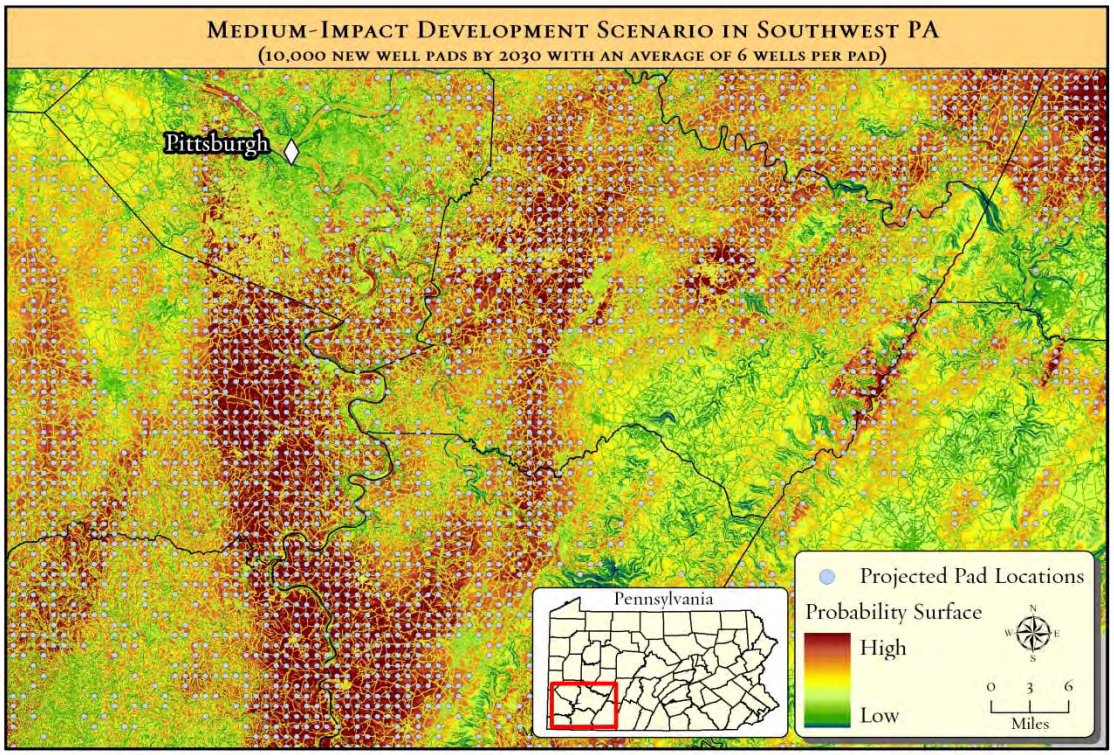
Still, we believe the overall geographic patterns in the projected gas development locations are relatively robust for several reasons. We used nearly 1,500 existing drilled or permitted well pads to build the model and nearly 500 additional drilled and permitted well pads to validate the model. This is typically a sufficient sample size for building predictive models. Additionally, reviews from industry, academic, and government agency reviewers indicate our methods and results are generally sound. Some reviewers expect future well pad locations to be more geographically expansive than our current projections indicate, especially in the Delaware watershed where only a few Marcellus test wells and permits have been issued. Our projections for Wayne County, for example, are likely underestimating future development potential.



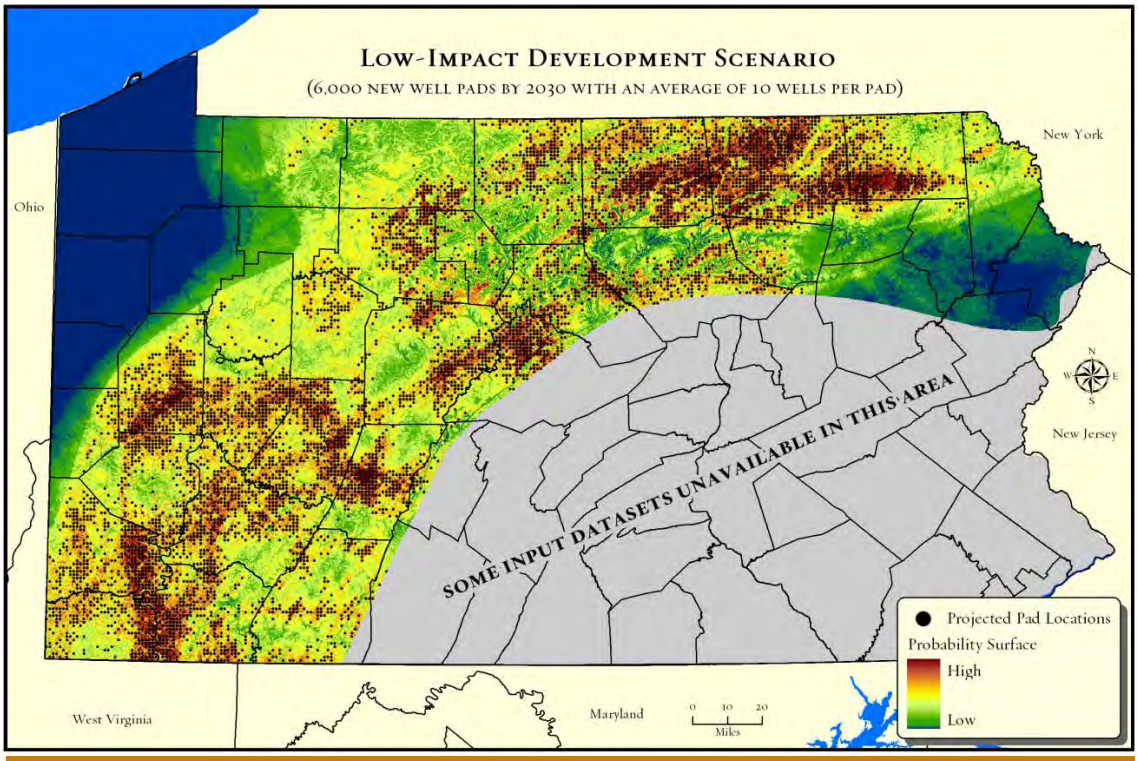
Map showing projected location of 10,000 new Marcellus Shale natural gas pads across Pennsylvania (medium development scenario).



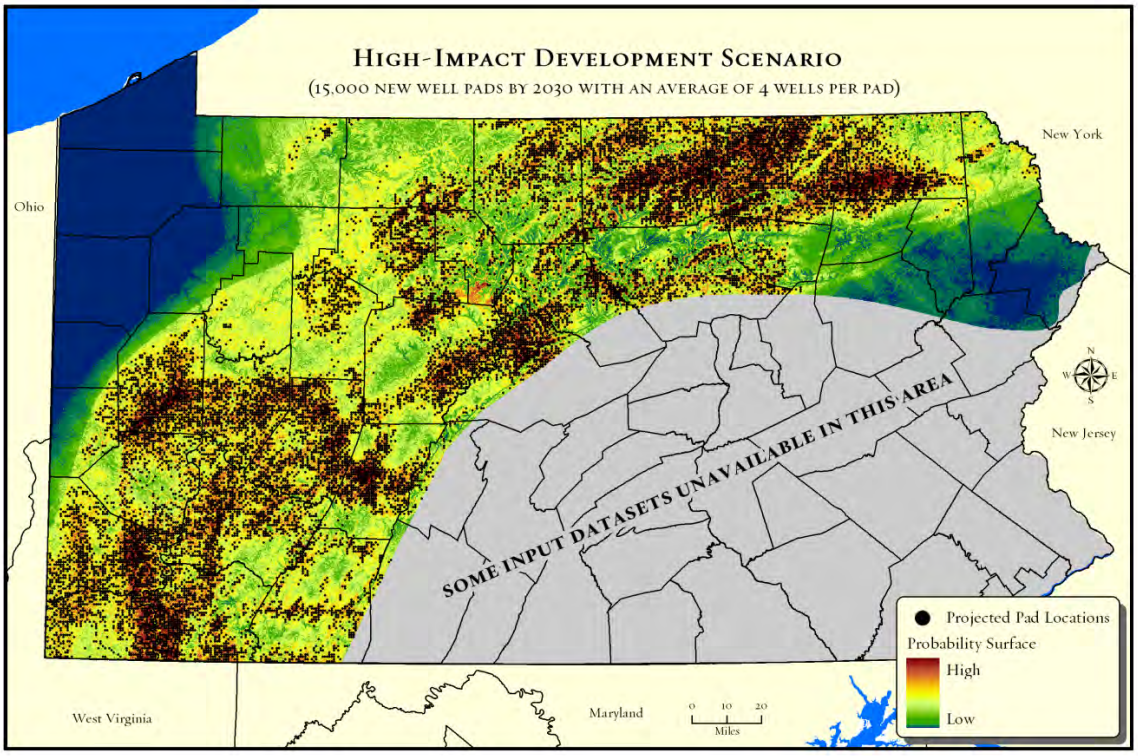
Map showing projected location of new Marcellus well pads in southern Susquehanna County under the medium development scenario.



Map showing projected location of new Marcellus well pads in southwestern Pennsylvania under the medium development scenario.



Map showing projected location of 6,000 new Marcellus well pads across Pennsylvania (low development scenario).



Map showing projected location of 15,000 new Marcellus well pads across Pennsylvania (high development scenario).

Conservation Impacts of Marcellus Shale Natural Gas Development

What is the overlap of the areas with the highest probability of future Marcellus gas development and those areas known to have high conservation values? To answer this question, we intersected the projected Marcellus well pads with areas previously identified and mapped as having high conservation values. We looked at several examples from four categories of conservation value, including:

- Forest habitats
- Freshwater habitats
- Species of conservation concern
- Outdoor recreation

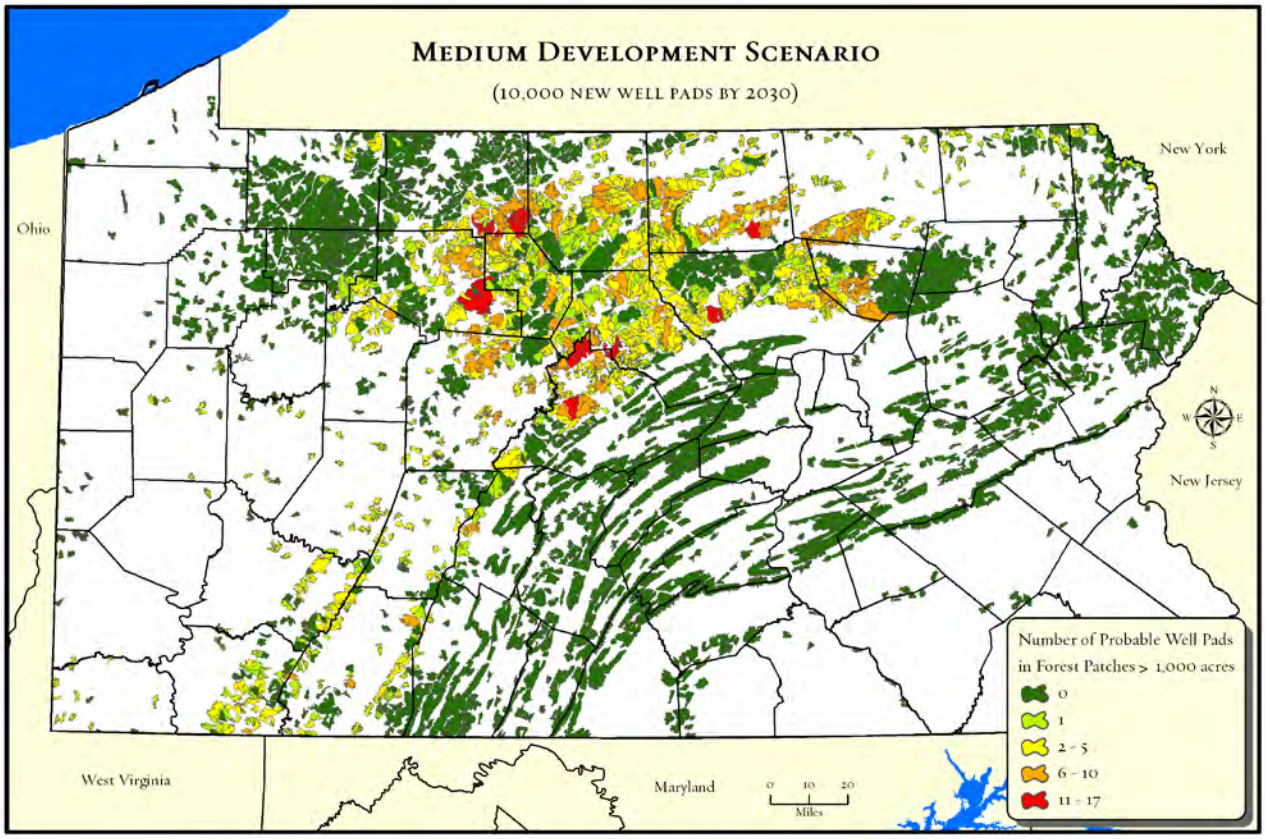
Substantial areas of overlap are indicated between likely future Marcellus development areas and Pennsylvania's most important forest, freshwater, sensitive species habitats, and outdoor recreation sites.

FORESTS

Forests are Pennsylvania's most extensive natural habitat type. Once covering at least 95 percent of the state's land area, forests were whittled away for agriculture, charcoal for iron smelting, and lumber until only a third of the state's forests remained. Forests have rebounded steadily to cover about 60 percent of the state, though a trend toward increasing net loss of forest has emerged during the past decade. Pennsylvania is famous worldwide for its outstanding cherry, oak, and maple hardwoods, and forests provide livelihoods for many thousands of Pennsylvanians in the forest products and tourism industries. They also contribute enormously to the quality of life for all Pennsylvanians by filtering contaminants from water and air, reducing the severity of floods, sequestering carbon dioxide emissions that would otherwise warm the planet, and providing a scenic backdrop to recreational pursuits.

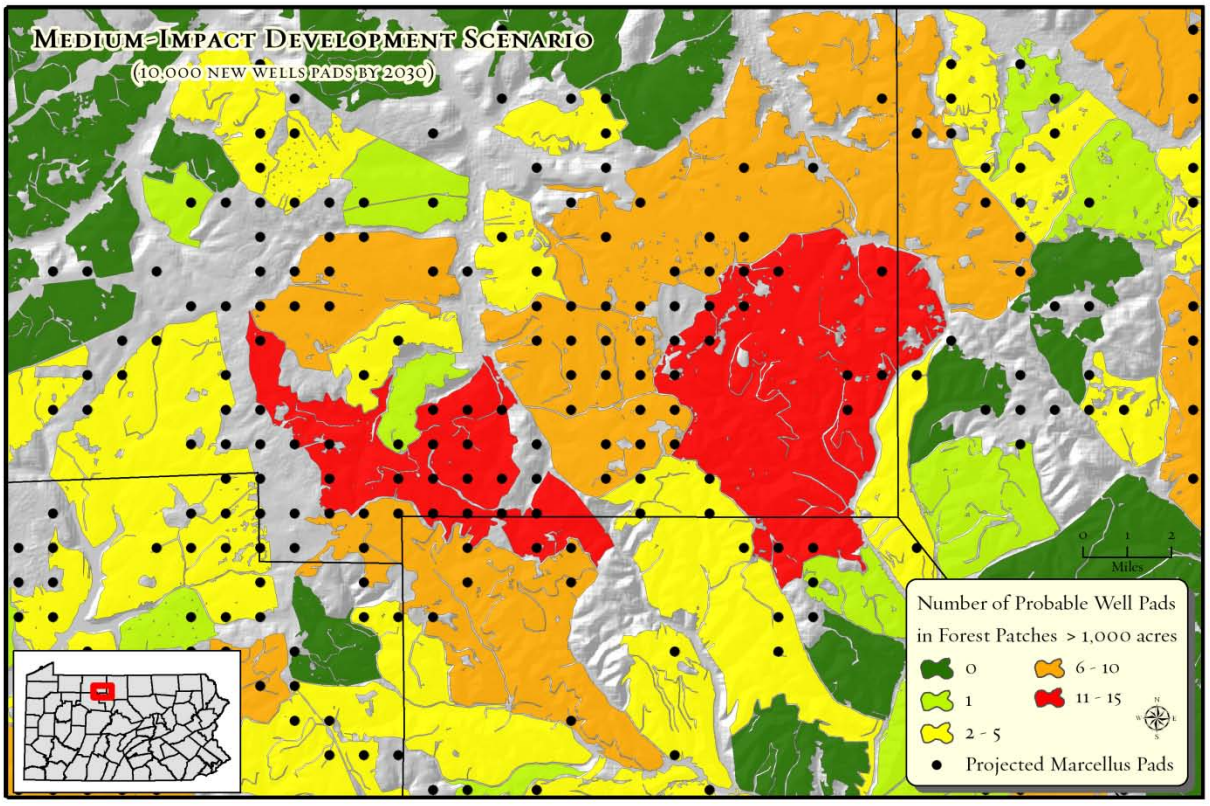
A majority of projected well locations are found in a forest setting for all three scenarios (64% in each case). The low scenario would see 3,845 well pads in forest areas. With an average cleared forest average of 8.8 acres per pad (including roads and other infrastructure), the total forest clearing would be approximately 33,800 acres. Indirect impacts to adjacent forest interior habitats would total an additional 81,500 acres. Forest impacts from the medium scenario (6,350 projected wells in forest locations) would be 56,000 cleared forest acres and an additional 135,000 acres of adjacent forest interior habitat impacts. For the high scenario (9,448 forest well pads), approximately 83,000 acres would be cleared and an additional 200,300 acres of forest interior habitats affected by new adjacent clearings. While the high Marcellus scenario would result in a loss of less than one percent of the state's total forest acreage, areas with intensive Marcellus gas development could see a loss of 2-3 percent of local forest habitats. Some part of the cleared forest area will become reforested after drilling is completed, but there has not been enough time to establish a trend since the Marcellus development started.

While all forests have conservation value, large contiguous forest patches are especially valuable because they usually sustain a wider array of forest species than small patches. They are also more resistant to the spread of invasive species, suffer less tree damage from wind and ice storms, and provide more ecosystem services – from carbon sequestration to water filtration – than small patches. The Nature Conservancy and the Western Pennsylvania Conservancy's Forest Conservation Analysis mapped nearly 25,000 forest patches in the state greater than 100 acres. Patches at least 1,000 acres in size are about a tenth of the total (2,700). Patches at least 5,000 acres are relatively rare (only 316 patches). In contrast to overall forest loss, projected Marcellus gas development scenarios indicate a more pronounced impact on large forest patches. For example, over 20 percent of patches greater than 1,000 acres are projected to have at least one well pad and associated infrastructure located in them. Most affected large patches have multiple projected well pads (as many as 29). The projections indicate larger patches are likely to be more vulnerable, with over a third projected to have at least one new well



Map showing number of probable Marcellus well pads in forest patches greater than 1,000 acres across Pennsylvania.

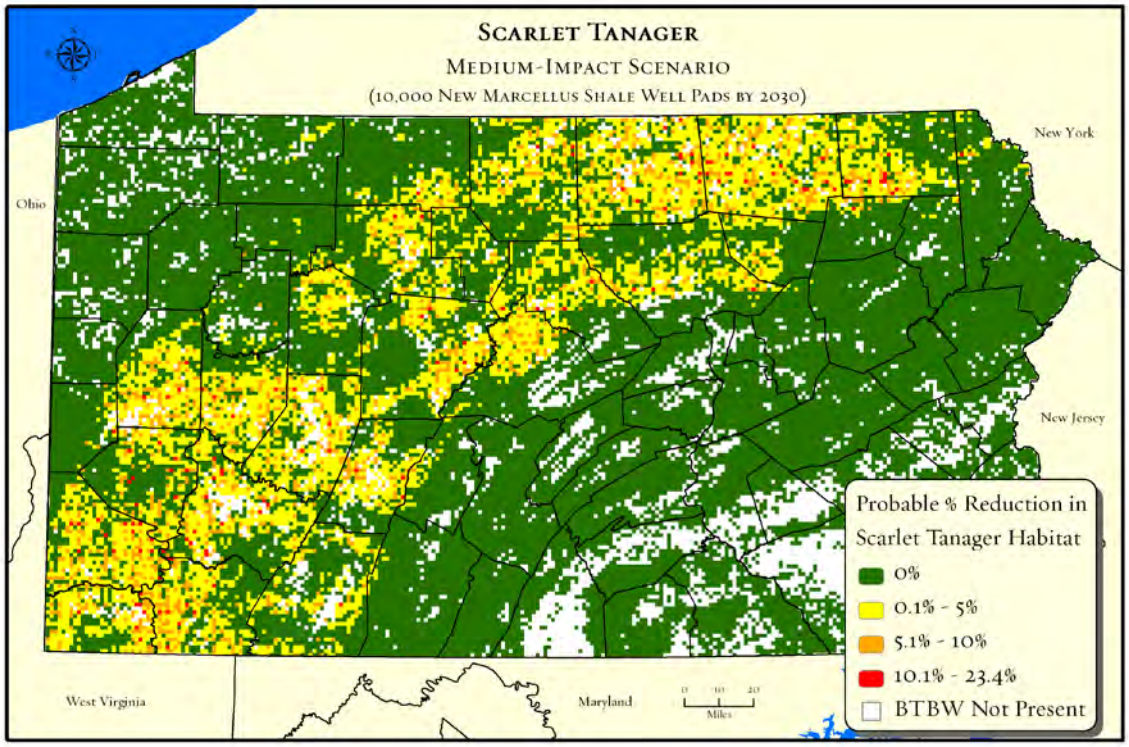
pad and road. Many affected large patches have multiple projected well pads (as many as 17 for patches). While one or two well pads and associated infrastructure will not necessarily fragment the large patch into smaller patches, each additional well pad increases the likelihood that the large patch will become several smaller patches with a substantially reduced forest interior habitat area.



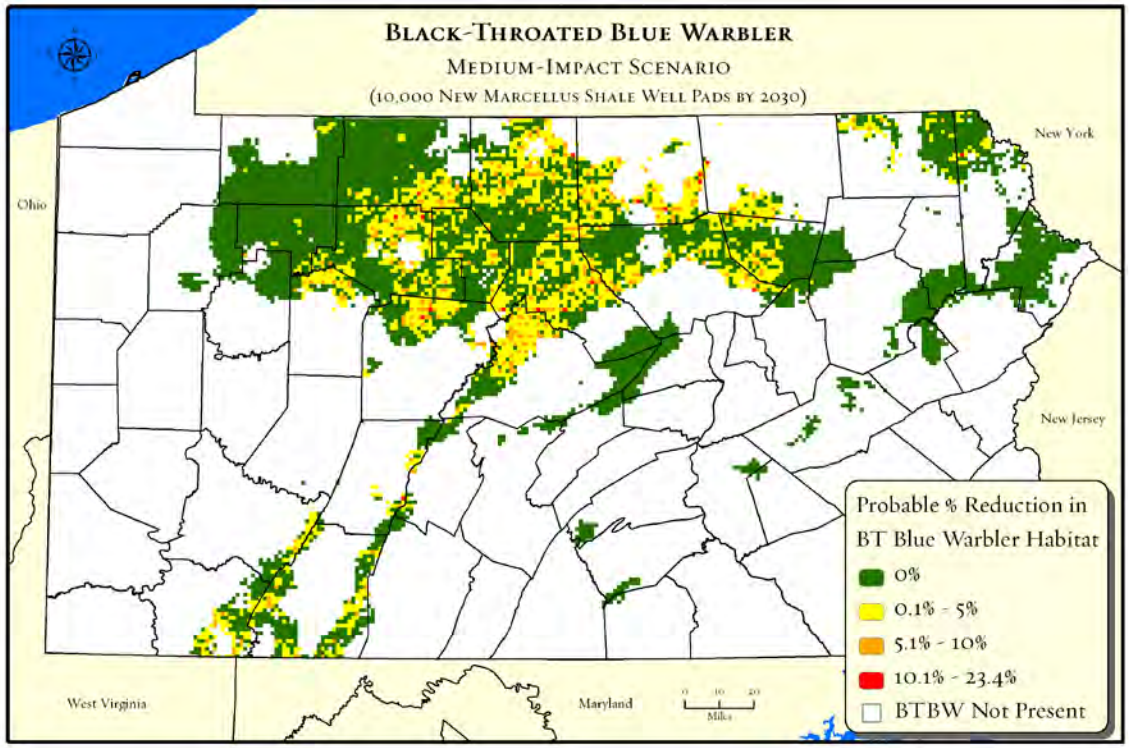
Map showing projected number of well pads in forest patches greater than 1,000 acres under the medium development scenario in Potter, Cameron, McKean and Forest Counties.

Bird species that nest in close canopy forest environments are often referred to as "forest interior" species. The Carnegie Museum of Natural History, Powdermill Nature Reserve and the Pennsylvania Game Commission recently completed Pennsylvania's Second Breeding Bird Atlas project. Thousands of experienced volunteer birders took point count counts using standardized protocols at 39,000 sites across the state. The result is an incredibly detailed data base that provides the most accurate reflection of the distribution and density of breeding birds in the United States. Density data for several forest interior nesting species were mapped and intersected with the projected Marcellus gas well pad locations. The resulting maps show the estimated reduction in habitat for that species in each Marcellus gas probability pixel (including both cleared forest and adjacent edge effects). Scarlet Tanagers are perhaps the most widespread forest interior nesting bird in the state. Since they are so widespread, a majority of their range in the state is outside of the most likely Marcellus development areas. In some locations, Scarlet Tanager populations could decline by as much as 23 percent in the Medium Scenario. Black-Throated Blue Warblers are more narrowly distributed in Pennsylvania favoring mature northern hardwood and coniferous forests with a thick understory, frequently in mountain terrain. Since most of their breeding range in Pennsylvania overlaps with likely Marcellus development areas, a higher proportion of their habitat could be affected.

Scarlet tanager © U.S. Fish and Wildlife Service



Map showing estimated percent loss of habitat for Scarlet Tanagers under medium scenario.

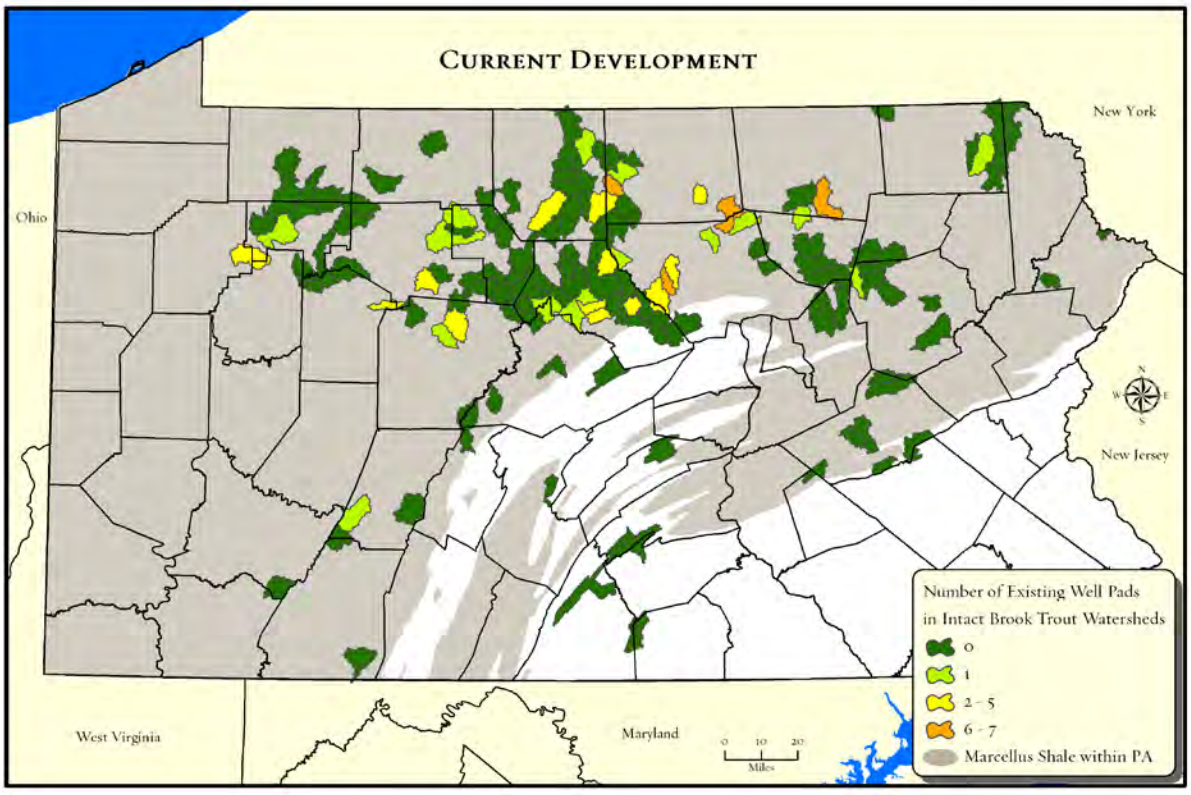


Map showing estimated percent loss of habitat for Black-Throated Blue Warblers under medium scenario.

FRESHWATER

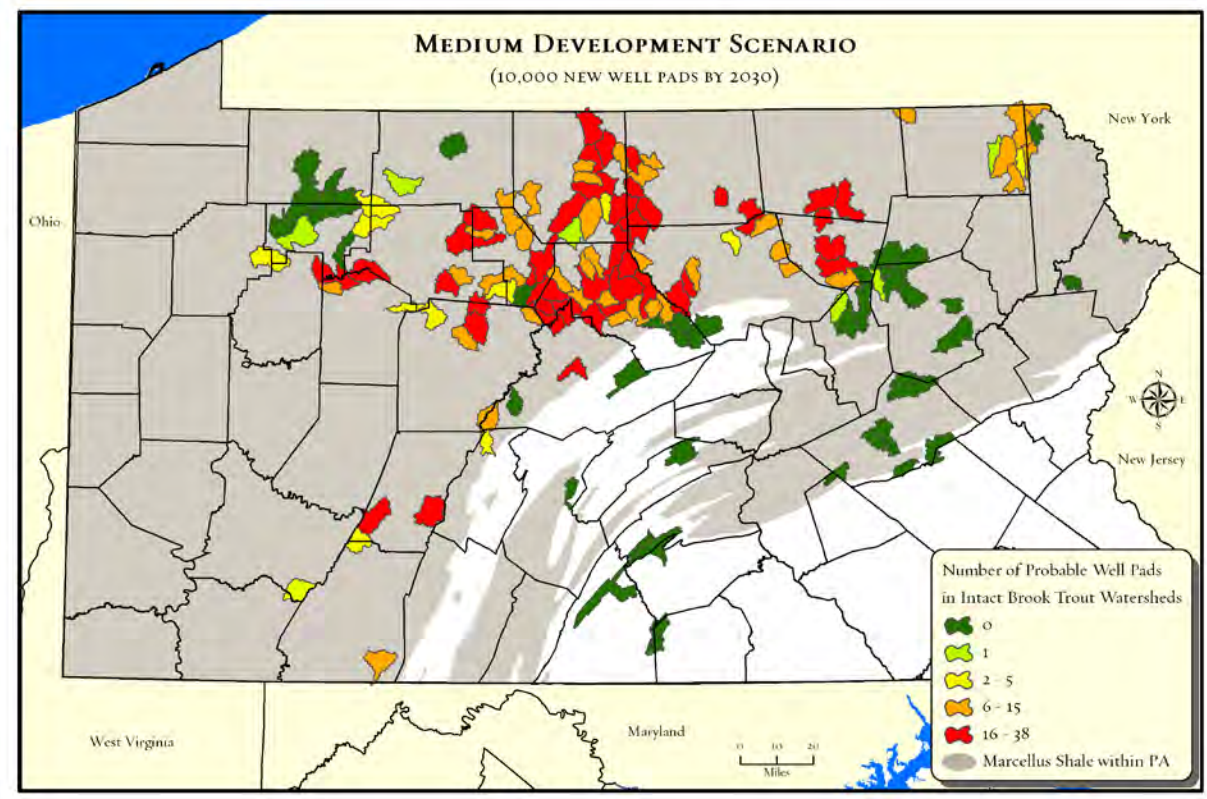
Home to three great river systems and one of the Great Lakes, Pennsylvania's fresh water resources are vital not only to the Commonwealth but to much of the eastern United States. The ***Ohio River*** basin contains the richest fresh water ecosystems in North America. In Pennsylvania, French Creek and parts of the Upper Allegheny River contain some of the most intact aquatic ecosystems in the entire basin. The ***Susquehanna* River** is the source of more than half the fresh water that enters the Chesapeake Bay, and most of the water that flows down the Susquehanna River originates in tributary headwaters across a wide swath of central Pennsylvania. Forming Pennsylvania's eastern boundary, the ***Delaware River*** is the longest undammed river in the eastern United States, one of the last strongholds for Atlantic coast migratory fish, and provides the drinking water source for nearly 20 million Americans living in Pennsylvania, New York, and New Jersey. Because of their importance to human health and livelihoods, the potential of Marcellus gas development to affect water flows and quality have received growing attention from regulatory agencies, natural gas companies, and environmental groups.

The intersection of gas development with sensitive watersheds has received less attention. High Quality and Exceptional Value (EV) watersheds have been designated by the Pennsylvania Department of Environmental



Map showing current number of Marcellus well pads in intact and predicted intact brook trout watersheds. Data source: Eastern Brook Trout Joint Venture.

Protection across the state. Our projections indicate 28 percent of High Quality and 5 percent of Exceptional Values streams have or will have Marcellus gas development during the next two decades presence of well pads in these watersheds may not be a problem as long as spill containment measures and erosion and sedimentation regulations are strictly observed and enforced in these areas. More specifically, the projections indicate 3,581 well pads could be located within ½ mile of a High Quality or Exceptional Values streams. Pads within close proximity to High Quality and especially Exceptional Value streams pose more risk than those at greater distances, as there is increased risk for potential spills and uncontained sediments to find their way into streams.



Map showing projected number of Marcellus well pads by 2030 in intact and predicted intact brook trout watersheds under medium scenario. Data source: Eastern Brook Trout Joint Venture.

Native brook trout are one of the most sensitive aquatic species in Pennsylvania watersheds. Brook trout favor cold, highly-oxygenated water and are unusually sensitive to warmer temperatures, sediments, and contaminants. Once widely distributed across Pennsylvania, healthy populations have retreated to a shrinking number of small watersheds. Many of these watersheds overlap with the Marcellus shale formation. A large majority (113) of the 138 intact or predicted intact native brook trout watersheds in Pennsylvania are projected to see at least some Marcellus gas development. Over half (74) are projected to host between 6 – 38 well pads, and the number reaches as high as 64 pads for some intact brook trout watersheds in the high scenario. Rigorous sediment controls and carefully designed stream crossings will be critical for brook trout survival in watersheds, especially upper watersheds, with intensive Marcellus development.

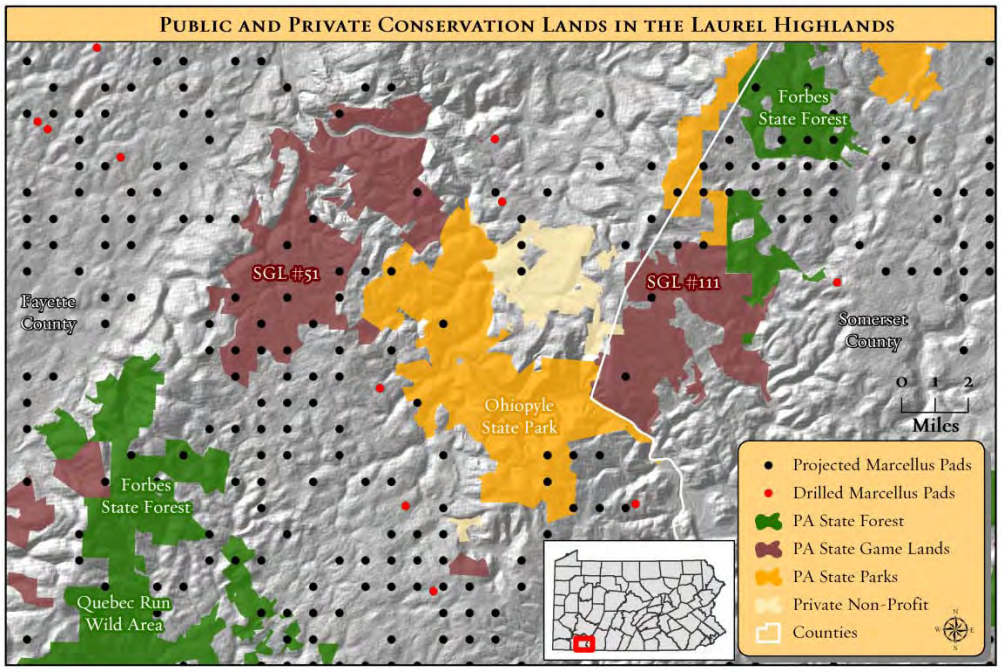
RARE SPECIES

Green salamander © Pennsylvania Fish and Boat Commission

Of the approximately 100,000 species believed to occur in Pennsylvania, just over 1 percent (1052) are tracked by The Pennsylvania Natural Heritage Program (PNHP). Due to low population sizes and immediate threats, these species are rare, declining or otherwise considered to be of conservation concern. PNHP records indicate that 329 tracked species have populations within pixels that have a relatively high modeled probability for Marcellus development. Nearly 40 percent (132) are considered to be globally rare or critically endangered or imperiled in Pennsylvania. Many are found in riparian areas, streams, and wetlands, while others are clustered in unusually biologically diverse areas such as the Youghiogheny Gorge. Some of these species may have only one, two or three populations left in the state. Two examples include the green salamander (*Aniedes aeneus)* with all known populations in relatively high probability Marcellus development pixels and snow trillium (*Trillium nivale*) with 73 percent of known populations in relatively high probability pixels. A well-managed screening system to identify the presence of these species and their preferred habitats will be critical to their survival as energy development expands across the state.

RECREATION

Pennsylvania has built one of the largest networks of public recreation lands in the eastern United States, but much of it could see Marcellus and other natural gas development in coming decades. Of the 4.5 million acres of state and federal lands in the state, we estimate as little as 500,000 acres are permanently protected from surface mineral development, including gas drilling. State and federal agencies do not own mineral rights under at least 2.2 million acres. Most other areas where the state does own mineral rights can be leased, such as the estimated 700,000 acres previously leased for gas development on state forest lands. Severe budget pressures will likely to tempt the legislature to lease additional lands in the future. Our projections excluded state Wild and Natural Areas, National Park lands, and Congressionally-designated Wilderness Areas but otherwise assumed that high probability Marcellus gas pixels on public lands could be developed. The low scenario projects 897 pad locations on State Forest and State Game Lands which expands to 1,438 well pads in the medium scenario and 2,096 pads in the high scenario. The focal area below illustrates what the overlap of future gas development and conservation lands could look like in the medium scenario for the southern Laurel Highlands. It projects 7 well pads in the portion of Forbes State Forest visible in the focal area above, 13 pads on State Game Lands 51, and 3 on State Game Lands 111.



Map showing projected Marcellus well pads under the medium scenario on public and private conservation lands in the Laurel Highlands.

Pennsylvania's state park system, recognized as one of the best in the nation, illustrates the challenge of protecting recreational values in areas of intensive Marcellus development. While the DCNR has a long standing policy of not extracting natural resources in state parks, it does not own the mineral rights under an estimated 80 percent of the system's 283,000 acres. Our projections indicate Marcellus well pads could be located in between 9 and 22 state parks.

AVOIDING FOREST IMPACTS IN THE LAUREL HIGHLANDS

The projected potential impacts of Marcellus gas energy development assume recent patterns of development will continue. Given the relatively large areas drained by Marcellus gas pads (depending on the lateral length and number of wells per pad), there is flexibility in how they are placed. This allows us potentially to optimize between energy production and conservation outcomes. To look at how conservation impacts could be minimized, we examined how projected Marcellus gas pads could be relocated to avoid forest

Projected Well Pads on State Lands (Medium Scenario)	
DCNR State Forests	**1,002**
DCNR State Parks	**41**
State Game Lands	**436**
Total State Lands	**1,479**

patches in the Southern Laurel Highlands in Fayette and Somerset counties. This area is important because it represents a unique ecological region with a large amount of state land as well as private farmland and forest land. The area is also facing great pressure to develop the Marcellus Gas resource. The focus area included approximately 350 square miles and included Chestnut Ridge on its western border and Laurel Ridge on its east. Within the area, there are two state parks (Ohiopyle State Park and Laurel Hill State Park), two State Game Lands (SGL 51, SGL 111), and state forest land (Forbes State Forest).

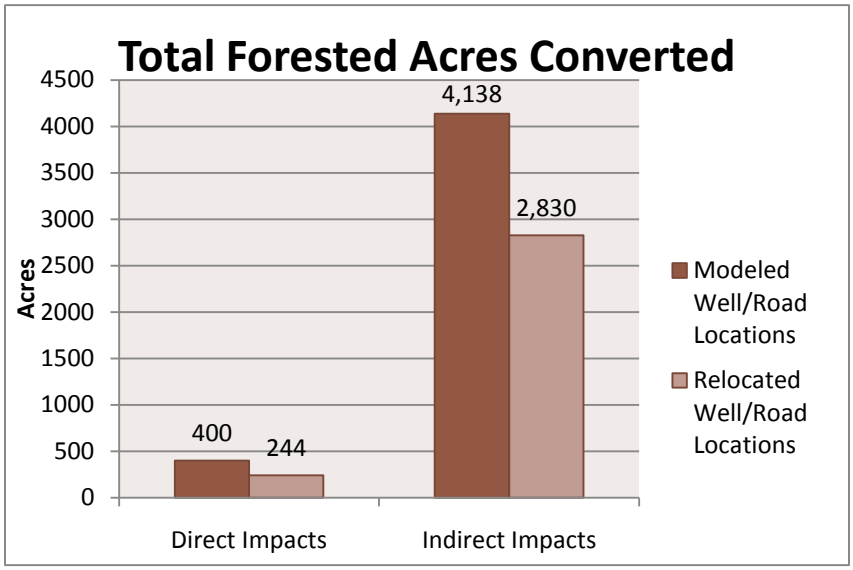
The Medium Scenario projected 127 well pads in the focus area. Fourteen well pads were projected in agricultural fields, 33 were in edge habitat (within 100 m of the forest edge), 11 fell within existing cleared areas (e.g. strip mines), and 69 were in forest. There were five pads on Ohiopyle State Park, and 13 within a mile of its boundary. Laurel Ridge State Park contained two pads. Forbes State Forest had seven modeled pads. State Game Lands 111 had 3 pads, and SGL 51 had 13. It was not clear if DCNR State Parks Bureau or the Game Commission control the sub-surface mineral rights beneath the 23 modeled pads. Given that 80 percent of mineral rights are severed on State Park and State Game Lands (and close to 100 percent in western parts of the state), we have assumed that drilling could happen at those projected locations.

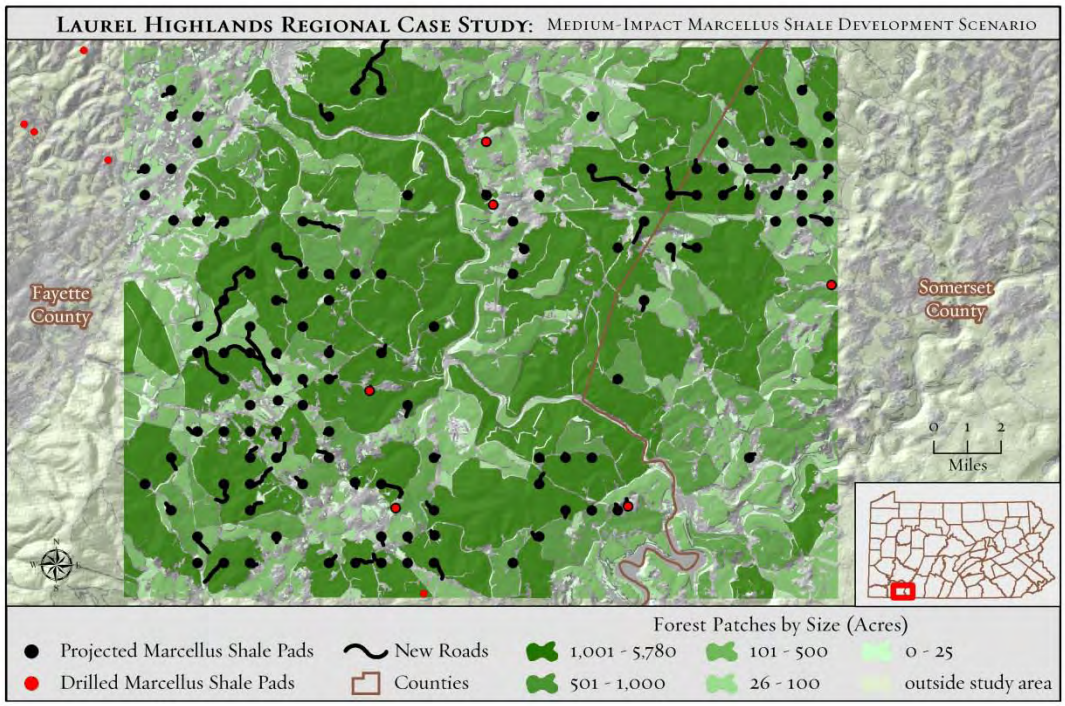
To assess additional impacts beyond the well pad itself, we placed a new and/or improved road from the projected pad to the nearest existing road (ESRI Roads Layer). We placed new roads along existing trails, paths and openings whenever detectable on aerial photo imagery (used Bing Maps and 2005-2006 PA Map imagery), avoiding wetlands, steep slopes, cliffs, rock outcrops, and buildings, and where possible, rivers, streams, and forest patches. The projected pads and roads required clearing 400 acres of forest.

Can a modest shift in the location of well pads reduce impacts to forest patches and conservation lands? To reduce the impacts to forest habitats, the wells were relocated to nearby existing anthropogenic openings, old fields, or agricultural fields. Attempts were made to maintain the 4,200 foot (1,260 m) distance between modeled wells. If nearby open areas did not exist, the locations of the well pads were moved toward the edges of forest patches to minimize impacts to forest interior habitats. A set of rules was developed and followed to minimize bias, including:

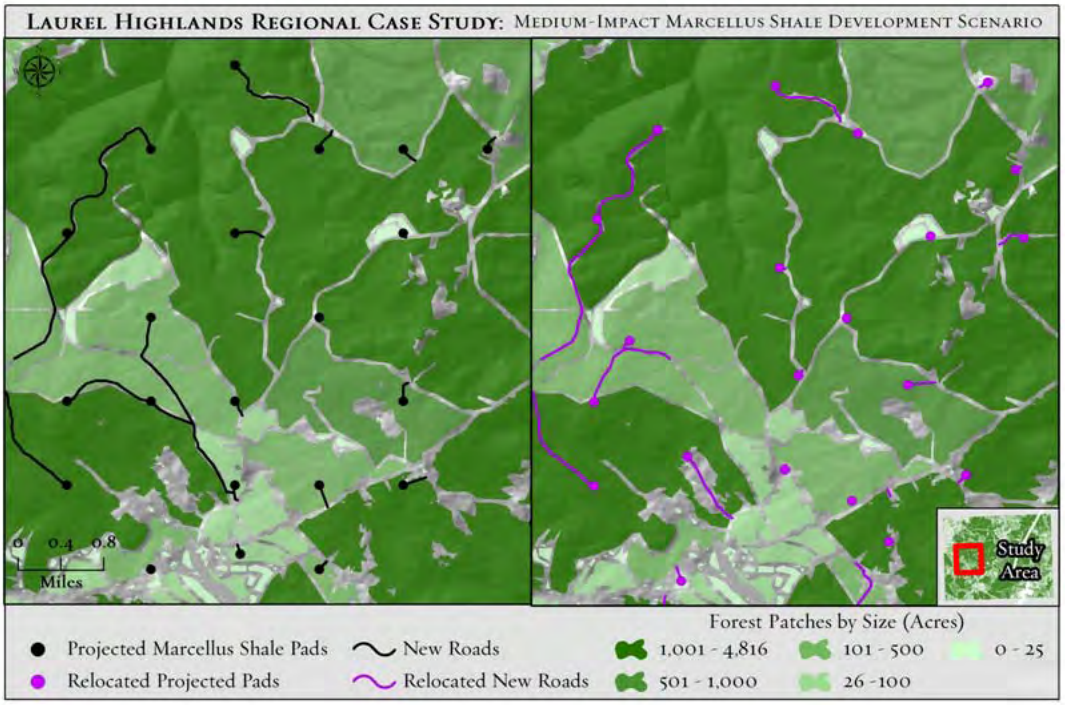
1. Modeled well pads were not relocated if they occurred in old fields or agricultural fields.
2. Modeled well pads that occurred in forest or edge habitat were moved but well pads were placed in the same general areas as the modeled well pad;
3. Attempts were made to avoid placing idealized wells any closer than the minimum distance between pads as specified by the medium scenario (1260 m);
4. Agriculture, cleared land (e.g., former strip mines), or otherwise opened land cover was favored over forest or edge for placing idealized well pads;
5. If the well pad could not be placed in an open area, forest edges were favored over deep interior forest;
6. Residential areas were avoided. Idealized well pads were placed at least 500 feet (150 m) from homes;
7. Wetlands, water, steep slopes, cliffs, rock outcrops, creeks and rivers, buildings and manicured lawns were avoided;
8. Relocated well pads were only placed in areas with similar to those that supported modeled pads.
9. Relocated well pads often were connected to roads using existing trails, paths and openings whenever detectable on aerial photo imagery (used Bing Maps and 2005-2006 PA Map imagery);
10. The same number of relocated well pads were placed on state lands and Western Pennsylvania Conservancy lands as they were in the modeled output;
11. When the modeled well pad occurred within a forest patch with no nearby alternative locations (due to proximity of other wells or environmental constraints), the projected well pad was not relocated.

The relocated wells and roads did not eliminate forest impacts in this heavily forested landscape, but there was a significant reduction. Total forest loss declined almost 40% while impacts to interior forest habitats adjacent to new clearings declined by a third.





Location of 127 projected Marcellus well pads and new roads in the study area in the southern Laurel Highlands.



Relocated well pads (on the right) reduced forest clearing and forest interior habitat impacts by 40 % and 33% respectively compared to the projected well pads (on the left).

Key Findings

Key findings from the Pennsylvania Energy Impacts Assessment for Marcellus Shale natural gas include:

- About 60,000 new Marcellus wells are projected by 2030 in Pennsylvania with a range of 6,000 to 15,000 well pads, depending on the number of wells per pad;

- Wells are likely to be developed in at least 30 counties, with the greatest number concentrated in 15 southwestern, north central, and northeastern counties;

- Nearly two thirds of well pads are projected to be in forest areas, with forest clearing projected to range between 34,000 and 83,000 acres depending on the number of number of well pads that are developed. An additional range of 80,000 to 200,000 acres of forest interior habitat impacts are projected due to new forest edges created by well pads and associated infrastructure (roads, water impoundments);

- On a statewide basis, the projected forest clearing from well pad development would affect less than one percent of the state's forests, but forest clearing and fragmentation could be much more pronounced in areas with intensive Marcellus development;

- Approximately one third of Pennsylvania's largest forest patches (>5,000 acres) are projected to have a range of between 1 and 17 well pads in the medium scenario;

- Impacts on forest interior breeding bird habitats vary with the range and population densities of the species. The widely-distributed scarlet tanager would see relatively modest impacts to its statewide population while black-throated blue warblers, with a Pennsylvania range that largely overlaps with Marcellus development area, could see more significant population impacts;

- Watersheds with healthy eastern brook trout populations substantially overlap with projected Marcellus development sites. The state's watersheds ranked as "intact" by the Eastern Brook Trout Joint Venture are concentrated in north central Pennsylvania, where most of these small watersheds are projected to have between two and three dozen well pads;

- Nearly a third of the species tracked by the Pennsylvania Natural Heritage Program are found in areas projected to have a high probability of Marcellus well development, with 132 considered to be globally rare or critically endangered or imperiled in Pennsylvania. Several of these species have all or most of their known populations in Pennsylvania in high probability Marcellus gas development areas.

- Marcellus gas development is projected to be extensive across Pennsylvania's 4.5 million acres of public lands, including State Parks, State Forests, and State Game Lands. Just over 10 percent of these lands are legally protected from surface development.

- Integration of conservation features into the planning and development of Marcellus gas well fields can significantly reduce impacts. For example, relocating projected wells to open areas or toward the edge of large forest patches in high probability gas development pixels in the southern Laurel Highlands reduces forest clearing by 40 percent and forest interior impacts by over a third.

Additional Information

- Geologic information on the Marcellus shale formation in Pennsylvania: http://www.dcnr.state.pa.us/topogeo/oilandgas/marcellus_shale.aspx

- Estimates of Marcellus shale formation gas reserves: http://geology.com/articles/marcellus-shale.shtml

- Baker-Hughes weekly oil and gas rig count http://gis.bakerhughesdirect.com/Reports/StandardReport.aspx

- Pennsylvania Department of Environmental Protection, Permit and Rig Activity Report: http://www.dep.state.pa.us/dep/deputate/minres/oilgas/RIG10.htm

- Copeland, H. E., K.E. Doherty, D.E. Naugle, A. Pocewicz, and J. M. Kiesecker. 2009. Mapping Oil and Gas Development Potential in the US Intermountain West and Estimating Impacts to Species: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0007400

- Overview of forest fragmentation impacts on forest interior nesting species: http://www.state.nj.us/dep/fgw/neomigr.htm

- Overview of Pennsylvania High Quality and Exceptional Value Streams: http://www.dcnr.state.pa.us/wlhabitat/aquatic/streamdist.aspx

- Pennsylvania Department of Environmental Protection, Chapter 93 Water Quality Standards, Exceptional Value and High Quality Streams: data downloaded from Pennsylvania Spatial Data Access: http://www.pasda.psu.edu

- Eastern Brook Trout Joint Venture intact brook trout watersheds: http://128.118.47.58/EBTJV/ebtjv2.html

- Overview of Carnegie Museum of Natural History, Powdermill Nature Reserve, and the Pennsylvania Game Commission's 2nd Pennsylvania Breeding Bird Atlas Project: http://www.carnegiemnh.org/powdermill/atlas/2pbba.html

- Pennsylvania Natural Heritage Program, including lists of globally rare and state endangered and imperiled species: http://www.naturalheritage.state.pa.us/

- U.S. Department of Agriculture, Natural Resources Conservation Service, National Agriculture Imagery Program: http://datagateway.nrcs.usda.gov/GDGOrder.aspx

- DigitalGlobe, GlobeXplorer, ImageConnect Version 3.1: http://www.digitalglobe.com

Wind

Wind has become one of the country's fastest growing sources of renewable energy. Pennsylvania is a leader in the industry as host to several wind company manufacturing plants and corporate headquarters. Wind energy development has been spurred by its potential to reduce carbon emissions, promote new manufacturing jobs, and increase energy independence. Technological advances have expanded the size and efficiency of wind turbines during the past decade. This, together with state and federal incentive programs, has facilitated wind development in Pennsylvania, which otherwise ranks relatively low among states for its potential wind generation capacity. The eight turbines installed next to the Pennsylvania Turnpike in Somerset County a decade ago have grown to nearly 500 turbines, with more permitted for construction (AWEA, 2010). Topography is a key factor in average wind speeds across Pennsylvania, so nearly all turbines have been built on mountain ridgelines or on top of high elevation plateaus.

Wind energy has become the most symbolic icon of the shift toward a low carbon economy. With no air emissions or water consumption, it is one of the cleanest renewable energy types. Communities across the state benefit economically as rural landowners lease their properties, skilled jobs are created to manufacture turbines, and workers are hired to install and maintain turbines. Wind development has faced controversy in some areas from neighboring landowners and those worried about impacts to migrating birds and bats. The wind industry, government agencies, and independent researchers have invested considerable effort in trying to better understand impacts on birds and bats. For example, 26 wind development companies have signed a cooperative agreement with the Pennsylvania Game Commission to conduct bird, bat and animal surveys using specified protocols in proposed development areas. Among other findings have been the discovery of the Pennsylvania's second largest Indiana bat maternal colony and a variety of previously undocumented foraging and roosting locations for the state's two rarest bats (Indiana and eastern small-footed). Less understood are the potential habitat impacts of wind development in the northeastern United States. This assessment, therefore, focuses on impacts to forest and stream habitats and selected species of conservation concern that may be vulnerable to development of ridgetop habitats.

What is Wind Energy?

Wind mills have powered grain processing and water pumping in agriculture around the world – most famously in the Netherlands – for centuries. The first modern wind facilities to generate electricity were built in California in the early 1980s. Rated at less than 0.5 MW capacity per turbine, the towers were only 50 feet tall. These facilities were poorly designed and generated considerable controversy because they caused significant mortalities to migrating hawks and eagles. Wind energy development did not expand appreciably until the late 1990s when newer turbine designs and federal energy incentives stimulated the development of new facilities. These turbines were rated at 1.0 or 1.5 MW capacity and reached about 200 feet high at the tip of their rotor. Since the power produced by a wind turbine is proportional to the cube of the blade size and how high in the air it is; turbine size, height and power ratings have expanded steadily. The largest turbines installed in Pennsylvania are now rated at

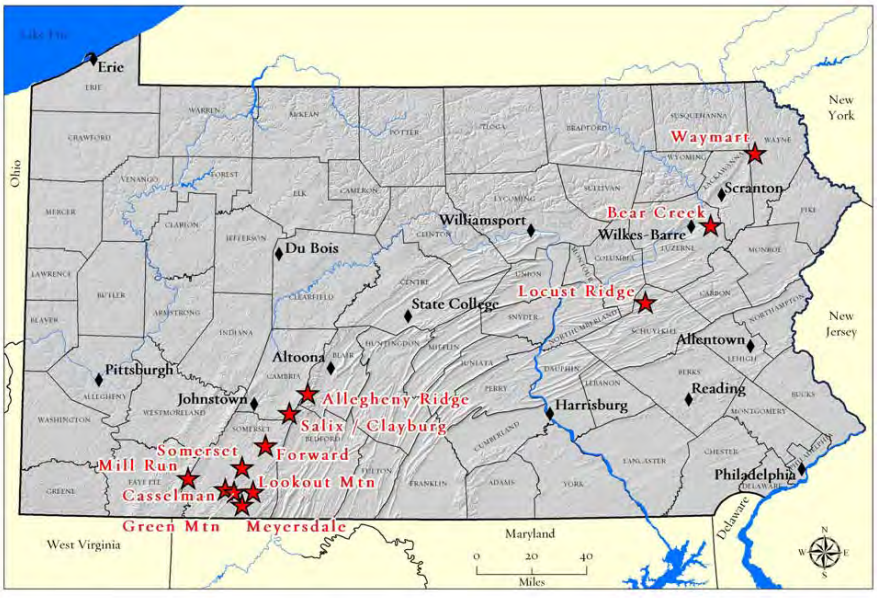
2.5 MW (the average was 1.8 MW in 2009) and reach over 400 feet to the tip of the rotor at the apex of its rotation.

Location is everything for wind development in the northeastern United States. Unlike the vast windswept plains in the Midwest and the intermountain West, high wind speeds in the Northeast are primarily confined to mountain ridgetops, plateau escarpments, and the Atlantic and Great Lake shorelines. Areas that have a wind power class rating of 3 or more (300 watts per m^2) are potentially feasible for wind power development. Wind companies will lease areas that seem to have the most favorable characteristics including wind class, flat pad sites, proximity to transmission lines, and proximity to existing highways. Before development, a wind development company will typically place an anemometer tower on potential development sites to improve knowledge about wind power at the site during a year or longer monitoring period. The turbines are mounted on pads at least 800 feet apart with an access road between towers. The average size of wind facilities has been growing steadily since the first eight were established in 2000. The two largest facilities are now between 75 and 100 turbines.

Several steps have been taken to address potential conflicts between wind development and wildlife in Pennsylvania. The Pennsylvania Game Commission (PGC) has a voluntary agreement in place with most wind companies active in the state to screen proposed facilities for possible impacts to birds and bats and migratory pathways. Participating wind companies carry out pre-construction monitoring for birds and bats. If possible conflicts are identified, PGC works with wind companies to avoid or minimize impacts and to continue monitoring post construction in some cases. Second, the Pennsylvania Wind and Wildlife Collaborative (PWWC) was established in 2005 with a state goal to develop a set of "Pennsylvania-specific principles, policies and best management practices, guidelines and tools to assess risks to habitat and wildlife, and to mitigate for the impact of that development." Several studies on wildlife and habitat issues have been commissioned, though guidelines and Best Management Practices (BMPs) have not been released.

Current and Projected Wind Energy Development

We documented the spatial foot print for 319 wind turbines at 12 wind facilities across the state by comparing aerial photos taken before and after development. Turbine pads, roads, and other new clearings were digitized for all 12 facilities. The ground excavated for turbines,

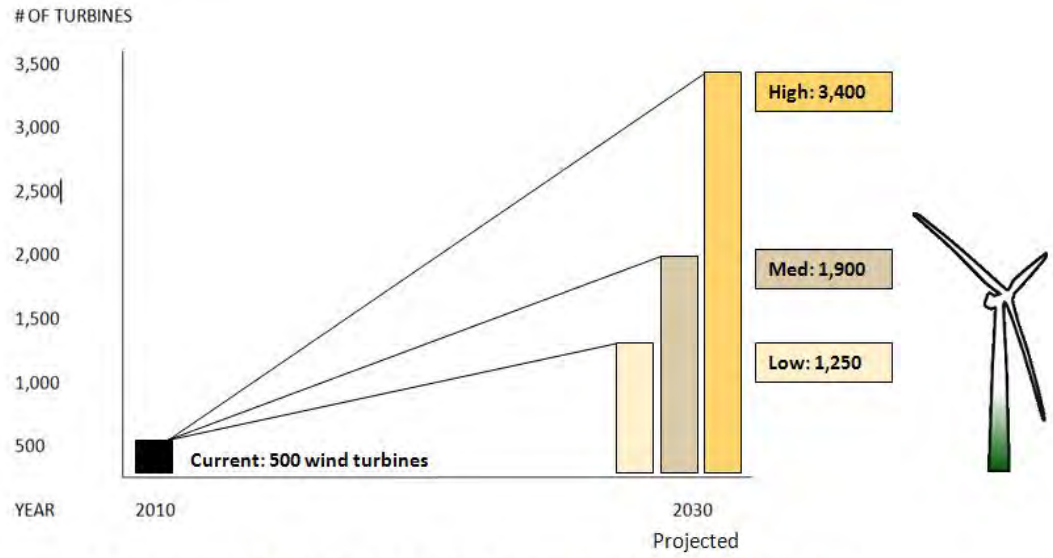


Map showing 12 wind facilities included in the spatial footprint analysis.

roads, and associated infrastructure (e.g., clearings for construction staging areas or electrical sub-stations) is the most obvious spatial impact. For each turbine site, the area for the turbine pad, new roads, staging areas, and sub-stations were digitized and measured. Turbine pads occupy 1.4 acres on average while the associated infrastructure (roads, staging areas and substations) takes up 0.5 acres, or a total of 1.9 acres of spatial impact per wind turbine.

Average Spatial Disturbance for Wind Energy Development in Forested Context (acres)		
Forest cleared for wind turbine	**1.4**	**1.9**
Forest cleared for associated infrastructure (roads, other cleared areas)	**0.5**	
Indirect forest impact from new edges	**13.4**	
TOTAL DIRECT AND INDIRECT IMPACTS	**15.3**	

As with Marcellus gas development, adjacent lands can also be impacted even if they are not directly cleared (See p. 9 for a description of forest edge impacts on forest "interior" species). To assess the potential interior forest habitat impact, we created a 330 foot buffer into forest patches from new edges created by wind turbine and associated infrastructure development. For turbine sites developed in forest areas (about 80% of the 319 turbines), an average area of 13.4 acres of interior forest habitat was lost in addition to the 1.9 acres of directly cleared forest.



Key drivers: Alternative Energy Portfolio Standard (AEPS) and projected contribution of wind to meeting that standard.

We project between 1,250 and 3,400 total wind turbines will be erected in Pennsylvania by 2030.

The number of wind turbines built in Pennsylvania will certainly expand during the next two decades. Various factors will drive exactly how many turbines are ultimately built including electricity prices, state and federal incentives, technological improvements, energy and climate policy, regulatory changes, and social preferences. Our projections assume economic, policy, and social conditions will remain favorable enough to promote steady expansion of wind development in the state since we cannot reasonably forecast energy prices, technological developments, and policy conditions. The key driver in our low scenario is that companies will use wind energy to meet 70 percent of the current Alternative Energy Portfolio Standard (AEPS) Tier 1 standard (8 percent of electric generation). This projection indicates an additional 750 turbines (2 MW average) will be added to the 500 turbines currently operating. The key driver in our medium scenario is that utilities will use wind energy to meet 70 percent of an expanded AEPS 15% Tier 1 standard, as proposed in recent draft legislation. That scenario would add 1,400 new turbines to those already built. The high scenario used in this assessment is based on the 20% wind power electric generation scenario used by the National Renewable Energy Laboratory in the Eastern Wind Integration Study (EWITS). This scenario would require 2,900 additional turbines.

Where are those new turbines in each scenario more and less likely to go? To start, we created a probability surface by looking at a range of variables that might be relevant to a company's decision to develop a wind facility with wind turbines that have already been built. We used the maximum entropy modeling approach used to develop the Marcellus gas probability surface (see p. 13) and built the model using 580 existing and permitted wind turbines. Variables that potentially drive wind energy development were chosen based on data availability and included wind power (W/m^2), distance to transmission lines, percent slope, distance to roads, and land cover. An additional 193 existing and permitted wind turbines were used to test the validity of the model's probability surface and the model was found to be 95.8% accurate in predicting existing and permitted turbines from randomly sampled undeveloped areas. The resulting probability map indicates many long, narrow high probability sites along ridge tops, and several wider areas on high plateaus and along the Lake Erie coastline.

To get a better sense of where wind development is more likely, we searched for the highest probability areas where wind turbine pads in each scenario might be located. The probability raster was re-sampled to 60 meter resolution (0.89 acres) to reflect the actual geographic footprint of wind turbines based on aerial photo assessment. We selected the highest available probability pixel for each scenario and then buffered that pixel by a minimum separation distance of 800 feet (240 meters – the site distance between turbines) between existing turbines before selecting the next highest available probability pixel. The highest probable pixels were then selected until the threshold for each impact scenario was reached (low – 700 turbines; medium – 1,200 turbines; high – 2,700 turbines). Areas incompatible for wind energy development (existing wind turbines, Wild and Natural Areas, and water bodies) were excluded from being selected as probable pixels. The highest probable pixels were then converted into points for map display purposes.

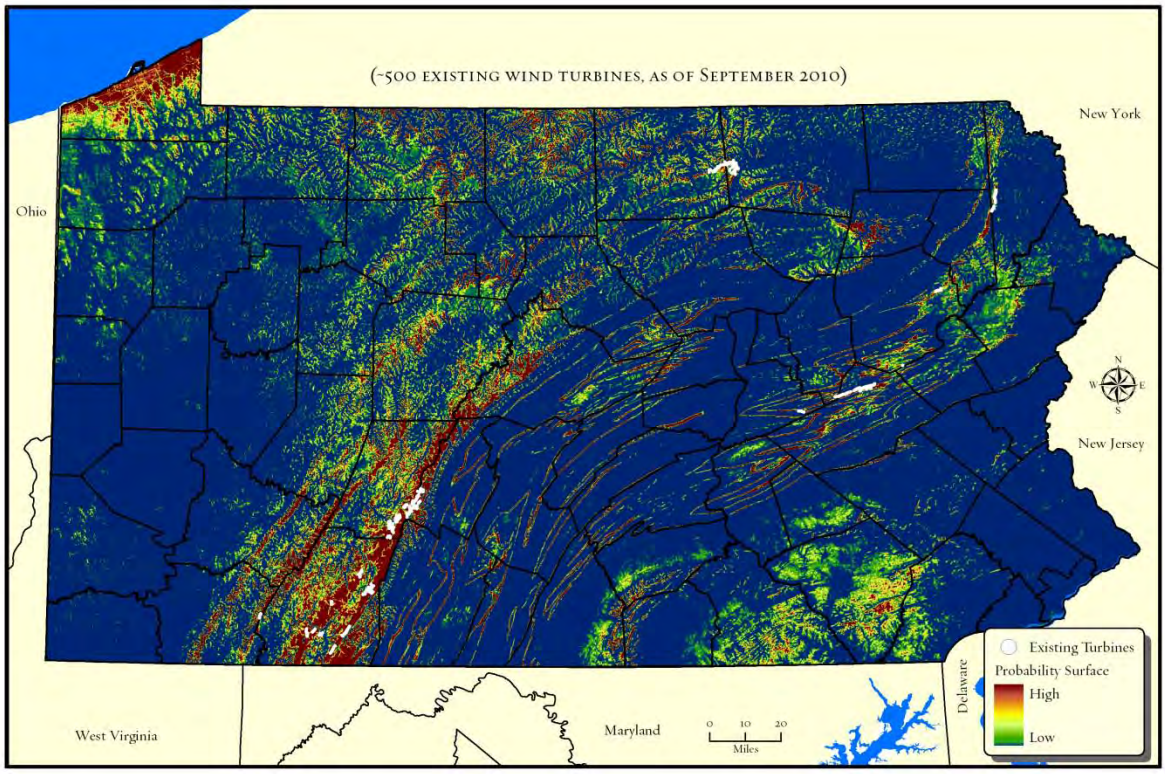
The resulting projected turbine locations occur in strings, groups, and widely scattered single or very small clusters (2-5) of turbines, mostly in southwest, north central and northeastern parts of Pennsylvania.

Wind turbines, however, are almost always located in clusters rather than widely separated locations for individual turbines. In order to represent viable wind farms, we selected clusters of pixels with high probability to represent probable farms based on the results of the model. The following steps were applied to standardize the selection process:

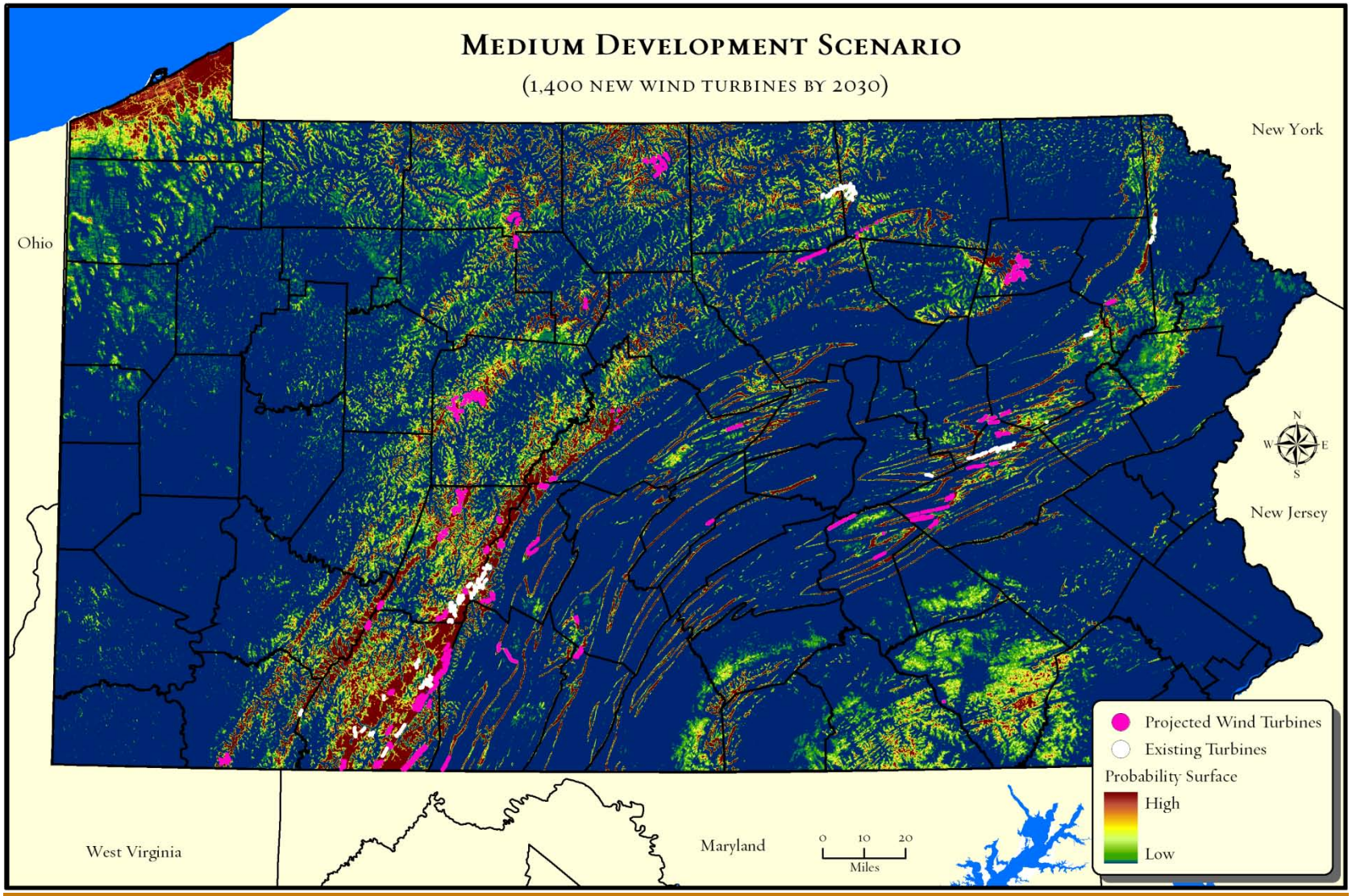
- All selected wind facilities had to be anchored by at least 6 projected wind turbine sites selected by the model

- Buffers of equaling four times the minimum turbine separation distance of 787 ft (totaling 3,148 ft) were applied to existing and permitted wind farms were in order to not 'expand' operating and soon to be operating facilities;
- Setbacks of 500 ft from the boundaries of state and federal lands were applied to exclude turbine placement areas adjacent to public land;
- Existing homes Areas (as visible in aerial imagery) were buffered by approximately 1,000 ft;
- Projected clusters (wind farms) were assigned to the low, medium, or high scenario based on the number of the assigned wind turbines to that scenario within the cluster.
- Solitary and very small clusters of wind turbines were relocated to relatively high probability pixels adjacent to projected wind turbine clusters of at least 6 turbines (an 800 feet buffer was applied to each modeled turbine to maintain proper spacing).

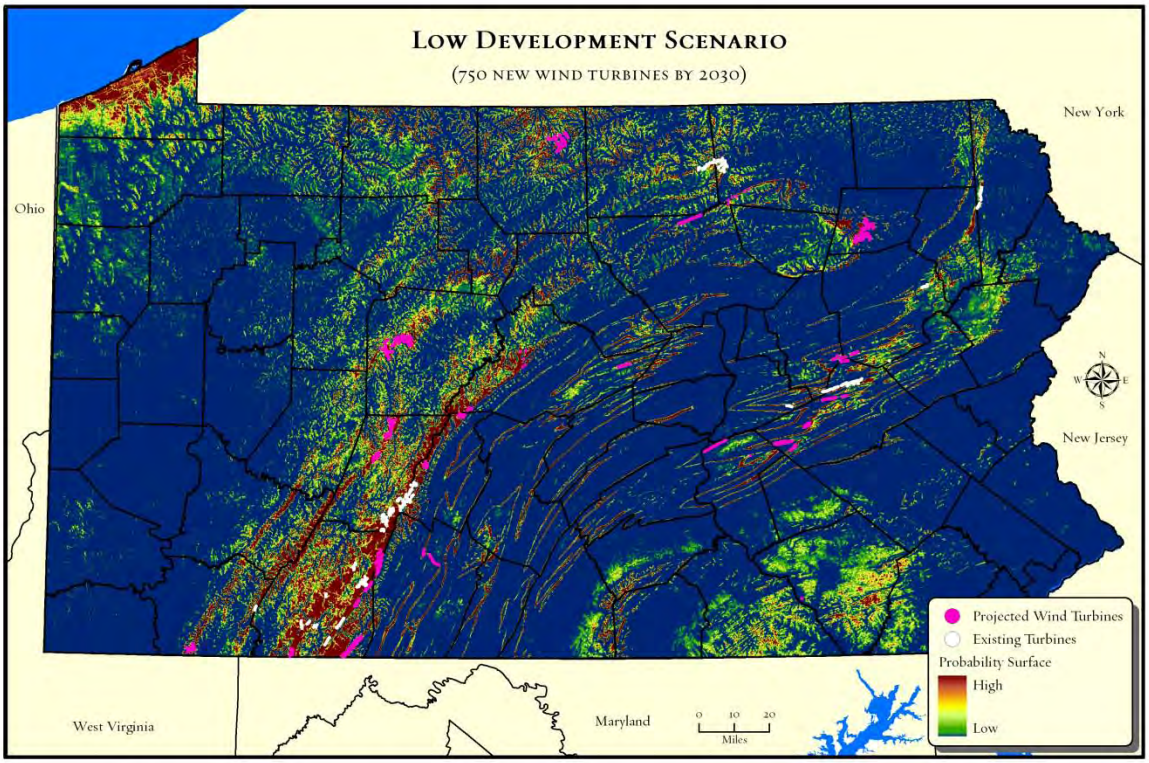
The scenarios are cumulative with the high scenario including the wind facilities for both the low and medium scenarios and the additional turbines needed to meet the high scenario quota.



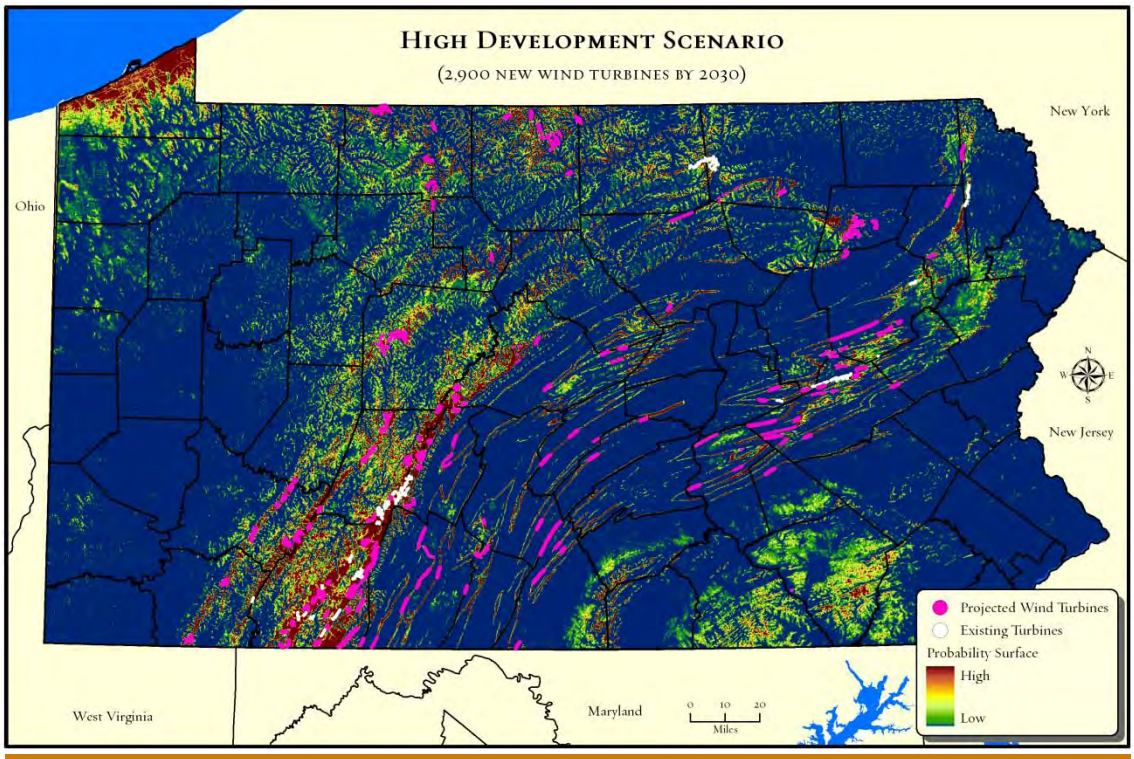
Map showing existing wind turbines with the probability that a given area will be developed indicated by color (dark red is high probability; dark blue is low).



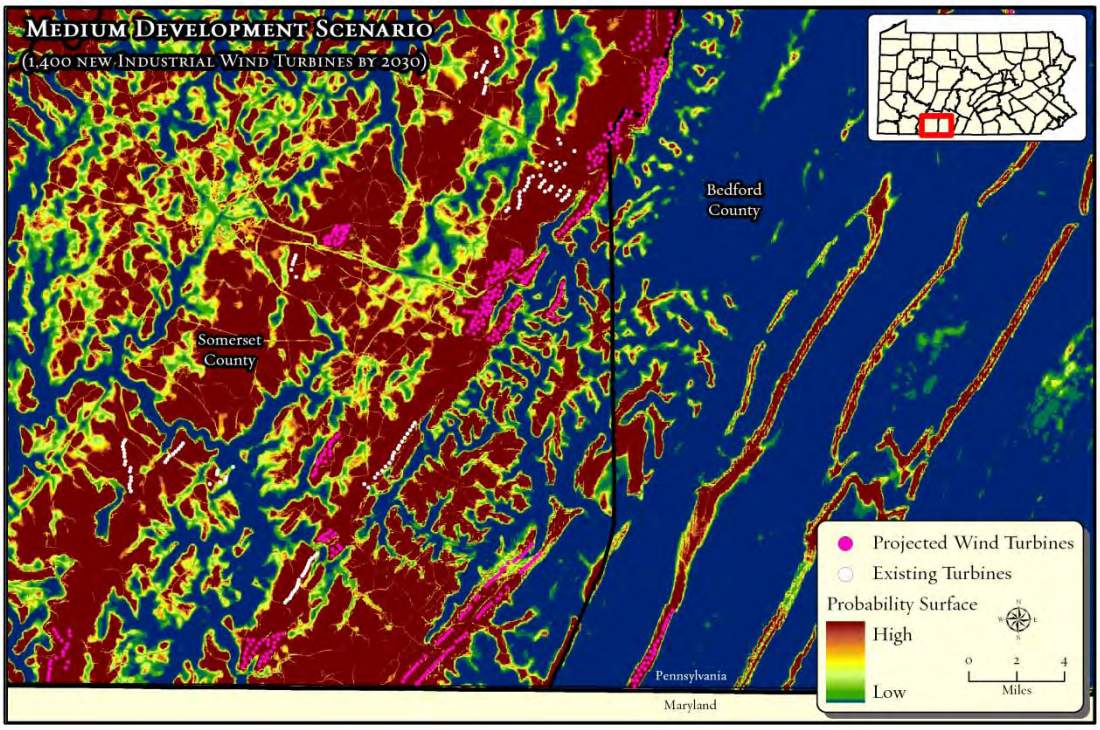
Map showing 1,400 new wind turbines projected by 2030 under the medium development scenario.



Map showing 750 new wind turbines projected by 2030 under the low development scenario.



Map showing 2,900 new wind turbines projected by 2030 under the high development scenario.



Map showing medium wind development scenario within Somerset and Bradford counties.

These geographic projections of future wind energy development are spatial representations of possible scenarios. They are not predictions. We faced several constraints in developing the geographic scenarios:

- We do not have the detailed wind power data that wind companies have developed through anemometer tower monitoring.
- We do not have the detailed location of wind energy leases.

Still, we believe the overall geographic patterns in the projected wind development locations are relatively robust for several reasons. We used over 500 existing or permitted wind turbines to build the model and nearly 200 additional existing and permitted wind turbine sites were used to validate the model. This is typically a sufficient sample size for building predictive models. They are also consistent with Black and Veatch (2010) projected locations for wind facilities under a 15% renewable energy portfolio standard.

Conservation Impacts of Wind Energy Development

What is the overlap of the areas with the highest probability of future wind energy development and those areas known to have high conservation values? To answer this question, we intersected the projected wind energy facilities with high conservation value areas. We looked at several examples from four categories of conservation value, including:

- Forest habitats
- Freshwater habitats

- Species of conservation concern
- Outdoor recreation

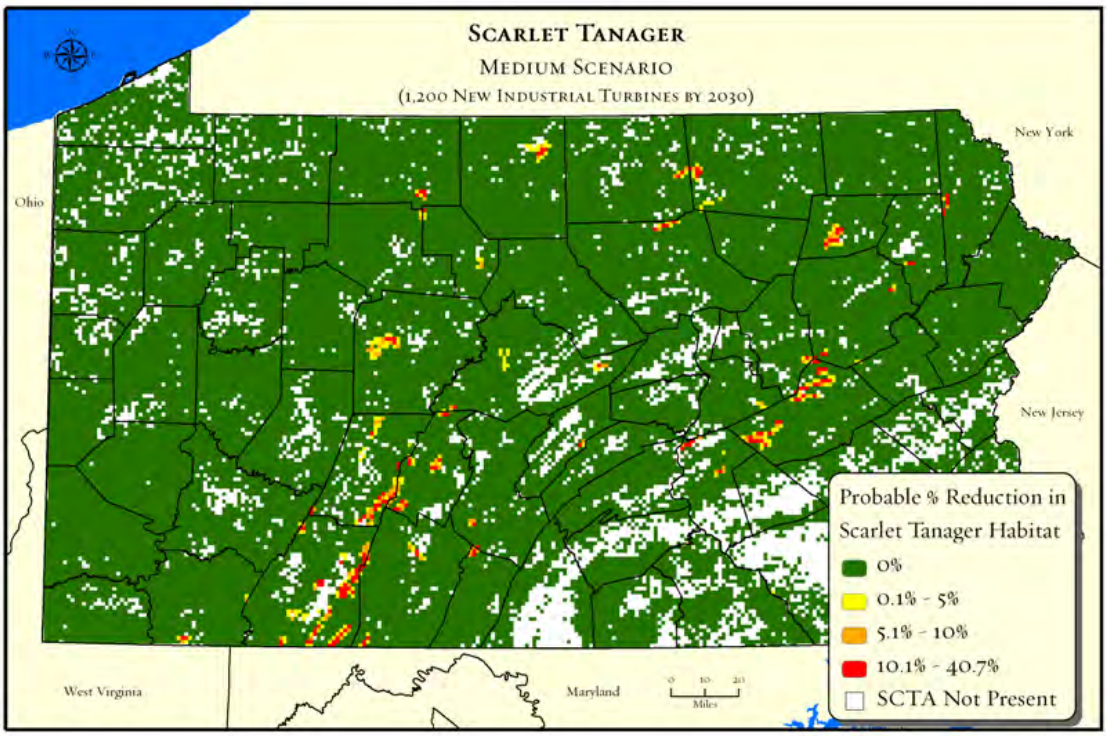
Areas of overlap between likely future wind development areas and priority conservation areas in Pennsylvania are substantially less than the conservation area overlap with likely future Marcellus development areas, largely because the projected foot print will be much smaller.

Forests

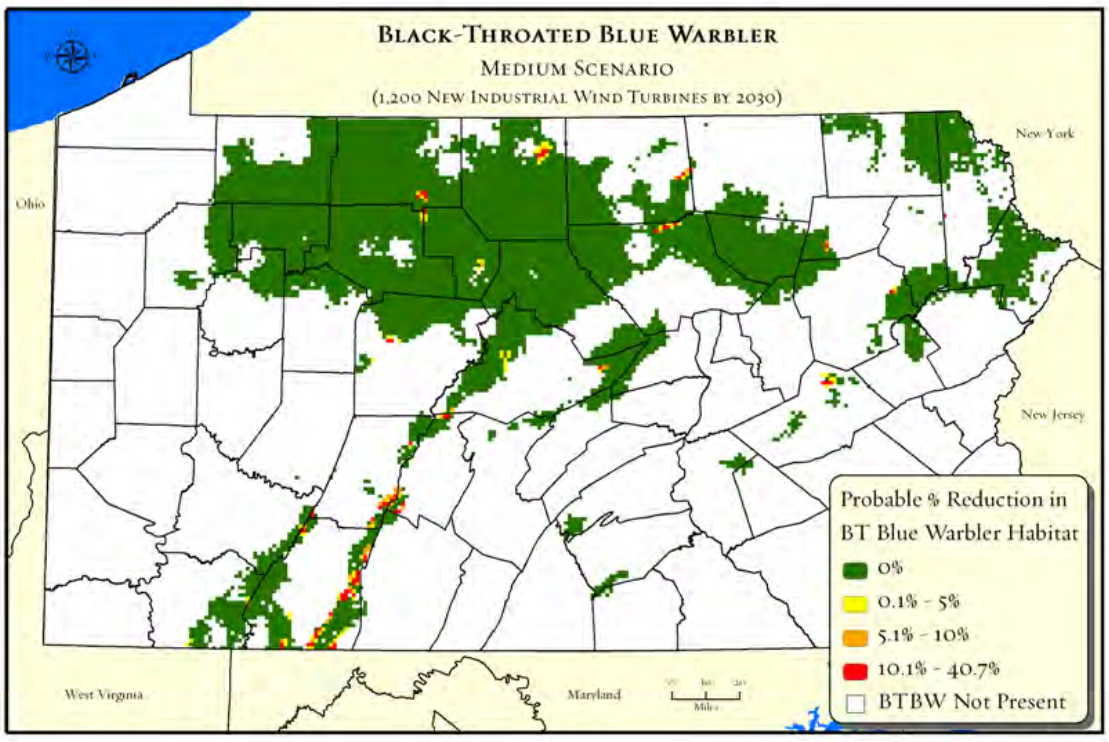
A large majority of projected wind turbines are found in forest patches, about 80 percent for each of the scenarios. The low scenario would see 600 new wind turbines in forest areas. With a cleared forest average of 1.9 acres per turbine (including roads and other infrastructure), the total forest loss would be a modest 1,140 acres. Indirect impacts to adjacent forest interior habitats would total an additional 7,920 acres. Forest impacts from the medium scenario (1,120 projected new turbines in forest locations) would be 2,128 cleared forest acres and an additional 15,840 acres of adjacent forest interior habitat impacts. For the high scenario (2,320 new turbines in forest areas) 4,408 acres would be cleared and an additional 30,624 acres of forest interior habitats would be affected by new adjacent clearings. On a statewide basis, the projected forest losses and accompanying interior forest habitat impacts will be minor given the Pennsylvania's 16 million acres of forest. Locally, these impacts could be significant for individual large forest patches where wind development takes place.

All forests have conservation value, but large contiguous forest patches are especially valuable because they sustain wide-ranging forest species, such as northern goshawk, than small patches. They are also more resistant to the spread of invasive species, can better withstand damage from wind and ice storms, and provide more ecosystem services – from carbon sequestration to water filtration – than small patches. The Nature Conservancy and the Western Pennsylvania Conservancy's Forest Conservation Analysis mapped nearly 25,000 forest patches in the state greater than 100 acres. Patches at least 1,000 acres in size are about a tenth of the total (2,700). The medium projected wind development scenarios indicate 73 patches (3%) greater than 1,000 acres in size are projected to have at least one wind turbine and associated infrastructure. Patches at least 5,000 acres in size are relatively rare (only 316 patches). The medium wind scenario indicates about 21 (7%) of these patches could be affected by future wind turbine development. Most affected large patches have multiple projected wind turbines (as many as 36). Typically, a large patch is split by wind development into two or three smaller patches due the linear pattern of development. Projected gas well pads, by contrast, are more likely to fragment a large patch into multiple smaller patches.

Forest interior bird species could be affected by the clearing of forest and adjacent edge effects that wind turbine facilities create in a forest context. We used data from the 2nd Breeding Bird Atlas Project (see p. 20) to assess the potential impact on forest interior species. The resulting maps show the estimated reduction in habitat for that species in each high wind development gas probability pixel (including both cleared forest and adjacent edge effects). Scarlet Tanagers are perhaps the most widespread forest interior nesting bird in the state. Since they are so widespread, the vast majority of their range in the state is outside of the most likely wind development areas. Scarlet Tanager populations could decline by an insignificant amount due to habitat losses projected in the medium scenario. Black-Throated Blue Warblers are more narrowly distributed in Pennsylvania favoring mature northern hardwood and coniferous forests with a thick understory, frequently in mountain terrain. Likewise, population declines would also be extremely small for Black-Throated Blue Warblers under the medium scenario.



Map showing estimated percent loss of habitat for Scarlet Tanagers under the medium wind scenario.

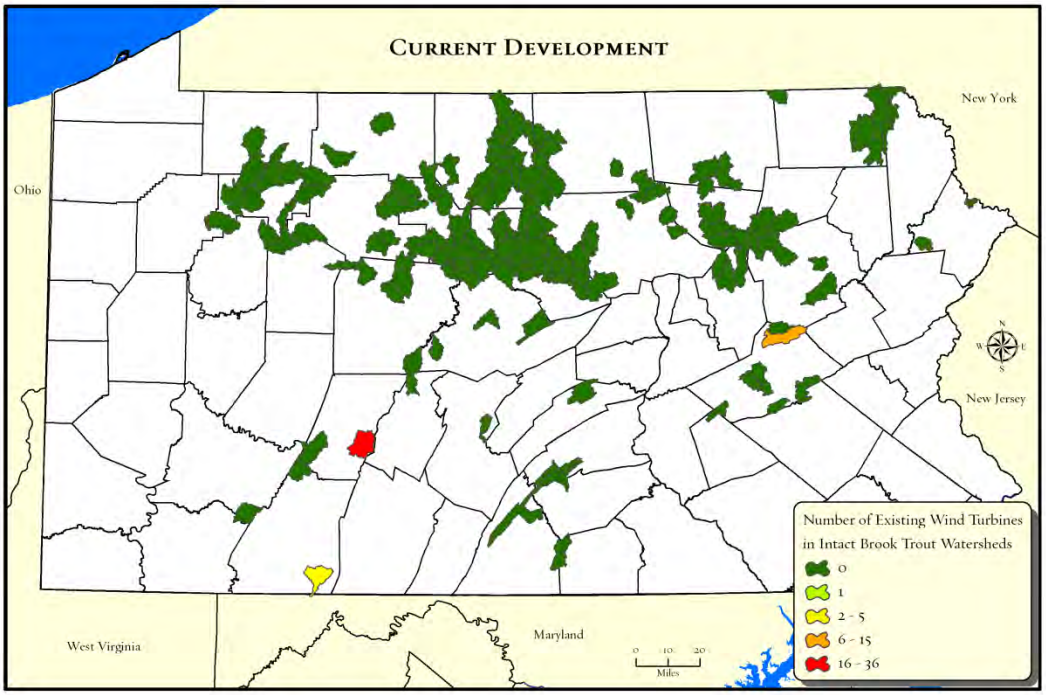


Map showing estimated percent loss of habitat for Black-Throated Blue Warblers under the medium wind scenario.

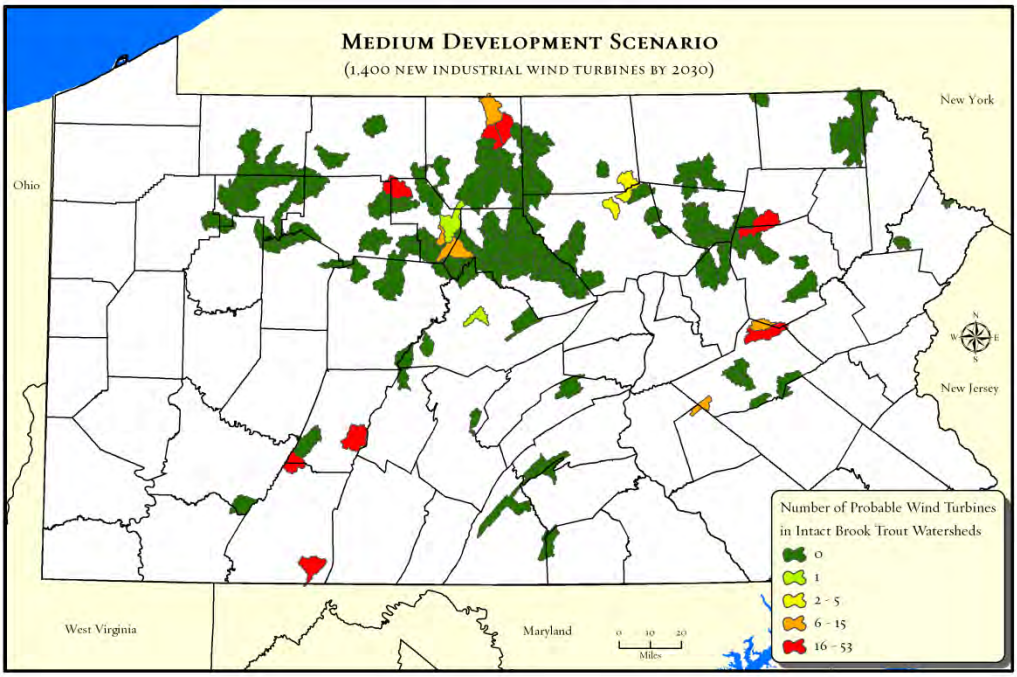
Freshwater

Wind energy and freshwater habitats are not often thought of in the same context since most wind facilities are generally in high elevation areas away from rivers and streams. The exceptions are small headwater streams, some of which may be classified as Exceptional Value watersheds. Our medium scenario projection indicates that 9 percent of future turbine development could be located within ½ mile of an Exceptional Value stream.

Native brook trout are one of the most sensitive species in Pennsylvania watersheds. Brook trout favor cold, highly-oxygenated water and are unusually sensitive to warmer temperatures, sediments, and contaminants. Once widely distributed across Pennsylvania, healthy populations have retreated to a shrinking number of small watersheds. The potential impact on intact brook trout watersheds, however, does increase significantly between the low to high scenarios. Wind turbines have been built in just five of the intact brook trout watersheds identified by the Eastern Brook Trout Joint Venture. That number would expand to 13 in the low scenario, 19 in the medium scenario, and 28 in the high scenario. The presence of wind turbines may pose a limited risk in many of these watersheds, principally from soil disturbance near headwater streams.



Map showing current number of wind turbines in intact and predicted intact brook trout watersheds.



Map showing projected number of wind turbines in intact brook trout watersheds (by 2030) under medium scenario.

Poorly designed or maintained sedimentation measures, especially on road cuts and stream crossings, is the principal risk to these sensitive populations.

Rare Species

Of the approximately 100,000 species believed to occur in Pennsylvania, just over 1 percent is tracked by The Pennsylvania Natural Heritage Program (PNHP). These species are rare, declining or otherwise considered to be of conservation concern. PNHP records indicate that 77 tracked species have populations within pixels that have a relatively high modeled probability for wind development. Most of these species are commonly found in rocky outcrops and scrub oak/pitch pine barrens habitats on ridgetops across the state. Only a handful of species, however, have more than a few occurrences overlapping with the relatively high probability wind development pixels. For example, the eastern timber rattlesnake (*Crotalus horridus*) and Allegheny woodrat (*Neotoma magister*) are strongly associated with rocky outcrops and talus slopes along or near ridgetops. Six percent of the rattlesnake's known rattlesnake breeding/denning sites and three percent of Allegheny woodrat den sites are located in relatively high wind probability pixels. The den sites are very small sites and do not include foraging areas. The Pennsylvania Natural Heritage Program has developed core habitat polygons for each Allegheny woodrat occurrence. Much larger than the den locations, these polygons indicate a much broader overlap – 43 percent – with relatively high probability pixels for wind development. The Northern long-eared Myotis bat (*Myotis septentrionalis*) has about eight percent of its known winter hibernation and summer roosting areas overlapping with relatively high probability wind development pixels. Ridgetop barrens communities in northeastern Pennsylvania have some of the state's largest concentrations of rare terrestrial species. The Nature Conservancy has mapped these communities, and some of these habitats overlap with high wind areas. In general, there appears to be relatively little overlap between tracked species occurrences in Pennsylvania and likely wind

development sites. For a handful of species, there is enough overlap to indicate the importance of surveys early in the project planning stage to identify the presence of rare species and their core habitats.

We have not addressed the potential impact of these scenarios on bird migration patterns and bat foraging populations. For more information on wind development impacts on bird and bat species, please see links to the Pennsylvania Game Commission, U.S. Fish and Wildlife Service, American Wind and Wildlife Institute, and Bat Conservation International.

Recreation

Wind development has not occurred on any state or federal lands in Pennsylvania to date. Since our projections assume there will not be a significant change in state land leasing policies for wind development, we have not projected new wind turbines in State Parks, State Forests or State Game Lands. Our projections, however, do indicate that wind turbines will be located in close proximity (sometimes as close as 500 feet) to many state lands. They are likely to be highly visible in some heavily visited areas, such as Blue Knob State Park in Bedford County, where natural landscape vistas are a prime attraction.

Key Findings

Key findings from the Pennsylvania Energy Impacts Assessment include:

- Projections of between 750 and 2,900 new wind turbines developed on ridgetops and high plateaus by 2030, depending on the size of the Pennsylvania Alternative Energy Portfolio standard. There are currently an estimated 500 wind turbines built in the state.

- Wind turbine facilities are likely to be developed in half of the state's counties, especially along the Allegheny front in western Pennsylvania and on high Central Appalachian ridges in central and northeastern parts of the state;

- Nearly eighty percent of turbine locations are projected to be in forest areas, with forest clearing projected to range between 1,140 and 4,400 acres depending on the number of turbines developed. An additional range of 7,900 to 30,600 acres of forest interior habitat impacts are projected due to new edges created by turbine pads and roads;

- On a statewide basis, the projected forest clearing from turbine development is relatively minor, though some of the state's largest forest patches (>5,000 acres) could be fragmented into smaller patches by projected wind turbine development;

- Impacts on forest interior breeding bird habitats appear to be limited, largely because the overall footprint for the projected wind turbine facilities is small in comparison to the typical breeding range of these species in Pennsylvania. The study did not assess impacts to migratory pathways for birds or foraging bats.

- Relatively few watersheds ranked as "intact" by the Eastern Brook Trout Joint Venture are affected by projected wind turbine development. Several intact watersheds, however, could see several dozen wind turbines. In a number of cases, these small watersheds are projected to see significant Marcellus gas development as well. Given the cumulative impact of these activities, rigorously designed and monitored sediment control measures will be needed to protect sensitive brook trout populations.

- A relatively small handful of rare species occurrences tracked by the Pennsylvania Natural Heritage Program are found in areas with high probability for wind development. These species tend to be associated with rocky outcrops and barrens communities typically found on ridge tops, including the Allegheny wood rat, the eastern timber rattlesnake, and the northern long-eared Myotis bat.

- Wind development is not projected to occur on Pennsylvania's public lands. Existing and projected wind turbines, however, will be close to some of Pennsylvania's most heavily visited outdoor recreation areas where scenic natural vistas are a major attraction.

Additional Information

- American Wind Energy Association (2010). U.S. Wind Projects Database. http://www.awea.org/la_usprojects.cfm
- Black and Veatch (2010) Study for the Community Foundation for the Alleghenies: Assessment of a 15 Percent Pennsylvania Alternative Energy Portfolio Standard: http://www.cfalleghenies.org/pdf/aepss.pdf
- Federal Aviation Administration (FAA) permits for wind turbines: https://oeaaa.faa.gov/oeaaa/external/public/publicAction.jsp?action=showCaseDownloadForm
- Federal Aviation Administration (FAA), Obstruction Evaluation / Airport Airspace Analysis (OE/AAA): https://oeaaa.faa.gov/oeaaa/external/public/publicAction.jsp?action=showCaseDownloadForm
- Pennsylvania Wind Farms and Wildlife Collaborative: http://www.dcnr.state.pa.us/wind/index.aspx
- PA Game Commission (2007) Wind Energy Voluntary Cooperative Agreement and First Annual Report for the Wind Energy Voluntary Cooperative Agreement: http://www.portal.state.pa.us/portal/server.pt?open=514&objID=613068&mode=2
- Pennsylvania Department of Environmental Protection, Chapter 93 Water Quality Standards, Exceptional Value and High Quality Streams: data downloaded from Pennsylvania Spatial Data Access: (www.pasda.psu.edu)
- U.S. Department of Energy TrueWind 80 Meter Wind Resource Maps: http://www.windpoweringamerica.gov/wind_maps.asp
- U.S. Fish and Wildlife Service Wind Turbine Advisory Committee: http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html
- U.S. Environmental Protection Agency summary of forest fragmentation effects: http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&lv=list.listByAlpha&r=219658&subtop=210
- Overview of forest fragmentation impacts on forest interior nesting species: http://www.state.nj.us/dep/fgw/neomigr.htm
- Overview of Pennsylvania High Quality and Exceptional Value Streams: http://www.dcnr.state.pa.us/wlhabitat/aquatic/streamdist.aspx
- Eastern Brook Trout Joint Venture intact brook trout watersheds: http://128.118.47.58/EBTJV/ebtjv2.html

- Overview of Carnegie Museum of Natural History, Powdermill Nature Reserve, and the Pennsylvania Game Commission's 2nd Pennsylvania Breeding Bird Atlas Project: http://www.carnegiemnh.org/powdermill/atlas/2pbba.html

- Pennsylvania Natural Heritage Program, including lists of globally rare and state endangered and imperiled species: http://www.naturalheritage.state.pa.us/

- U.S. Department of Agriculture, Natural Resources Conservation Service, National Agriculture Imagery Program: http://datagateway.nrcs.usda.gov/GDGOrder.aspx

Testimony on the Economic and Environmental Impacts of Hydraulic Drilling of Marcellus Shale on Philadelphia and the Surrounding Region

Before The Joint Committees on the Environment and Transportation & Public Utilities of the Council of the City of Philadelphia

David Velinsky, Ph.D.
Vice President for Environmental Research
The Academy of Natural Sciences

Good morning. I appreciate the opportunity to speak on this crucial issue. I am Dr. David Velinsky and I am the Vice President for Environmental Research at the Academy of Natural Sciences. The Academy is Philadelphia's natural history museum, and our environmental research program has been studying human impacts on the environment for over sixty years. I direct an interdisciplinary team of scientists and technical staff that focuses on the ecological processes and environmental health of natural systems, particularly waterways, watersheds, and estuaries.

My colleague, Dr. Boufadel, and I were invited to provide scientific background on the issue of gas drilling in the Marcellus Shale and to discuss its potential impacts on the environment. I'd like to thank the Council for asking Temple University and the Academy of Natural Sciences to speak at this hearing. Our institutions are two of Philadelphia's important scientific resources, and we are pleased to apply our scientific capabilities to a topic of critical interest to our City and the Commonwealth of Pennsylvania. As our institutions propose to collaborate further on studying the Marcellus Shale, it is very appropriate that we are co-presenters today.

Today I'm going to start with some of the basic science of the Marcellus Shale and the natural gas deposited within it; touch on the drilling method known as hydraulic fracturing; and then look at some of the potential impacts of the drilling practice on the aquatic and terrestrial ecosystems. Finally I will discuss some preliminary research that has been conducted on these impacts, and briefly touch upon the further research that we feel is necessary to resolve a variety of uncertainties that surround the potential impacts of gas drilling in the Marcellus Shale. Dr. Boufadel's testimony will then focus on the hydrogeology of drilling and the potential below ground impacts.

I would also note that the Academy of Natural Sciences does not take a position on the overall advantages or disadvantages of obtaining gas from the Marcellus Shale. We recognize the enormous potential of this resource, for both the possible economic benefit of the Commonwealth and as an energy source with reduced greenhouse gas

emissions. As environmental scientists, our role is to outline the potential changes to our ecosystem that may result from this process and to point out relative levels of uncertainty.

The Marcellus Shale, as this slide indicates, runs roughly from New York to West Virginia and lies on average about a mile underground (a little less than the distance from City Hall to the Art Museum), although that varies widely and in some places, such as Marcellus, New York, where it protrudes above the surface. As you can see from this map, a significant proportion of the Marcellus Shale is located under Pennsylvania, particularly along the Susquehanna Basin and, to a lesser extent, the Delaware.

What actually is the Marcellus Shale we've heard so much about? Technically, shale is a fine-grained sedimentary rock formed from mud deposited in ancient river bottoms, lagoons or even the continental shelf. There are types of shale formations around the world that occupy regions below the earth's surface. The Marcellus Shale was formed about 300 million years ago in an enclosed sea that once covered part of Pennsylvania. Microscopic algae produced in the surface waters were deposited in the bottom of the ancient sea that had low oxygen, and then were eventually covered over with other types of sediments. The methane gas was formed as the organic rich sediment degraded over time. This process needed the right temperature, pressure and time for methane to form and remain. This gas is now embedded in the tiny pores of the shale.

I would point out that the Marcellus is only one of many classes of shale that were formed by ancient geological processes. As you can see from the diagram, in this region there are shales that lie both above and below the Marcellus, and some of these may also contain gas. In fact, the presence of shale gas has been known for some time and extracting shale gas has been done in other parts of the country.

However until recently, it was believed that most of this shale gas could not be effectively utilized. Many shale gas deposits have low permeability, that is to say, the deposits are trapped in the grain of the rock, and there isn't enough pressure for the gas to be withdrawn by simply boring a well into it. Many of these shales are also located at depths that were not easily reached by conventional drilling technologies.

This was the case until recently with the Marcellus gas. Several recent developments, however, have made it a more promising fuel source. First, new studies, notably by USGS and then Penn State, revealed that the extent and potential volume of the gas was much larger than previously estimated. Secondly, technical advances in drilling, specifically horizontal drilling combined with the older technique of hydraulic fracturing, have now provided a means for economically accessing the gas.

This method is quite simple in principle, although in the past was a daunting engineering

task. Wells are drilled down to the level of the Marcellus Shale—as mentioned, roughly a mile—and the drilling tool is turned horizontally into the shale. Explosives are introduced into the horizontal bore, loosening the rocks, and then high-pressure water—a few million gallons per well—is pumped into open factures in the shale. The gas then flows through these fractures and is withdrawn through the vertical shaft.

I will leave it to the representatives of the drilling companies to explain any further details or clarify anything I've missed on the process. The questions we are considering are the potential environmental impacts of the gas drilling.

I would point out that while hydraulic fracturing and it's relationship to water quality has received the most attention, the impacts resulting from the entire process of gas drilling in the shale must be considered. We need to think about whether there are specific impacts on water quality and quantity, but we also have to look at larger impacts on natural resources and the natural services, such as water filtration, that are provided by the existing ecological systems. I will discuss this latter concept, known as ecosystem services, in few moments.

In terms of overall impacts, as these photos show, gas drilling is an industrial process. There is the footprint of the well pad itself, the extraction and transportation of water to be used for fracturing, the disposal of fracturing water once it has been used (about a third of the amount is withdrawn from the well), potential impact of these activities on ground water, and the attendant issues that come from roads, construction, truck traffic, and air and noise issues, to name a few.

I'm not saying that these processes can't be managed or that they are unjustified from a cost-benefit perspective, but it is doubtful that they could be done with zero impact. However careful and conscientious drillers may be—and many are trying to be—it would be simplistic to say you could introduce these sorts of activities into natural or agricultural settings without altering elements of the system.

Let's take a moment and look specifically at the fracturing water, since that has received the most attention. On average about three million gallons of water are used for each well. The effect of this practice on water *quantity* quite simply depends on the source of the water. Three million gallons withdrawn from the Delaware down at Penn's Landing would not have a measurable effect on the flow of the river—it's simply too small a fraction. Three million gallons withdrawn from a small upland waterway—what we call a first- or second-order stream—could have a significant impact on available water locally and its biological diversity.

A number of substances are added to the fracturing water to increase its effectiveness in obtaining the gas. These substances include lubricants to reduce friction, biocides and scale inhibitors to prevent bacterial growth, and coarse substances to assist the fracturing. None of these, for the most part, are found naturally in waterways. While

best practices are that none of the fracturing water will ever be released into the environment, the level of risk involved in using these substances must be assessed.

In addition to the chemicals added to the water prior to use, the fracturing process adds a number of substances from the underground environment to the water that is withdrawn. As result, withdrawn fracturing water has very high levels of total dissolved solids.

The measure of *total dissolved solids or* TDS, is simply the amount of material in dissolved form—including minerals, salts or metals—that are in a given volume of water. High total dissolved solids can be a serious impairment to water quality in freshwater systems. As this slide shows, the amount of various dissolved materials in fracturing water exceeds by many orders of magnitude that found in typical river water. Substances such as barium and strontium, normally in trace amounts, are in very high relative concentrations in withdrawn fracturing water.

Is this a potential impact on the environment? Again, it depends on how the water is handled and how and where it is disposed of. The introduction of three million gallons of fracturing water with the TDS noted to the Delaware at Penn's Landing would probably have no measurable effect on the river as a whole. Three million gallons of such water spilled into a first- or second-order stream would have a profound impact on the local aquatic system. It should be noted that there is no economical treatment process for TDS other than dilution. In other words, at some point this water will have to be introduced into larger waterway or injected in deep wells.

So, to summarize there are several potential sources of environmental impact from gas drilling in the Marcellus Shale. First, water withdrawal could have impacts locally on the quantity of water available for natural processes. Second, there could be impacts on water quality. This could happen from accidental spills; treatment of withdrawn water; or other, as yet poorly understood processes. Dr. Boufadel will address some of the potential impacts on groundwater movement and quality.

The third area of potential impact is habitat and land fragmentation. This issue is not directly related to hydraulic fracturing but may be the most significant and least considered of the potential problems. Fragmentation is simply the reduction in the amount of forest cover and natural open space, breaking it up into smaller fragments, and a loss of connectivity between these fragments, in other words reducing the amount of space available for organisms, and interrupting or blocking important ecological processes in an area.

The effects of habitat fragmentation due to human alterations of the landscape have been studied for many years and are well understood. We know that there are critical sizes of contiguous natural systems that must be present for diverse populations of organisms to function, and we know that those sizes and diversities of organisms are

necessary for ecological processes to occur.

This latter function—ecological processes—is sometimes called ecological services, because they represent a variety of potentially costly services that human societies get for free from natural ecosystems. I mention this because it is important to understand that we don't preserve natural systems just out of some altruism or fuzzy moral sense. We preserve natural systems because human society depends on them directly, whether it is for water filtration, air quality, or fertile soil.

The combined effects of habitat fragmentation and potential release of fracturing water into natural systems could have significant impacts on aquatic ecosystem services. Changes in TDS can be toxic, both on a chronic and acute scale, to aquatic organisms, reducing the size of biological communities and ultimately impacting human needs such as fisheries and water quality. Studies by Academy scientists, as well as from other local institutions, has shown that headwater forested streams provide the greatest filtration capacity for nutrient removal.

In summary, both loss of forest area and introduction of increased TDS can reduce or impair ecosystem service in small watersheds such as those in the upper Delaware. In particular removal of nutrient pollution, a major environmental stressor in agricultural landscapes, can be impaired by fragmentation and by changes in water chemistry such as increased TDS.

At this time there is very little information available as to the impacts of long-term exposure of a watershed to Marcellus Shale drilling activities, nor do we know if there is a cumulative impact of drilling activity—and in particular of possible exposure to water with elevated TDS—on the ecosystem services of a small watershed.

Let me be clear on this point. The question we believe needs to be addressed is whether there is a threshold point past which a certain density of drilling activity has a impact on the ecological health and services of the watershed regardless of how carefully drilling is conducted. Past studies that have looked at particular well sites or particular incidents fail to give a picture of the chronic impacts that might be expected from drilling and especially hydraulic fracturing.

We are saying that regardless of the practices being followed by drillers, there may be a point at which drilling will have a definite signal in the ecological function of a watershed. Conversely, there may be some level of activity, some maximum number of well pads, below which, drilling doesn't have measurable ecological impact. Right now we have no idea if either of those are valid hypotheses. We are proposing multi-variable cumulative ecological studies that would answer those questions.

One of the ways we measure ecological functioning is to look at certain key chemical indicators and at the abundance of certain types of organisms. Testing the electrical

conductivity of a waterway is a good way of assessing the TDS and also a good proxy for human caused disturbance. This is because increases in pollution, erosion, water withdrawal and many other disturbances are often reflected by increased contamination of the water.

There are also certain organisms, notably amphibians and particular orders of insects that are highly sensitive to degraded and contaminated environments. By sampling watersheds for these measures, we are able to get an approximation the relative heath of the watershed and the ecosystem services of which it is capable.

To at least get preliminary assessment of cumulative impact of drilling in the shale, Academy scientists have been working with a University of Pennsylvania graduate student to collect data on water chemistry and indicator organisms. I would now like to briefly review the preliminary results of that research. Let me emphasize, this data is very tentative and will require further review and replication, but it does suggest that the impact of the drilling may be directly connected to density of drilling.

Our researcher looked at measures of ecological function downstream in nine small watersheds - three in which there had been no drilling, three in which there had been a defined low density of drilling activity and three in which there had been a defined high density of drilling activity.

Three indicators were measured: the conductivity of the water, the abundance of certain sensitive insects (also called an EPT index) and the abundance of salamanders. This last measure is particularly important as amphibians are especially vulnerable to changes in the environment and absence of amphibians is often an ecological "early warning" system.

The results of the research can be seen in these graphs. For each of the measures, there was a significant difference between high-density drilling locations and locations with no or low density drilling. Water conductivity was almost twice as high in the high density sites as it was in the low density and reference sites, while number of both salamanders and sensitive insects were approximately 25% reduced. Statistical analysis indicates that there is a less than 5% probability that these differences were the result of random chance.

This suggests that there is indeed a threshold at which drilling—regardless of how it is practiced—will have a significant impact on an ecosystem. Conversely it also suggests that there may be lower densities of drilling at which ecological impact cannot be detected.

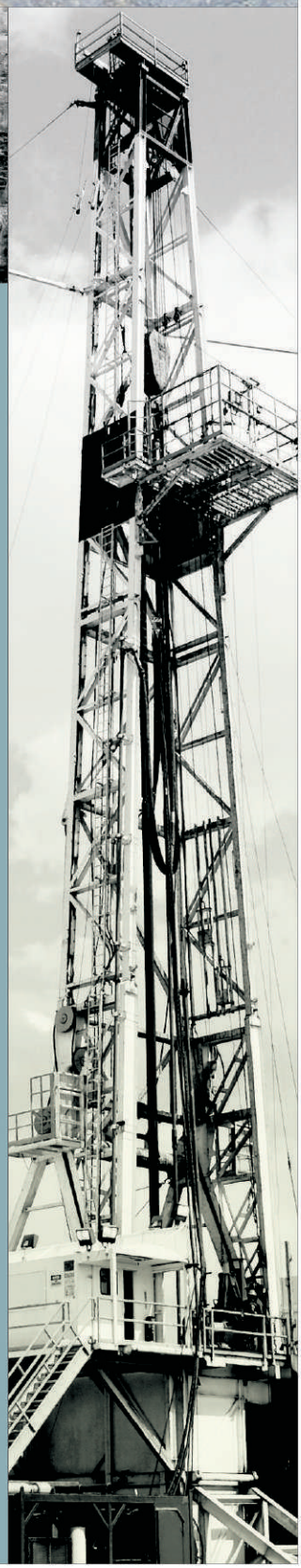
With this initial data, which I emphasize remains tentative; we are proposing a comprehensive research plan to the State DEP (i.e., Growing Greener Program), which would develop guidelines and an assessment tool for regulators and managers to

minimize the ecological impact of drilling. Our goals are to determine if this apparent threshold in the preliminary data remains valid over a larger sample, and to better understand the interactions between well density, size of the impacted stream and watershed, and the resulting ecological indicators.

We propose to look at four streams in each of three size classes for each of the three levels of well density (none, low and high). We will also use computer modeling to analyze the impact of drilling on deforestation. When this study has been completed, we will be able to indicate with a much higher level of certainty what the ecological risks are of drilling in the shale and how they might be managed. It is this and other types of scientific studies that are needed to provide regulators and drillers the necessary information for environmentally sound gas extraction from Pennsylvania.

In conclusion, I would like to thank the Council for this opportunity to discuss these issues. We believe the gas in the Marcellus Shale could have positive effects on the Pennsylvania economy, and there may be possible ways it could be extracted safely. Again, I'd like to emphasize that the Academy does not take a position on the overall advantages or disadvantages of obtaining gas from the Marcellus Shale. At this time, however, there remain significant uncertainties and we urge a cumulative impact assessment on the scale described above before any large-scale drilling occurs.

New York City Department of Environmental Protection



FINAL IMPACT ASSESSMENT REPORT

Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed

December 2009

HAZEN AND SAWYER
Environmental Engineers & Scientists

L B G

a joint venture

New York City Department of Environmental Protection

Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed

Final Impact Assessment Report

December 22, 2009

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Executive Summary

This report presents the results of an assessment performed by the New York City Department of Environmental Protection (NYCDEP) and its consultants, the Joint Venture of Hazen and Sawyer, P.C., and Leggette, Brashears and Graham, Inc., evaluating potential impacts to the NYC water supply resulting from development of natural gas resources in the Marcellus shale formation. The Marcellus[1] shale is one of the largest potential sources of developable energy in the U.S. and covers an area of 95,000 square miles; the New York State portion is approximately 18,700 square miles. The Catskill and Delaware watersheds that provide 90 percent of New York City's unfiltered drinking water supply are underlain by relatively thick sections of the Marcellus that are expected to have high gas production potential and be targeted for development. Within the watershed, there are approximately 1,076 square miles that are not currently protected and are potentially available for the placement of well pads, impoundments, chemical storage, and other elements of natural gas drilling.

Development Activities

Based on densities of development in other shale gas formations in the United States, the area of unprotected or nominally developable land in the watershed, and the number of wells needed to efficiently exploit the resource, it is estimated that between 3,000 and 6,000 gas wells could be constructed in the watershed in the next two to four decades. Initial rates of development would be relatively low (5 to 20 wells per year), but could escalate rapidly to 100 to 300 or more wells per year under favorable economic and regulatory conditions.

Extraction of natural gas from the Marcellus and other shale formations relies on horizontal drilling and high-volume hydraulic fracturing (fracking). A Marcellus well in the New York City (NYC) watershed region would likely be drilled vertically to a depth of 4,000 to 6,000 feet, and extend horizontally a comparable distance through the target shale formation. Natural gas extraction requires that the shale be hydraulically fractured along the lateral portion of the well to increase the permeability of the shale and allow gas to flow into the well at economically viable rates. The fracturing process involves pumping three to eight million gallons (MG) of water and 80 to 300 tons of chemicals into the well at high pressures over the course of several days. Roughly half the injected solution returns to the surface as "flowback" water containing fracturing chemicals plus naturally occurring and often very high levels of total dissolved solids, hydrocarbons, heavy metals, and radionuclides. Flowback water is not amenable to conventional wastewater treatment, and must be disposed of using underground injection wells or industrial treatment facilities. The region currently has insufficient treatment and disposal capacity to handle the expected wastewater volumes.

Water for the fracturing process is typically drawn from surface water bodies and trucked to the drill site; local groundwater supplies may also be used if available. Hauling of water, wastewater, and equipment to and from the drill site requires on the order of 1,000 or more truck trips per well. The entire process, from site development through completion, takes approximately four to ten months for one well. Multiple horizontal wells are typically drilled from a common well pad roughly five acres in size. One multi-well pad can accommodate six or more wells and can

[1] It should be noted that there are other gas-bearing formations such as the Utica Shale that may be targeted for development in the future.

recover the natural gas from a spacing unit covering a maximum of one square mile. New York requires that all wells from a pad must be drilled within three years of the first well, so sites will experience a relatively high and constant level of heavy industrial activity for at least one and up to three years. The fracturing process may be repeated multiple times over the life of a well to restore declining gas production rates. Wells will generally discharge poor quality brine water from the target formation over their useful life.

Table ES-1, described in more detail in Section 4.1, illustrates the magnitude of cumulative water, wastewater, and chemical volumes associated with large-scale hydraulic fracturing operations for a 6,000 well "full build-out" scenario, with and without refracturing.

Table ES-1: Cumulative Water, Wastewater, and Chemical Volumes Associated with Hydraulic Fracturing

Parameter (units) *Estimate (source)*	Without Refracturing	With Refracturing	
		10-Year Interval	5-Year Interval
Total Number of Wells	6,000	6,000	6,000
CUMULATIVE BASIS			
Total Number of Frack Jobs *Full build-out, high scenario*	6,000	24,000	48,000
Frack Chemicals Used (tons) *1.0% of fracture fluid*	1,000,000	4,000,000	8,000,000
Waste TDS (tons) *100,000 mg/l TDS (dSGEIS)*[2]	12,510,000	27,522,000	47,541,000
ANNUAL BASIS[1]			
Water Demand (mgd) *4 MG per frack job*	3.6 to 5.5	5.5 to 8.2	11.7 to 14.2
Wastewater Production (mgd) *50% Flowback + 0.075 MG/yr Produced Water*	2.6 to 3.5	3.9 to 5.3	6.7 to 8.4
Waste TDS for Disposal (tons/day) *100,000 mg/l TDS in waste (dSGEIS)*[2]	1,100 to 1,500	1,600 to 2,200	2,800 to 3,500
Water Req'd to Dilute TDS to 500 mg/l (mgd)	500 to 700	800 to 1,100	1,300 to 1,700
Frack Chemicals (tons/day) *1.0% of fracture fluid*	150 to 230	230 to 340	490 to 590

Notes:
1. Ranges describe the median and the maximum of the annual average values for each development year. Data for the no-refracturing scenario are drawn from the 20-year period of well development. Data for the refracturing scenarios are drawn from the full 60-year period of development and refracturing.
2. The dSGEIS reports median and maximum values of TDS as 93,200 mg/l and 337,000 mg/l, respectively. The concentration of TDS in flowback reportedly increases with time. The determination of median value may include relatively low concentration samples from initial flowback.

Potential Impacts

The West-of-Hudson watershed is a pristine, largely undisturbed landscape, with only minimal industrial activities. These natural and land use factors combine to yield water of very high quality with little or no chemical contamination. Natural gas well development in the West-of-Hudson watershed at the rates and densities observed in comparable formations will be accompanied by a level of industrial activity and heightened risk of water quality contamination that is inconsistent with the expectations for unfiltered water supply systems.

Intensive natural gas well development in the watershed brings an increased level of risk to the water supply: risk of degrading source water quality, risk to long-term watershed health and the City's ability to rely on natural processes for what is accomplished elsewhere by physical and chemical treatment processes, risk of damaging critical infrastructure, and the risk of exposing watershed residents and potentially NYC residents to chronic low levels of toxic chemicals. In addition to surface risks to the watershed, extensive hydraulic fracturing of horizontal wells will present subsurface contamination risks via naturally occurring faults and fractures, and potential alteration of deep groundwater flow regimes, as indicated by the geological cross-section presented as Figure ES-1.

Each of these risks is discussed in greater detail in this document. They have been identified based on review of the progression of natural gas development in other areas, documented incidents of surface water and shallow groundwater contamination associated with natural gas resource development, and review of regional geological features. NYC operates over 100 miles of water supply tunnels west of the Hudson River, the construction of which provided direct experience with respect to faults and deep fluid migration through bedrock. The assessment of risks to the City's water supply system takes into account seepages of methane and deep formation water, and faults and other natural geological features encountered during tunnel construction. As shown in Figure ES-2, water supply tunnel routes intersect numerous geological faults and fractures, many of which extend laterally for several miles, and vertically through several underlying geological strata. Each of these features represents an existing potential pathway for fluid migration.

The difficulty of remediating diffuse contamination and other risks once allowed into the environment, and the potentially catastrophic consequences of damage to critical water supply infrastructure, make clear that a conservative approach towards natural gas drilling in the NYC watershed and in the vicinity of infrastructure is warranted. In short, the rapid and widespread industrialization of the watershed resulting from natural gas drilling would upset the balance between watershed protection and economic vitality that the City, its State and federal regulators, and its upstate partners have established over the past 15 years.

Development of natural gas resources using current technologies thus presents potential risks to public health and would be expected to compromise the City's ability to protect the watershed and the continued, cost-effective provision of a high-purity water supply. A robust assessment of risks from drilling would consider site-specific factors assessed on a well-by-well basis and would consider detailed knowledge of local fracture, infrastructure, hydrologic, and other conditions at a finer scale than watershed-level analysis. In recognition of the possibility that horizontal drilling and hydraulic fracturing may one day be allowed to proceed, measures for reducing some, but not all, risks to water quality and water supply infrastructure are summarized in an appendix.

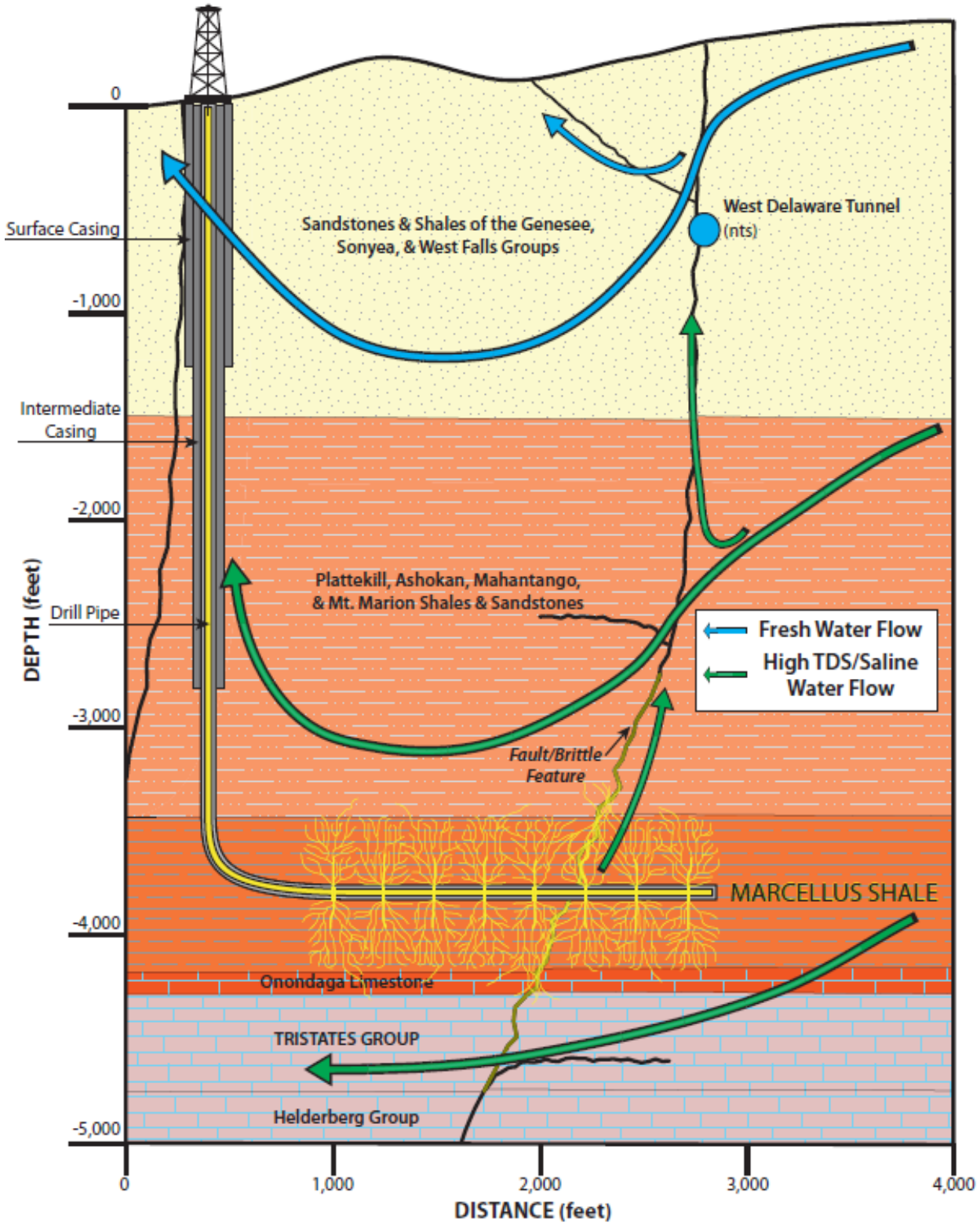


Figure ES-1: Potential Flow Disruption and Contamination Mechanisms

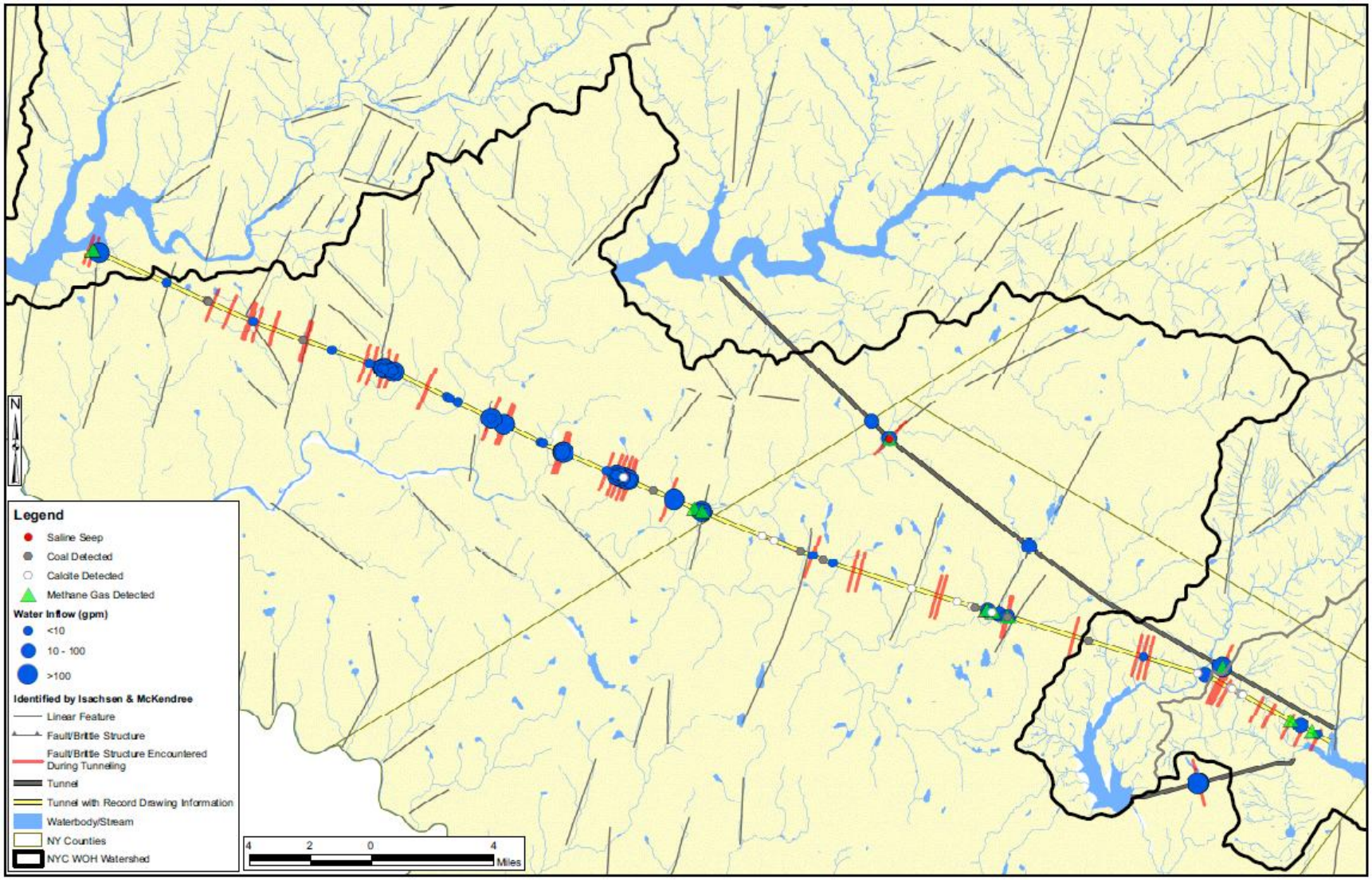


Figure ES-2: Map of the East and West Delaware Tunnels and Neversink Tunnel

Section 1: Introduction

1.1 Project Background

In recognition of increased natural gas development activity in New York State and its potential to impact New York City's water supply, the NYCDEP has undertaken the project, *Impact Assessment of Natural Gas Production in the NYC Water Supply Watershed*. Natural gas development activities have the potential to impact the quality and quantity of NYC's water supply through land disturbance, toxic chemical usage, disruption of groundwater flow pathways, water consumption, and waste generation. The overall goal of the project is to identify potential threats to the continued reliability and high quality of New York City's water supply by providing an assessment of the potential impacts of future natural gas development activities in or near the NYC watershed on water quality, water quantity, and water supply infrastructure.

NYCDEP retained the Joint Venture of Hazen and Sawyer, P.C., an environmental engineering firm, and Leggette, Brashears & Graham, Inc., a hydrogeologic and environmental consulting firm, to assist in performing this assessment. The first phase of the project included evaluation of regional hydrogeology and development of a conceptual hydrogeologic model of the region, characterization of activities and impacts associated with natural gas well development, review of a database of drilling and fracturing chemicals, examination of case studies from other formations, and preparation of a preliminary infrastructure assessment. Results from the first phase were summarized in a Rapid Impact Assessment Report issued in September 2009.

The current Final Impact Assessment Report incorporates the previous work into a cumulative watershed risk assessment and provides further evaluation of subsurface migration pathways and risks to NYC infrastructure.

1.2 New York City Water System and Source Protection Measures

The New York City water system is comprised of three separate supply systems – the Catskill, Delaware, and Croton systems. Approximately 90 percent of the City's water supply (more than one billion gallons per day) is drawn from the Catskill and Delaware systems located west of the Hudson River in upstate New York. As such, it is NYCDEP's mission and responsibility to protect both the NYC water supply system and public health and safety, ensuring continued reliability in serving nine million consumers within New York City and upstate communities (in Westchester, Putnam, Orange, and Ulster Counties) who depend on the New York City system as the primary source of their drinking water. The NYC watershed is a working watershed that supports multiple uses. The 1997 Watershed Memorandum of Agreement signed by New York State Department of Environmental Conservation (NYSDEC), NYCDEP, Environmental Protection Agency (EPA), environmental parties, and numerous local governments committed the parties to foster economic development within the watershed that is consistent with principles of watershed protection.

The City's decision to pursue source water protection was based in part on the existing quality of the water and in part on the belief that keeping pollutants out of the water was in the long term a more sustainable strategy than the more conventional approach used by most water suppliers – employing treatment technologies to remove pollutants after they get in the water.

The West-of-Hudson watershed is a pristine, largely undisturbed landscape, characterized by high rates of forest cover (78 percent) and predominantly rural land uses. Development has historically been confined to the river valleys and impervious surfaces cover a mere 1.2 percent of the land area. Dairy farms are a common part of the rural landscape, particularly in the far western reaches of the watershed, and there are minimal industrial activities. These natural and land use factors combine to produce a very high quality water from the Catskill/Delaware watershed.

Beginning in the early 1990s, NYCDEP initiated development and implementation of a suite of programs designed to preserve and enhance the existing quality of the Catskill/Delaware source waters. Prior to undertaking design of protection programs, NYCDEP initiated a comprehensive water quality monitoring program. Samples were taken at various locations and frequencies to accurately characterize water quality conditions throughout the watershed. Data acquired through this effort was used to identify existing and potential pollution sources and to identify pollution control strategies. Based on monitoring data, NYCDEP identified the primary threat to water quality as coliforms, pathogens, nutrients and turbidity. To this day, those pollutants – which largely derive from natural sources, limited residential development, and agriculture – remain the primary pollutants of concern for the New York City water supply.

DEP's watershed protection program is based on water quality science supported by extensive monitoring and water quality data. Various program elements seek to either remediate existing sources of pollution or to prevent future sources. The overall program has been tailored to be mindful of and support the economic vitality of the communities and the residents of the Catskills. The major elements of the watershed protection program include:

- Land Acquisition – increasing the amount of land to be preserved in its natural condition;
- Watershed Regulations – primarily targeting stormwater and wastewater pollution from development;
- The Watershed Agricultural Program – working with watershed farmers to implement pollution control practices on farms;
- The Stream Management Program – working with riparian landowners to restore degraded streams to more natural conditions;
- The Wastewater Treatment Upgrade Program – funding the upgrade of all pre-1997 WWTPs in the watershed to state-of-the-art tertiary treatment;
- The New Infrastructure and Community Wastewater Management Programs – designing and constructing new wastewater infrastructure for communities with concentrations of failing or likely-to-fail septic systems;
- The Septic Rehabilitation Program – funding the repair or replacement of failing septic systems for individual residences and small businesses;
- The Stormwater Retrofit and Future Stormwater Controls Control Programs – seeking to address pollution from stormwater runoff, either by retrofitting existing sites or funding compliance with the Watershed Regulations; and
- The Watershed Forestry Program – working with owners of forested land to promote a vigorous forest landscape and forestry practices that are protective of water quality.

Taken together, these programs effectively address the current range of human activity in the watershed that could threaten water quality. Instrumental to the success of the City's program has been the strong collaboration between a multitude of stakeholders – watershed

representatives and residents, environmental groups, regulatory agencies and NYCDEP. These partnerships are key to the success of the programs because certain elements have the potential to modify individual property rights and community growth goals. The City has worked to develop programs that strike an appropriate balance between water quality preservation and community interests.

Due to the high quality of the West-of-Hudson water supplies and the extensive watershed protection efforts of NYCDEP and numerous stakeholders, EPA has determined in successive Filtration Avoidance Determinations that NYC's Catskill and Delaware supplies satisfy the requirements for unfiltered surface water systems established in the Surface Water Treatment Rule and the Interim Enhanced Surface Water Treatment Rule. The most recent Filtration Avoidance Determination was issued in 2007 and establishes requirements for continued watershed protection efforts through 2017. A core requirement for filtration avoidance is a watershed control program that can identify, monitor, and control activities in the watershed which may have an adverse effect on source water quality.

Proof of the effectiveness of the City's approach lies in the fact that water from the Catskill/Delaware system continues to be of exceptionally high quality and is virtually free of chemical contaminants. Water supply monitoring is extensive and far exceeds regulatory requirements, both in the watershed and in the distribution system. NYCDEP operates five modern water quality laboratories throughout the watershed and distribution system, and processes approximately 50,000 samples from 1,400 sample locations for up to 240 contaminants and 600,000 analyses per year. Analyses performed include those for basic physical parameters, nutrients and metals, and tests for disease-causing organisms such as bacteria, viruses and protozoans. Additionally, the water supply is routinely scanned for synthetic organic compounds at watershed locations and throughout the distribution system. Extensive monitoring is used to ensure that NYCDEP delivers the highest quality water to the consumer and helps to instill a high degree of public confidence in the water supply system.

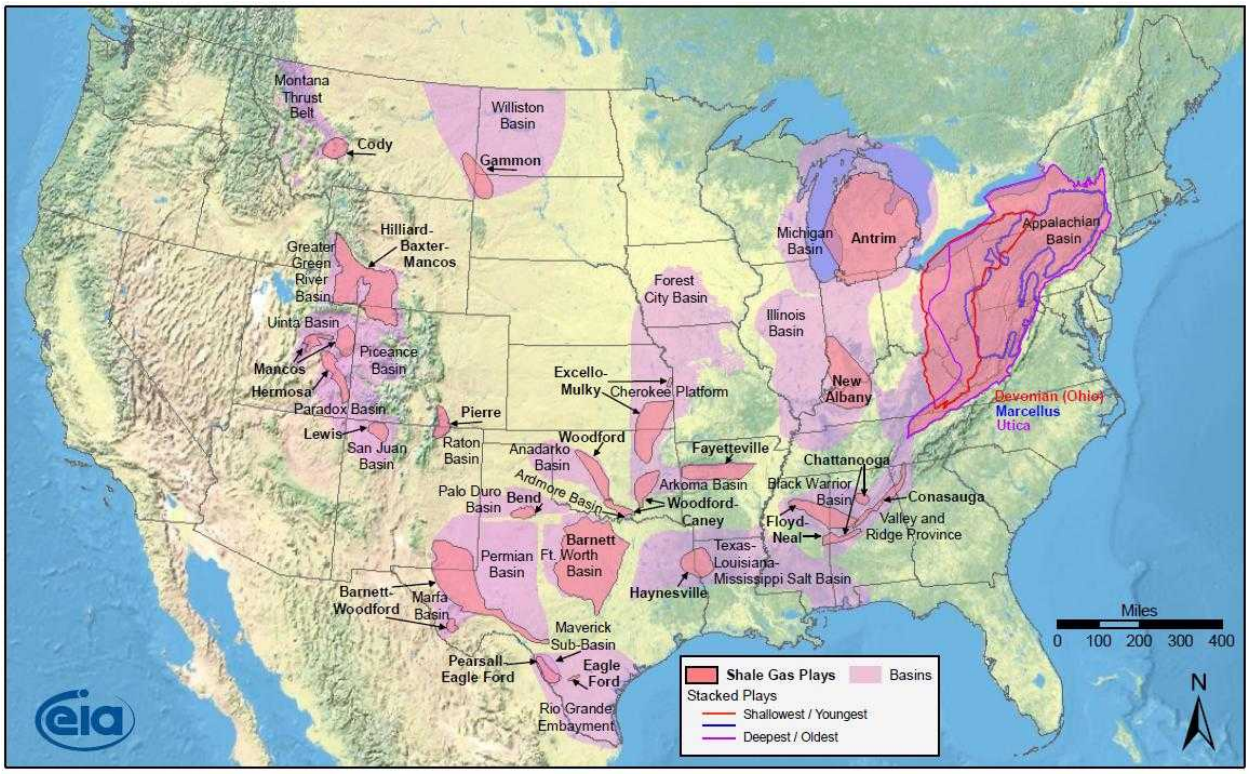
1.3 Trends in Drinking Water Regulations

Currently, the federal Safe Drinking Water Act requires the monitoring of about 90 contaminants in water supply systems. Additionally, the Unregulated Contaminant Monitoring Rule and the Candidate Contaminant Listing process require EPA to establish criteria for expanding the number of contaminants subject to monitoring requirements, and require EPA to make determinations on regulating additional contaminants. As a result of these rules and listing processes, as public health concerns associated with chemical contaminants continue to increase, and as analytical techniques improve, the trend will be toward more stringent drinking water regulations in the future. The number of regulated contaminants will expand and the maximum contaminant levels (MCLs) of contaminants are likely to decrease. The recent heightened national concern over pharmaceuticals and emerging contaminants, and most recently the Environmental Working Group's report on chemical contamination in water supply utilities in the United States,[2] gives a clear indication that the public's expectation is for contaminant-free drinking water. This expectation is consistent with NYCDEP's mission to deliver the highest quality water possible to the consumer.

[2] Available at http://www.ewg.org/tap-water/home.

1.4 Overview of Natural Gas Well Development

Shale formations with gas producing potential are distributed throughout much of the United States (Figure 1-1). Recent technological advances such as hydraulic fracturing and horizontal drilling, in combination with market forces, have made the development of shale gas resources economically viable. The most heavily developed shale gas "play" is the Barnett in Texas and dates back only to the late-1990s. The Fayetteville in Arkansas and the Haynesville in Louisiana and Texas are other major plays that have been more recently developed. There is currently substantial interest in the Marcellus formation because of its size and gas-producing potential.



Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

Figure 1-1: Gas-Producing Shale Formations in the US

Shales are generally considered geologically "tight" formations with limited permeability and primary porosity.[3] Hydraulic fracturing is employed to increase permeability and porosity of the rock mass and enhance the movement of gas to the well bore. Horizontal drilling is employed to increase the areal extent from which gas can be drawn to a single well location. The Marcellus and other potential gas-producing formations underlie most of New York, and the state is currently in the process of approving horizontal drilling and high-volume hydraulic fracturing for exploiting these resources.

The natural gas development process using horizontal drilling/high-volume hydraulic fracturing is initiated in a similar manner to traditional gas exploration and includes mapping and geologic

[3] Primary porosity is the void space that remains between grains of sediment deposits after initial deposition and rock formation. Sedimentary rocks, such as the Marcellus Formation, are formed from the compaction of sediments. Secondary porosity results from fractures or other post-depositional physical changes to the formation.

analysis, seismic testing, leasing of mineral rights from landowners, and submission of well permit applications. Each well is assigned to a spacing unit, which roughly corresponds to the area of land from which the well is assumed to be extracting natural gas. For multiple horizontal wells drilled from a common well pad, as is expected for most Marcellus wells, a spacing unit of up to 640 acres (one square mile) is allowed.[4] Spacing unit requirements do not limit the number of horizontal wells that may be drilled from a multi-well pad. Instead, the total number of wells per spacing unit is governed by the number of wells needed to efficiently and economically extract the natural gas resources within a given spacing unit. Industry reports cited in the draft Supplemental Generic Environmental Impact Statement[5] indicate that six to ten wells will be developed per well pad in the Marcellus.

Initial site activities include clearing, grading, and construction of site access road, well pad, and utilities. The size of the pad is expected to be on the order of five acres. Total area requirements including well pad and related features such as roads and pipelines are estimated at seven acres per well pad based on data from the Fayetteville shale.[6] Once the site is prepared and the drill rig and ancillary equipment are set up, operators begin drilling the well. In the New York area, wells will likely consist of a 3,000- to 7,000-foot deep vertical section that extends from the surface to the target formation, plus a horizontal section that extends laterally for an additional 2,000 to 6,000 feet. The lateral section is not allowed to extend beyond a specified setback distance from the spacing unit boundary.

Construction of gas wells in the Marcellus formation requires drilling through shallow freshwater aquifers and penetrating deeper geologic formations that contain naturally-occurring contaminants such as hydrocarbons, metals, radionuclides, and high salinity. The well borehole creates a conduit for fluid to flow between these previously isolated geologic formations. To prevent such flow, the annular space between the well casing and the formation is filled with grout.

After the well is drilled, cased, and grouted, the operator proceeds with hydraulic fracturing operations to stimulate gas production. The process entails injecting a mixture of water and chemicals into the well at high pressure to create fractures in the gas-bearing formation, thus increasing its permeability and enhancing the release of gas for collection. Sand or other inert materials (i.e., proppants) are injected with the fluid mixture to prop open the fractures. A typical fracturing operation may require on the order of three to eight million gallons of water, depending on formation characteristics, lateral length, and fracture design. Water may be obtained from surface or groundwater sources; to date most fracking operations have used fresh or low salinity water.

A variety of chemical additives are added to fracking fluid to control fluid properties. Chemicals are often cited as making up 0.5 to 2.0 percent of the fracking fluid. For a four million gallon fracture operation, this translates to 80 to 330 tons (160,000 to 660,000 lbs) of chemicals per

[4] Natural gas well spacing unit requirements are defined in ECL §23-0501.
[5] Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program – Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs.
[6] U.S. Department of the Interior. 2008. *Reasonably Foreseeable Development Scenario for Fluid Minerals: Arkansas*. Prepared for the Bureau of Land Management Eastern States Jackson Field Office. March 2008.

well. The exact chemical composition of many additives is not known. Of the known chemical components, many are toxic to the environment and human health.

The active drilling and fracturing process requires on the order of four to eight weeks per well. When support activities such as site clearing and grading, pad construction, mobilization and demobilization of drill rigs and other equipment, water delivery, and waste disposal are included, the time during which a drill site can be considered active is on the order of four to ten months for one well, depending on site-specific conditions. For a multiple well pad, site activities may be sequenced such that multiple wells are under various stages of concurrent development. All wells from a multi-well pad must be completed within the three year permit period. A high volume of heavy truck traffic (approximately 800 to 1,200 trips per well) is required during the development process to convey equipment, chemicals, water, and waste to and from the site.

Wastewater disposal is a critical feature of hydraulic fracturing operations. A sizeable fraction (approximately 10 to 50 percent or more) of the original fracturing fluid volume is returned to the surface as "flowback" over a period of several weeks. Flowback water contains chemical additives and naturally occurring formation materials, including high levels of total dissolved solids, metals and naturally occurring radioactive material (NORM). Flowback water is trucked off-site for disposal at underground injection wells, certain municipal wastewater treatment plants (WWTPs), or industrial WWTPs.

When drilling and stimulation operations are complete, the drill rig and equipment are removed and the site is partially restored. If the well produces gas, pumping and treatment equipment are installed at the site and pipelines are constructed to connect the well to the regional transmission network. Tanks are also constructed for temporary storage of the "produced" water that the gas well discharges during the course of normal operation.

As the well ages and the gas production rate declines, the well may be re-fractured to boost productivity. Limited data from the Barnett shale indicates the interval between re-fracturing operations could range from one to more than ten years. The useful life of a well may be on the order of 20 to 40 years; at the end of this time the well is plugged and abandoned. For locations overlying "stacked" shale plays, which appears to be the case in the NYC West-of-Hudson watershed, it is unclear whether multiple gas-bearing formations in the "stack" would be developed simultaneously, or if development of other formations would ultimately require the service life of the site to be extended. Once there are no longer other wells or collection facilities operating on the same well pad, the site can be fully restored.

1.5 Regulatory Context for Gas Exploration and Development

Federal Regulations

Many of the activities associated with natural gas development have the potential to pollute air or water and therefore fall under the nominal jurisdiction of a number of federal environmental regulations, including the Clean Water Act, the Safe Drinking Water Act, the Clean Air Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act and the Toxic Release Inventory reporting requirements of the Emergency Planning and Community Right to Know Act. However, each of these regulations currently contain important exemptions regarding the definition, reporting, use, and disposal of the toxic chemicals required during hydraulic fracturing and other gas development activities. At

this time there are few constraints on natural gas development at the federal level, and related activities are generally regulated at the state level.

State Regulations

Natural gas development in New York is regulated by the NYSDEC, which under the Environmental Conservation Law (ECL) is charged with conserving, improving and protecting natural resources and the environment, preventing water, land and air pollution, and authorizing the development of gas properties to increase the ultimate recovery of oil and gas resources.

In 1992, NYSDEC finalized a Generic Environmental Impact Statement (GEIS) on the Oil, Gas and Solution Mining Regulatory Program as part of the State Environmental Quality Review Act (SEQRA) process. At the time the GEIS was drafted, the use of horizontal drilling and high-volume hydraulic fracturing for oil and gas extraction in shale and tight sandstone reservoirs was not technologically feasible. Since that time extraction technologies have matured and led to commercially viable development of the Marcellus and other formations. In 2008, Governor Paterson directed NYSDEC to prepare a supplemental GEIS (SGEIS) to review potential additional impacts related to these technologies.

The draft SGEIS was released on September 30, 2009, and included analysis of potential impacts and established a number of permit conditions for drilling applications. Several salient conditions established in the dSGEIS include:

- A requirement for site-specific SEQRA reviews for wells within 1,000 feet of NYCDEP infrastructure, well pads within 300 feet of a reservoir, or well pads within 150 feet of other surface waters. Outside of these setbacks, no additional watershed-specific review is required (i.e., wells may be drilled anywhere else in the NYC watershed or adjacent to tunnels without additional review).
- Baseline and periodic ongoing groundwater water quality testing is required for private wells within 1,000 to 2,000 feet of a gas well.
- Operators are required to disclose to NYSDEC the fracturing products (i.e., additives) that will be used for a given well.
- Surface water withdrawals must allow a specified passby flow to maintain stream habitat.
- Various mitigation plans are required for visual impacts, noise impacts, invasive species, and greenhouse gases.

The dSGEIS is presently under review and is not anticipated to be finalized until 2010. Therefore the proposed permit conditions and mitigation requirements included in the final SGEIS may differ from those described herein.

NYC Watershed Regulations

With the exception of requiring NYCDEP approval of stormwater management plans for activities meeting certain impervious surface or disturbance thresholds, the NYC Watershed Rules and Regulations have little or no applicability to horizontal drilling and high-volume hydraulic fracturing activity in the watershed.

1.6 Report Organization

- Section 2 describes regional geology and hydrogeology and discusses pathways for subsurface migration of fracturing chemicals and formation water;
- Section 3 describes the rates and densities of natural gas well development in comparable formations, and estimates the number of wells that could be constructed in the NYC watershed on an annual basis and under a full build-out scenario;
- Section 4 presents an assessment of cumulative impacts of natural gas well development in the NYC watershed;
- Appendix A provides more detail on the geology and hydrogeology of the region;
- Appendix B provides more information on rates and densities of well development;
- Appendix C provides more detail on the analysis of surface spills; and
- Appendix D identifies potential mitigation measures for reducing the risk of impacts to the water supply.

Section 2: Area Geology

This section presents an overview of the subsurface conditions in the NYC watershed region, including evaluation of gas-producing potential, description of rock strata and geologic features, analysis of water resources, and a summary of data provided by tunnel construction records.

2.1 Shale Gas Potential and the NYC Watershed

The Marcellus formation is one of a series of "stacked" Appalachian plays that also include the Utica Shale. These formations underlie an area of approximately 95,000 square miles[7] that extends from eastern Kentucky, through West Virginia, Ohio and Pennsylvania and into southern/central New York. The Marcellus formation is estimated to contain 200 to 500 trillion cubic feet (tcf) of total natural gas reserves and is considered one of the largest potential sources of developable energy in the U.S.[8]

In New York, the Marcellus formation (Figure 2-1) lies beneath all or part of 29 counties and the entirety of the 1,585 square miles of NYC's West-of-Hudson watersheds. The maximum depth (ca. 6,500 feet) occurs along the Delaware River at the New York - Pennsylvania border, and the formation is shallowest to the east and north. The NYC watershed area is underlain by relatively thick areas of the Marcellus formation that are estimated to have relatively high gas production potential. Within the West-of-Hudson watersheds, 1,076 square miles are not protected and are subject to gas exploration and development activities. This area represents less than six percent of the approximately 18,700 square miles of the Marcellus formation that are in New York State.

Analysis of the depth, thickness, organic content, thermal maturity, and other characteristics of the Marcellus formation has been performed as part of an ongoing study by the New York State Museum.[9] Figure 2-1, which is drawn from the New York State Museum study, shows the approximate depth to the top of the Marcellus formation (top portion) and the approximate thickness of the formation (lower portion). The dotted contours also indicate the transformation ratio associated with the formation, which is an estimate of the thermal maturity of the organic material.[10] The higher the ratio, the more gas that is potentially available.

While acknowledging uncertainties that prevent precise delineation of areas with the highest gas production potential, the authors of the study suggest that drilling in New York is likely to start in the thickest and deepest areas of the formation, which includes southern Tioga, Broome, Delaware and Sullivan Counties, which border the northeast corner of Pennsylvania, before progressing north and west. These areas are also attractive for gas production because of their proximity to the Millennium pipeline and other regional natural gas transmission infrastructure.

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[7] ALL Consulting, Groundwater Protection Council. (2009). *Modern Shale Gas Development in the United States: A Primer*. Prepared for: U.S. Dep't of Energy Office of Fossil Energy and National Energy Technology Laboratory.

[8] Navigant Consulting, Inc. (2008). *North American Natural Gas Supply Assessment*, Prepared for: American Clean Skies Foundation.

[9] Smith, T. and J. Leone. New York State Museum. *Integrated Characterization of the Devonian Marcellus Shale Play in New York State*. Presented at the Marcellus Shale Gas Symposium of the Hudson-Mohawk Professional Geologists' Association, April 29, 2009. Accessed from www.hmpga.org/Marcellus_presentations.html.

[10] Transformation ratio refers to the percentage of Kerogen (an organic solid, bituminous mineraloid substance) occurring in the unit, that has been destructively converted to oil or gas by ambient geological forces (i.e., pressure, temperature) .

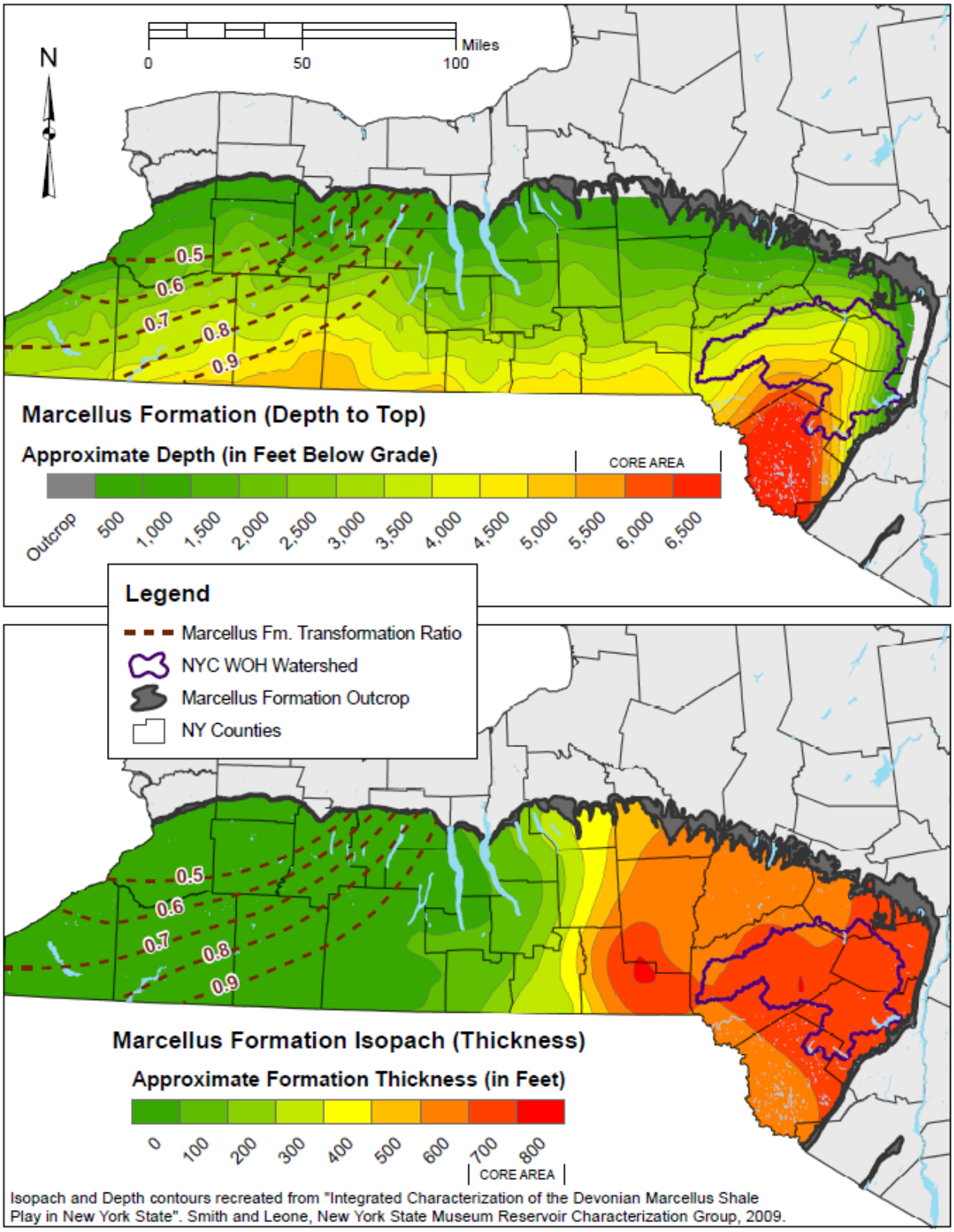

Figure 2-1: Extent and Characteristics of Marcellus Formation in New York

The supposition that the area identified in the New York State Museum study may be highly productive is supported by the intense leasing activity observed in this area and in neighboring counties in northeast Pennsylvania, as well as the ongoing development of a major regional drilling services facility in Horseheads (Chemung County), New York. County locations and additional detail on drilling activity in the region are presented subsequently in Figure 3-4.

2.2 Regional Geology

Figure 2-2 shows the bedrock geology underlying the West-of-Hudson components of NYC's water supply system (Appendix A). It identifies the uppermost layer of underlying bedrock, locations of mapped geologically brittle structures in relation to watershed boundaries, reservoirs, aqueducts, streams and rivers. The contours mapped in Figure 2-2 show the approximate depth to the top of the Marcellus formation. These contours indicate that the formation dips steeply westward in the eastern portion of the watershed, while the dip from north to south is less steep.

The uppermost layer of bedrock is identified in Figure 2-2 by color-coding keyed to the geologic cross-section of Figure 2-3. These figures indicate that virtually the entire watershed is underlain by rock of the West Falls, Sonyea and Genesee Groups, which are Upper (or Late) Devonian period in age (over 360 million years old). The Upper Devonian Groups are in turn underlain by Middle Devonian aged rocks of the Hamilton Group. The orange-shaded band framing the east boundary of the watershed corresponds to Middle Devonian formations and defines the extent of Upper Devonian rock.

The Marcellus formation occurs at the base of the Middle Devonian Hamilton Group and is primarily composed of organic-rich shale units. It is overlain and underlain by sedimentary rock units (e.g., sandstone, shale, siltstone and limestone) of varying natural gas and fossil fuel resource potential. As indicated by Figure 2-3, the Utica Shale, which is part of the Lorraine Group, underlies the Marcellus as well as the entirety of the West-of-Hudson watersheds.

2.3 Water Resources and Hydrogeologic Conditions

The topography of the region comprises six major drainage basins occupied by a NYC reservoir and its tributaries. The three western-most (Cannonsville, Pepacton, and Neversink) are sub-watersheds of the Delaware River Basin; the remaining three (Rondout, Schoharie, and Ashokan) are hydrologically within the Hudson River Basin.

Surface water in the region generally originates as precipitation, which is either captured directly within the waterbody itself, or indirectly, as runoff and groundwater discharge (known as "baseflow"). There is a hydraulically continuous relationship between groundwater and surface water in the region developed from a series of interdependent flow regimes. Under natural conditions, these flow regimes are in hydrogeologic equilibrium as evidenced by major ionic chemical signatures reflective of the comprising water types (i.e., shallow versus deep), indicating that groundwater in very deep geologic formations is typically older and chemically distinct from groundwater in overlying flow regimes.[11] Typically, groundwater from deep formations and flow regimes is not potable, due to high total dissolved solids, and does not mix directly with shallow, fresh groundwater and surface water.

[11] A Conceptual Hydrogeologic Model for the West-of-Hudson watershed region is developed and described in the September 2009 *Rapid Impact Assessment* report.

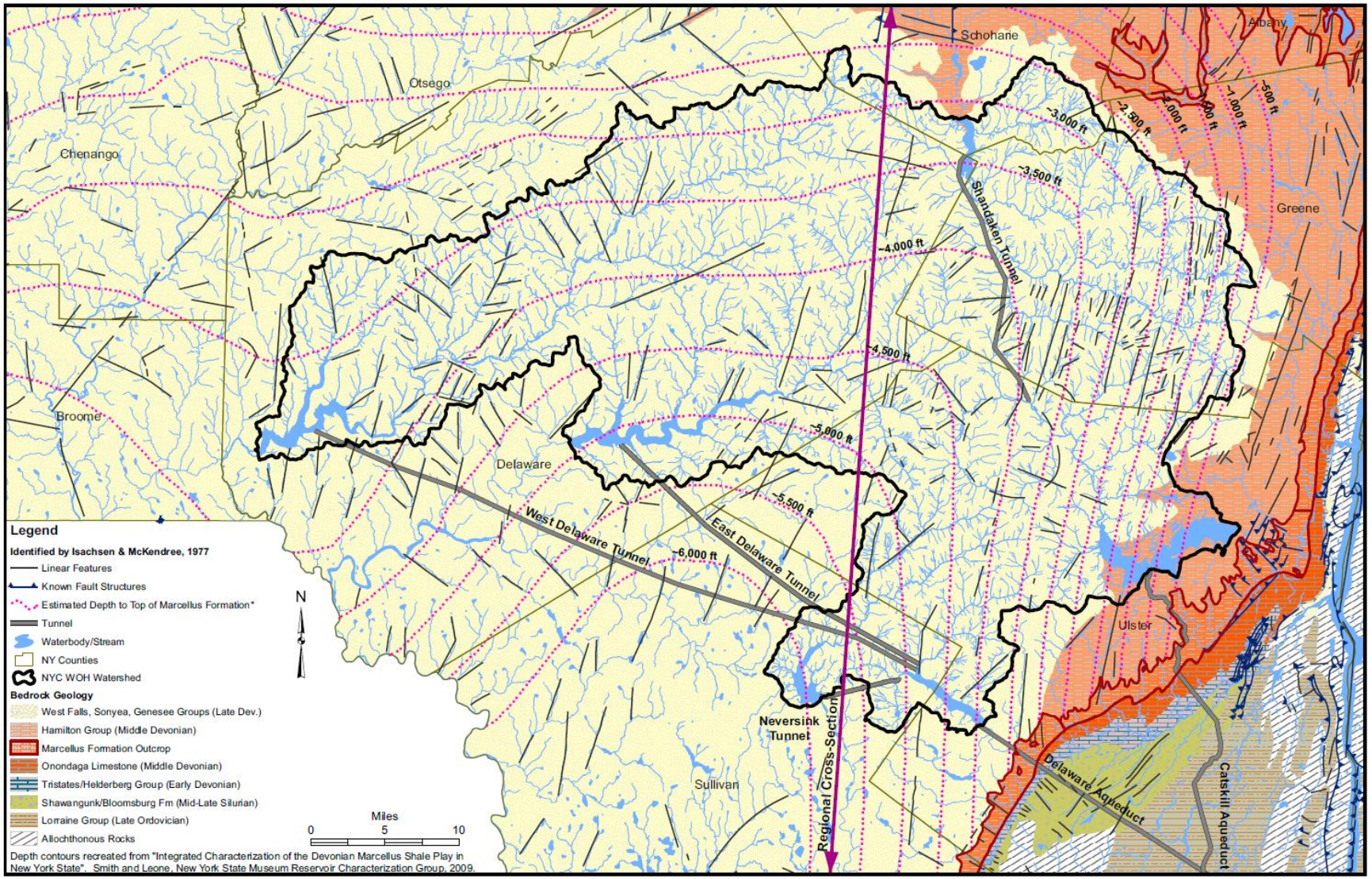

Figure 2-2: Bedrock Geology of the Catskill Region

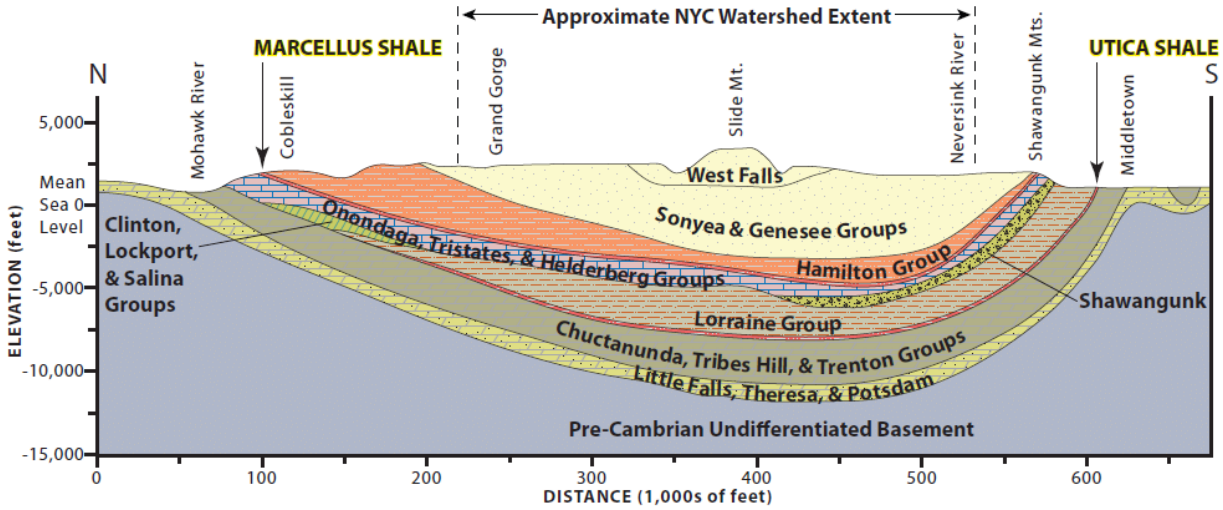

Figure 2-3: Cross-Section of Catskill Region Bedrock Geology

Limited inter-regime flow can be compromised by naturally-occurring, vertically extensive brittle structures as well as the interception of such structures during gas well drilling and stimulation. Abandoned or improperly sealed wells, casing or grouting failures, existing geologic fractures, and new fractures (generated during well development and stimulation) that propagate beyond the target formation can create or enhance hydraulic pathways between previously isolated formations. These hydraulic pathways can permit fluids within geologic formations (such as methane or brine water) to contaminate shallow groundwater, surface water, and subsurface infrastructure. In the case of the Marcellus formation, which is characterized as "overpressurized," fluids in the formation will follow the path of least resistance which, in addition to traveling toward the wellhead, will also follow any existing fractures and be forced upward toward the surface.[12]

2.4 Faults and Other Brittle Structures

The development of natural gas resources using hydraulic fracturing and horizontal well drilling technology relies upon vertical separation distance and low permeability of the intervening rock strata to prevent hydraulic communication between shallow aquifers and deeper gas bearing formations. Given the reliance on overlying rock to isolate hydraulically fractured strata from near-surface flow regimes, an evaluation of the presence and potential extent of geologically formed faults and fractures in the region has been performed. These geological features and other brittle structures can and do serve as conduits that facilitate migration of contaminants, methane, or pressurized fluids from deep formations towards the surface, potentially impacting aquifers and subsurface infrastructure.

Figure 2-4 presents faults, shear zones and other brittle structures as mapped by Isachsen and McKendree (1977) in New York State. The blue-colored features correspond to faults and shear

[12] The dSGEIS (pg. 5-131) reports a pressure gradient in the Marcellus formation of 0.55 to 0.60 psi per foot of depth (i.e., 1.27 to 1.39 feet of pressure per foot of depth). Gas reservoirs that exhibit greater than 0.4 to 0.5 psi per foot of depth (ranging up to 0.7 to 1.0 psi per foot) may be characterized as "overpressurized" (Craft, B.C. and Hawkins, M.F., 1991, *Applied Petroleum Reservoir Engineering*, Prentice Hall).

zones, and the gray features correspond to "Topographic and Tonal Linear Features." Many of these features represent breaks or fractures in the bedrock. The faults and shear zones identified in this study have been mapped on the basis of direct observation in outcrop or boreholes and are associated with movement of the comprising rock masses parallel to the feature. Such movement is commonly associated with "seismic events" such as earthquakes. The "linear features" are typically identified using aerial photographs, maps, and other related methods and may correspond to the suspected locations of faults (although not directly observed in outcrop). In some cases, these features are continuations of known, mapped faults and brittle structures. This data is not likely to present all faults and fractures that might exist at depth

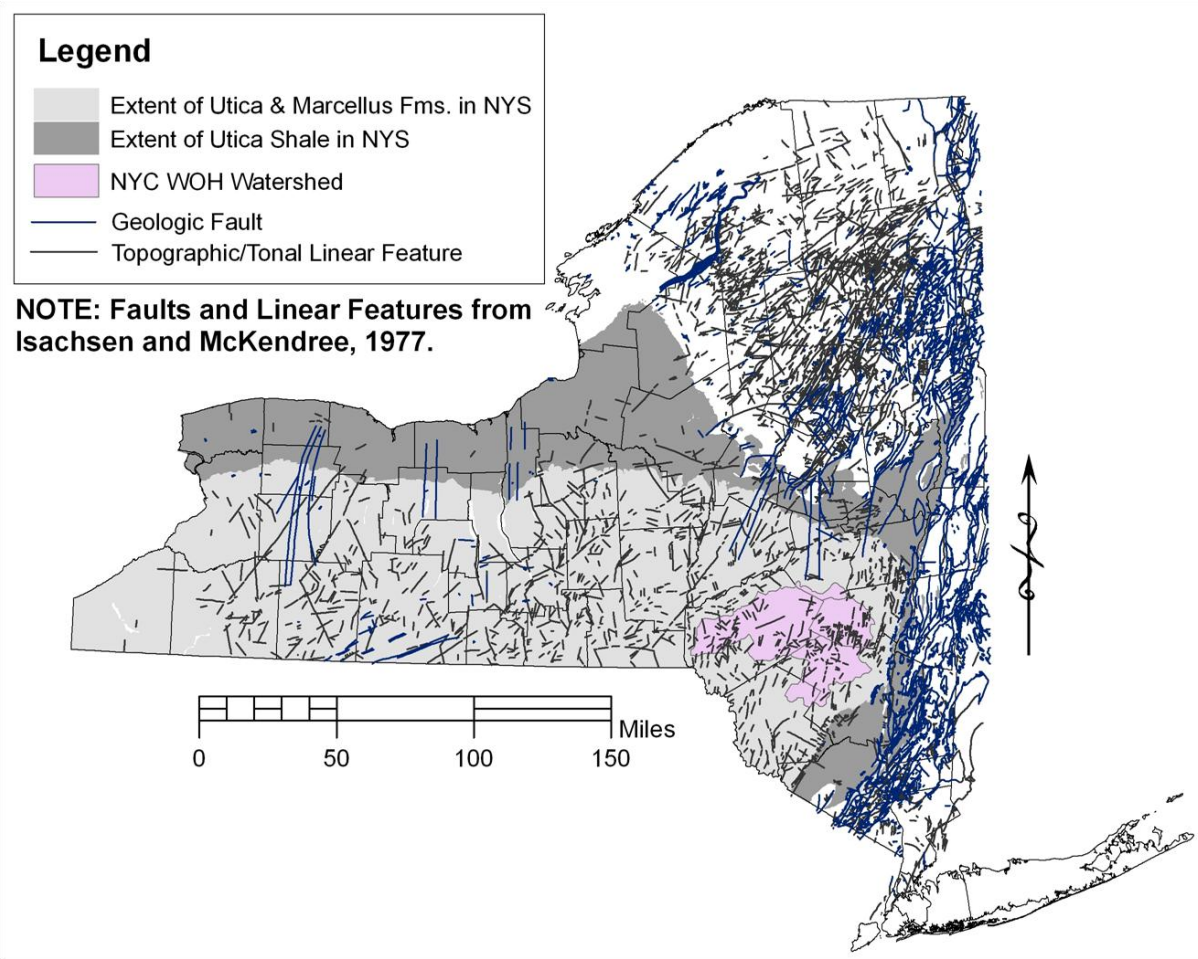

Figure 2-4: Map of Geologic Faults and Linear Features in New York State

Recognizing the significance of brittle structures (i.e., faults, shear zones, fractures and other linear features) to act as migration pathways for fluids from deeper formations, a statistical analysis of the lengths of these reported features in the vicinity of NYC's West-of-Hudson water system has been performed as part of this assessment. The brittle structures in the region commonly extend laterally for distances in excess of several miles and vertically to depths in excess of 6,000 feet. Some of these features intersect one another and some cross NYC infrastructure components. Given that the process relied upon by Isachsen and McKendree to identify the brittle structures concentrated on a large-scale area and recognized only those

observable at the land surface, a reasonably conservative assumption is that even more such features and intersections with infrastructure are present. The lengths of identified fractures provide a guide for establishing buffer distances needed to ensure separation of water system components and natural gas drilling activities affecting deep formations.

Based on a statistical analysis of identified fractures and brittle structures in the region, 50 percent of the mapped features have lengths in excess of three miles, and more than 10 percent exceed seven miles in length (Appendix A).

Based on Isachsen and McKendree, the area within and around the NYC watershed is dominated by numerous "linear features" that typically correspond to fractures, both mapped and un-mapped. As such, the intervening rock masses (both horizontally and vertically) between the Marcellus formation and fresh water aquifers or subsurface infrastructure should not be considered as an impermeable barrier, since they are fragmented by a significant number of fractures. The existence of vertical fractures is evident in local rock outcroppings. A local example of such vertically persistent fractures that typify the bedrock character is presented in Figure 2-5, which shows two photos of Plattekill formation outcrops near Ashokan Reservoir. Evident in each photo are vertical fractures that extend across multiple layers of the formation. The Plattekill formation is part of the Hamilton Group of interbedded shales, siltstones and sandstones that overlie the Marcellus formation and underlie NYC tunnels and fresh groundwater and surface water sources.

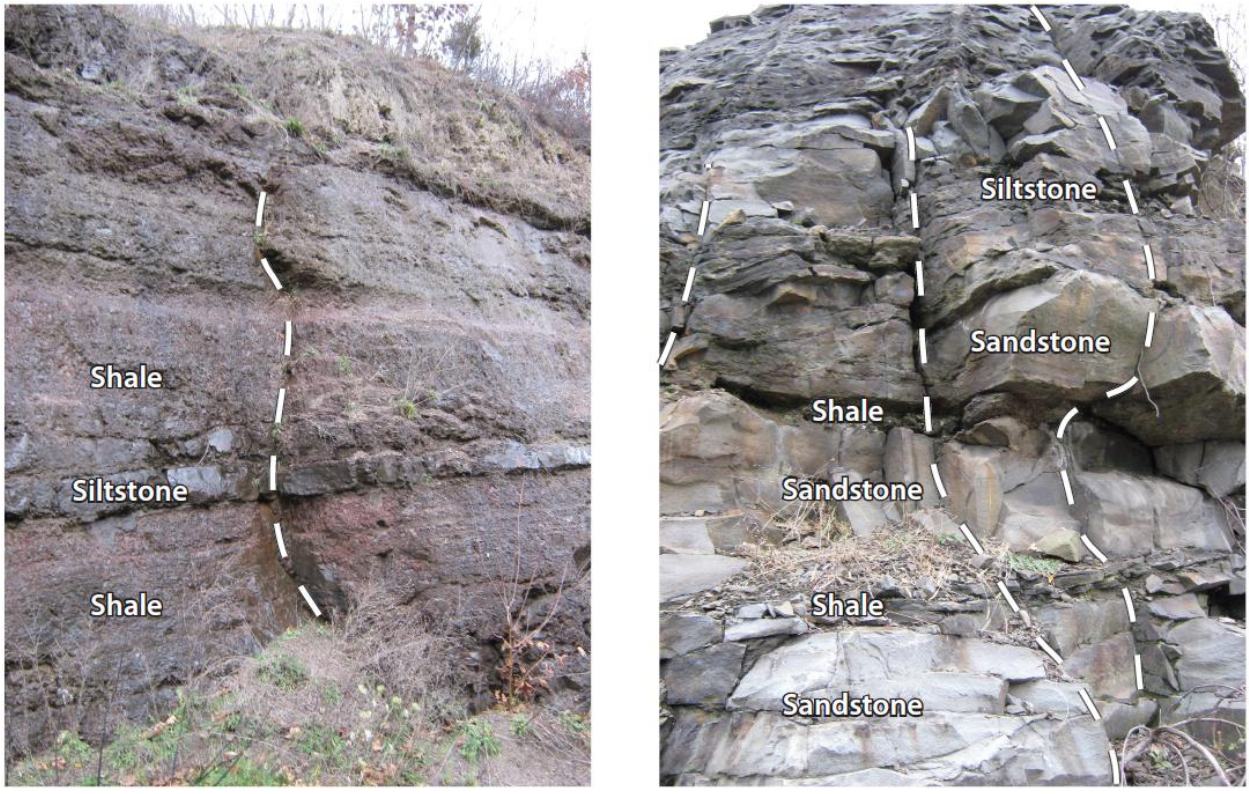

Figure 2-5: Outcrops of the Hamilton Group (Plattekill Formation) near Ashokan Reservoir Showing Persistence of Vertical Fractures across Lithologic Units

2.5 NYC Water Supply Infrastructure Relative to Geological Features

NYC's West-of-Hudson water supply infrastructure has been evaluated in relation to local and regional geologic features. This evaluation has included a review of record drawings and construction documentation, and focused on vertical separation from the Marcellus formation as well as geological features documented during tunnel construction.

Infrastructure Depth and Vertical Separation from Marcellus Formation

The West-of-Hudson water supply tunnels are constructed from several hundred to about 1,000 feet below grade. Regional surface topography ranges from about elevation 1,000 to 2,500 feet. The tunnels upstream of the Rondout and Ashokan Reservoirs are located approximately 1,000 feet above sea level; the tunnels leading from these reservoirs are about 500 feet below sea level. The vertical distance between the Marcellus formation and NYC water supply infrastructure varies from direct contact at the eastern edge of the formation's occurrence, to about 4,500 feet in the western portion of the watershed. Portions of the Shandaken Tunnel, the Catskill Aqueduct, and the bottom of Ashokan Reservoir are separated by as little as 500 feet from the underlying Marcellus formation. Separation increases for infrastructure and reservoirs to the west and the south with increasing depth of the formation. To the west, vertical separation between Delaware system reservoirs and tunnels and the Marcellus ranges from about 2,000 to 4,500 feet.

Geological Features Documented During Construction

Evidence of naturally occurring fluid migration associated with brittle features is reported on record drawings that document the construction of NYC's infrastructure. NYCDEP records indicate that the East and West Delaware Tunnels and Neversink Tunnel construction encountered numerous groundwater seeps, saline water seeps, subsurface fractures, and methane inflows corresponding to the locations of mapped brittle structures. In 1957, methane that had seeped into the West Delaware Tunnel ignited, injuring three miners.[13] Construction of the Rondout-West Branch section of the Delaware Aqueduct also encountered numerous methane seeps. Frequent groundwater and saline water seeps were also encountered during construction of Shandaken Tunnel, sections of the Catskill Aqueduct, and the Rondout-West Branch tunnel.[14] These occurrences substantiate that fractures in the bedrock are naturally providing pathways for the movement of deep formation fluids.

Figure 2-6 highlights a section of the West Delaware Tunnel, where a linear feature identified from regional mapping was encountered as a fault at tunnel depth during construction, as documented in the accompanying excerpt from a tunnel geology drawing. Geological features encountered during construction, including faults and other geological brittle structures, and various seeps, are located on the geologic map of the Delaware system tunnels presented as Figure 2-7. Figure 2-8 shows the geologic features located along a profile of the West Delaware Tunnel, in relation to local surface topography and surficial features, and estimated depth of the Marcellus formation.

[13] The Delaware Water Supply News, April 1, 1964, 23:189, p. 1063.
[14] New York City geologic record drawings.

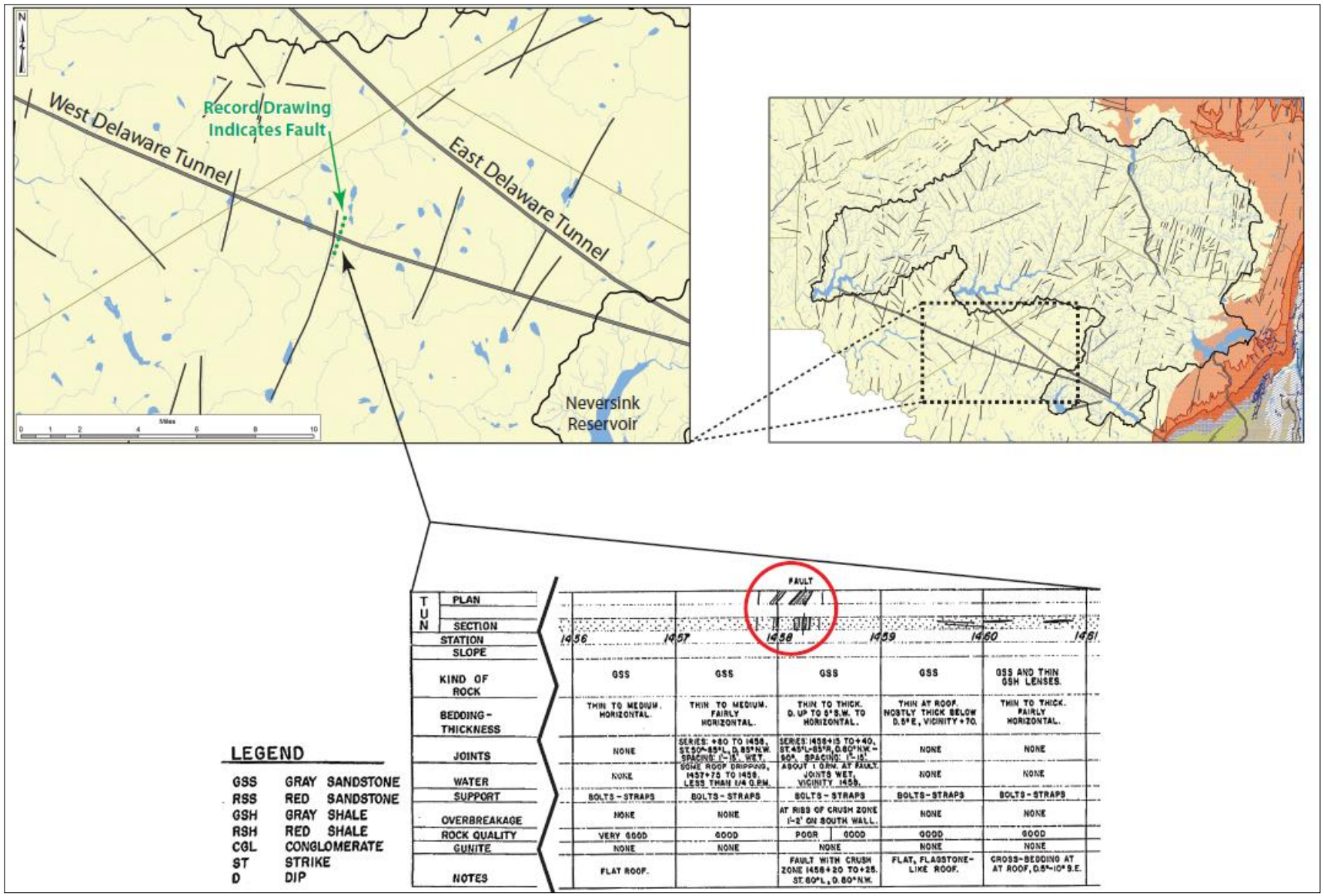

Figure 2-6: Example from West Delaware Tunnel Showing Correlation of Surface Linear Features with Faults Observed During Construction

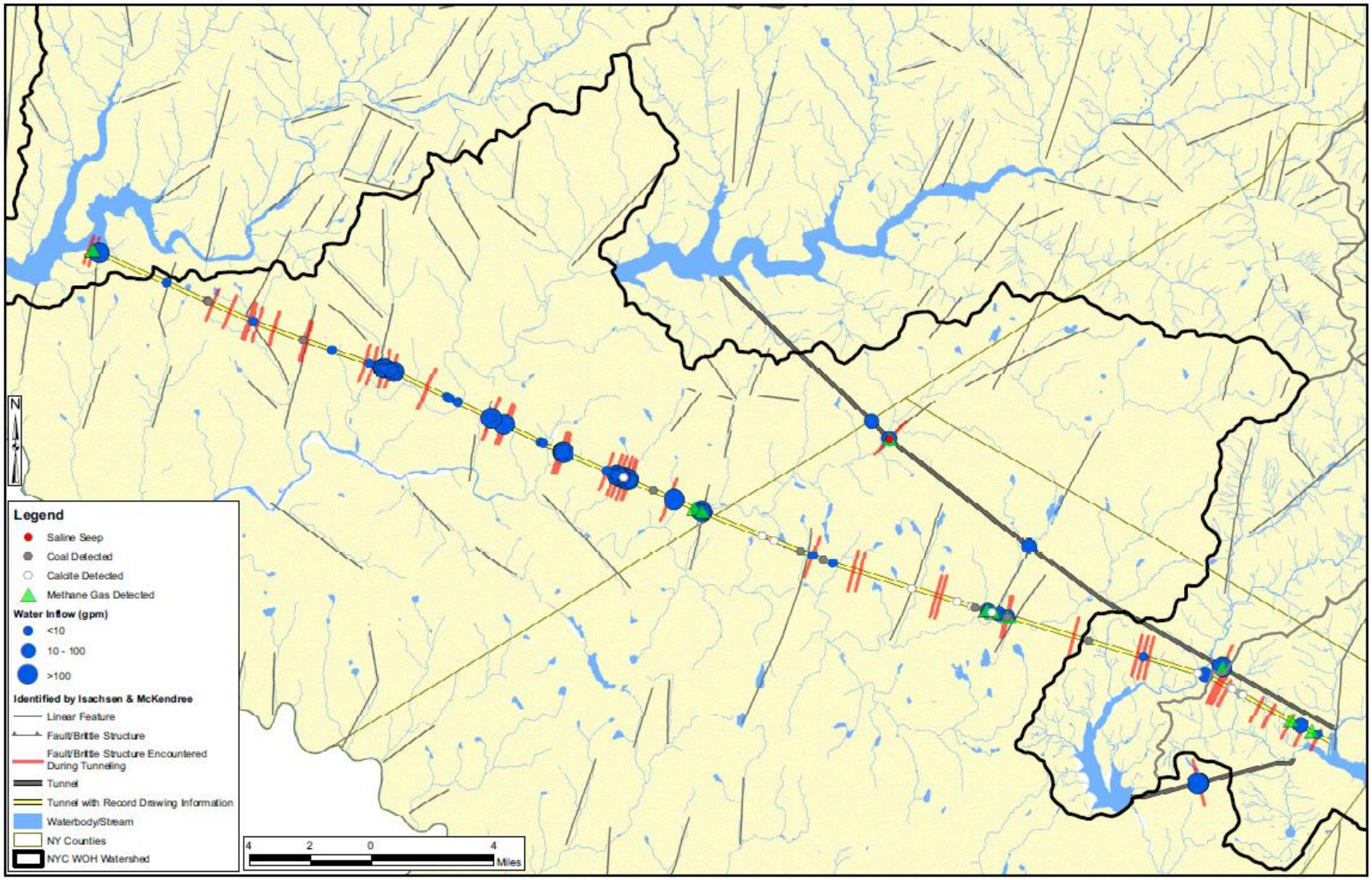

Figure 2-7: Map of the East and West Delaware Tunnels and Neversink Tunnel

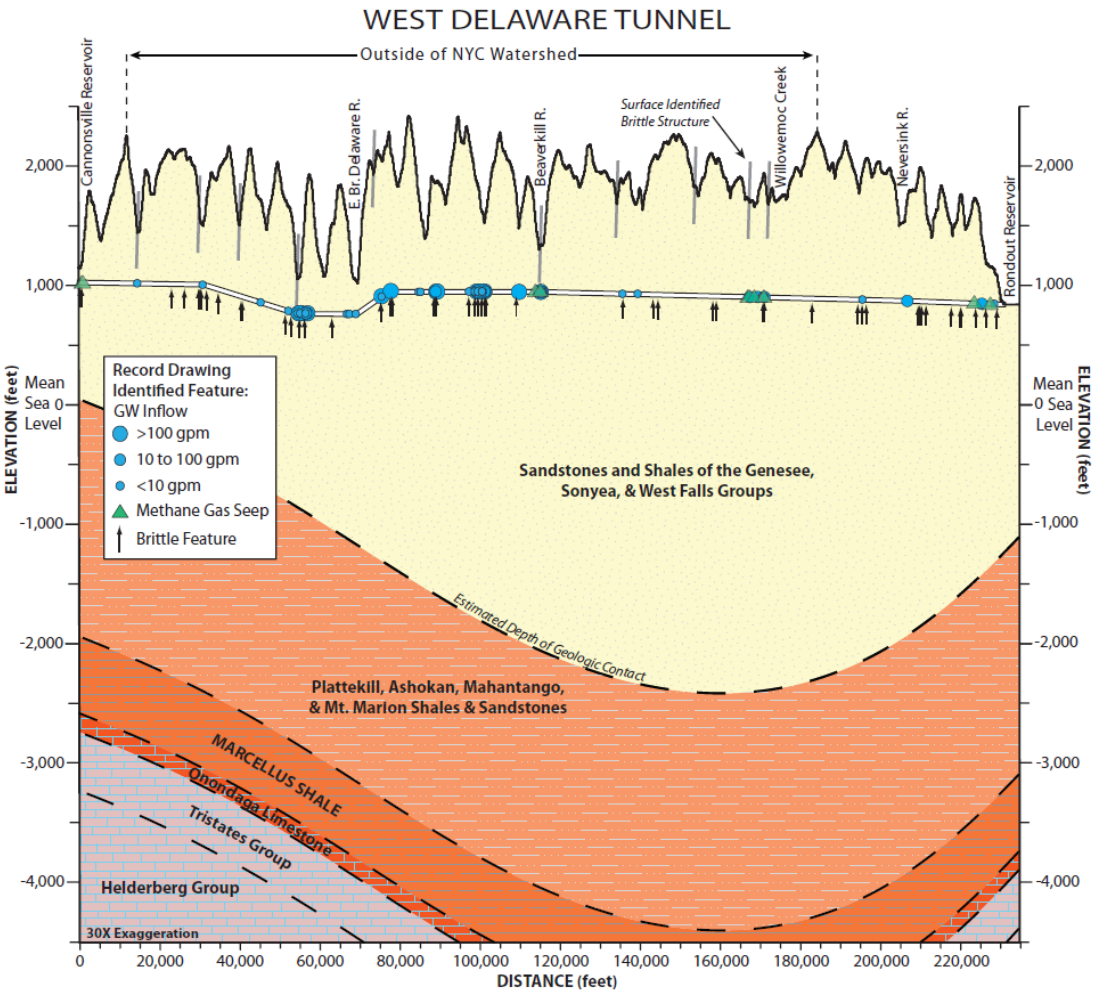

Figure 2-8: Geologic Cross Section of the West Delaware Tunnel

2.6 Summary

Available data, ongoing research performed by the New York State Museum, and comparison with natural gas development progress in northeast Pennsylvania suggests that the NYC watershed is underlain by relatively thick portions of the Marcellus formation with presumably high gas production potential. In addition to the Marcellus, other gas-bearing shale strata underlie the watershed and could be developed in the future. Overall, the NYC watershed area can be expected to be the focus of gas resource development activity comparable to or exceeding that of other contemporary shale gas plays, and this activity can be expected to last for decades.

Under natural conditions, upper geological strata are largely isolated from both methane and water in deep geological strata (formation water). Formation water is typically not potable, even before the addition of chemicals used in the hydrofracturing process. The saline water and methane seeps encountered at grade and in shallow formations near NYC infrastructure during the construction of water system tunnels provide the most reliable evidence that existing fracture systems and pressure gradients will transmit fluid from deeper formations. Taken together with the expected rate and development of gas drilling quantified in Section 3, this evidence of natural migration leads to the conclusion that there is a reasonably foreseeable risk to water supply

operations from methane, fracking chemicals, and/or poor quality, saline formation water migrating into overlying groundwater, watershed streams, reservoirs, tunnels, and other infrastructure.

For these reasons, any evaluation of subsurface migration potential associated with future gas development must fully consider all known and foreseeable linear features and fractures. Extensive subsurface fracture systems and known "brittle" geological structures exist that commonly extend over several miles in length, and as far as seven miles in the vicinity of NYC infrastructure (Appendix A). In addition, the net hydraulic conductivity of a formation must be considered, including the influence of faults and fractures, not just the bulk properties of the rock matrix. Naturally occurring fractures in the rock can result in relatively high localized hydraulic conductivity values; these would be several orders of magnitude greater than those considered in analyses provided as technical support of the dSGEIS.

Section 3: Rates and Densities of Natural Gas Well Development

The Marcellus formation is an extensive resource that occurs beneath much of the State and will require tens of thousands of wells to fully exploit. The risks and impacts from any given individual well may be negligible and acceptable, but when evaluated in the context of hundreds or thousands of other wells, the risks and impacts may be significant and unacceptable. As such, cumulative impacts from many wells constructed throughout the watershed must be evaluated in order to fully characterize the potential risk from concurrent activities at multiple locations. Consistent with this understanding, the dSGEIS establishes the *aggregate* and not the *individual* as the appropriate basis for analysis of regional impacts: "*The level of impact on a regional basis will be determined by the amount of development and the rate at which it occurs.*"[15]

This section provides estimates for the annual rate and ultimate density of natural gas wells that could be developed in the NYC watershed under proposed regulations. These rates and densities are then combined with quantity estimates for various activities associated with one individual well to develop cumulative values (Section 4).

Sufficient data is available from shale gas plays that have been under development in other areas over the last two to ten years to develop reasonable ranges of annual rates of well construction (Appendix B). Since these other plays are still under development, the data from these plays underestimates the expected full build-out density. Therefore, estimates for the total number of wells to be constructed in the watershed are derived from estimates of developable area within the NYC West-of-Hudson watershed combined with average expected well densities per square mile.

3.1 Rates and Densities of Well Development in other Formations

Four major shale gas plays were identified for comparison purposes: Barnett (Texas), Fayetteville (Arkansas), Haynesville (Louisiana), and Marcellus (Pennsylvania) (Figure 1-1). These formations are all gas-bearing shales that require hydraulic fracturing for economic production and have been developed using a combination of horizontal and vertical wells.

Data on New York's Marcellus formation depth, thickness, organic content, thermal maturity, and other factors that have been analyzed by the New York State Museum's Reservoir Characterization Group indicate that the NYC watershed is underlain by portions of the Marcellus with high gas production potential. As such this assessment focuses on counties in other formations that have similarly high potential for gas production. Salient features of these formations and the counties selected for comparison are summarized in Table 3-1.

Well development rates and density for the four shale gas formations and their selected counties are summarized in Figure 3-1, Figure 3-2, and Figure 3-3. Figure 3-1 shows the annual rate of development in the other shale gas plays. Figure 3-2 depicts the density trends noted in the four comparable shale gas plays over the past decade, and Figure 3-3 presents current densities (2009).

[15] dSGEIS Chapter 6.13.2.

Table 3-1: Areas of Major Shale Gas Plays Comparable to Marcellus formation in NYS

Formation (State)	Approximate # Years under Development	Total Formation Area (mi2)	Selected Counties	Area (mi2)	% of Formation Area in Selected Counties
Barnett (TX) (Newark East field)	13	5,000	Denton, Johnson, Tarrant, Wise	3,512	70%
Fayetteville (AR) (B-43 field)	6	9,000	Cleburne, Conway, Faulkner, Van Buren, White	3,589	40%
Haynesville (LA)	3	9,000	Bossier, Caddo, De Soto, Red River	3,100	34%
Marcellus (PA)	2	95,000	Bradford, Lycoming, Susquehanna, Tioga	4,374	5%

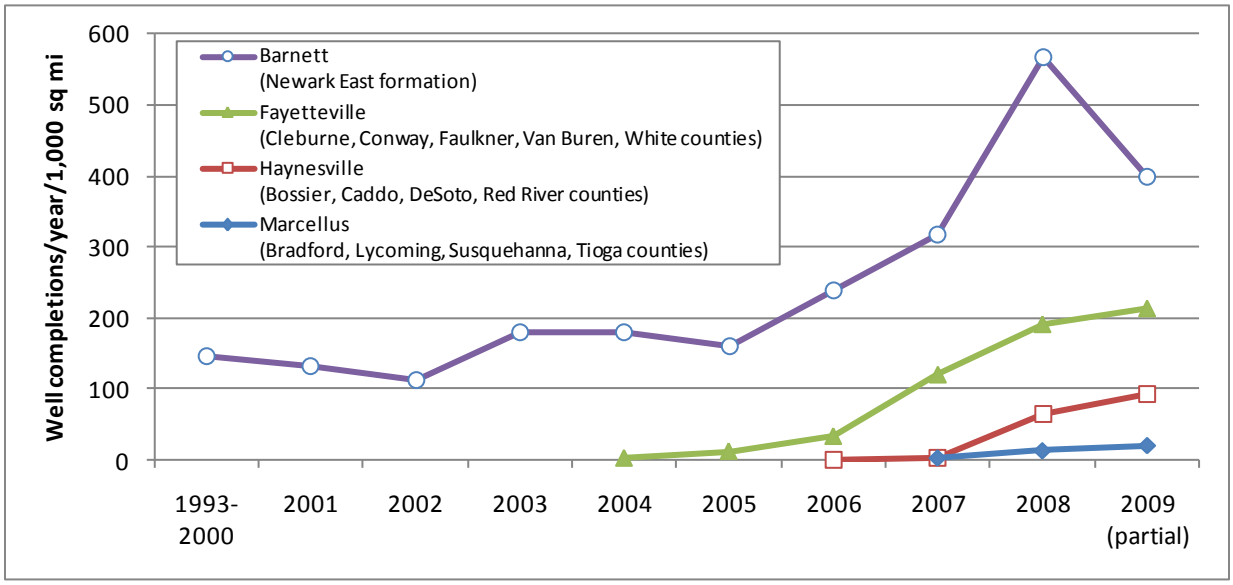

Figure 3-1: Annual Well Completion Rates in Core Counties of Comparable Shale Gas Plays (2001-2009)

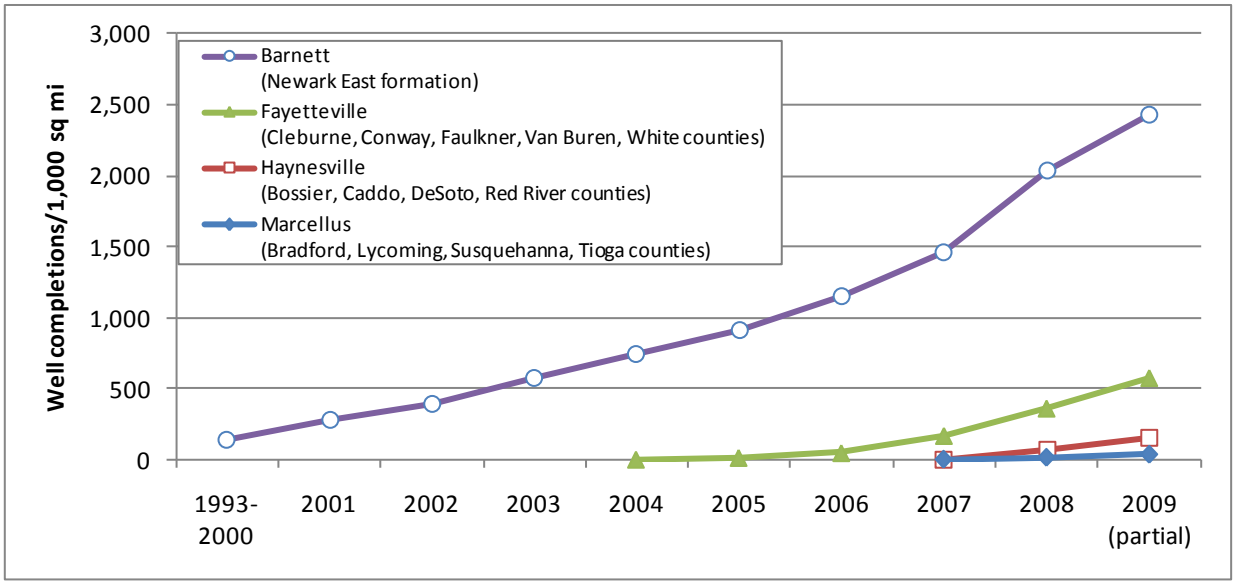

Figure 3-2: Well Density in Comparable Shale Gas Plays (2001-2009)

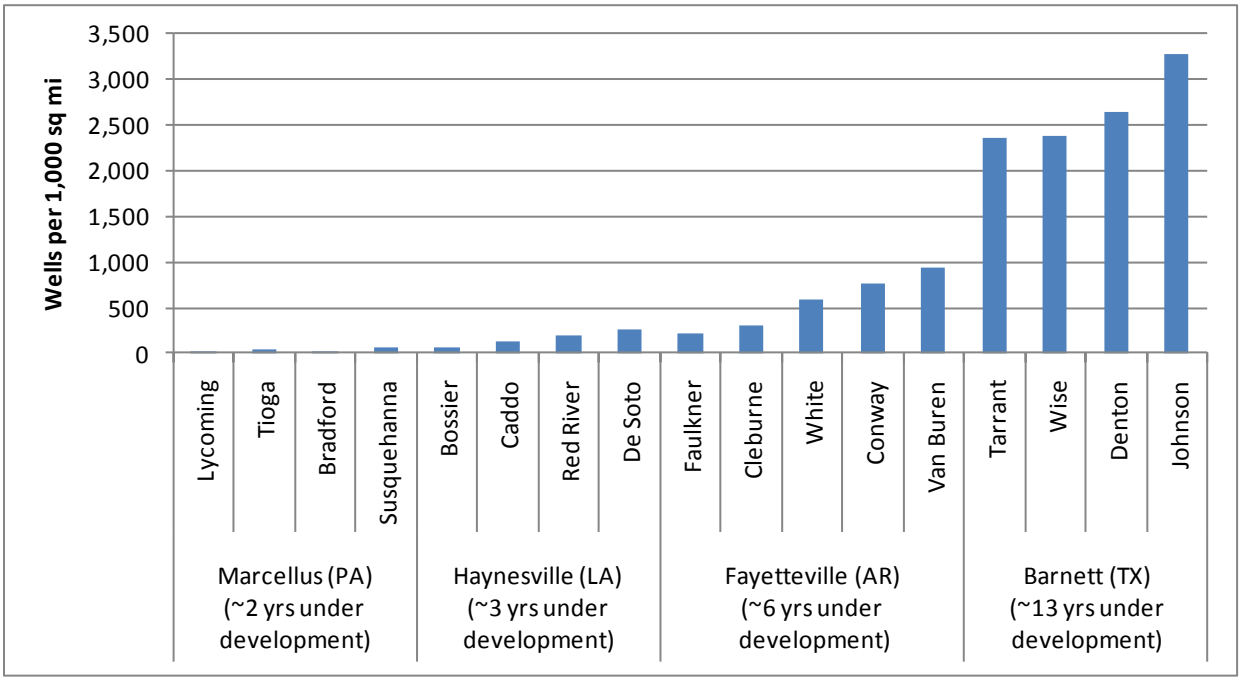

Figure 3-3: Current Well Density in Core Counties of Comparable Shale Gas Plays (2009)

Mapping of natural gas exploration activities in the Marcellus formation in eastern Pennsylvania reveal an accelerating rate of well construction over the two-year period from 2007 to 2009, as shown in Figure 3-4. NYSDEC Notices of Intent to issue well permits in neighboring portions of New York State are also shown. It is reasonable to expect that the pattern and pace of development that could occur in New York State would be similar to that experienced in eastern Pennsylvania. It is important to note that the level of well development shown in the bottom

figure reflects the very early stages of development of the formation, and that a roughly one order of magnitude increase in well density should be anticipated.

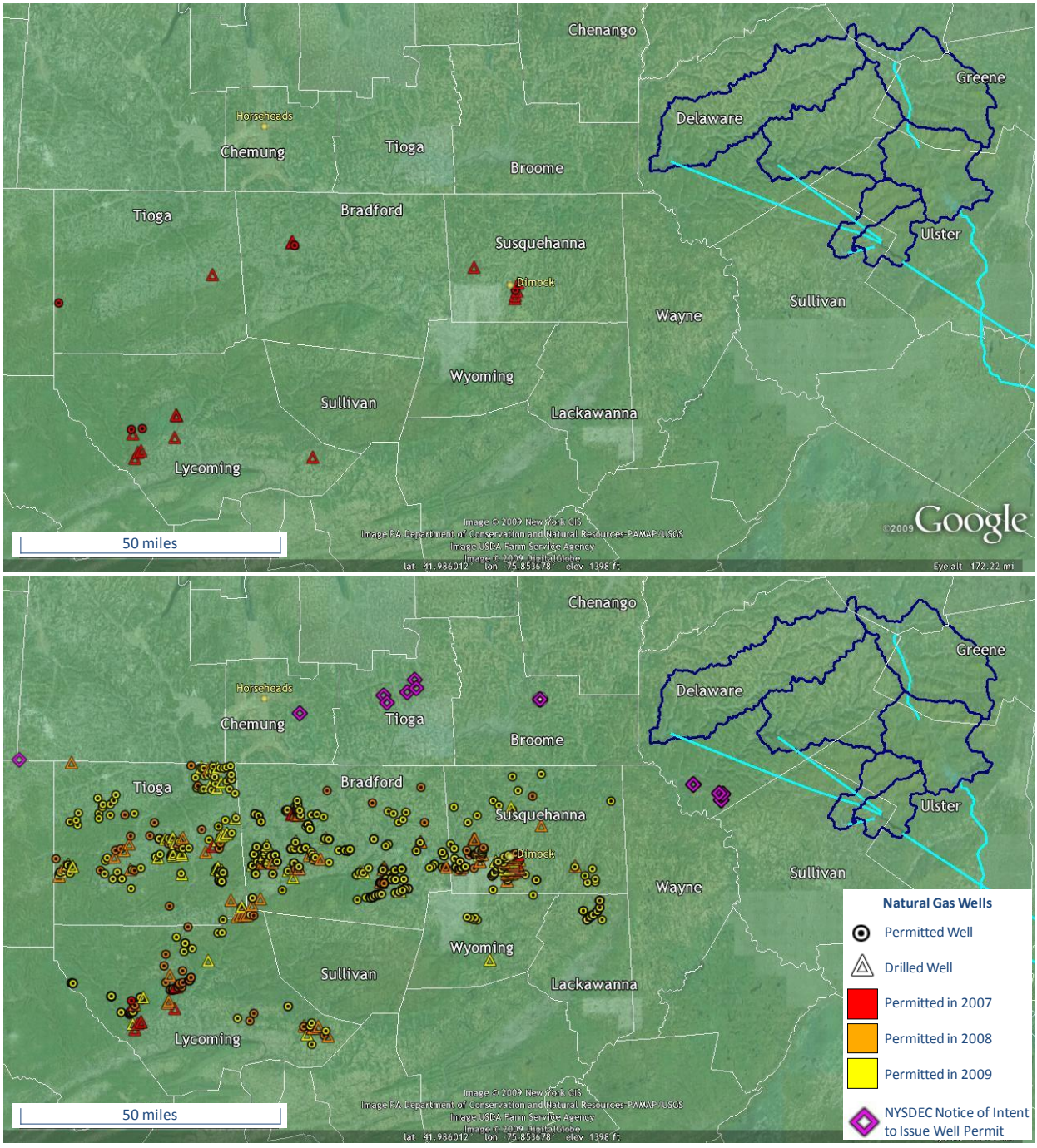

Figure 3-4: Marcellus Formation Gas Well Permitting and Completion in New York and Pennsylvania Core Counties in 2007 (Top) and 2009 (Bottom)[16]

[16] Pennsylvania Department of Environmental Protection Well Data as of 9/30/09 (http://www.dep.state.pa.us/dep/deputate/minres/oilgas/RIG09.htm, accessed 10/21/09). NYSDEC data on Notices

Rates of natural gas well development in the comparable major shale gas formations provides the basis for the scenarios presented in Table 3-2 and are consistent with well development patterns observed to date. Therefore, the scenarios provided are reasonable for estimating potential impacts within the NYC watershed even though the actual rate of development is uncertain due to numerous factors, including natural gas prices, regional economic conditions, State regulations, and formation productivity.

Table 3-2: Annual Natural Gas Development Scenarios

Rate Scenario	Average Annual Well Completions per 1,000 Square Miles	Description
Low	5 to 20	Drilling rate during the early years of the play as operators refine their understanding of the resource and continue to lease land and apply for permits.
Moderate	100 to 300	Rate of well completion that has been sustained for a number of years in other shale gas plays
High	500, based on well completions (potentially as high as 800, based on permit applications)	Rate of development that could potentially occur in the most profitable areas under favorable conditions (e.g., gas prices are very high).

3.2 Rate and Density of Well Development in the NYC Watershed

To calculate the total number of wells that could be developed in the NYC watershed, an average well density was estimated and then applied across the total developable area within the watershed.

In estimating the developable area within the watershed, state forest preserve area[17] and lands controlled by NYC through ownership and conservation easements (shown in Figure 3-5 and Figure 3-6) were excluded.[18] The remaining "uncontrolled" area (1,076 square miles, or 68 percent of the watershed) was then assumed to be between 50 and 100 percent developable. This range of development is consistent with other nearby areas of the Marcellus formation region, such as Bradford County, which has experienced mineral leasing of nearly 85 percent of the total county land area. The resulting estimate of the land area in the NYC watershed available for natural gas development is thus on the order of 500 to 1,000 square miles.

Although New York regulations allow up to 16 wells per square mile, the dSGEIS indicates a lower density, approximately six to nine wells per square mile, is more likely. This estimate is corroborated by recent permit applications in Sullivan County, which are based on five to six wells per square mile.[19] Well densities to date in excess of three wells per square mile over areas comparable in size to the NYC watershed have been documented in other shale gas plays with significantly higher localized densities (e.g., Denton County, TX has a well density of 5.5 wells

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of Intent to Issue Well Permits in Spacing Units Which Conform to Statewide Spacing in New York State as of 10/26/2009 (http://www.dec.ny.gov/dmndata/Well_Reports/Unit_Spacing_SW_Rpt.html, accessed 10/27/2009)

[17] The estimates of State forest preserve land in Figure 3-6 only include land in the Catskill State Forest Preserve, which cannot be leased or sold without a constitutional amendment. The estimates do not include other state land in the NYC watershed which is not afforded a similar level of protection.

[18] Compulsory integration may bring peripheral areas of NYC-controlled or state lands under development.

[19] NYSDEC. 2009. *Notices of intent to issue well permits in spacing units which conform to statewide spacing in New York state*. (http://www.dec.ny.gov/dmndata/Well_Reports/Unit_Spacing_SW_Rpt.html, accessed 9/2/09).

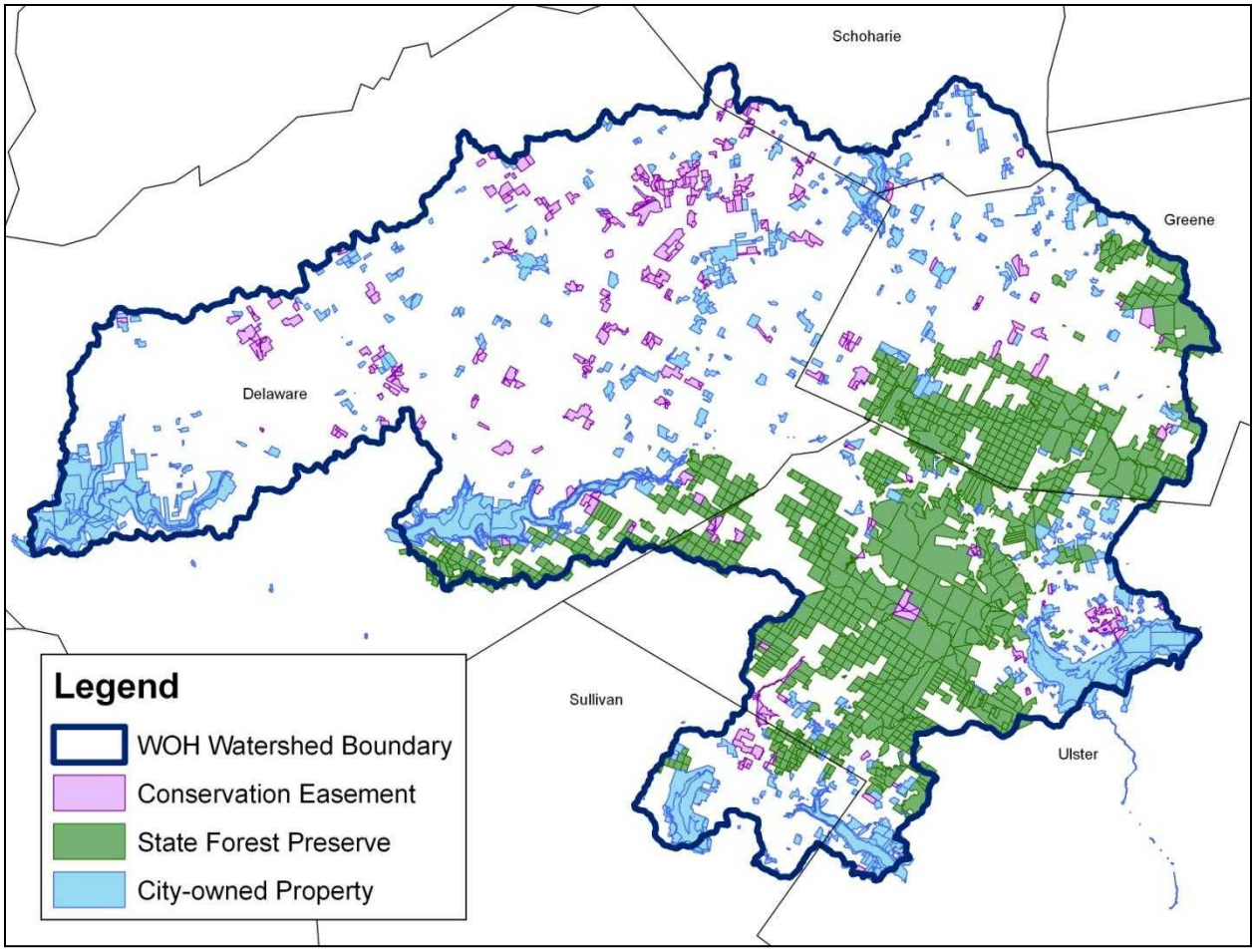

Figure 3-5: NYC West-of-Hudson Watershed Land Ownership (April 2009)

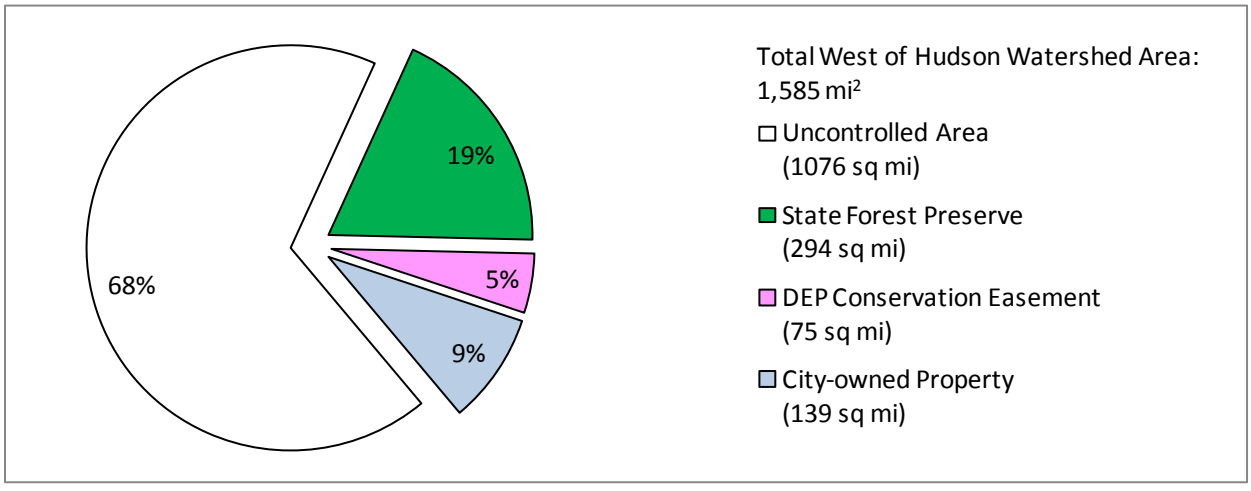

Figure 3-6: Ownership Status of West-of-Hudson Watershed Land (April 2009)

per square mile over approximately 400 square miles [40 percent] of the county area). It has not been established that these areas have been completely developed so still higher densities are possible. Similarly, annual well completion rates in excess of five wells per square mile have been documented, and permit applications suggest that these rates could be higher also. Given the available data, a working estimate of six wells per square mile over the developable area within the watershed is reasonable.

At six wells per square mile, and assuming that 50 to 100 percent of the currently uncontrolled land is ultimately developed, it is estimated that on the order of 3,000 to 6,000 wells could potentially be drilled in the watershed. This estimate is based on the best available data on industry intent for developing the resource in conformance with New York state regulations at this time, and presents a range of development within the watershed that is consistent with that observed in comparable plays.

3.3 Summary

Reasonably foreseeable natural gas well development scenarios for the NYC watershed can be calculated based on experience in comparable formations. Annual well completion rates would likely be 5 to 20 wells per year initially, but could accelerate rapidly under favorable economic and regulatory conditions, averaging 100 to 300 wells per year, and potentially peaking at 500 wells per year. Consistent with NYSDEC spacing unit requirements and development in other formations, it is estimated that between 3,000 and 6,000 wells could ultimately be drilled and fractured in the NYC watershed. This does not include re-fracturing of the same wells, nor does it include drilling and fracturing of wells to tap natural gas in the Utica, Oriskany, or Trenton/Black River formations underlying the NYC watershed.

Section 4: Cumulative Impacts

This section presents an assessment of cumulative impacts associated with natural gas well development in the NYC watershed. The primary focus of the analysis is on drinking water quality, water supply reliability, and infrastructure integrity. This section does not address other potential impacts (e.g., noise, air pollution, habitat disruption, induced growth), though such impacts may occur and deserve full consideration. A summary of estimates of quantifiable gas well development activities is presented for an individual well, for well development on an annual basis, and for a "full build-out" scenario. Subsequent subsections review cumulative impacts in greater detail.

4.1 Quantification of Gas Well Development Activities

Table 4-1 quantifies several critical activities that occur during well drilling and fracturing operations, including site disturbance, water usage, chemical usage, flowback and produced water generation, and truck trips. Estimates for each of these activities are presented for one individual well, based on data presented in the Rapid Impact Assessment Report and the dSGEIS and supporting technical reports. These individual well estimates are then applied to multiple wells to develop order of magnitude estimates of cumulative quantities on an annual basis and a full build-out basis. Assumptions for the annual and total number of well completions under low and high development scenarios are based on estimates presented in Section 3.

Table 4-1 does not account for impacts associated with refracturing that may be conducted to restore declining gas well production rates. Experience in the Barnett shale provides some guidance with respect to the frequency of re-fracturing that may occur in the Marcellus. Based on data in the dSGEIS,[20] two re-fracturing intervals, five and ten years, were examined for the purpose of developing a screening-level assessment of impacts associated with refracturing (Table 4-2).

To develop these estimates, it was assumed that the natural gas wells are constructed over the course of a 20-year development period, and that each individual well has a service life of 40 years.[21] As such, natural gas development and production activities occur over the course of 60 years. Alternative scenarios describing the rate of well completion during the 20-year development period were developed; in all cases the peak annual rate of well completion was limited to 500 wells per year. For the high (6,000 well) build-out scenario and a five year refracturing interval, an additional 42,000 hydrofracturing operations would occur in the watershed over the life of the gas play. For a ten-year interval, an additional 18,000 hydrofracturing operations would occur.

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[20] The dSGEIS states that "*Hydraulically fractured wells in tight gas shale often experience production rate declines of over 50% in the first year. Fractured Barnett shale wells generally would benefit from refracturing within 5 years of completion, but the time between fracture stimulations can be less than 1 year or greater than 10 years*." (dSGEIS, ICF Task 1 Report - Technical Analysis of Hydraulic Fracturing).

[21] The typical well-life expected for horizontally drilled wells in the Marcellus Shale has not yet been established or identified in the dSGEIS. The 40-year service life assumption is made in light of reported estimates for Barnett Shale wells. As an example, a recent article concerning potential royalty estimates assumed a 30-year well life without re-fracturing, but also indicated that it was expected that most Barnett wells would be re-fractured within 7 years, and that continuous re-fracturing could double or even triple the life of the wells. Other sources also estimate Barnett well-life in excess of 30 years. Source: *2008 Tarrant County Barnett Shale Well Revenue Estimate for Neighborhoods* by Gene Powell. Excerpt from May 5, 2008 *Powell Barnett Shale Newsletter*.

Table 4-1: Summary of Individual and Cumulative Impact Estimates

Parameter (units) *Estimate (source)*	Quantity for One Well (range)	Annual Well Development (Quantity/year)		Full Build-out (Total Quantity)	
		Low	High	Low	High
Developable Area (sq mi)	--	--	--	500	1,000
Percent of Total Watershed Area *Total Watershed area is 1585 sq. miles*	--	--	--	32%	63%
Number of Wells *Assume 6 wells/square mile*	1	20	500	3,000	6,000
Site Disturbance (acres) *4 – 6 wells/pad (dSGEIS)*	7	28	700	4,200	8,400
Water Consumption (MG) *Industry and dSGEIS*	4 (3 to 8)	80	2,000	12,000*	24,000*
Chemical Usage (tons) *0.5 to 2% of fracture fluid; assume 1% (dSGEIS)*	167 (83 to 334)	3340	83,500	500,000*	1,000,000*
Flowback (MG) *10 to ~70% of fracture fluid; assume 50%* [1]	2 (0.4 to 2.8)	40	1,000	6,000*	12,000*
Produced Water (MG /yr) *Industry and dSGEIS*	0.075 (0.015 to 0.15)	1.5	37.5	225	450
Truck trips *800 – 2000 per well (RIA)* *890 – 1340 per well (dSGEIS)*	1,200 (800 to 2000)	24,000	600,000	3,600,000*	7,200,000*

Notes:
1. Flowback volume estimates vary widely. The dSGEIS cites flowback as 9% to 35% of fracture fluids for horizontal Marcellus wells in Pennsylvania, but also assumes flowback as 50% of fracture fluid in its estimates of truck trips. NETL cites 25% to 100%.[22] Annual well development calculations use 0.4 MG and 2.8 MG for the low and high estimates, respectively.
* These totals do not include allowance for re-fracturing operations.

Related quantities of water, wastewater and chemicals are summarized in Table 4-2 for the high (6,000 well) development scenario with and without refracturing. Estimates for wastewater quantities assume the same values for fracturing fluid volume, fracture fluid flowback and produced water as for the initial fracturing job, as indicated in Table 4-1. Flowback and produced water estimates are combined to estimate total wastewater production. Waste disposal requirements are represented by calculation of the total dissolved solids (TDS) load assuming a TDS concentration of 100,000 mg/l for both flowback and produced water, which is based on the median reported in the dSGEIS. In order to provide an initial assessment of the feasibility of disposal through dilution with other waste streams, dilution calculations have also been performed that assume that the maximum permissible effluent concentration would be limited to 500 mg/l. Lastly, the total mass of fracturing chemicals is totaled, assuming that these constitute one percent by weight of hydro-fracturing fluid. The resulting estimates are summarized in Table 4-2.

[22] National Energy Technology Laboratory (NETL). 2009. Project description for *Sustainable Management of Flowback Water during Hydraulic Fracturing of Marcellus Shale for Natural Gas Production*.

Table 4-2: Impact of Refracturing on Cumulative Water, Wastewater, and Chemical Volumes

Parameter (units) *Estimate (source)*	Without Refracturing	With Refracturing	
		10-Year Interval	5-Year Interval
Total Number of Wells	6,000	6,000	6,000
CUMULATIVE BASIS			
Total Number of Frack Jobs *Full build-out, high scenario*	6,000	24,000	48,000
Frack Chemicals Used (tons) *1.0% of fracture fluid*	1,000,000	4,000,000	8,000,000
Waste TDS (tons) *100,000 mg/l TDS (dSGEIS)*[2]	12,510,000	27,522,000	47,541,000
ANNUAL BASIS[1]			
Water Demand (mgd) *4 MG per frack job*	3.6 to 5.5	5.5 to 8.2	11.7 to 14.2
Wastewater Production (mgd) *50% Flowback + 0.075 MG/yr Produced Water*	2.6 to 3.5	3.9 to 5.3	6.7 to 8.4
Waste TDS for Disposal (tons/day) 100,000 mg/l TDS in waste (dSGEIS)2	1,100 to 1,500	1,600 to 2,200	2,800 to 3,500
Water Req'd to Dilute TDS to 500 mg/l (mgd)	500 to 700	800 to 1,100	1,300 to 1,700
Frack Chemicals (tons/day) *1.0% of fracture fluid*	150 to 230	230 to 340	490 to 590

Notes:
1. Ranges describe the median and the maximum of the annual average values for each development year. Data for the no-refracturing scenario are drawn from the 20-year period of well development. Data for the refracturing scenarios are drawn from the full 60-year period of development and refracturing.
2. The dSGEIS reports median and maximum values of TDS as 93,200 mg/l and 337,000 mg/l, respectively. The concentration of TDS in flowback reportedly increases with time. The determination of median value may include relatively low concentration samples from initial flowback.

The calculations summarized in Table 4-2 indicate that a 5-year refracturing interval would require sustained water diversion needs on the order of 12 to 14 mgd and approximately 10 mgd of wastewater disposal capacity on an annual average basis. Even without including re-fracturing quantities, sustained water demands of 5.5 mgd and wastewater generation of 3.5 mgd can be anticipated within the watershed. Given the expected development of gas drilling and therefore wastewater services across the entire region, it is reasonable to assume that wastewater generated locally may be disposed of locally. Fracturing chemical usage is estimated to range from 150 tons per day without refracturing to nearly 600 tons per day for refracturing at a 5-year interval.

Note that the analysis summarized in Table 4-2 presents annual average rates; shorter-term variations can be expected to exceed these estimates. The analysis includes well drilling activities for Marcellus spacing units only; additional drilling to develop other formations, if these prove feasible, would be in addition to these estimates. Finally, these estimates are only for wells which are assumed to be located within roughly two-thirds of the NYC West-of-Hudson watershed. Water, wastewater and disposal requirements for wells elsewhere in NYS would be in addition to the quantities summarized above.

Impacts of the estimates presented in Table 4-1 and Table 4-2 are discussed further in the following sections.

4.2 Land Disturbance, Site Activity, and Truck Traffic

Land Disturbance

Site development for a natural gas well begins with clearing and grading land for the well pad, water and wastewater storage area, access road, and utility corridor. Most Marcellus wells are expected to be drilled on multi-well pads; industry estimates cited in the dSGEIS suggest these pads will be on the order of five acres in size. These estimates do not include the area required for access roads, gas transmission lines, or centralized impoundments. The total site disturbance including pad and related features such as road and pipelines is estimated at seven acres per well pad based on data from the Fayetteville Shale.[23]

Once all wells are drilled and completed on a pad, the site is partially restored, leaving an area of roughly one to three acres for maintenance access, produced water storage, and gas production equipment. The site will remain in a partially restored state for the duration of the well's productive life (~20 to 40 years). Full surface restoration of the site occurs after the well is plugged and abandoned.

Assuming a pad size of seven acres and four to six wells per pad, the total land disturbance associated with 3,000 to 6,000 wells in the watershed is on the order of 4,200 to 8,400 acres (6.5 to 13.1 square miles). The total amount of land disturbance on an annual basis will depend on the number of active drill pads in a given year. This is expected to range from less than five active pads per year (fewer than 35 acres per year) in the early years of development to 100 or more (700+ acres per year) during peak years.

Impacts associated with site development activities include habitat loss and fragmentation, conversion of forest or pasture land to gravel or other low permeability compacted material, and increases in stormwater runoff and erosion potential due to reduced infiltration rates, increased flow velocities, and lack of vegetative protection. Drilling sites will likely require a NYCDEP-approved stormwater pollution prevention plan that can be expected to help reduce some of the impacts associated with site disturbance. Review and inspection of stormwater plans/facilities will increase the workload of NYCDEP personnel compared to current levels.

Site Activity

Though well sites and associated disturbance are generally described as temporary impacts, it is important to note that sites will remain active for much longer than the nominal four to eight weeks required to drill and fracture one well. When the time required for initial pad construction, mobilization and demobilization of drill rigs and other equipment, water delivery, flowback time, and waste disposal is considered, the total duration of pre-production activities during which a drill site can be considered active is on the order of four to ten months for one well, depending on site-specific circumstances.[24] During this time, activities may be staged so that multiple wells are under various stages of concurrent development at any given time.

[23] U.S. Department of the Interior. 2008. *Reasonably Foreseeable Development Scenario for Fluid Minerals: Arkansas*. Prepared for the Bureau of Land Management Eastern States Jackson Field Office. March 2008.
[24] See dSGEIS Table 5-15.

Given that six to ten wells are expected to be required to fully exploit the natural gas resources in a 640-acre spacing unit, and given that ECL §23-0501 requires all horizontal wells in a multi-well shale unit to be drilled within three years, it is reasonable to expect that a given well site will be undergoing a relatively high and constant level of industrial activity for at least one and up to three years. This same level of activity can be expected to recur periodically over the life of the well, depending on the frequency of subsequent re-fracturing operations.

Truck Traffic

Development of natural gas resources in the watershed will be accompanied by a significant increase in the level of heavy truck traffic compared to current conditions. The dSGEIS estimates the number of truck trips per well at roughly 900 to 1,300, approximately two-thirds of which are for water and wastewater hauling. On an annual basis, the number of additional truck trips per year could range from 24,000 to 600,000, depending on the number of wells drilled in a given year (Table 4-1). The increased number of travel cycles in the area will increase the risk of accidents.

NYCDEP owns and maintains 94 miles of secondary two-lane highways and 32 bridges in the West-of-Hudson watershed. Large volumes of truck traffic will stress these and other local roads and bridges, thus increasing maintenance and capital costs but also increasing the risk of accidents that result in leakage or spillage of hazardous materials. The risks associated with such spills are quantified in Section 4.5.

Other Drilling Infrastructure

In addition to trucking activity, gas well development in the watershed will be accompanied by provision of equipment and material supply systems (warehouses, garages, support services), gas gathering and pipeline systems, compressor stations, and waste disposal systems.

4.3 Water Withdrawals

The volume of water required to fracture a horizontal well depends on a variety of factors, including characteristics of the target formation, the length of the lateral, and fracture goal. Industry data cited in the dSGEIS indicates that on the order of three to eight million gallons of water may be required to fracture a horizontal well in the Marcellus formation. Assuming an average of four million gallons per well, the estimates presented in Table 4-2 indicate that on the order of one to two billion gallons per year of additional demand could be placed on the watershed's resources. Note that these estimates do not include possible diversions of water from the NYC watershed for fracturing of wells outside the watershed. Withdrawals of this magnitude may appear insignificant; however, given current and future demands for water from the NYC system any reduction in system yield is of concern. Extrapolating from OASIS modeling done to support the development of the current Delaware Reservoirs Flexible Flow Management Program (FFMP), a reduction of system inflows on the order of four million gallons per day would require the expansion of system storage by approximately 1 billion gallons to maintain safe yield.[25]

[25] Flexible Flow Management Program, Agreement of the Parties to the 1954 U.S. Supreme Court Decree, Effective December 10, 2008 (http://water.usgs.gov/osw/odrm/documents/FFMP_FINAL.pdf).

Excessive surface water withdrawals could reduce inflow to NYC reservoirs, reduce available supplies, and decrease the probability of refilling reservoirs prior to drawdown. Excessive groundwater withdrawals could deplete aquifers, resulting in reduced baseflow in watershed streams or wetlands. The severity of such impacts will depend heavily on the total amount of withdrawals from the West-of-Hudson watersheds, as well as the timing of such withdrawals. Withdrawals during periods when reservoirs are full and spilling would likely have little or no impact on supply reliability. In contrast, withdrawals during dry periods could increase the length of time spent under drought watch, warning, or emergency conditions.

Excessive withdrawals could also impact water system operations by requiring increased reservoir releases to meet in-stream flow requirements. For example, large volume water withdrawals downstream of Pepacton, Cannonsville, or Neversink Reservoirs could necessitate additional releases from those reservoirs to satisfy Delaware Basin release requirements. Similarly, withdrawals from the Upper Esopus Creek could require increased releases from Schoharie Reservoir to meet Esopus Creek minimum flow requirements. Excessive water withdrawals may also impact aquatic habitat and biota.

It has been reported that in the absence of control mechanisms, a number of streams in Washington County in southwestern Pennsylvania (outside the jurisdiction of the Delaware and Susquehanna River Basin Commissions) have been nearly drained or pumped dry from excessive withdrawals for Marcellus wells.[26] Such a scenario in the NYC watershed could result in adverse impacts to water supply reliability.

4.4 Chemical Usage

Water and sand have been reported to comprise 98 to 99.5 percent of the fracturing fluid mixture, with the remaining 0.5 to 2.0 percent consisting of an array of chemical additives used to control fluid properties during the various stages of the fracking process.[27,28,29] Though the *proportion* of chemicals in fracturing fluid is indeed low relative to the large amounts of water required by the fracturing process, meaningful assessment of potential water quality impacts requires that chemicals additives be expressed on a mass basis.

Table 4-3 summarizes the proportion and the mass of water, proppant (sand), and each of 12 major classes of chemical additives required for a single four million gallon fracture operation. The proportions in this mixture are based on data from the Fayetteville Shale, as presented in the dSGEIS.[30] Chemical additives make up 0.446 percent of this mixture, or roughly 82 tons. For a frack mix with one to two percent chemicals, the mass of chemical additives would be approximately 167 tons and 324 tons, respectively. Chemical usage estimates presented in Section 4.1 assume that chemical additives make up one percent of the fracturing fluid mixture. Under this assumption, development of 6,000 wells over a 20 year period would entail fracturing

[26] Parsons, J. (2008). *Pa. Streams Drained Dry By Drillers*. WTAE, Pittsburgh, November 13, 2008.
[27] Arthur, J.D., B. Bohm, B.J. Coughlin, and M. Layne. (2008). *Evaluating the Environmental Implications of Hydraulic Fracturing in Shale Gas Reservoirs*. ALL Consulting, Tulsa OK.
[28] Fortuna Energy (2009). *Marcellus Natural Gas Development*. Presented at NYWEA 2009 Spring Technical Conference, West Point, NY, June 2, 2009.
[29] U.S. Department of Energy, Office of Fossil Energy. (2009). *Modern Shale Gas Development in the United States: A Primer*, prepared by the Ground Water Protection Council and ALL Consulting, Washington, DC.
[30] dSGEIS, URS Technical Report *Water-Related Issues Associated With Gas Production in the Marcellus Shale*, Figure 2-1.

chemical usage at a rate of 150 to 230 tons per day, or up to 590 tons per day with refracturing at 5-year intervals.

Table 4-3: Mass of Water, Sand and Major Classes of Fracturing Fluid Chemical Additives Required for one 4 MG Fracture Operation

	Percent by mass[1]	Mass required for one 4 MG fracturing operation (tons)
Water	90.6%	16,690
Proppant	8.96%	1,651
Acid	0.11%	20.3
Surfactant	0.08%	14.7
Friction Reducer	0.08%	14.7
Gelling Agent	0.05%	9.2
Clay Stabilizer/Controller	0.05%	9.2
Scale Inhibitor	0.04%	7.4
pH Adjusting Agent	0.01%	1.8
Breaker	0.01%	1.8
Crosslinker	0.01%	1.8
Iron Control	0.004%	0.7
Bactericide/Biocide	0.001%	0.2
Corrosion Inhibitor	0.001%	0.2
Total (all constituents)	100.0%	18,423 tons
Total (chemicals only)	**0.446%**	**82.2 tons**

Notes:
1. dSGEIS, URS Technical Report *Water-Related Issues Associated With Gas Production in the Marcellus Shale*, Figure 2-1.

Chemicals in drilling and fracturing fluid may be introduced into surface waters and ultimately into the water supply as a result of vehicle accidents during transport of raw chemicals to a drill site or removal of wastes from the site, via spills resulting from improper chemical storage and handling at drill sites, and via airborne and subsurface pathways. Chemicals introduced into the ground during the hydraulic fracturing process are not fully recovered. Based on data from horizontal Marcellus wells in northern Pennsylvania reported in the dSGEIS, on the order of 65 to 90 percent of the fracturing fluid may remain in the subsurface. As described in Section 2 and subsequently in Section 4.6, these chemicals can migrate beyond the fracture zone into overlying groundwater, watershed streams, reservoirs, and directly into tunnels and ultimately enter the water supply.

Chemical usage is a significant concern for watershed water quality because many drilling and fracturing fluid additives contain chemicals that are known to be toxic to the environment and hazardous to human health. This concern is heightened by the fact that the exact chemical composition of many additives is not disclosed. Well drilling and fracking products are proprietary and typically protected by trade secret laws, thereby limiting disclosure requirements. Consequently data is limited on the identity and amounts of specific chemicals that could be used during drilling and fracturing operations in or near the NYC watershed.

The fracturing chemical data obtained by NYSDEC from service companies and chemical suppliers during the dSGEIS preparation process highlights the difficulty in obtaining full chemical composition data. Data was received for 197 products, 23 percent of which were not characterized by full chemical composition data. The 197 products were composed of 260 unique chemical components and another 40 components which are mixtures or otherwise not fully characterized. This challenge is also evidenced in a database of fracturing products and chemicals developed by The Endocrine Disruption Exchange (TEDX, Paonia, CO) and reviewed in connection with this project. The database identifies 435 products composed of over 340 individual chemical constituents. The exact chemical composition of over 90 percent of the products in the database is unknown.

Of the known constituents identified in the dSGEIS and by TEDX, many are recognized as hazardous to water quality and human health. The dSGEIS identified chronic or acute health effects such as cancer or impacts to the reproductive, respiratory, gastrointestinal, liver, kidney, or nervous systems for one or more chemicals in nine of eleven chemical structural categories. The analysis did not characterize health effects for each individual chemical, citing "very limited" compound-specific toxicity data for many fracturing chemicals. Of the products identified in the TEDX database, significant percentages contain one or more chemicals that are associated with negative health effects: cancer (33% of products contain one or more chemicals associated with cancer), endocrine disruption (41%), reproductive problems (34%), immune suppression (58%), genetic mutation (43%), and other adverse health impacts.

The use of fracturing fluid additives containing known or suspected carcinogens, endocrine disrupting compounds (EDCs), or other contaminants that may cause human health impacts from long-term or chronic exposure at very low doses is of particular concern to the water supply. As mentioned above in Section 1.3, the regulations concerning drinking water quality are continually evolving. It is reasonably foreseeable that future regulations will include lower thresholds and encompass emerging contaminants of concern, including EDCs. Accordingly, the introduction of hundreds of tons per day of fracturing chemicals into the watershed over a period of several decades, the possibility of subsequent gradual penetration of low levels of contaminants into the environment and the water supply via multiple transport pathways, and the difficulty of removing many of these contaminants from groundwater and surface supplies, pose public health risks that should be carefully considered and avoided.

4.5 Surface Spills

Accidental spills, leaks, and releases associated with natural gas well drilling and fracturing activities have resulted in hundreds of documented groundwater and surface water contamination incidents across the country. Surface spills can be a relatively common occurrence at well sites because the drilling and fracturing process involves transfer of large volumes of fluids between trucks, tanks, wells, pits, etc., often at high flow rates and pressures, substantially increasing the likelihood of a spill due to human error, equipment failure, or accident.

Surface spills in the NYC watershed may be categorized as resulting in either acute or chronic impacts based on proximity to streams and reservoirs. Acute spills are considered here to include accidental or intentional chemical releases that occur adjacent to or in a stream or reservoir. Chronic spills are considered to occur at the well site or beyond the immediate vicinity of a stream or reservoir.

Acute Spills

There are a number of acute surface spill scenarios of concern in the NYC watershed, such as a truckload of raw fracking chemicals or a tanker of flowback/produced water releasing its contents into a NYC reservoir or tributary stream. In addition to substantially compromising operations and public confidence in the water supply, acute spills could also result in MCL violations. Given the enormous volume of chemicals and wastewater that could be transported into and generated within the NYC watershed over a multi-decade development period, acute spill scenarios are realistic and should be expected. This is particularly true in light of the proximity of roads adjacent to NYC reservoirs and the heavy volume of truck traffic required to haul wastewater and chemicals.

To examine the sensitivity of the NYC water supply to acute spills of fracturing chemicals, an analysis of the mass of fracturing chemicals required to violate an MCL at Kensico Reservoir was conducted (Appendix C). The analysis is based on fracturing chemical data and assumptions presented in dSGEIS supporting documents.[31] Both the dSGEIS analysis and the following analysis are structured as simple dilution calculations that assume the chemical mass enters a reservoir directly and is completely and instantaneously mixed with its contents.

Consistent with dSGEIS assumptions, reservoirs were assumed to be one-third full. Such low storage levels would only be expected to occur under severe drought conditions. However, the one-third full assumption is equivalent to the more realistic situation in which the reservoirs are relatively full and the contaminant mass mixes with only one-third of the reservoir's volume as a result of short-circuiting. Complete mixing in reservoirs with volumes as large as NYC's is not a reasonable assumption under most circumstances. Short-circuiting due to stratification, density currents, and prevailing flow patterns is considered more typical.

Two spill scenarios were considered, the key difference between them being the volume into which the chemical mass is diluted:

- Scenario 1 dilutes the contaminant mass with the contents of Kensico Reservoir. This represents a situation in which a load of fracturing chemicals spills into Rondout and the chemicals short-circuit into the intake chamber and are conveyed downstream to Kensico Reservoir.
- Scenario 2 dilutes the contaminant mass with the contents of Kensico and Rondout Reservoirs. This represents a situation in which a load of fracturing chemicals spills into Rondout or near its mouth and mixes completely with the contents of Rondout and Kensico. This is also representative of the impact of spill into Cannonsville, Pepacton, or Neversink Reservoirs that occurs near their respective intake structures.

Under these simple dilution assumptions, the mass of chemical required to violate an MCL is simply the product of the reservoir volume and the MCL, which is 0.05 mg/l for all chemicals considered here. To gauge the number of wells or hydrofracturing operations associated with the mass of chemical required to violate an MCL, data from the dSGEIS analysis was used to

[31] dSGEIS, Alpha Technical Report, *Survey of Regulations in Gas-Producing States, NYS Water Resources, Geology, New York City Watershed, Multi-Well Operations, and Seismicity*, Section 4.8 and Tables 4.3 – 4.5.

develop an estimate of the mass of each chemical required to fracture one well.[32] This data is presented in Table 4-4, along with an estimate of the mass of chemicals required to violate an MCL in Kensico, expressed in terms of fracture job equivalents, for both Scenarios 1 and 2.

Table 4-4: Fracturing Chemical Spill Scenarios for Kensico Reservoir

Chemical *0.05 mg/l MCL for all chemicals*	Estimated mass required to fracture one well (kg)	Fracture job equivalents required to exceed MCL	
		Scenario 1 (dilution with volume of Kensico)	Scenario 2 (dilution with volume of Kensico + Rondout)
2,2,-Dibromo-3-Nitrilopropionamide (1)	3019	0.6	1.7
Methanol (1)	1565	1.2	3.2
Ethylene Glycol (1)	1110	1.7	4.6
C12-15 Alcohol, Ethoxylated (2)	1110	1.7	4.6
Ethoxylated Castor Oil (2)	555	3.5	9.1
Isopropanol (Isopropyl Alcohol) (2)	555	3.5	9.1
Ethoxylated C11 Alcohol (1)	555	3.5	9.1
Alcohols C9-11, Ethoxylated (1)	391	4.9	12.9
(1) dSGEIS Frack Mix 1 (2) dSGEIS Frack Mix 2			

For Scenario 1, the mass of chemicals associated with just one to five hydraulic fracturing operations could be sufficient to violate an MCL at Kensico Reservoir. For Scenario 2, the mass of chemicals associated with two to thirteen hydraulic fracturing operations could be sufficient to violate an MCL at Kensico Reservoir.[33]

This analysis should not be taken to indicate that these or comparable spill scenarios would constitute an imminent threat to public health. In the event of a major spill operators would respond immediately upon learning of the event and take appropriate operational measures to protect the water supply, including water quality sampling, adjusting intake levels, reducing flow rates or taking reservoirs off-line, etc.

This analysis does suggest that large scale development of natural gas wells in the watershed, and associated substantial increases in chemical and waste hauling, can be fairly characterized as increasing the risk of water quality impairment relative to current conditions. It also highlights the importance of stream and reservoir buffers in mitigating such risks.

Though this analysis has focused on MCLs, it is important to note that water quality contamination is important in and of itself, even if it does not trigger an MCL violation. NYCDEP's mission is not to supply water that merely meets regulatory limits but "to reliably

[32] Due to confidentiality requirements the dSGEIS analysis does not present data on the mass composition of additives or the mass of additives or constituent chemicals required to fracture a well. The scenarios presented in the dSGEIS analysis do provide sufficient information to back-calculate the mass of chemicals required to fracture a well.

[33] Undiluted hydrofracking chemicals are trucked to well sites and then mixed with large volumes of water. Multiple wells may be fractured on a well pad sequentially or at nearby wellpads and therefore significant quantities of undiluted chemicals could be involved in a surface spill.

deliver a sufficient quantity of *high quality drinking water* and to ensure the *long term sustainability* of the delivery of this most valuable resource."[34]

Chronic Spills

In addition to acute spills, it is reasonable to expect that development of natural gas resources in the watershed will be accompanied by an increased frequency of chemical, wastewater and fuel spills at or near well pads. This is a natural outcome of a complex and intensive industrial activity occurring dozens or hundreds of times per year across the watershed. Site spills can be reduced through implementation of best management practices (BMPs) for pollution prevention, waste minimization, chemical handling and storage, etc. Even with appropriate BMPs and regulations, however, mechanical failures, human errors, and accidents are inevitable. Impacts will be minor when on-site personnel respond quickly and limit the impacts of the incident. But significant contamination can occur when spills go undetected, plans are not followed, equipment is not maintained, and/or BMPs are not implemented.[35]

Even if most site spills are mitigated with minimal impact, the chronic occurrence of multiple spills per year over a period of several decades can be expected to compromise public confidence in the quality of NYC's unfiltered water supply.

4.6 Subsurface Migration

Subsurface migration of fracturing fluids or formation water and pressures could present risks to potable water supplies if such fluids were to intercept a shallow fresh water aquifer or NYC infrastructure. Potential migration pathways include migration of fracturing and formation fluids along the well bore as well as migration across and out of the penetrated and hydraulically fractured strata. This section identifies risks associated with these migration pathways. Containment of fluids within the well-bore is provided for by well construction techniques that include multiple casings and cemented annular spaces extending below fresh water aquifers. The competency of the overlying strata and control of the fracturing process to limit induced fractures to the target formation are relied upon to provide a hydraulic barrier for containment of fracturing and formation fluids within the gas-bearing formation.

The review of regional geology and tunnel construction data presented in Section 2 indicates that vertical migration of deep groundwater, methane and/or fracking chemicals is a foreseeable occurrence, given the existence of naturally occurring and laterally extensive vertical brittle geological structures, and the documentation of faults and seeps during tunnel construction. This section also considers whether activities and subsurface alterations that can be anticipated to accompany natural gas exploration and development would present a risk to subsurface water supply infrastructure or operation.

The presence of numerous brittle structures in the regional bedrock is well documented. Presently identified brittle structures that have been mapped in the Catskill/Delaware watershed can extend up to seven miles laterally and up to 6,000 feet in depth.[36,37] The vertical and lateral persistence of these features in conjunction with the potential for failed casings or other

[34] NYCDEP-BWS Mission Statement.
[35] Case studies are provided in the Rapid Impact Assessment, NYCDEP, 2009.
[36] Hill et al, 2008.
[37] Engelder and Lash, 2008.

unforeseen occurrences could result in significant surface and subsurface contamination of fresh water aquifers, as illustrated by incidents in other well fields, most notably documented in Garfield County, Colorado (migration of toxic formation material through subsurface fractures) and Dimock, Pennsylvania (migration of natural gas to the surface via improperly cased wells). Similar mechanisms could permit migration of material into the fresh water aquifers that comprise the NYC West-of-Hudson watersheds and present potential risks to water quality and tunnel lining integrity.

Existing Migration Pathways

Brittle geological features such as faults, fractures and crushed zones were encountered during water supply tunnel construction. Groundwater inflows were also encountered at numerous locations during tunnel construction, and in several cases, these align with mapped faults, fractures or linear features. More importantly saline, methane, and hydrogen sulfide seeps were encountered as well. These seeps are considered to be indicative of a hydraulic connection to naturally-occurring pressurized groundwater/fluids from much deeper strata. Existing connections to deeper strata can transmit pressurized fluids (e.g., saline and/or radioactive formation water and residual hydrofracturing chemicals) upward to the vicinity of the fresh water aquifer and tunnels (and to the surface).

Casing and/or grouting problems, improper plugging or abandonment of wells, extensive subsurface fractures and the region-wide development requiring the operation of thousands of wells may enhance existing hydraulic connections and/or create new connections. Wells that are not properly plugged and abandoned could become a conduit for the introduction of contaminated fluids into the fresh water aquifer. It is estimated that location and condition records are lacking for over 50 percent of the previously constructed oil and gas wells in New York State. State-wide this amounts to approximately 40,000 existing wells that could serve as migration pathways for injected fluids but for which regulators do not have sufficient information to take protective actions. Given the prior history of oil and gas development, most of these are presumably in the western part of the state. However, some gas wells were drilled in the watershed region, indicating prior interest in developing the resource and the possibility of undocumented or improperly abandoned wells.

Effects on Underlying Strata and Migration Pathways

The force of thousands of feet of overlying rock produce high lithostatic pressures in deep low permeability gas reservoir rock units such as the Marcellus formation. Given the low primary porosity of these units they are often considered to act as a hydraulic barrier that can prevent the migration of fluids from lower formations to overlying strata. Hydrofracturing for natural gas development diminishes the isolating properties of the targeted shale, compromising the integrity of this subsurface barrier between surface aquifers and naturally occurring, low quality formation water, as well as other fluids introduced into the shale.

New fractures generated during well development and stimulation that propagate vertically beyond the target formation can create or enhance hydraulic pathways between previously isolated formations. Technical supporting documents provided with the dSGEIS indicate that:

> *"Hydraulically induced fractures often grow asymmetrically and change directions due to variations in material properties. In formations with existing natural fractures, such as*

the Barnett and Marcellus shales, hydraulic fracturing can create complex fracture zones as fracturing pressure reopens existing fractures and as induced fractures and existing fractures intersect. Actual fracture patterns are generally more complex than the current conceptual models predict." (dSGEIS ICF Task 1 Report, p5)

This, and several other similar statements in technical documentation provided in support of the dSGEIS, suggest that extension of induced hydraulic fractures above the target formation, although not an intended result, can be anticipated to occur in some cases when hydrofracturing a large number of wells. Furthermore, subsurface features are expected to be stressed or altered in the future as a result of naturally occurring geologic changes and/or disturbances associated with widespread hydraulic fracturing. The dSGEIS indicates that fracturing may be accompanied by "as much as" a one percent increase in volume of the hydrofractured rock. It is reasonable to anticipate that this would alter rock stresses over an indeterminate distance which could facilitate fluid migration along existing brittle geological structures. The long-term impacts from thoroughly and extensively fracturing and expanding a rock unit that underlies a widespread area to the greatest extent that is economically feasible and then depressurizing the formation through the removal of compressed gas is difficult to quantify; especially in terms of how the overall activity will impact brittle structures in the overlying strata. Potential impacts that can be anticipated include movement of fluids at faults and fractures, alteration of subsurface flow pathways, vertical migration of fluid and depressurization of confined material as illustrated in Figure 4-1.

Injection Well Operations

Underground injection is an alternative sometimes used for disposal of waste water produced by natural gas production. Class II underground injection wells are employed in other gas plays, and as of November 2008, there were reportedly over 60 permits for Class II UIC wells for flowback water disposal in New York.[38] While there is uncertainty as to the geological feasibility of underground injection in the watershed region, the potential operation of injection wells could create additional risk to the NYC West-of-Hudson watershed and related water supply infrastructure, as injection well operation presents many of the same risks for subsurface migration of fluids and has been associated with seismic events elsewhere.

Pressure Gradients

Lithostatic pressures acting on the Marcellus formation and its limited transmissivity account for the observed high confining pressures of the fluids occurring within the formation.[39] These confining pressures can result in hydraulic grades well above the elevation of any of NYC's reservoirs, or the pressure in water supply tunnels, even without considering the pressure increases imposed during hydrofracturing. Vertical migration of fluids (e.g., brine, methane, hydrogen sulfide) from deeper strata and infiltration into water supply tunnels is hydraulically possible, even with tunnels in operation.

[38] ALL Consulting, LLC *(*Arthur, J.D, Bohm, B., Coughlin, B.J., Layne, M.). *Evaluating the Environmental Implications of Hydraulic Fracturing in Shale Gas Reservoirs.* Presented at the International Petroleum & Biofuels Environmental Conference, Albuquerque, NM, November 11-13, 2008.

[39] Hill, David G.; Lombardi, Tracy E. and Martin, John P. 2008. *Fractured Shale Gas Potential in New York.* New York State Energy Research and Development Authority, Albany, New York.

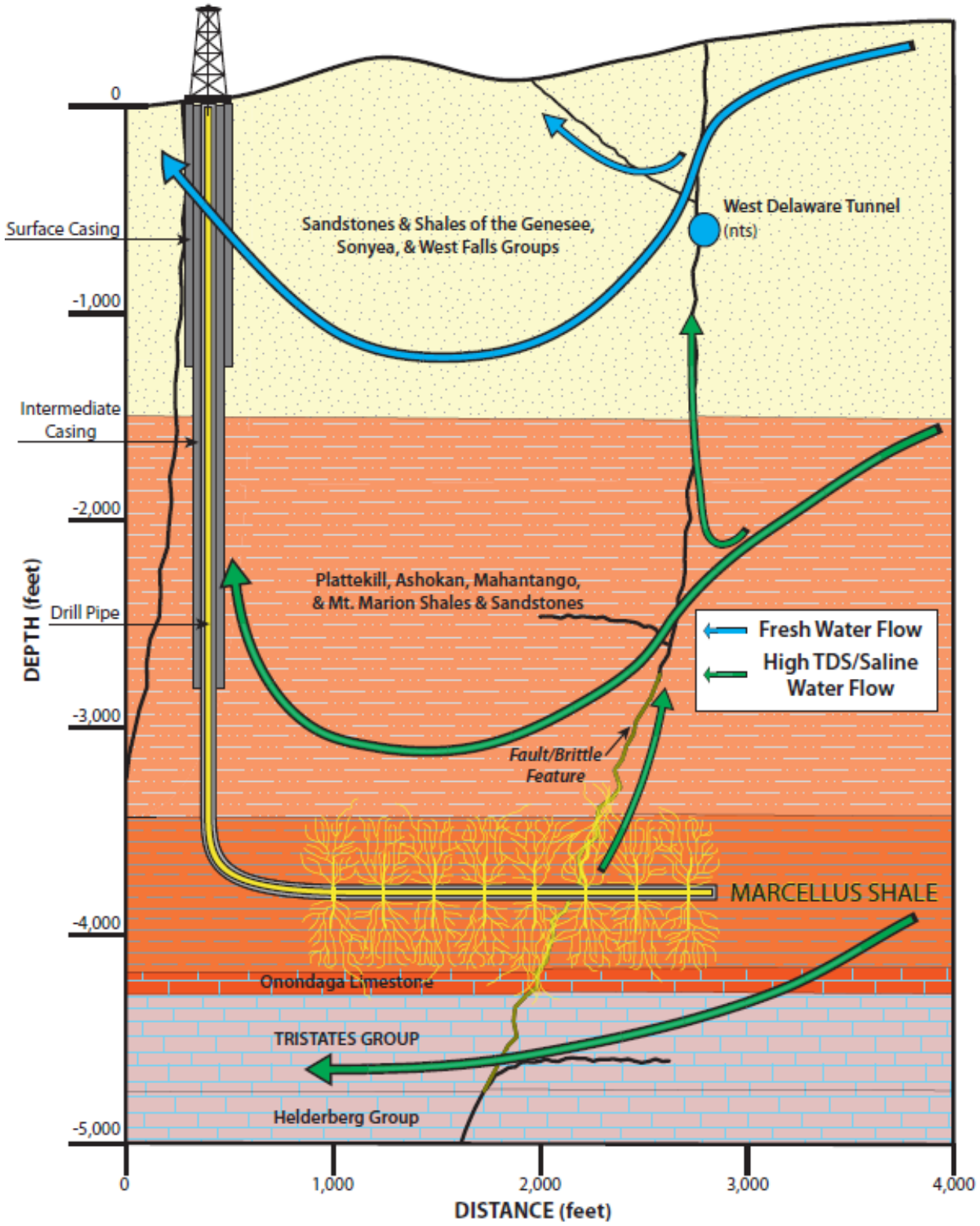

Figure 4-1: Examples of potential flow regime disruption mechanisms

NYC Tunnel and Aqueduct Impacts

NYC operates over 100 miles of deep-rock water supply tunnels in the West-of-Hudson region. Although these tunnels are generally located in overlying strata, in some locations they are in direct contact with the Marcellus formation. Primary impact considerations for this infrastructure are described below.

Tunnel Lining Structural Considerations

The unreinforced linings of NYC tunnels were designed to keep water in, not to withstand external pressures beyond those anticipated in their design. The incremental increase in fluid pressure that could theoretically be transmitted from the Marcellus could exceed the compressive strength of tunnel liners. Structural analysis of concrete tunnel liners exposed to asymmetric external pressure loads indicates that there is potential for detrimental effects on the liners upon the imposition of uneven external pressures as low as 25 psi. These detrimental effects could include liner cracks, which would facilitate infiltration of pressurized fluids. Pressure transmission to the vicinity of tunnels could occur during fracturing, or it could occur after fracturing, when newly expanded fractures expose tunnel linings to naturally occurring formation pressures. During hydrofracturing operations, tunnel liners could be exposed to still higher pressures.

Infiltration to Water Supply Tunnels

Sections of deep-rock tunnels could be subject to inflow of fluids from deeper strata through cracks in tunnel lining. This could occur most readily during the rare occasions when a tunnel is out of service, dewatered, and internal pressures are reduced, or in a tunnel which operates at atmospheric pressure, as does much of the Shandaken Tunnel that leads from Schoharie Reservoir to Esopus Creek. As indicated by the consideration of the degree of confining pressures occurring in the Marcellus, it is also hydraulically possible for pressurized fluids from deeper formations to infiltrate an operating tunnel. Additional liner cracks can be anticipated to develop as the tunnels age, due to normal geologic activity (e.g., seismic activity), and to changes in subsurface conditions associated with widespread hydrofracturing, gas reservoir depletion/withdrawal and injection well operation.

An analysis of the chemical concentrations in flowback water documented in the dSGEIS and their potential influence on water quality in flow conveyed by NYC's water supply tunnels is summarized in Table 4-5. The analysis has been performed for tunnels operating at 500 mgd, using both the maximum and median concentrations reported in the dSGEIS for flowback water.[40] It shows that there are several constituents of flowback water which could cause tunnel discharges to exceed prevailing water quality limits upon infiltration into water supply tunnels at relatively modest rates. Most of these exceedances are associated with infiltration rates of several hundred gallons per minute, rates which were documented during tunnel construction. However, documented concentrations of barium, a toxic heavy metal, would cause water quality exceedances upon infiltration to tunnels at rates as low as 10 to 20 gallons per minute. Also of note are the analyses for elevated concentrations of chlorides and total dissolved solids (TDS). These constituents are associated with the target formation and are most characteristic of

[40] With the exception of the Rondout-West Branch section of the Delaware Aqueduct, which has a hydraulic capacity of 890 mgd, the capacities of the remaining West-of-Hudson tunnels range from 500 to 700 mgd, although they are typically operated at flow rates several hundred mgd below capacity.

produced water rather than flowback. As such, the available mass of these constituents would not be limited to that introduced directly by hydrofracturing.

Table 4-5: Infiltration Rate to Tunnels that Would Cause Tunnel Discharge to Exceed NYSDEC Part 703 Water Quality Limit

Parameter	NYSDEC Part 703 Water Quality Limit (mg/l)	Flowback Concentration Estimates[1] (mg/l)		Infiltration Rate that Would Cause Tunnel Discharge to Exceed Part 703 Limits[2] (gpm)	
		Median	Maximum	At Median Flowback Concentration	At Maximum Flowback Concentration
Chlorides	250	56,900	228,000	1,520 gpm	380 gpm
TDS	500	93,200	337,000	1,860 gpm	510 gpm
Barium[3]	1	662	15,700	520 gpm	20 gpm
Benzene	0.001	0.48	1.95	720 gpm	180 gpm

Notes:
1. Flowback concentrations per dSGEIS Table 5-9.
2. Assumes aqueduct flow of 500 mgd. Infiltration rates calculated for water quality standard violations would be proportionately lower at lower aqueduct flows.
3. Supporting documents included with the dSGEIS list barium concentrations as high as 19,200 mg/l.

Given that the lengths of the West-of-Hudson tunnels range from 5 to 45 miles, and groundwater infiltration was encountered at rates of 100 gpm or more at some locations during construction, the calculated infiltration rates are not implausible especially if existing fractures are widened or additional fractures are created. Allowing for the long-term influence of extensive hydrofracturing and possible injection well operation, the possibility of infiltration from an overpressurized source at rates calculated above is a realistic risk to water quality conveyed by NYC's water supply tunnels. If maximum contaminant levels become more stringent, as is likely, then even lower infiltration rates could violate regulatory limits.

In summary, there is sufficient pressure under natural and gas-well enhanced conditions to drive fluids or gas upward from deep formations into tunnels or above grade, via geological faults or fractures, and there is potential for both structural damage to tunnel liners and violations of regulatory limits.

Water Supply Operations

The enhanced migration of fluids from deep formations could also include the migration of gases such as methane and hydrogen sulfide. Migration could occur through pre-existing brittle structures and may be further influenced by laterally extensive zones of elevated hydraulic conductivity associated with tunnel routes and vertically drilled shafts. Tunnel and shaft routing configurations may also permit the accumulation of methane and/or hydrogen sulfide in pockets of the infrastructure that require access from time to time for inspection and/or maintenance purposes. In such instances, the accumulation of either of these gases could represent an increased health and safety risk. The most serious potential consequence would be a methane gas explosion, which could threaten personnel and seriously damage critical infrastructure.

Related Precedent

The migration of fracking chemicals and/or poor quality formation water into overlying groundwater, watershed streams, reservoirs, and directly into tunnels is a reasonably foreseeable risk. The failures postulated above are not theoretical: they have occurred, at least with respect to impacts on streams and groundwater. A well-documented case occurred in Garfield County, Colorado in 2004 where natural gas was observed bubbling into the stream bed of West Divide Creek.[41] In addition to natural gas, water sample analyses indicated ground water concentrations of benzene exceeded 200 micrograms per liter and surface water concentrations of benzene exceeded 90 micrograms per liter – 90 times the NYSDEC Part 703 water quality limit for discharge of benzene to surface waters. Operator errors, in conjunction with the existence of a network of faults and fractures, led to significant quantities of formation fluids migrating vertically nearly 4,000 feet and horizontally over 2,000 feet, surfacing as a seep in West Divide Creek. It should be noted that the vertical separation between the Marcellus Shale and the West Delaware Tunnel ranges between 3000 and 5500 feet, well within the vertical distance seen in this incident in Garfield County, Colorado. Clearly there is a very real potential for methane migration from the Marcellus shale to the City water supply tunnels.

Although remedial casings installed in the well reportedly reduced seepage, the resulting benzene plume has required remediation since 2004. Subsequent hydrogeologic studies have found that ambient groundwater concentrations of methane and other contaminants increased regionally as gas drilling activity progressed, and attributed the increase to inadequate casing or grouting in gas wells and naturally occurring fractures.[42]

Groundwater contamination from drilling in the Marcellus shale formation was reported in early 2009 in Dimock, PA, where methane migrated thousands of feet from the production formation, contaminating the fresh-water aquifer and resulting in at least one explosion at the surface.[43,44] Migrating methane gas has reportedly affected over a dozen water supply wells within a nine square mile area. The explosion was due to methane collecting in a water well vault. Pennsylvania Department of Environmental Protection has since required additional ventilation, installed gas detectors and taken water wells with high methane levels offline at impacted homes to reduce explosion hazards. At this time the root cause remains under investigation and a definitive subsurface pathway is not known. This case is of particular concern since the terrain and geology in Pennsylvania is very similar to that of the NYC watershed: Dimock is only 35 miles from Deposit, NY and the Cannonsville Reservoir Dam.

In addition to these cases, there have been numerous reports of smaller, localized contamination incidents that have resulted in well water being contaminated with brine, unidentified chemicals, toluene, sulfates, and hydrocarbons.[45] In most cases the exact cause or pathway of the contamination has not been pinpointed due to the difficulty in mapping complex subsurface features. The accumulating record of contamination events that are reportedly associated with, or

[41] Colorado Oil and Gas Conservation Commission (COGCC). 2004. *Order no. 1V-276.* (http://cogcc.state.co.us/orders/orders/1v/276.html accessed 3/13/09).
[42] G. Thyne. *Review of Phase II Hydrogeologic Study.* Prepared for Garfield County. (CO) December 12, 2008.
[43] Wilber, T., *DEP zeros in on gas tainting water.* Binghamton Press and Sun Bulletin. January 30, 2009.
[44] Wilber, T., *PA officials reviewing Cabot drilling plan.* Binghamton Press and Sun Bulletin. October 13, 2009.
[45] See Rapid Impact Assessment Report for a discussion of various case studies of contamination.

in close proximity to hydrofracturing and natural gas well operations, suggests water quality impairments and impacts can be reasonably anticipated.

4.7 Wastewater Treatment and Disposal

Fracturing fluids that are returned to the surface as flowback and produced water from the formation tend to have very high TDS and chlorides, and may be contaminated with hydrocarbons, radionuclides, heavy metals, and fracturing chemicals, thus requiring specialized treatment and disposal. Approaches to treatment and disposal of drilling wastewater that have been employed elsewhere include:

- Underground injection wells;
- Industrial wastewater treatment followed by reuse or surface disposal; and
- Industrial pretreatment, followed by conventional treatment and surface disposal.

Underground injection is a common and frequently preferred method for disposal of drilling and fracturing waste. The feasibility of underground injection at the capacity that will be needed to accommodate waste from extensive development of the Marcellus formation as a natural gas resource has not been established. If underground injection proves feasible, the number of injection wells in New York could increase substantially. Injection well failures resulting in surface and groundwater contamination have been reported elsewhere.[46] Injection well operation has also been associated with induced seismicity which could increase subsurface migration of fluids from hydrofractured strata and other deep formations.

Treatment and disposal of wastewater is complicated by the high concentrations of numerous constituents of the waste stream and the presence of constituents that are not amenable to conventional treatment, such as naturally-occurring radionuclides and high concentrations of heavy metals. Experience in Pennsylvania to date is relevant to the issues that will face New York, and a concise summary of the waste disposal situation in Pennsylvania is provided in the abstract for a paper presented at the September 2009 Eastern Regional Meeting of the Society of Petroleum Engineers:

> *"In the Commonwealth of Pennsylvania, new regulatory limits have been proposed further limiting discharges. The Pennsylvania Department of Environmental Protection announced on April 15, 2009 that all industrial discharges will be limited to 500 mg/l TDS on January 1, 2011. There are currently no facilities in the state that can treat flowback fluids to this level. The options for an economic solution are few for operators in dealing with these saline flowback fluids. Evaporation/crystallization (EC), the only established technology for treatment of the produced waters that can achieve the newly proposed TDS limit, produces a very highly concentrated brine solution or large volumes of crystalline salt cake that still must be disposed. A 1 million gal/day crystallization plant will generate approximately 400 tons/day of salt waste. Unless some beneficial use for these residues can be found, they will require disposal in a secure solid waste facility. A typical municipal landfill cannot accept large volumes of crystalline salts and suitable facilities can do so only at a premium. Further, an EC plant is very energy intensive and*

[46] Hudak, P.F., Wachal, D.J. *Effects of Brine Injection Wells, Dry Holes and Plugged Oil/Gas Wells on Chloride, Bromide, and Barium Concentrations in the Gulf Coast Aquifer, Southeast Texas, USA.* Environment International. Vol. 26. Issues 7-8. June 2001. Pages 497-503. Copyright 2001. Elsevier Science, Ltd.

thus has the potential for increased air quality impact and greenhouse gas emissions in addition to its cost of operation. The Marcellus shale gas industry may be left with no economically viable disposal options."[47]

The 400 ton per day figure cited above corresponds to a solids concentration of approximately 100,000 mg/l, which is comparable to the median value reported for flowback samples in the dSGEIS (93,200 mg/l), and well below the maximum reported value of 337,000 mg/l.[48] As such, the solids load generation rate of 400 tons per million gallons could be higher.

Recycling of flowback can help to reduce the volume of wastewater generated, but the high concentration of scale-forming constituents limits the amount that can be recycled. Treatment and further dilution with fresh water is typically needed for re-use of flowback water, and significant quantities of residuals remain to be disposed. As noted above, currently available industrial treatment options are very limited. Treatment of Marcellus gas well wastes is the subject of several current research initiatives, but these are at very early stages. In general the availability of adequate treatment and disposal facilities for natural gas wastewater is severely limited.

Table 4-2 estimates the annual average wastewater generation rate for the full build-out scenario of 6000 wells in the watershed at 2.6 to 3.5 mgd, without allowance for additional load that could be generated by refracturing operations. To meet a 500 mg/l effluent limit for a 3.5 mgd, 100,000 mg/l TDS waste stream by dilution only would require 700 mgd of fresh water. The solids load associated with this waste stream would be *1,100 to 1,500 dry tons per day*. For comparison, the NYCDEP wastewater treatment plants serving NYC treat approximately 1.2 billion gallons of sewage per day and produce about 400 tons per day of dry sludge solids.

Judging by the flow rates calculated to dilute this waste stream, it is evident that dilution is unlikely to provide a feasible solution, once the gas resource is developed to a significant degree. The viability of injection wells in this region for waste disposal is unproven. Lastly, the only established technology for treatment would produce large volumes of solids which will need to be transported and disposed of, and which will likely include elevated levels of radioactivity which would further limit solids disposal options.

The quantities cited above are for an assumed 6,000 well full build-out scenario, and necessarily rely on a number of estimates with respect to flowback and produced water rates. However, these estimates are for potential gas well development within the NYC West-of-Hudson watershed alone, and do not take into account gas industry waste streams that would be generated in any other areas in New York State or Pennsylvania. If allowance is made for refracturing, these waste estimates could be about 2.5 times higher.

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[47] Blauch, M.E. (Superior Well Services, Inc.); Myers, R.R., Moore, T. R.; Lipinski, B.A. Exco - North Coast Energy, Inc.; Houston, N.A. (Superior Well Services, Inc.). *Marcellus Shale Post-Frac Flowback Waters - Where is All the Salt Coming from and What are the Implications?* SPE Eastern Regional Meeting, 23-25 September 2009, Charleston, West Virginia, USA. Copyright 2009. Society of Petroleum Engineers Paper Number 125740-MS. Abstract referenced at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-125740-MS&soc=SPE December 2009.

[48] NYSDEC. 2009. *Draft supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program (SGEIS)*. New York State Department of Environmental Conservation Division of Mineral Resources, Albany, NY.

Clearly, the development of natural gas resources will present a significant waste disposal challenge for which there is no clear or viable solution evident at this date. Failure to adequately account for regional wastewater disposal needs has resulted in at least one recent incident of surface water quality violations. In October 2008 excessive gas well brine disposal at publicly-owned treatment works (POTWs) in the Monongahela Basin contributed to high TDS in the river and its tributaries.[49] The elevated TDS concentrations caused taste and odor problems in drinking water, high levels of brominated disinfection by-product precursors at water treatment plants, and violations of particulate limits in power plant emissions. Waste disposal is a direct concern for NYCDEP, as the absence of economically viable disposal options will incentivize irresponsible and illegal waste handling and disposal practices.

[49] *Pennsylvania DEP Investigates Elevated TDS in Monongahela River*. Water and Wastes Digest. October 27, 2008

Section 5: Summary

This section summarizes the impacts of natural gas development using horizontal drilling/high-volume hydraulic fracturing on the NYC water supply watershed and infrastructure.

Rate and Density of Well Development in the NYC Watershed

Reasonably foreseeable natural gas well development scenarios for the NYC watershed based on experience in comparable formations suggest that under favorable economic and regulatory conditions annual well completion rates would increase from initial rates as low as 5 to 20 wells per year to an average of 100 to 300 wells per year, potentially peaking at 500 wells per year. Consistent with NYSDEC spacing unit requirements and development in other formations, it is estimated that on the order of 3,000 to 6,000 wells could ultimately be drilled and fractured in the NYC watershed. This does not include re-fracturing of the same wells, nor does it include drilling and fracturing of wells to tap natural gas in the Utica, Oriskany, or Trenton/Black River formations underlying the NYC watershed. Development of these formations would require additional well construction but not necessarily new ancillary infrastructure.

Meaningful assessment of risks and impacts must be guided by the scale of natural gas development. Any individual hydraulic fracturing operation poses a relatively small risk to the water supply. But at the rates and densities of development as currently practiced elsewhere in the Marcellus and comparable formations, the likelihood of negative impacts and the subsequent risk to the water supply is substantially higher. When the issue is considered from the standpoint of not one well but of hundreds or thousands of wells, the cumulative risks become significant. Prevention of polluting activities is certain to protect water quality and infrastructure from these cumulative risks. To illustrate minimum mitigation measures that would be required to reduce risks for any one individual impact, Appendix D sets forth certain mitigation strategies.

The following are considered foreseeable risks, and merit detailed consideration:

Land Disturbance, Site Activity, and Truck Traffic (Industrialization)

- High levels of site disturbance, truck traffic and intensive industrial activity, on a relatively constant basis, over a period of decades, and attendant impacts on overall watershed health.
- Trucking activity will be accompanied by provision of equipment and material supply systems (warehouses, garages, support services), gas gathering and pipeline systems, compressor stations, and waste disposal systems.
- Without some limits on the rate or density of development in the watershed, it is reasonable to expect that a significant and relatively rapid industrialization of the NYC watershed could occur.

Tunnel Integrity and Subsurface Migration

- Widespread hydraulic fracking will permanently and irreversibly compromise a significant geological formation that presently constitutes part of the subsurface system that isolates near-surface, fresh water flow regimes from non-potable, highly saline waters of deeper formations.
- The subsurface impact of repeated and extensive fracturing on intervening strata will increase the likelihood of the migration of hazardous chemicals and/or poor quality formation water and infiltration into overlying groundwater, watershed streams, reservoirs, and tunnels.

- The inadvertent extension of fractures beyond the target strata, and long-term changes in subsurface stresses will likely increase the number and capacity of migration pathways through the geologic strata underlying the watershed, and increase the likelihood of subsurface contamination of the water supply system.
- Infiltration of formation or fracking fluids could cause tunnel discharges to exceed NYSDEC discharge standards even at low infiltration rates.
- Transmittal of pressurized fluids from presently isolated deep formations could expose the external surfaces of the unreinforced concrete tunnel liners to excessive pressures and compromise liner integrity.

Water Withdrawals

- Despite representing a small portion of overall watershed yield, withdrawals for hydrofracturing could significantly impact commitments for water supply and habitat protection, particularly during periods of drought. The severity of impacts will depend on the amount and timing of withdrawals. Withdrawals while reservoirs are spilling would have little impact. Withdrawals during dry periods could increase the duration of drought watch, warning, or emergency conditions.
- Delaware Basin withdrawals downstream of the NYC West-of-Hudson reservoirs could impact system operations by requiring increased releases to meet in-stream flow requirements. Similarly, withdrawals from the Upper Esopus Creek could require increased releases from Schoharie Reservoir to meet minimum downstream flow requirements.
- Excessive water withdrawals may also impact aquatic habitat and biota.

Chemical Usage

- Introduction of hundreds of tons per day of fracturing chemicals into the watershed over a period of several decades will likely be accompanied by the gradual dispersion of low levels of toxic chemicals into the environment and potentially the water supply via multiple transport pathways.

Surface Spills

- A chronic and persistent occurrence of small scale surface spills and contamination incidents will inevitably accompany the thousands upon thousands of fluid transfer activities necessary for widespread hydrofracturing and gas well operation, and can be expected to reduce public and regulatory agency confidence in the quality and safety of the water supply.
- Occasional acute spills that could cause operational impacts, potential MCL violations and further undermine confidence in the ability to maintain current high water quality standards.

Wastewater Treatment and Disposal

- The flowback and produced waters resulting from hydrofracturing and gas well operations will produce an industrial-strength waste stream characterized by exceptionally high concentrations of a wide range of substances with the potential for adverse health and water quality effects which can be expected to exceed existing treatment and assimilative capacities within a few years.
- There is high level of uncertainty as to whether effective waste treatment processes and sufficient capacity will be available in the future. Sufficient dilution capacity is unlikely to be available. Residuals productions associated with the only presently available treatment

technology could produce a waste stream that amounts to three to four times the dry sludge total disposed of by NYC's fourteen wastewater treatment plants.

- Solids disposal options will be further limited by elevated levels of radioactivity.
- Waste management and transport will likely contribute to a long-term, low level increase in truck traffic and transport of hazardous chemicals.
- Siting of injection wells and or treatment facilities will add an additional category of industrial activity to the region.
- Widespread use of injection wells, if geologically feasible, would provide additional contaminant transport pathways and could possibly increase low-level seismic activity, increasing opportunity for subsurface contaminant transport.

Filtration Avoidance Determination

- Given the importance of watershed protection for unfiltered water supply systems, major changes in land use and/or increased levels of industrial activity in the watershed could jeopardize the Filtration Avoidance Determination granted to the Catskill and Delaware water systems and decrease public confidence in the high quality of the NYC water supply.
- In the event that filtration is ultimately required, NYC expects that the current $10 billion filtration plant design would not be adequate to remove the chemicals that could be introduced into the watershed. Advanced oxidation, granular activated carbon adsorption, and/or membrane filtration processes could be required. All of these advanced processes are significantly more expensive than the current design, and it is quite possible that the available treatment site would not even accommodate the additional treatment technology. Net impacts on overall treatment facility requirements processes would be expected to increase costs by at least 50 percent and possibly more than 100 percent relative to the current design.

Taken together, these potential impacts - some very likely, some less so, many simply unknown –suggest that large-scale horizontal drilling/high-volume hydraulic fracturing in the NYC watershed will substantially increase the overall risk to the NYC water supply compared to current conditions.

This assessment has focused on activities and impacts that would most directly affect NYC's water supply system. Other effects, which for the purposes of this effort have been considered to be secondary, would not necessarily be minor or insignificant. Induced growth, and the economic changes that it would bring, can adversely impact water quality. It often results in additional demand on roads and other local infrastructure, including schools, local water supply and municipal wastewater treatment systems, hospitals and emergency services. Adverse air quality impacts and impacts on flora, wildlife and soil chemistry can also be expected given the level of industrial activity that would accompany hydraulic fracturing and horizontal drilling operations, particularly if implemented at rates and densities employed elsewhere.

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August 10, 2010

COMMENTS ON THE SCOPE OF THE EPA'S PROPOSED STUDY OF HYDRAULIC FRACTURING

By Paul A. Rubin

Hydraulic fracturing of shale formations and related surface activities has the potential to permanently and irreparably harm ground and surface water resources in New York State. Extensive existing fracture and fault networks throughout the Appalachian Basin may provide upward pathways for contaminant and gas migration through geologic zones believed to be physically isolated, based on incomplete data. As a result, there are significant health and environmental risks associated with advancing horizontal gas drilling in Otsego County, New York and elsewhere in the Appalachian Basin.

Herein, HydroQuest provides a comparison between Otsego County ground and surface water resources and those in New York City's West of Hudson River watershed, demonstrating that they are virtually indistinguishable and require similar water quality protection. I offer this conclusion based on my training as a geologist, hydrogeologist, and hydrologist with more than twenty-eight years of professional environmental experience which includes work conducted for the New York State Attorney General's Office (Environmental Protection Bureau), Oak Ridge National Laboratory (Environmental Sciences Division), the New York City Department of Environmental Protection, and as an independent environmental consultant as President of HydroQuest. Within the broad field of hydrology, I have specialized expertise in both ground and surface water hydrology.

The notion has been recently advanced that some Appalachian basin watersheds (i.e., New York City West of Hudson River and Syracuse) are more vulnerable to contaminant excursions and therefore, should be afforded greater protection through a more stringent permitting process. The decision to exclude New York City and Syracuse from the "generic" review process must stem from the respectively larger populations supplied by these water resources. It appears to be strictly a political decision, without defensible scientific, geological or hydrologic basis.

The potential environmental threats to Otsego County ground and surface water resources from hydraulic fracturing-related contaminant excursions are not significantly different than those present in New York City's West of Hudson River or Syracuse watersheds. **The following set of six colored GIS map figures provide the scientific rational in support of considering Otsego County and New York City watershed areas equally.** These figures may also be viewed at: http://hydroquest.com/OtsegoConfidential/.

Figure 1: **The bedrock geology of the Otsego County and New York City West of Hudson River watershed areas is essentially the same.** As depicted in Figure 1, many of the upper bedrock units present in Otsego County are the same as those present in New York City's West of Hudson watersheds. Geologically, these units are comprised of a series of sedimentary shales, siltstones, sandstones, and some conglomerates layered from the Honesdale Formation downward through and below the Marcellus Formation. These rock units were deposited under the same hydrologic conditions through the widespread area now recognized by geologists as the Catskill Delta. Before the sediments of these rock units were lithified into bedrock, they were shed northwesterly from the ancestral Acadian Mountains.

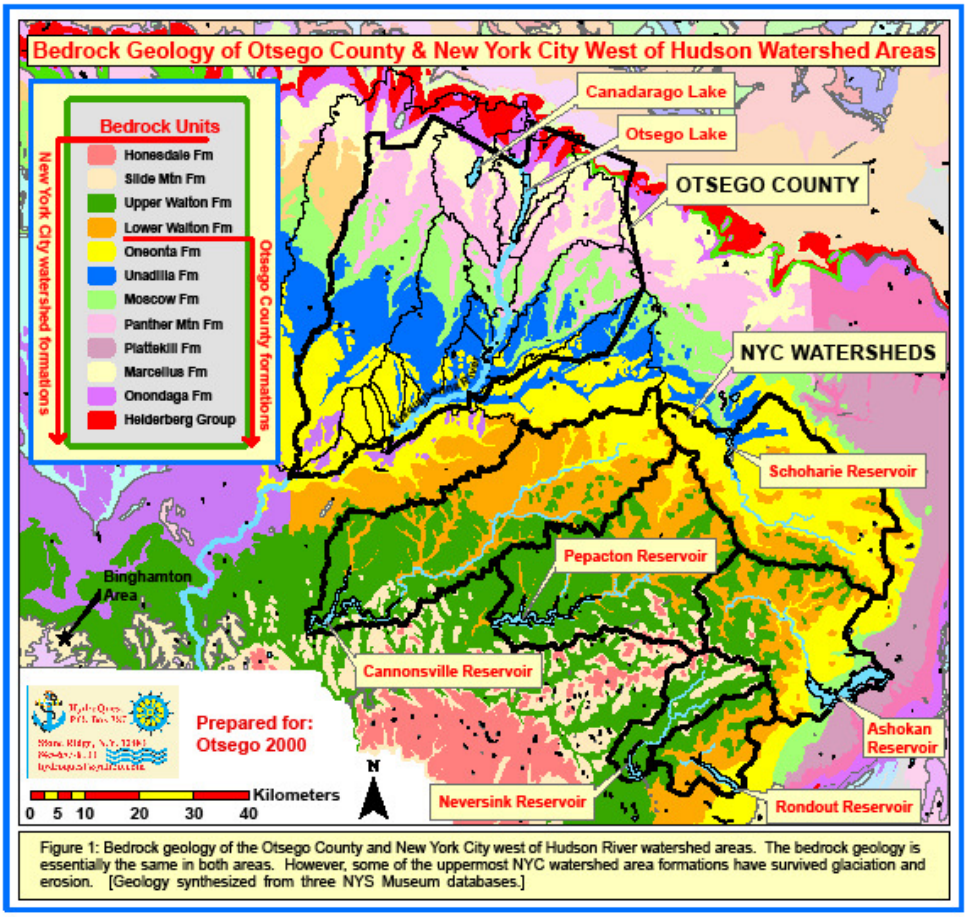

Figure 1: Bedrock geology of the Otsego County and New York City west of Hudson River watershed areas. The bedrock geology is essentially the same in both areas. However, some of the uppermost NYC watershed area formations have survived glaciation and erosion. [Geology synthesized from three NYS Museum databases.]

Figure 1.

As reflected in Figure 1, it is apparent that erosion has, in places, removed some of the uppermost bedrock units through glaciation and erosion. In places, both Otsego County and New York City watershed areas have the same bedrock units exposed at the ground surface (e.g., Oneonta Formation). Significantly, geologically and hydrologically, ground and surface water flow in both the Otsego County and New York City watershed areas behaves similarly – all potentially being vulnerable to gas field related contaminants from below and above. Indeed, because some of the Otsego County bedrock formations are stratigraphically closer to the Marcellus Shale than those in New York City watersheds, the risk of contamination is even greater there. Geologically, there is no reason why Otsego County watersheds should not be afforded the same degree of protection as NYC watershed.

Carbonates of the Onondaga Formation and Helderberg group outcrop in the northern portion of Otsego County. These carbonate formations, while stratigraphically lower than the Marcellus shale, overlie other shale beds that may be gas rich (e.g., the Utica shale of the Trenton Group). This is indicated by gas leases over these formations (see Figure 5). These carbonate formations are recognized among karst hydrologists as being karstic or cave/conduit bearing in nature. An important aspect of karst is its effect on water supply and contaminant transport. Water in solution conduits can travel up to several kilometers per day, and contaminants can move at the same rate. This poses serious problems when monitoring for water quality. Contaminants enter the ground easily through sinkholes and sinking streams, and filtering is virtually non-existent. Even small solution conduits can transmit groundwater and contaminants hundreds of times faster than the typical unenlarged fracture network. Hydrofracking related contaminants that may enter karstic solution conduits, from below or above, would quickly degrade groundwater and surface water quality. As a result of the DEC's failure to address this significant environmental concern, it must be studied by the EPA.

Figure 2: **The Draft SGEIS fails to reference all known fault and fracture information**. The DSGEIS relies on outdated and limited fault and fracture set locations throughout New York State. Figure 2 is the chart prepared by consultants for inclusion in the DGSEIS. Many more were known at the time of the issuance of the DSGEIS as reflected in Figures 3 and 4, discussed below. As a result of the DEC's failure to analyze more recent fault mapping, the risk of ground and surface water contamination through seismic activity stemming from natural causes or from lubrication and pressurization along dormant faults through fracturing has not been adequately addressed and must be studied by the EPA.

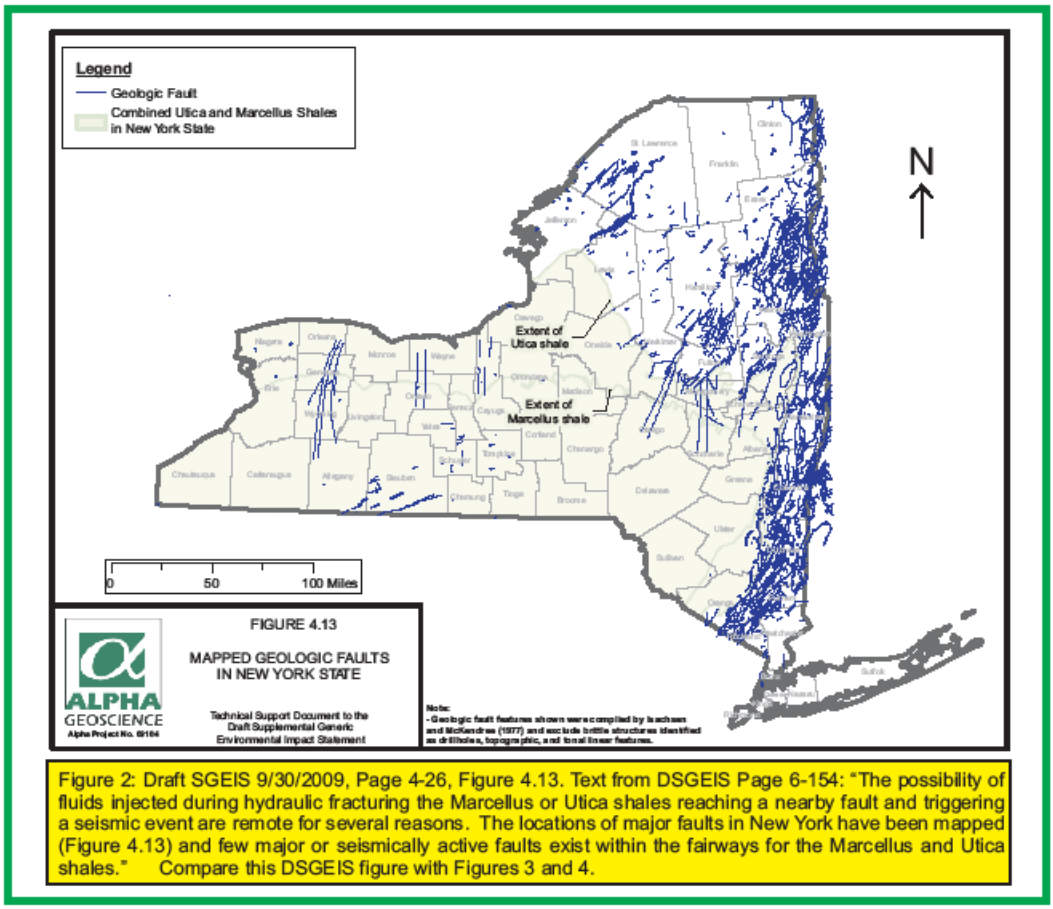

Figure 2: Draft SGEIS 9/30/2009, Page 4-26, Figure 4.13. Text from DSGEIS Page 6-154: "The possibility of fluids injected during hydraulic fracturing the Marcellus or Utica shales reaching a nearby fault and triggering a seismic event are remote for several reasons. The locations of major faults in New York have been mapped (Figure 4.13) and few major or seismically active faults exist within the fairways for the Marcellus and Utica shales." Compare this DSGEIS figure with Figures 3 and 4.

Figure 2.

Figures 3 and 4: **Numerous confirmed faults and lineaments known in Otsego County and New York State were not discussed in the DEGEIS. These and other faults may provide pathways for contaminated fracture fluids, deep-seated saline water, radioactivity, and gas migration to migrate to aquifers, reservoirs, lakes, rivers, streams, wells, and even homes.** Jacobi and Smith (2002) document the epicenters of three seismic events in eastern Otsego County. These seismic events indicate that earth movement occurs from great depth along faults upward to aquifers and potentially to exposure at the ground surface. The great lateral extent of these faults, and their visually observable connectivity with other faults, confirms that the process of hydraulic fracturing, which may interconnect naturally occurring faults and fractures, has a great and very real potential of causing contaminants to migrate to aquifers and surface water from localized zones across and beyond county and watershed boundaries.

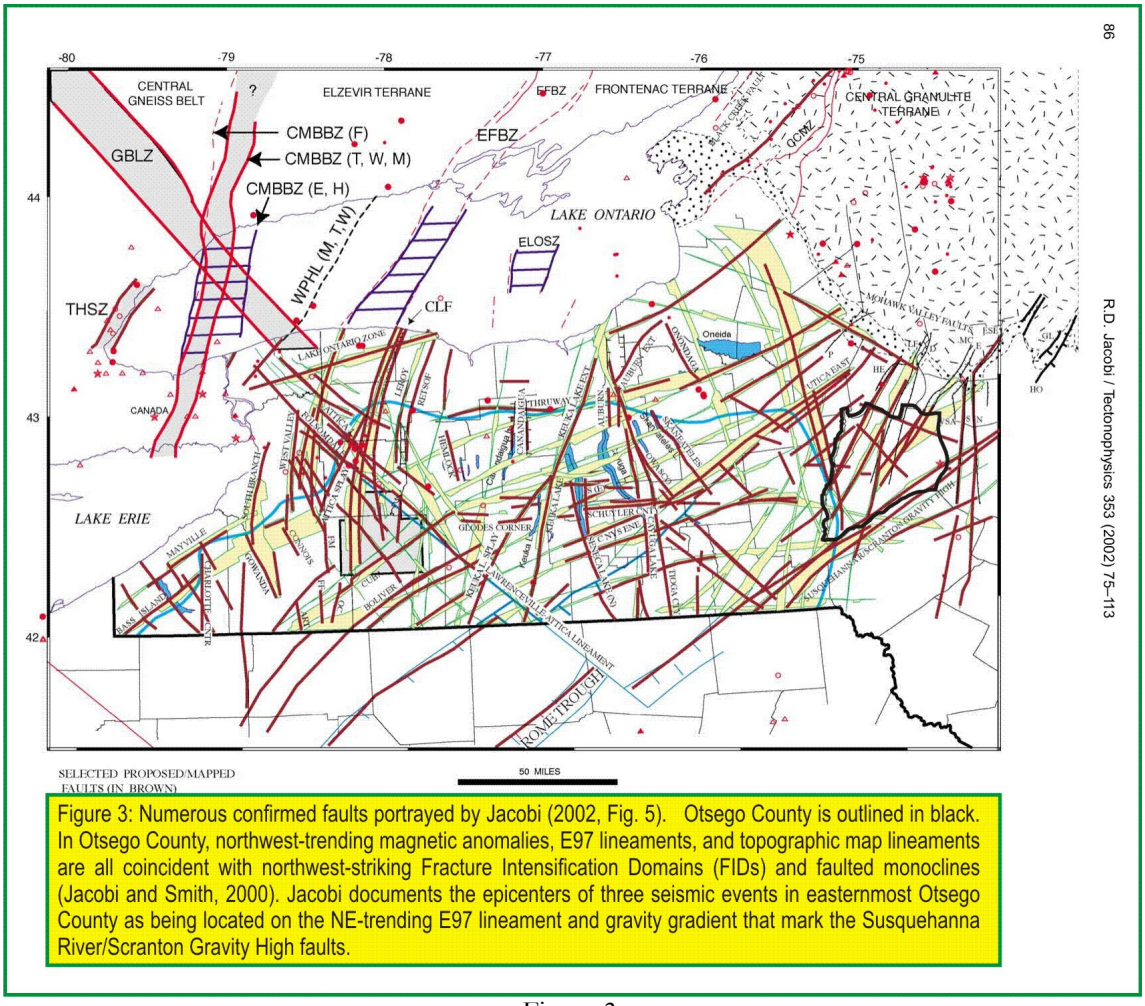

Figure 3: Numerous confirmed faults portrayed by Jacobi (2002, Fig. 5). Otsego County is outlined in black. In Otsego County, northwest-trending magnetic anomalies, E97 lineaments, and topographic map lineaments are all coincident with northwest-striking Fracture Intensification Domains (FIDs) and faulted monoclines (Jacobi and Smith, 2000). Jacobi documents the epicenters of three seismic events in easternmost Otsego County as being located on the NE-trending E97 lineament and gravity gradient that mark the Susquehanna River/Scranton Gravity High faults.

Figure 3.

Fracking contaminants, once mobilized vertically along fault planes and fractures, especially under pressurized conditions, can reach freshwater aquifers. Even if all fracking fluids were comprised of non-toxic chemicals, the risk of interconnecting deep saline-bearing formations (i.e., connate water) and/or radioactive fluids with freshwater aquifers is not warranted. Any commingling of deep-seated waters, with or without hazardous fracking fluids is unacceptable. Documented gas excursions near existing gas fields demonstrate that vertical pathways are open. If gas can migrate to the surface it is highly likely that hydrocarbon and contaminant-rich Light Non-Aqueous Phase Liquids (LNAPLs) will also reach aquifers and surface water resources. These contaminants may then also migrate to down gradient wells, principal aquifers, and waterways.

Importantly, these Figures provide a very <u>conservative</u> approximation of the actual number of fractures and faults present throughout Otsego County and New York State. In establishing a relationship between seismicity and faults, Jacobi (2002) examined Fracture Intensification Domains (FIDs), E97 lineaments (Fig. 3), topographic lineaments, gradients in gravity and magnetic data, seismic reflections profiles, and well logs. Jacobi states:

> *"In interbedded shales and thin sandstones in NYS, fractures within the FID that parallel the FID characteristically have a fracture frequency greater than 2/m, and commonly the frequency is an order of magnitude greater than in the region surrounding the FID."*

Jacobi (2002) portrays an earthquake of magnitude 4.5-4.9 as having occurred in Otsego County (Fig. 3). Jacobi makes a case for repeated reactivation along faults in the Appalachian Basin. Furthermore, and importantly, Jacobi addresses his and Fountain's identification of FIDs based on soil gas anomalies over open fractures:

"Certain sets of FIDs are marked by soil gas anomalies commonly less than 50 m wide (Jacobi and Fountain, 1993, 1996; Fountain and Jacobi, 2000). In NYS, the background methane gas content in soil is on the order of 4 ppm, but over open fractures in NYS, the soil gas content increases to 40-1000+ ppm."

The fact that Jacobi and Fountain have successfully identified and measured methane seepage from fractures that most likely extend downward to gas producing shales shows that open vertical pathways already exist, confirming the risk of increasing gas excursions as a result of hydraulic fracturing. Clearly, Jacobi and Fountain's work suggests that expanding fractures that now naturally release methane from gas-rich shales will provide even greater gas and contaminant migration pathways when interconnected and widened via hydraulic fracturing. Failure to recognize this and to allow expansive interconnection of existing faults and fractures is a recipe for environmental disaster throughout Otsego County and the Appalachian basin.

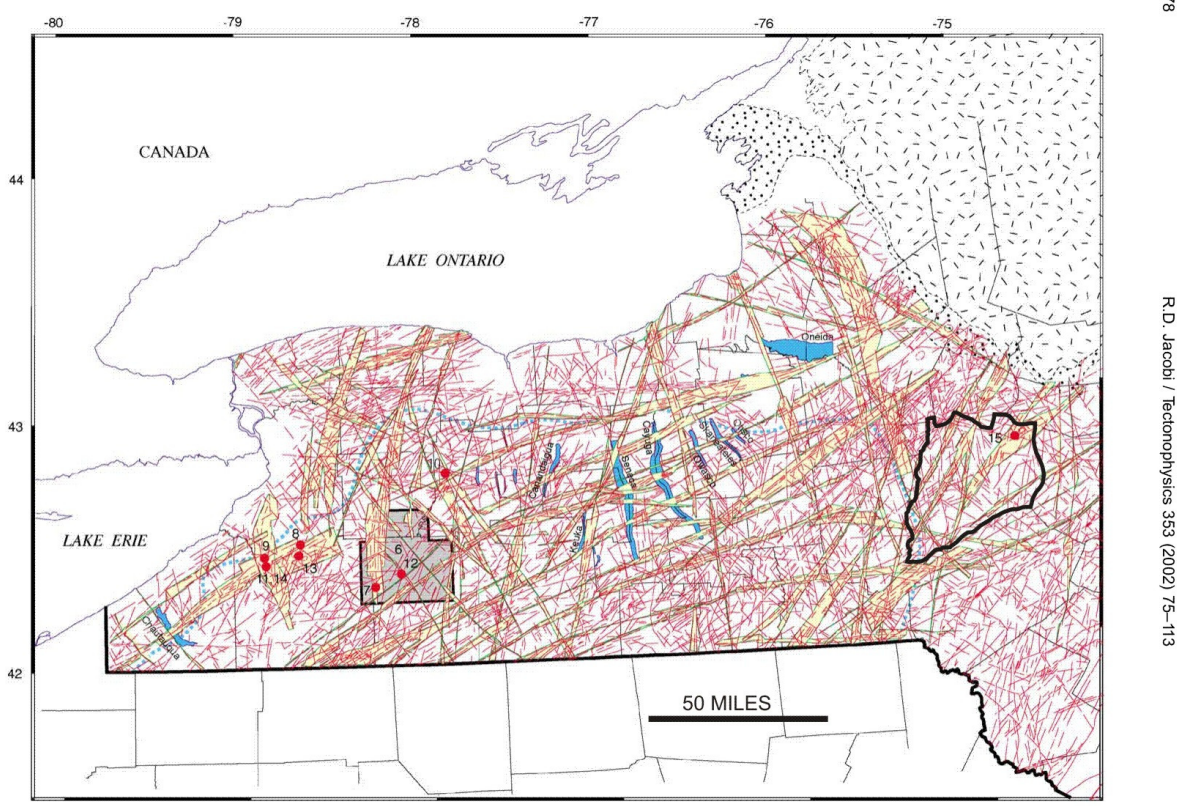

Figure 4: 1997 Landsat lineaments (red lines) as portrayed in Robert D. Jacobi's Figure 2 (2002). Lineaments and faults are widespread throughout the Appalachian Basin in New York State. These fractures and basement faults were examined via analysis of Landsat images, DEM data, aerial photography, side-looking aperature radar, hyperspectral imaging, soil gas anomalies, and field groundtruthing. Jacobi demonstrates that many of these features are seismically active. This contrasts with findings of few fractures and little seismicity presented in the DSGEIS. These and other closely spaced fractures may provide pathways for upward methane and radioactive gas migration after hydrofracturing. Similarly, high angle faults may provide upward pathways for pressurized, contaminant-laden, hydrofracturing fluids to reach freshwater aquifers. Otsego County is outlined in black.

Figure 4.

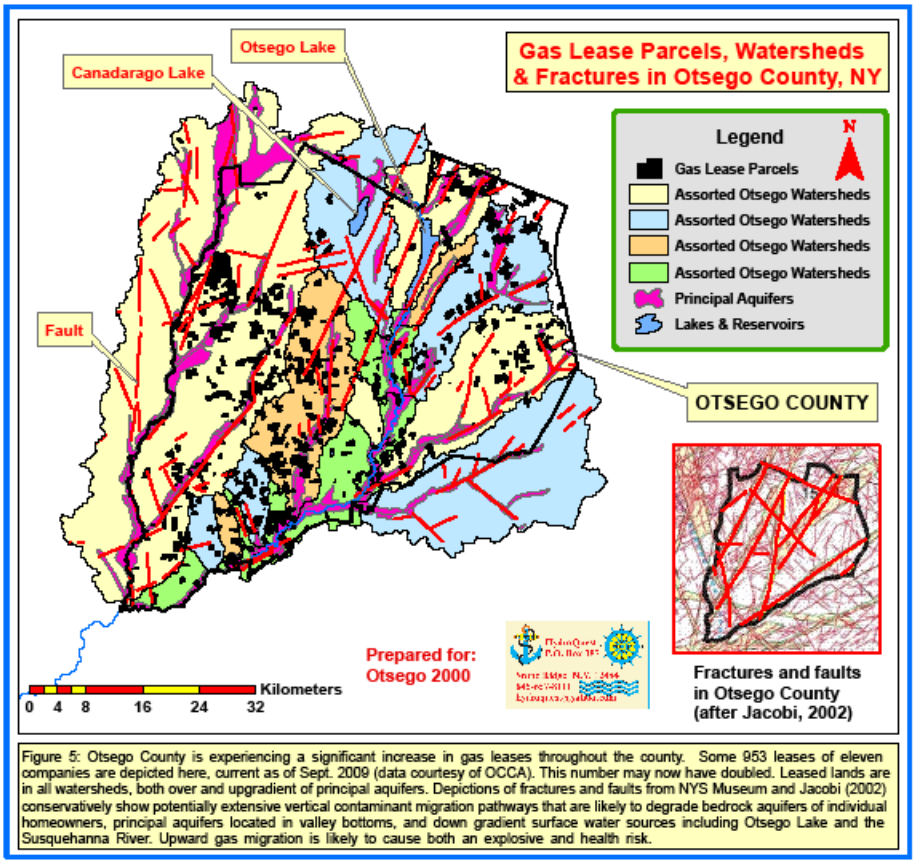

Figure 5.

Figure 5: **Gas leases in Otsego County are increasing throughout all watersheds, thereby potentially jeopardizing the water quality of principal aquifers, wells, reservoirs, and surface waterways.** Otsego County is experiencing a significant increase in gas leases throughout the county. Some 953 leases of eleven companies are depicted here, current as September 2009. This number may now have doubled. Leased lands are found in all watersheds, both over and up gradient of principal aquifers. Depictions of fractures and faults from the New York State Museum and Jacobi (2002) conservatively show extensive vertical contaminant migration pathways that are likely to degrade bedrock aquifers of individual homeowners, principal aquifers located in valley bottoms, and down gradient ground and surface water sources including Otsego Lake and the Susquehanna River.

A 2008 OCCA map of gas leases shows many overlying principal aquifers and others within a 1-mile buffer of major surface water supplies (i.e., Otsego Lake, Wilber Lake). The risk to aquifers, rivers, streams, lakes, reservoirs, and the Susquehanna River should not be tolerated. Because the density, location, aperture width, and length of all fractures (often present and not visible beneath a soil mantle) are not known, it would not be prudent to risk placement of gas wells and their respective chemical storage or impoundment sites anywhere within watersheds that contain reservoirs used for public water supplies (e.g., Lake Otsego, Wilbur Lake, New York City reservoirs). The contaminant risk, risk to public water quality perception, and potential remedial costs are not warranted by the potential economic and energy gain.

This conclusion is supported by a growing catalog of hydro-fracking related accidents in other gas-field plays (see e.g., Hazen and Sawyer, 2009). Accidental spills of fracking fluids and flow-back water has the potential of contaminating ground and surface water. Similarly, lateral and upward migration of hydro-fracturing chemicals pose a real risk to County aquifers, especially to moderate and high yield unconfined aquifers situated in stream valleys that receive their base flow recharge from up-gradient groundwater aquifers. Approximately 60% of Otsego County listed community and non-community water supplies rely on groundwater.

Aquifer contamination may retard residential growth in the county and may degrade principal and primary aquifers. Similarly, many high yielding unconfined aquifers may flow into and recharge the Clinton Street - Ballpark Valley Aquifer System that is a sole source of drinking water for approx. 127,555 residents of Vestal, Johnson City, Endicott, Nichols, Waverly, and Owego. Beyond this, the City of Binghamton and other downstream communities' primary water source is the Susquehanna River - a water supply system analogous to that of NYC's, except without impounded reservoirs.

Figure 6: **Watersheds throughout Otsego County and the New York City west of Hudson River basins are physically located atop similar bedrock types which recharge geologically similar underlying aquifers.** Ground and surface water flow throughout most of Otsego County provides the drinking water source for private and community wells, high-yielding principal aquifers, lakes, and reservoirs. In and beyond Otsego County, this water coalesces to form the Susquehanna River and recharge a sole source aquifer – the source water for the City of Binghamton and other down stream communities. Geologically and hydrologically, with the exception of more above ground impoundments, water resources of Otsego County are equally vulnerable to surface and subsurface chemical excursions documented as being associated with hydro-fractured gas wells and flow-back water impoundments elsewhere.

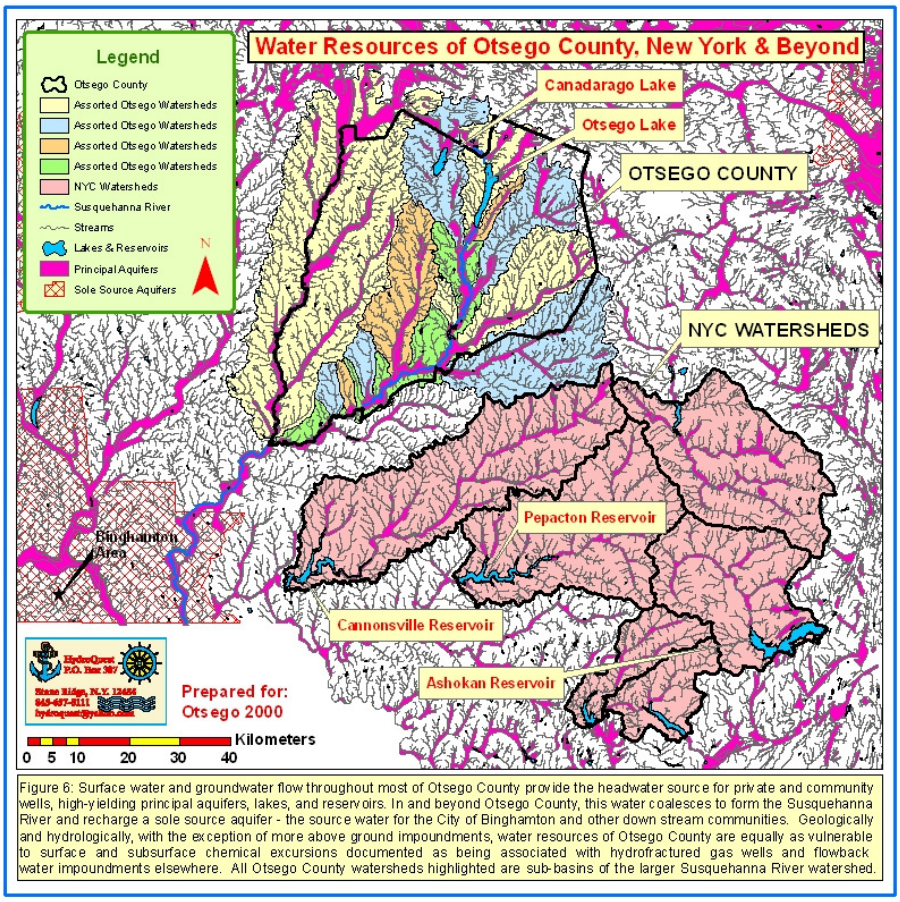

Figure 6: Surface water and groundwater flow throughout most of Otsego County provide the headwater source for private and community wells, high-yielding principal aquifers, lakes, and reservoirs. In and beyond Otsego County, this water coalesces to form the Susquehanna River and recharge a sole source aquifer - the source water for the City of Binghamton and other down stream communities. Geologically and hydrologically, with the exception of more above ground impoundments, water resources of Otsego County are equally as vulnerable to surface and subsurface chemical excursions documented as being associated with hydrofractured gas wells and flowback water impoundments elsewhere. All Otsego County watersheds highlighted are sub-basins of the larger Susquehanna River watershed.

Figure 6.

Conclusion

The characterization of vertical fractures, faults, and methane soil gas in Otsego County and elsewhere in the Appalachian Basin in the DSGEIS is inadequate and, as such, does not sufficiently address pre-existing contaminant (i.e., gas and fluid) pathways that extend from the Marcellus shale to aquifers and the ground surface. Drilling, hydro-fracturing and enhancement of gas-bearing fractures may significantly increase gas excursions to formerly isolated geologic formations. Review of reports and news articles indicate that significant environmental contamination has

occurred in geologically similar settings, including explosive hazards and groundwater and surface water contamination.

Documentation by Jacobi of Fracture Intensification Domains based on methane soil gas anomalies over open fractures reveals evidence that naturally occurring fractures and faults provide upward gaseous migration pathways, even in the absence of deep hydro-fracturing in the Marcellus shale. If fracture and fault networks are integrated and enlarged via hydro-fracturing processes, it is likely that methane and radioactive gas excursions will increase.

The reality of oil and gas development in New York State and elsewhere is that for a variety of reasons hydrocarbons have contaminated ground and surface waters. Reasons for this include poor containment of fracturing fluids, spills of flow-back water, intentional illegal disposal, mixing of different formation waters (e.g., brine and fresh water), inadequately grouted casing, spills, and various forms of operator error. Gas production in Otsego County and elsewhere in the Appalachian Basin would almost certainly result in contaminant excursions, even under the best planned conditions. The presence of confirmed fractures and faults that extend from gas-rich geologic beds to the ground surface, some of which extend laterally for miles and are closely linked with others formed under similar structural conditions, pose potential contaminant pathways to surface waterways, reservoirs, and freshwater aquifers.

Because the density, location, aperture width, and length of all fractures (often present and not visible beneath a soil mantle) are not known, it would not be prudent to risk placement of numerous gas wells within watersheds that contain lakes and reservoirs used for public water supplies (e.g., Lake Otsego, Wilbur Lake, New York City reservoirs). From a water quality standpoint three facts stand out: 1) there is a point at which the actual total number of toxic contaminants introduced into a groundwater flow system no longer matters because the water is unlikely to ever be potable again no matter how much money is spent attempting to remediate it, 2) eventually, even deep groundwater flow systems discharge to surface water, albeit it may take many years to occur (i.e., analogous to a slowly ticking time bomb), and 3) it makes little sense to jeopardize the quality of surface and groundwater by intentionally introducing vast quantities of toxic contaminants into the environment, especially where gas-conducting fractures and faults are known to extend from gas-bearing formations to the ground surface.

It is important to recognize that once our natural resources have been compromised as a result of an operator error, a major contaminant excursion, or an unforeseen breaching of geologic beds, that it is often impossible to remediate and restore them to their pre-existing conditions. Failed confining beds and contaminated natural resources often represent an irrevocable commitment of our lands. Our decision to risk New York State resources and properties must weigh all the health and environmental risks against exploitation of short-lived gas reserves and financial gain.

References

Hazen and Sawyer, 2009, Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed, Rapid Impact Assessment Report. Sept. 2009. Prepared for NYCDEP.

Jacobi, R.D., 2002, Basement faults and seismicity in the Appalachian Basin of New York State. Tectonophysics, v. 353, Issues 1-4, 23 August 2002, p. 75-113.

Jacobi, R.D. and Smith, G.J., 2000, Part I. Core and cutting analyses, surface structure, faults and lineaments, and stratigraphic cross-sections based on previous investigations. In: Jacobi, R.D., Cruz, K., Billman, D. (Eds.), Geologic Investigation of the Gas Potential in the Otsego County Region, Eastern New York State: Final Phase One Report to Millennium Natural Resources Development, L.L.C. NYSERDA, Albany, NY, 45 pp.

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 825419
Watershed Name: N. Branch Culkins Creek	Quality HQ:

Permittee	OGO #	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20012-	04/29/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E STE 2020	HL RUTLEDGE 1 1	
	Municipality: Damascus / County: Wayne	
HOUSTON, TX 77060-2424	7½ ' Quadrangle Name: Galilee	Map Section #: 2

Phone	Project #	Latitude	Longitude
(281) 847-6031		41-43-43.2000	-75-11-32.1000

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1440 feet	8350 feet	GS	South 7820 feet West 6983 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/29/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Site ID	Primary Fac ID: 728266
Client Id: 277879	Subfacility Id

Well Record and Completion Report

ll Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20012-		

Address	Well Farm Name & Well #	Serial #
363 N SAM HOUSTON PKWY E STE 2020,	HL RUTLEDGE 1 1	

City	State	Zip Code	County	Municipality
HOUSTON	TX	77060-2424	Wayne	Damascus

Phone	Fax	USGS 7.5 min. quadrangle map
(281) 847-6031		Galilee

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth – Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type Size Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20012--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine: ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728266
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879	Well API # (Permit / Reg): 37-127-20012-	
Address: 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well #: HL RUTLEDGE 1 1	Serial #
City: HOUSTON	State: TX / Zip Code: 77060-2424	County: Wayne	Municipality: Damascus
Phone: (281) 847-6031	Fax		

B. Land Application of Tophole Water

Date applied	pH
Volume (bbls)	Spec. cond. (µmhos/cm)

C. Off-site Waste Disposal

Type: ☐ Driling Fluid (803) **Amount:** bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: **Qty:** bbls or tons

Method of disposal or reuse

☐ Disposal Well (04) ☐ Sewage Treatment Plant (10)

☐ Landfill (05) ☐ Brine Treatment Plant (12)

☐ Other (08)

Facility Information

Name | Permit #

Hauler Information

Name

Address

City | State | Zip Code

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees | Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E. ☐ Dusting

☐ Lined pit, complete Section E. ☐ Solidification

☐ Land application, complete Section F. ☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY	

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Dear Operator:

Enclosed please find well permit(s) issued for drilling or altering a well. Developing this resource in a safe and environmentally protective manner is of utmost importance. As you may be aware, there have been several recent incidences where water supplies have been affected by natural gas migration. In order to prevent future impacts to the Commonwealth's water resources and provide a mechanism for ensuring public safety, the Department is providing the following information as a reminder of the cementing requirements for oil and gas wells.

Cementing

Properly cementing the casing of a well is critical to protecting water resources, preventing gas migration, and ensuring well integrity. If the casing is improperly cemented or if insufficient cement is used, such as when cement is not returned to the surface, the operator should notify the Department pursuant to 25 Pa. Code § 78.86.

In addition, when cementing surface casing, 25 Pa. Code § 78.85 states that the cement must be allowed to set for at least 8 hours *and* until the cement attains a compressive strength of at least 350 psi. While the cement is setting, the casing must not be disturbed. This includes any activity that may cause movement or pressure changes to the casing or the cement sheath surrounding the casing. After the cement is set, care must be taken when drilling through the plug to prevent damaging the seal at the casing seat. Disturbing the casing while cement is setting or damaging the seal at the casing seat may provide a mechanism for gas and other fluids to escape from the well and contaminate groundwater and water supplies. If this occurs, the operator must notify the Department.

In addition, the Department also reminds you of the following reporting requirements for oil and gas wells.

Reporting

1. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(a) of Chapter 78 of the Oil and Gas Regulations, a **Well Record** must be submitted to the Department within thirty (30) days of cessation of drilling or altering a well.

2. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(b) of Chapter 78 of the Oil and Gas Regulations, a **Completion Report** must be submitted to the Department within thirty (30) days of completion of the well. A copy of the Well Record and Completion Report is enclosed with this letter. This is a newly revised form which requires the operator to certify that the well has been cased and cemented according to the requirements of 25 Pa. Code Chapter 78. Well Record and Completion Report forms that do not contain this certification will not be accepted by the Department. Additional copies of this form can be obtained from the Department's eLibrary at http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-9841

3. Pursuant to Section 212(a) of the Oil and Gas Act, a report specifying the well status and production on the most well-specific basis available is to be provided to the Department. Section 78.121 of Chapter 78 details the reporting time frames required for various well types, waste reporting, and the acceptable format for the **Well and Waste Production Report** submissions.

4. Also note that pursuant to Section 212(b) of the Oil and Gas Act, the Department has the authority to request and does hereby request you submit a digital copy on CD of **ALL Well Logs** (temperature, electrical, radioactive, gamma ray, neutron, induction, resistivity, multi-arm caliper, acoustic, optical, etc.) that have been run on this well.

The above records and logs are to be submitted to the Department of Environmental Protections, Oil and Gas Management, 230 Chestnut St., Meadville, Pa 16335-3481 to the attention of the Regional Oil and Gas Manager.

Thank you for your cooperation in this matter.

Sincerely,

S. Craig Lobins
Regional Manager
Oil and Gas Management

Please note that the most recent revision of the Application for Drilling or Altering a Well must be submitted with all drilling applications. Please check the website below for the most recent revisions for all forms.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/o_gforms.htm

The Erosion,Sediment& Storm water Control Module is no longer being accepted for ESCGP-1 applications. Please submit the complete ESCGP-1 application for any projects. The most recent revisions must be submitted along with the application fee of $500.00

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 827248
Watershed Name: Little Equinunt Creek	HQ

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20015-	05/07/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020		Farm Name & Well Number: EM SCHWEIGHOFER 1 1	Well Serial #
		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½ ' Quadrangle Name: Long Eddy	Map Section #: 8
Phone: (281) 847-6031	Project #	Latitude: 41-45-15.0000	Longitude: -75-10-58.3000
Surf Elev at Site: 1311 feet	Anticipated Total Depth: 8350 feet / Well Type: TE	Offset distances referenced to NE corner of map section. South 13664 feet West 4419 feet	

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **05/07/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	NC
Check # 1064289	Amount $ 1500.10

$1250
+250
@1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes: Vertical test well	OGO # 67425	Objection Date - Do not issue before: 4/5/10	Well Permit # 127-20015
	Bond # 12382		Special Cond. A B C D E F
	C: 3/16/10 Del G: 4/5/10 INV: 5-7-10	Date Approved 4/20/10 JS	Watershed Name: Little Equinunk Creek
			Designation: (HQ) EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
E.M. Schweighofer	1-1	

County	Municipality	Project # (from DEP)
WAYNE	DAMASCUS	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled,** if known:_____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☒ Other (specify)

vertical test well

APPLICATION FEE
Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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DEP USE ONLY
Date Stamps/Notes
Auth 827248
Site 732146
Clnt 277879
APS 715652
Acct 675003
PF 728807
SF 1010511

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "**Coordination of a Well Location with Public Resources**" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

Signature of Applicant

The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	*(Print or Type)*	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date
Donald F. Sleeth III			3-10-10

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

5500-PM-OG0001 Rev. 10/2009

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
E.M. Schweighofer-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 — Record of Notification / Written Consent

127 - 20015

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Jeffrey Holloway ✓	Address: 519 Chicopee Road Equinunk, PA 18417-3071						X						X
Name: Sheila Bochicchio ✓	Address: 204 Eller Cove Road Weaverville, NC 28787-9713						X						X
Name: Greg Ratti ✓	Address: 141 Highwood Avenue Leonia, NJ 07605-2007						X			2/13/10	2/17/10		
Name: Edward M & Marian Schweighofer ✓	Address: 10 Twin Brook Farm Ln Tyler Hill, PA 18469-4037	X					X						X
Name: Prairie Hill Hunting Club ✓	Address: 2631 Hancock Hwy Equinunk, PA 18417-3001						X			2/19/10	3/1/10		
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☒ Landowner with water supply within 1,000 ft. Marian Schweighofer 2/8/10	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Jeffrey Holloway	Date 2-18-10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location Marian Schweighofer 2/8/10	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location Edward M. Schweighofer 2/8/10	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
E.M. Schweighofer-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA, LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

127-20015

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Jeffrey Holloway	Address: 519 Chicopee Road Equinunk, PA 18417-3071						X						X
Name: Sheila Bochicchio	Address: 204 Eller Cove Road Weaverville, NC 28787-9713						X						X
Name: Greg Ratti	Address: 141 Highwood Avenue Leonia, NJ 07605-2007						X			2/13/10	2/17/10		
Name: Edward M & Marian Schweighofer	Address: 10 Twin Brook Farm Ln Tyler Hill, PA 18469-4037	X					X						X
Name: Prairie Hill Hunting Club	Address: 2631 Hancock Hwy Equinunk, PA 18417-3001						X			2/19/10	3/1/10		
Name:	Address:												
Name:	Address:												

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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☑ water supply, or ☐ building within 200 feet	Date 3/19/2010
Address (of above) Shirley A. Bochicchio	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Rodney Young
Prairie Hill Hunting Club
3386 Hancock Highway
Equinunk, PA 18417

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) Randy Young C. Date of Delivery 3/1/10

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from servic) 91 7108 2133 3937 7523 1766

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Greg Ratti
141 Highwood Ave.
Leonia, NJ 07605

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) Greg Ratti C. Date of Delivery 2-17-10

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 91 7108 2133 3937 7523 1568

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

Angie Prather

Confirmation Services

Package ID: 9171082133393775231643
Destination ZIP Code: 78002
Customer Reference:
Recipient: Mr. Sammy De Spain
Address: P.O. Box 5816
Georgewest, Tx 78022

E-CERTIFIED
PRIORITY CBP ENV/PKG
PBP Account #: 13945647
Serial #: 4253999
FEB 19 2010 12:27P

Amie Faul

Confirmation Services

Package ID: 9171082133393775231650
Destination ZIP Code: 18443
Customer Reference:
Recipient: William S. Dane Briggs
Address: 117 High Bridge Rd.
Milanville, PA 18443

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 22 2010 5:55P

D. Wooley

Confirmation Services

Package ID: 9171082133393775231667
Destination ZIP Code: 77210
Customer Reference:
Recipient: City of Houston Municipal Courts
Address: PO Box 4996
Hou. Tx 77210

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 23 2010 10:37A

Confirmation Services

Package ID: 9171082133393775231766
Destination ZIP Code: 18417
Customer Reference:
Recipient: Randy Young
Address: Prairie Hill Hunting
Equinunk, PA 18417

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
FEB 24 2010 3:41P

Confirmation Services

Destination ZIP Code: 33418 — 1STCL REGULAR FLAT

Customer Reference:

Recipient: Diego Edelmann — PBP Account #: 13945647

Address: 253 Isle Way — Serial #: 4253999

Palm Beach Gardens, FL FEB 16 2010 1:56P

A. Faul

Confirmation Services

Package ID: 9171082133393775231551 — E-CERTIFIED

Destination ZIP Code: 28787 — 1STCL REGULAR FLAT

Customer Reference:

Recipient: Sheila Bochicchio — PBP Account #: 13945647

Address: 204 Eller Cove Road — Serial #: 4253999

Weaverville, NC 28787 — FEB 12 2010 1:56P

A. Faul

Confirmation Services

Package ID: 9171082133393775231568 — E-CERTIFIED

Destination ZIP Code: 07605 — 1STCL REGULAR FLAT

Customer Reference:

Recipient: Greg Ratti — PBP Account #: 13945647

Address: 141 Highwood Ave — Serial #: 4253999

Leonia, NJ 07605 — FEB 12 2010 1:56P

D. Finley

Confirmation Services

Package ID: 9171082133393775231575 — E-CERTIFIED

Destination ZIP Code: 78214 — 1STCL REGULAR FLAT

Customer Reference:

Recipient: Doris Ellis — PBP Account #: 13945647

Address: 814 Pleasanton Rd #324 — Serial #: 4253999

San Antonio, TX 78214 — FEB 16 2010 4:10P

D. Finley

Confirmation Services

Package ID: 9171082133393775231582 — E-CERTIFIED

Destination ZIP Code: 77584 — 1STCL REGULAR FLAT

Customer Reference:

Recipient: Billy W Cockrell — PBP Account #: 13945647

Address: 17214 Harkey Rd County Rd 103 — Serial #: 4253999

Pearland, TX 77584 — FEB 17 2010 12:46P

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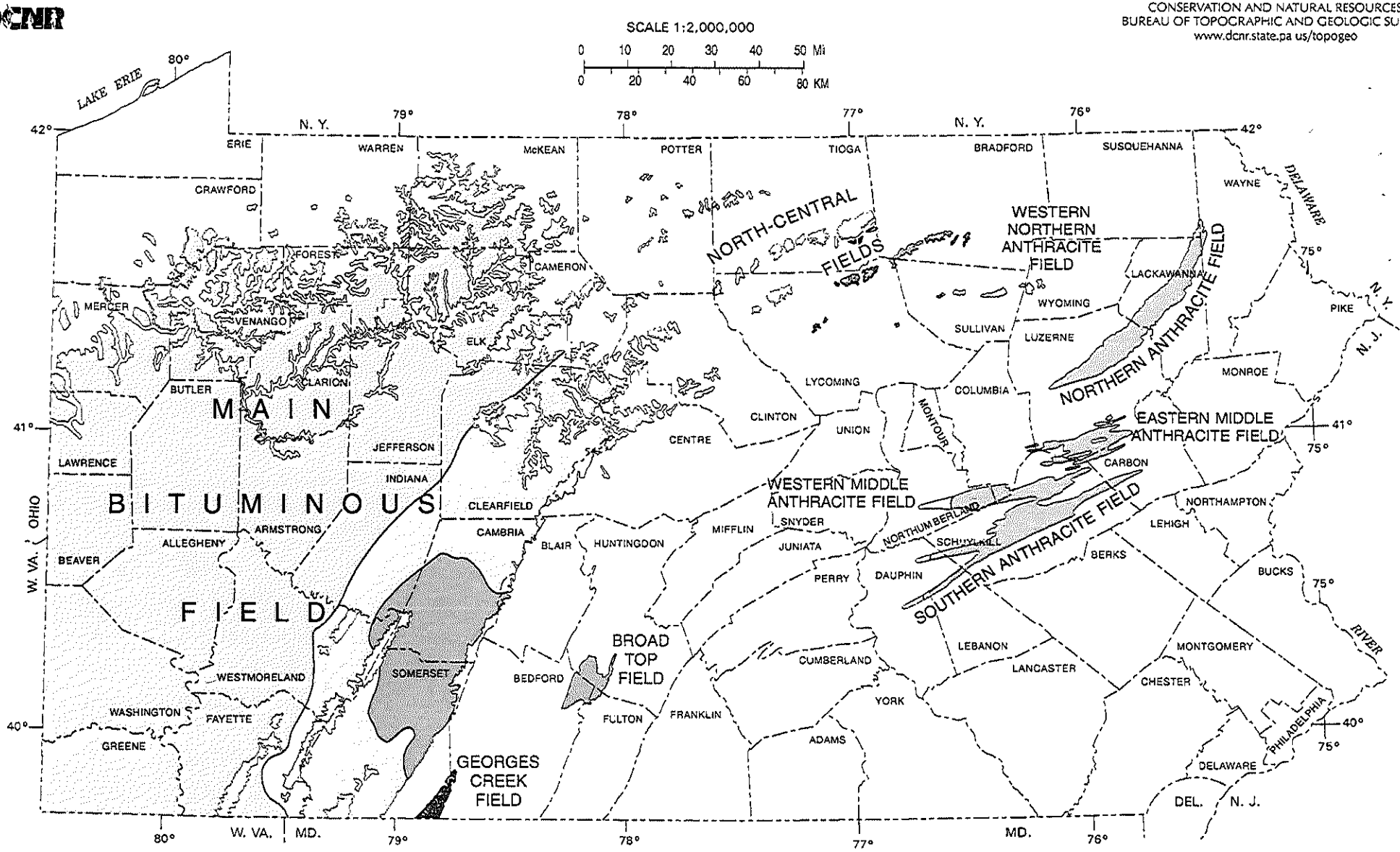
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

MAP 11

DISTRIBUTION OF PENNSYLVANIA COALS

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF
CONSERVATION AND NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
www.dcnr.state.pa us/topogeo



EXPLANATION

BITUMINOUS FIELDS

- High-volatile bituminous coal
- Medium-volatile bituminous coal
- Low-volatile bituminous coal

ANTHRACITE FIELDS

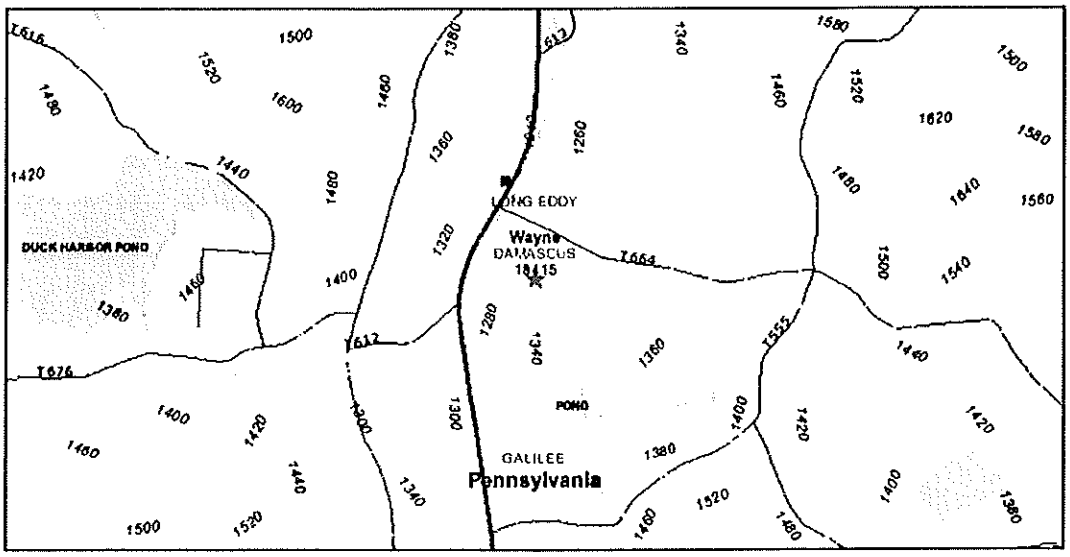
- Semi-anthracite
- Anthracite

Prepared by Bureau of Topographic and Geologic Survey.
Third Edition, Revised, 2000; Third Printing, 2008.

2200-MP-DCNR0855
Printed on Recycled Paper

1. PROJECT INFORMATION

Project Name: **Newfield-7-Schweighofer**
Date of review: **1/21/2010 10:09:47 AM**
Project Category: **Mining,Oil or Gas (including roads and pipelines),New Well**
Project Area: **N/A**
County: **Wayne** Township/Municipality: **Damascus**
Quadrangle Name: **LONG EDDY**
ZIP Code: **18415**
Decimal Degrees: **41.7541603 N, -75.1828497 W**
Degrees Minutes Seconds: **41° 45' 14.98" N, -75° 10' 58.26" W**



2. SEARCH RESULTS

Agency	Results	Response
PA Game Commission	No Known Impact	No Further Review Required
PA Department of Conservation and Natural Resources	No Known Impact	No Further Review Required
PA Fish and Boat Commission	No Known Impact	No Further Review Required
U.S. Fish and Wildlife Service	No Known Impact	No Further Review Required

As summarized above, Pennsylvania Natural Diversity Inventory (PNDI) records indicate no known impacts to threatened and endangered species and/or special concern species and resources within the project area. Therefore, based on the information you provided, no further coordination is required with the jurisdictional agencies. This response does not reflect potential agency concerns regarding impacts to other ecological resources, such as wetlands.

3. AGENCY COMMENTS

Regardless of whether a DEP permit is necessary for this proposed project, any potential impacts to threatened and endangered species and/or special concern species and resources must be resolved with the appropriate jurisdictional agency. In some cases, a permit or authorization from the jurisdictional agency may be needed if adverse impacts to these species and habitats cannot be avoided.

These agency determinations and responses are **valid for one year** (from the date of the review), and are based on the project information that was provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the following change: 1) project location, 2) project size or configuration, 3) project type, or 4) responses to the questions that were asked during the online review, the results of this review are not valid, and the review must be searched again via the PNDI Environmental Review Tool and resubmitted to the jurisdictional agencies. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt.

PA Game Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Department of Conservation and Natural Resources

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Fish and Boat Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

U.S. Fish and Wildlife Service

RESPONSE: No impacts to **federally** listed or proposed species are anticipated. Therefore, no further consultation/coordination under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* is required. Because no take of federally listed species is anticipated, none is authorized. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

4. DEP INFORMATION

The Pa Department of Environmental Protection (DEP) requires that a signed copy of this receipt, along with any required documentation from jurisdictional agencies concerning resolution of potential impacts, be submitted with applications for permits requiring PNDI review. For cases where a "Potential Impact" to threatened and endangered species has been identified before the application has been submitted to DEP, the application should not be submitted until the impact has been resolved. For cases where "Potential Impact" to special concern species and resources has been identified before the application has been submitted, the application should be submitted to DEP along with the PNDI receipt, a completed PNDI form and a USGS 7.5 minute quadrangle map with the project boundaries delineated on the map. The PNDI Receipt should also be submitted to the appropriate agency according to directions on the PNDI Receipt. DEP and the jurisdictional agency will work together to resolve the potential impact(s). See the DEP PNDI policy at

http://www.naturalheritage.state.pa.us.

5. ADDITIONAL INFORMATION

The PNDI environmental review website is a **preliminary** screening tool. There are often delays in updating species status classifications. Because the proposed status represents the best available information regarding the conservation status of the species, state jurisdictional agency staff give the proposed statuses at least the same consideration as the current legal status. If surveys or further information reveal that a threatened and endangered and/or special concern species and resources exist in your project area, contact the appropriate jurisdictional agency/agencies immediately to identify and resolve any impacts.

For a list of species known to occur in the county where your project is located, please see the species lists by county found on the PA Natural Heritage Program (PNHP) home page (www.naturalheritage.state.pa.us). Also note that the PNDI Environmental Review Tool only contains information about species occurrences that have actually been reported to the PNHP.

6. AGENCY CONTACT INFORMATION

PA Department of Conservation and Natural Resources
Bureau of Forestry, Ecological Services Section
400 Market Street, PO Box 8552, Harrisburg, PA. 17105-8552
Fax:(717) 772-0271

U.S. Fish and Wildlife Service
Endangered Species Section
315 South Allen Street, Suite 322, State College, PA. 16801-4851
NO Faxes Please.

PA Fish and Boat Commission
Division of Environmental Services
450 Robinson Lane, Bellefonte, PA. 16823-7437
NO Faxes Please

PA Game Commission
Bureau of Wildlife Habitat Management
Division of Environmental Planning and Habitat Protection
2001 Elmerton Avenue, Harrisburg, PA. 17110-9797
Fax:(717) 787-6957

7. PROJECT CONTACT INFORMATION

Name: Betsy Collins
Company/Business Name: Tetra Tech, NUS
Address: 661 Andersen Drive, Foster Plaza 7
City, State, Zip: Pittsburgh, PA 15220
Phone: (412) 921-8250 Fax: (412) 921-4040
Email: Betsy.Collins@tetratech.com

8. CERTIFICATION

I certify that ALL of the project information contained in this receipt (including project location, project size/configuration, project type, answers to questions) is true, accurate and complete. In addition, if the project type, location, size or configuration changes, or if the answers to any questions that were asked during this online review change, I agree to re-do the online environmental review.

applicant/project proponent signature

1/21/10
date

NEWFIELD

RECEIVED
APR 02 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

April 1, 2010

PADEP Oil & Gas Management
230 Chestnut St.
Meadville, PA 16335

Subject: Newfield Appalachia PA LLC – DEP ID# 277879
E.M. Schweighofer Well #1-1

To Whom It May Concern:

Please include this letter of clarification as part of our permit application associated with the above captioned well.

This permit is to develop a well which is intended solely for exploratory purposes. A core is to be taken from several formations throughout the drilling process of this well and additional scientific study is to be performed on multiple formations including, but not limited to, geophysical logs, micro-seismic studies and fluid sampling. As permitted and configured, this well is not to be completed for production, not to be hydraulically fractured and is not to produce gas. In the future, this wellbore will either be plugged and abandoned per PADEP regulations, converted to inactive status and utilized as a monitoring well, or reconfigured and converted to a production well. Prior to either plugging and abandonment, conversion to inactive status or reconfiguration and conversion to production, we acknowledge that additional permitting will be necessary with approvals from the PADEP and other regulatory bodies with jurisdiction.

Sincerely,

Donald F. Sleeth
Drilling Manager

Tetra Tech NUS

Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745
Tel: (412) 921-7090
Fax: (412) 921-4040

LETTER OF TRANSMITTAL

DATE: 9 April 2010	JOB NO.: 112C02679
ATTENTION: Aaron O'Hara	
RE: Newfield – Schweighofer 1-1 Well Plat	

TO

Pa DEP Northwest Regional Office

230 Chestnut Street

Meadville, Pa 16335

814-332-6870

WE ARE SENDING YOU [*X*] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
1			Schwieghofer Well Plat 1-1 – sealed original

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ___ copies for approval

[x] For your use [ ] Approved as noted [ ] Submit ____copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return ____ corrected prints

[ ] For review and comment [ ] For Your Signature

[ ] **FOR BIDS DUE** _____ **19** ___ [ ] **PRINTS RETURNED AFTER LOAN TO US**

REMARKS:

Attached is the revised original Schweighofer well plat with the revisions based upon our telephone conversation on 6 April 2010. Should you require any additional information, please contact me (412) -921-8873 at any time.

SIGNED _____

Allan R. Berenbrok, P.E.

CC: file (w/a)
Andrew Strassner (w/a)
Don Sleeth (w/a)

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	G:
	Permit #: 127-20015	
	Project #:	C:

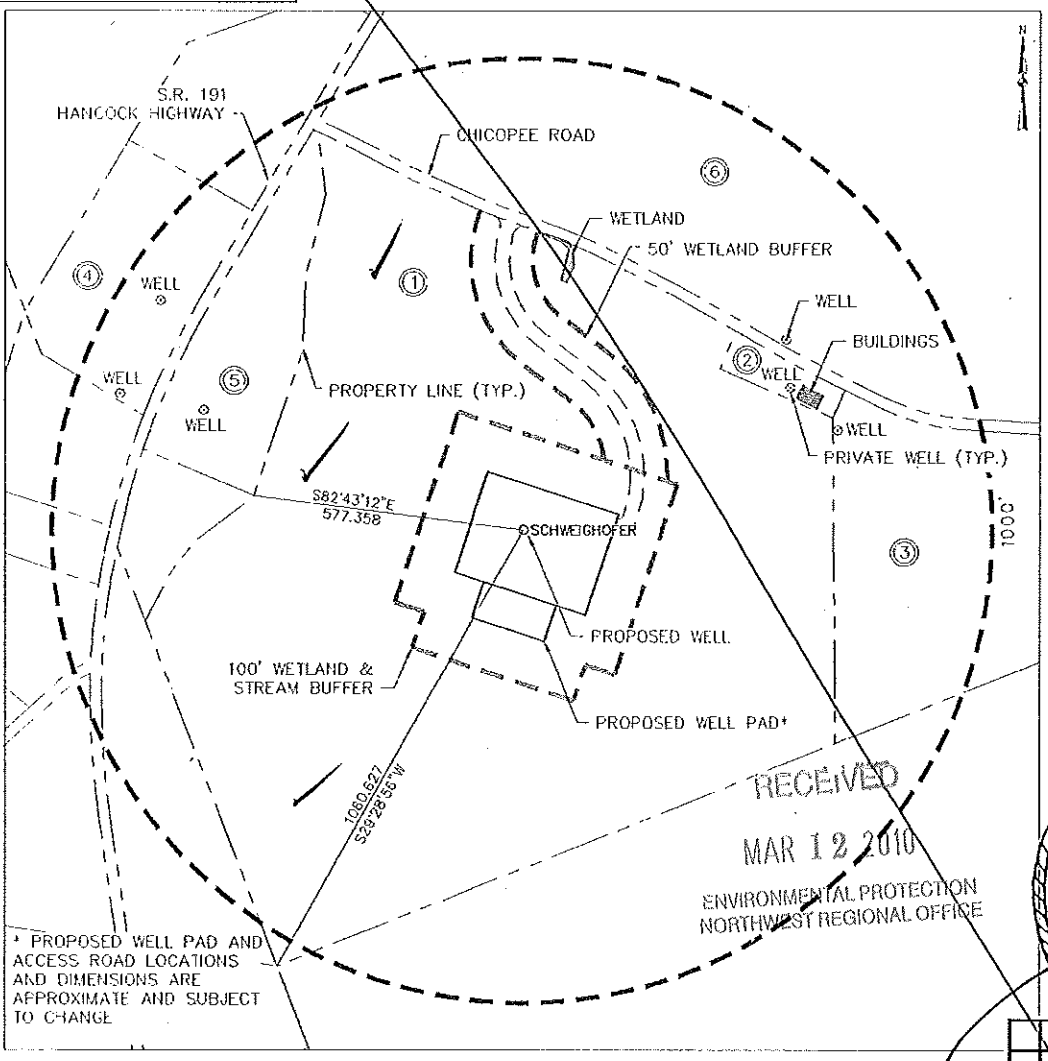
Denotes location of well on topo map.

True Latitude: NORTH
41°45' 15.0"

True Longitude: WEST
75° 10' 58.3"

Well is located on topo map 13,664 feet south of latitude 41° 47' 30"

Well is located on topo map 4,419 feet west of longitude 75° 10' 00"



1. N/F EDWARD M & MARIAN SCHWEIGHOFER 006291 37.463939
2. N/F JEFFERY R HOLLOWAY 006307 0.447538
3. N/F SHEILA A BOCHICCHIO 112935 9.400663
4. N/F PRAIRIE HILL HUNTING CLUB 006305 3.38604
5. N/F GREG RATTI 006306 3.072882
6. N/F EDWARD M & MARIAN SCHWEIGHOFER 006291 54.359303

Well Northing - Y
588790.223

Well Easting - X
2668860.3

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
037282-E

Surveyor or Engineer: Tetra Tech | Phone #: 412-921-8873 | Dwg #: 7 | Date: 02-16-2010 | Scale: 400 | Tract Acreage:

Lat & Long Metadata — Method GPS — Accuracy +/- 1 ft. — Datum NAD83

Elevation Metadata — Method GPS — Accuracy +/- 1 ft. — Datum NAD 83 — Survey Date Jan 2010

Applicant / Well Operator Name: Newfield Appalachia PA LLC	DEP ID#: 277879	Well (Farm) Name: E.M. SCHWEIGHOFER	Well #: 1-1 / Serial #:
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX, 77060		County: WAYNE	Municipality: DAMASCUS / Well Type: Test
Surface Landowner / Lessor: Edward and Marian Schweighofer		USGS 7½' Quadrangle Map Name: LONG EDDY, NY 0444	Map Section: 8 / Surface Elevation: 1310.88 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth ft.: TVD 8350 ft. / TMD 8350 ft.

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Jeffrey Holloway	N62d 2' 10"E 646'	N/A	N/A
Sheila Bochicchio	N27d 28' 18"E 704'	N/A	N/A
Greg Ratti	N69d 26' 30"W 725'	N/A	N/A

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G:
	Permit #	
	Project #	C:

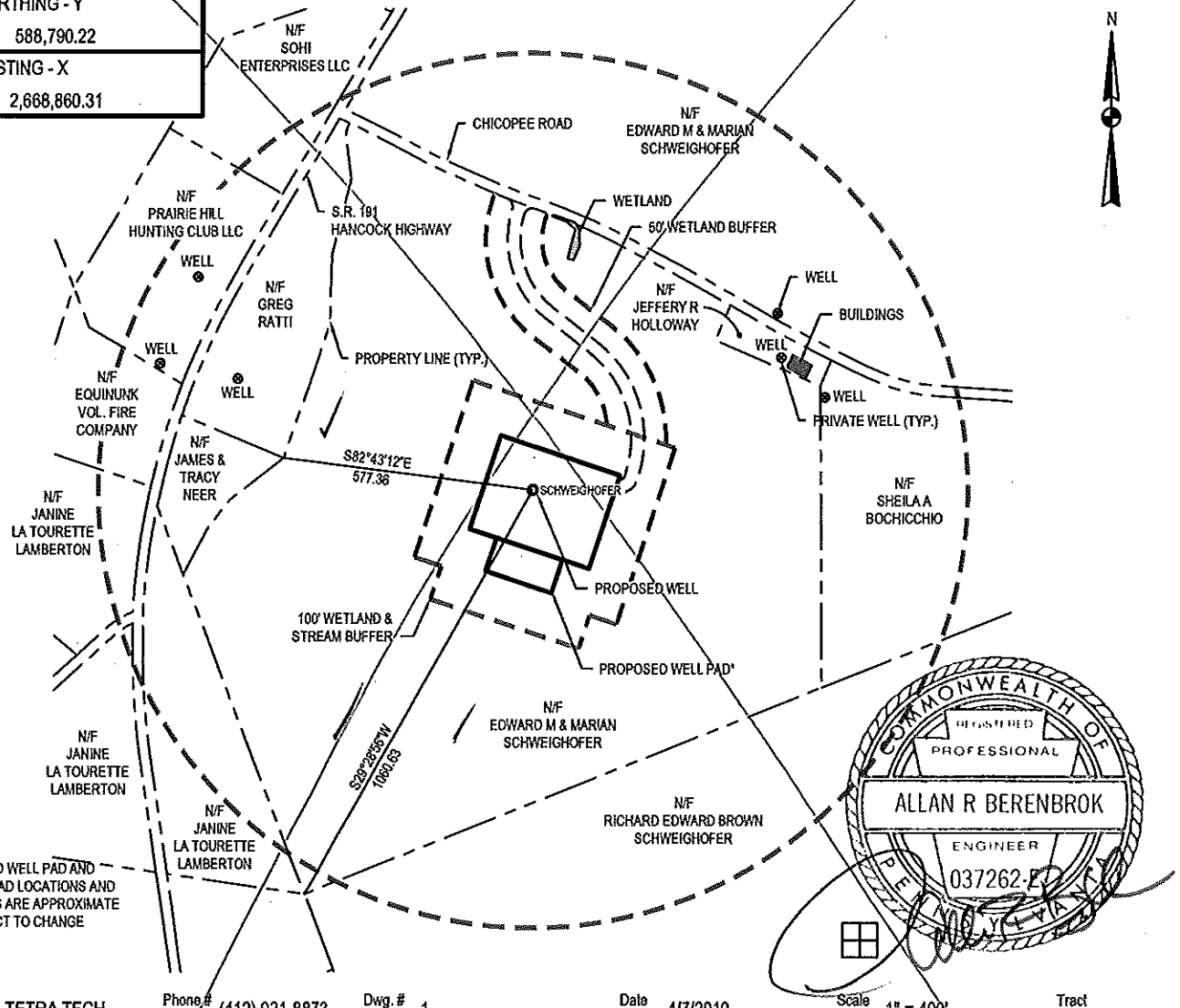
Denotes location of well on topo map.

True Latitude: NORTH	True Longitude: WEST	WELL NORTHING - Y	WELL EASTING - X
41 ° 45 ' 15.0 "	75 ° 10 ' 58.3 "	588,790.22	2,668,860.31

Well is located on topo map 13,664 feet south of latitude 41 ° 47 ' 30 "

Well is located on topo map 4,419 feet west of longitude 75 ° 10 ' 00 "

RECEIVED
APR 12 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE



* PROPOSED WELL PAD AND ACCESS ROAD LOCATIONS AND DIMENSIONS ARE APPROXIMATE AND SUBJECT TO CHANGE

Surveyor or Engineer TETRA TECH | Phone # (412) 921-8873 | Dwg. # 1 | Date 4/7/2010 | Scale 1" = 400' | Tract Acreage

Lat. & Long Metadata			Elevation Metadata			Survey Date
Method GPS	Accuracy +/- 1	ft. Datum NAD83	Method GPS	Accuracy +/- 1	ft. Datum NAD83	Jan. 2010

Applicant / Well Operator Name	Well(Farm) Name	Well #	Serial #
Newfield Appalachia PA LLC	E.M. Schweighofer	1-1	

Address	County - Code	Municipality	Well Type
363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060	Wayne	Damascus	Vertical Test

Surface Landowner / Lessor	USGS 7 1/2 Quadrangle Map Name	Map Section	Surface Elevation
Edward and Marian Schweighofer	Long Eddy, NY	8	1310.88 ft.

Target Formation(s)	Angle & Course of Deviation (Drilling)	Anticipated Total Depth
Onondaga	N/A	TVD 8350 ft. TMD 8350 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Jeffery Holloway	N62d 2' 10"E 646'	N/A	N/A
Sheila Bochicchio	N27d 28' 18"E 704'	N/A	N/A
Greg Ratti	N69d 26' 30"W 725'	N/A	N/A
Prairie Hill Hunting Club LLC	N71d 20' 29"W 907'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\Schweighofer Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/9/2010 9:11:31 AM

Tetra Tech NUS

Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745
Tel: (412) 921-7090
Fax: (412) 921-4040

LETTER OF TRANSMITTAL

DATE: 16 April 2010	JOB NO.: 112C02679
ATTENTION: Aaron O'Hara	
RE: Newfield – Teeple 1-1 and Schweighofer Well Plat	

TO

Pa DEP Northwest Regional Office

230 Chestnut Street

Meadville, Pa 16335

814-332-6870

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
1			Teeple Well Plat 1-1 – sealed original
1			Schweighofer Well Plat – sealed original

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ___ copies for approval

[x] For your use [ ] Approved as noted [ ] Submit ____copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return ____ corrected prints

[ ] For review and comment [ ] For Your Signature

[ ] **FOR BIDS DUE** _____ **19** ___ [ ] **PRINTS RETURNED AFTER LOAN TO US**

REMARKS:

Attached is the revised original Teeple and Schweighofer well plat with the revisions based upon our telephone conversation on 16 April 2010. Should you require any additional information, please contact me (412) -921-8873 at any time.

SIGNED _____

Allan R. Berenbrok, P.E.

CC: file (w/a)
Andrew Strassner (w/a)
Don Sleeth (w/a)

Phone Contact Log

Date/Time: 4/5/10 **Permit Number(s):** 127-2015

Company: Tetra Tech

Contact: Betsy Collins

Phone: 412-921-8250

Deficiencies Addressed:

Bochicchio course and distance to water supply

Bochicchio signature

topo mark

wetland < 1 acre?

4/12/10 New plats received - Bochicchio water supply

left Message Allen Berenbrok 412-921-8873 4/16/10

4/19/10 New plats Received

Denial Date:

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: AO 4/19/10
	Permit # 127-20015	C:
	Project #	

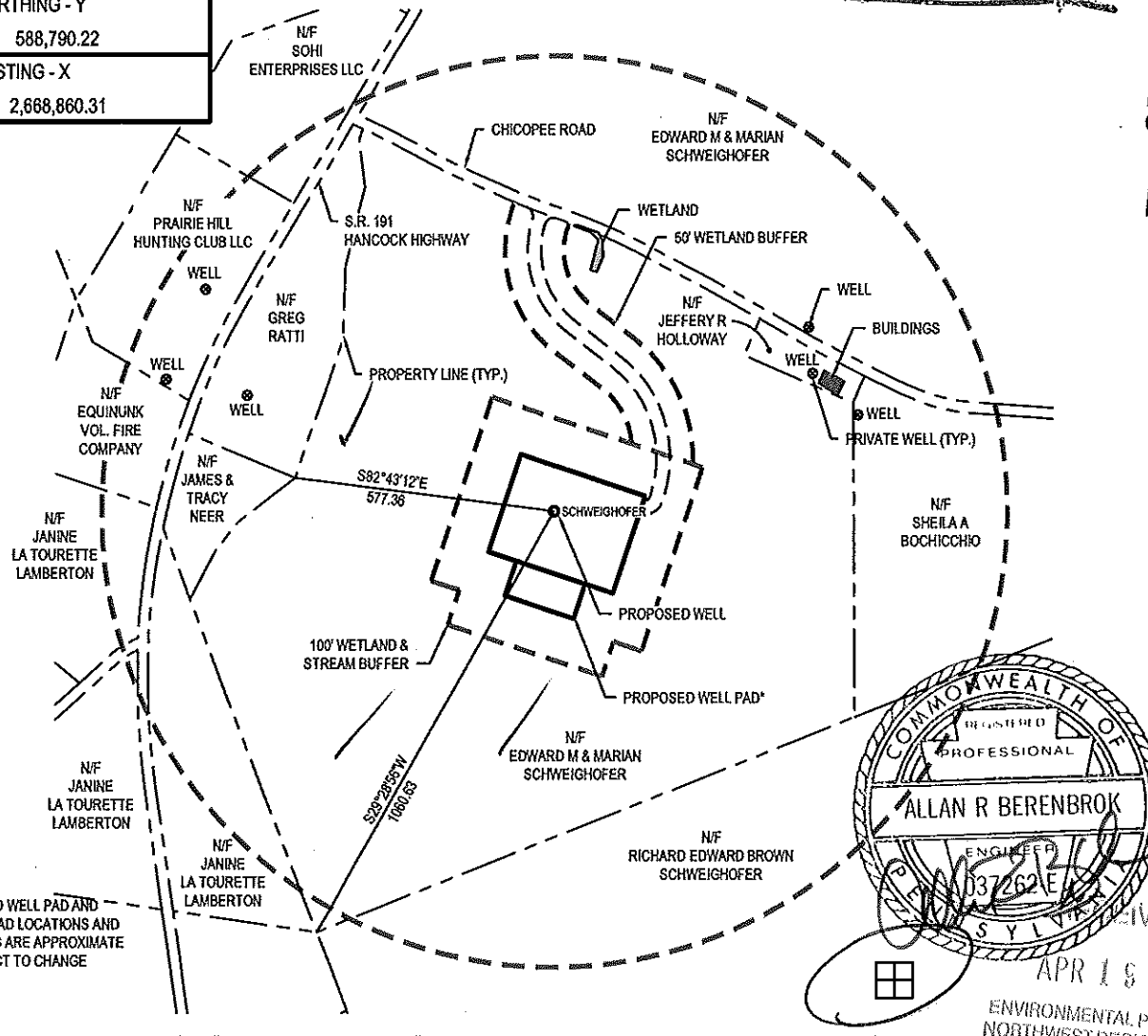
Denotes location of well on topo map.

Well is located on topo map 13,664 feet south of latitude 41 ° 47 ' 30 "

True Latitude: NORTH	41 ° 45 ' 15.0 "
True Longitude: WEST	75 ° 10 ' 58.3 "
WELL NORTHING - Y	588,790.22
WELL EASTING - X	2,668,860.31

HQ WATERSHED Little Equinunk Creek

Well is located on topo map 4,419 feet west of longitude 75 ° 10 ' 00 "



COMMONWEALTH OF REGISTERED PROFESSIONAL ALLAN R BERENBROK ENGINEER 037262E

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NORTHWEST REGIONAL OFFICE

Surveyor or Engineer TETRA TECH Phone # (412) 921-8873 Dwg. # 1 Date 4/16/2010 Scale 1" = 400' Acreage

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name Newfield Appalachia PA LLC		Well(Farm) Name E.M. Schweighofer	Well # 1-1 / Serial #
Address 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code Wayne / Municipality Damascus	Well Type Vertical Test
Surface Landowner / Lessor Edward and Marian Schweighofer		USGS 7 1/2 Quadrangle Map Name Long Eddy, NY	Map Section 8 / Surface Elevation 1310.88 ft.
Target Formation(s) Onondaga		Angle & Course of Deviation (Drilling) N/A	Anticipated Total Depth TVD 8350 ft. TMD 8350 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Jeffery Holloway	N62d 2' 10"E 646'	N/A	N/A
Sheila Bochicchio	N72d 28' 18"E 704'	N/A	N/A
Greg Ratti	N69d 26' 30"W 725'	N/A	N/A
Prairie Hill Hunting Club LLC	N71d 20' 29"W 907'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/16/2010 12:42:29 PM

5500-FM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	DEP Application Tracking #	G: Aco 4/19/10
	Permit # 127-20015	C:
	Project #	

Use only if you need additional space for listings.

Applicant / Well Operator Name	Well(Farm) Name	Well #	Serial #
Newfield Appalachia PA LLC	E.M. Schweighofer	1-1	

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Prairie Hill Hunting Club LLC	N57d 42' 43"W 913'	N/A	N/A
Edward and Marian Schweighofer	N54d 14' 30"E 692'	N/A	N/A

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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

R:_Marcellus Shale Projects\Newfield\26679 - Newfield Wells\Well Plat Permits\Permit Drawings\Schweighofer Well Pad Plat Exhibit C.dwg PIT BEN.HOPPE 4/9/2010 9:12:08 AM

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

	DEP USE ONLY	
Permittee's eFACTS ID		Auth ID
277879		827248
Watershed Name		HQ
Little Equinunt Creek		

Permittee	OGO #	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20015-	05/07/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E STE 2020	EM SCHWEIGHOFER 1 1	
	Municipality: Damascus / County: Wayne	
HOUSTON, TX 77060-2424	7½ ' Quadrangle Name: Long Eddy	Map Section #: 8

Phone	Project #	Latitude	Longitude
(281) 847-6031		41-45-15.0000	-75-10-58.3000

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1311 feet	8350 feet	TE	South 13664 feet West 4419 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **05/07/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Record and Completion Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728807
Client Id: 277879	Subfacility Id

Il Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
NEWFIELD APPALACHIA PA LLC	277879	37-127-20015-		

Address	Well Farm Name & Well #	Serial #
363 N SAM HOUSTON PKWY E STE 2020,	EM SCHWEIGHOFER 1 1	

City	State	Zip Code	County	Municipality
HOUSTON	TX	77060-2424	Wayne	Damascus

Phone	Fax	USGS 7.5 min. quadrangle map
(281) 847-6031		Long Eddy

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
		ft.	ft.	ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No

Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20015--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; fl.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID: 728807
Client Id: 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879	Well API # (Permit / Reg): 37-127-20015-	
Address: 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well #: EM SCHWEIGHOFER 1 1	Serial #
City: HOUSTON	State: TX / Zip Code: 77060-2424	County: Wayne	Municipality: Damascus
Phone: (281) 847-6031	Fax		

B. Land Application of Tophole Water

Date applied	pH
Volume (bbls)	Spec. cond. (µmhos/cm)

C. Off-site Waste Disposal

Type: ☐ Drilling Fluid (803) **Amount:** bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: **Qty:** bbls or tons

Method of disposal or reuse

☐ Sewage Treatment Plant (10)
☐ Disposal Well (04)
☐ Brine Treatment Plant (12)
☐ Landfill (05)
☐ Other (08)

Facility Information

Name | Permit #

Hauler Information

Name

Address

City | State | Zip Code

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees | Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E.
☐ Lined pit, complete Section E.
☐ Land application, complete Section F.
☐ Dusting
☐ Solidification
☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Instructions for Well Site Restoration Report

Form 5500-FM-OG0075

Use this form to file the Well Site Restoration Report as required under 25 Pa. Code § 78.65(3). This report is to be filed with the department within 60 days after the restoration of the well site.

Section A. Operator and Well Information

Enter the name, address and telephone number of the well operator/permittee.

Provide the requested well information.

Section B. Land Application Of Tophole Water

Land application of tophole water must be performed in accordance with 25 Pa. Code § 78.60.

Provide the date(s) when tophole water was applied to the land, the estimated volume discharged, and the pH and specific conductance readings of the tophole water.

Section C. Off-site Waste Disposal

If disposing of residual waste off-site, complete this section.

Check the box next to each type of waste taken off-site for disposal. More than one box may be checked. Identify the number of barrels of drilling or fracing fluid removed. If checking "other", identify the waste and show the amount in either barrels or tons. Circle the appropriate unit of measurement.

Check the box next to the type of facility or site receiving the waste. Provide the name and permit number of the facility.

Provide the name and address of the person or company hauling the waste.

Section D. On-site Disposal – Drill Cuttings or Waste

If disposing of drill cuttings and/or residual waste on-site in accordance with 25 Pa. Code § 78.61 (Disposal of drill cuttings), § 78.62 (Disposal of residual waste—pits), or § 78.63 (Disposal of residual waste—land application), complete this section.

Locate the approximate center of the disposal area by giving the course in degrees and the distance in feet from the wellhead.

Describe the types of materials that were disposed on-site. Include drill cuttings above the surface casing seat, drill cuttings below the surface casing seat, cement returns, drilling muds, frac sands, and any other material that is being disposed on-site. Indicate any additives that were in the materials being disposed.

Additives are usually present to modify the performance of cement, drilling muds or frac sands. An example might be salt or oil in drilling muds.

Check the box next to the on-site disposal methods used. If "other" is checked, briefly describe the method of disposal.

Section E. Pit Disposal

If disposing of drill cuttings under 25 Pa. Code § 78.61 (Disposal of drill cuttings) complete the pit dimensions part of this section. If disposing of drill cuttings and/or residual waste under 25 Pa. Code § 78.62 (Disposal of residual waste—pits), complete all of this section.

Describe the procedures used to close the pit. The procedures should conform to requirements in 25 Pa. Code § 78.62.

Describe the type of material and thickness used for the subbase and pit liner. The manufacturer should be identified when describing the type of material used for the pit liner.

Provide the dimensions of the pit, giving the appropriate length, width, and depth in feet.

Section F. Land Application

If disposing of drill cuttings and/or residual waste including contaminated drill cuttings under 25 Pa. Code § 78.63, complete this section.

Provide the approximate length and width of the land application area in feet. Indicate the ratio of waste to soil by volume. As an example, if a 3-inch layer of waste was mixed into a 6-inch layer of soil the ratio would be 1/2. In no case may the ratio exceed 1/1.

Complete the chemical analysis information if it is requested by the department. The analysis is to be performed on the waste soil mixture after land application has occurred. See the guidelines for land application in the "Oil and Gas Operators Manual" for taking samples and for analysis methods.

If more room is needed to complete any section, provide the information on 8 ½" by 11" sheets of paper and attach to this form. Indicate the sections the information applies to.

Please note that the most recent revision of the Application for Drilling or Altering a Well must be submitted with all drilling applications. Please check the website below for the most recent revisions for all forms.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/o_gforms.htm

The Erosion,Sediment& Storm water Control Module is no longer being accepted for ESCGP-1 applications. Please submit the complete ESCGP-1 application for any projects. The most recent revisions must be submitted along with the application fee of $500.00

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Dear Operator:

Enclosed please find well permit(s) issued for drilling or altering a well. Developing this resource in a safe and environmentally protective manner is of utmost importance. As you may be aware, there have been several recent incidences where water supplies have been affected by natural gas migration. In order to prevent future impacts to the Commonwealth's water resources and provide a mechanism for ensuring public safety, the Department is providing the following information as a reminder of the cementing requirements for oil and gas wells.

Cementing

Properly cementing the casing of a well is critical to protecting water resources, preventing gas migration, and ensuring well integrity. If the casing is improperly cemented or if insufficient cement is used, such as when cement is not returned to the surface, the operator should notify the Department pursuant to 25 Pa. Code § 78.86.

In addition, when cementing surface casing, 25 Pa. Code § 78.85 states that the cement must be allowed to set for at least 8 hours *and* until the cement attains a compressive strength of at least 350 psi. While the cement is setting, the casing must not be disturbed. This includes any activity that may cause movement or pressure changes to the casing or the cement sheath surrounding the casing. After the cement is set, care must be taken when drilling through the plug to prevent damaging the seal at the casing seat. Disturbing the casing while cement is setting or damaging the seal at the casing seat may provide a mechanism for gas and other fluids to escape from the well and contaminate groundwater and water supplies. If this occurs, the operator must notify the Department.

In addition, the Department also reminds you of the following reporting requirements for oil and gas wells.

Reporting

1. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(a) of Chapter 78 of the Oil and Gas Regulations, a **Well Record** must be submitted to the Department within thirty (30) days of cessation of drilling or altering a well.

2. Pursuant to Section 212(b) of the Oil and Gas Act and Section 78.122(b) of Chapter 78 of the Oil and Gas Regulations, a **Completion Report** must be submitted to the Department within thirty (30) days of completion of the well. A copy of the Well Record and Completion Report is enclosed with this letter. This is a newly revised form which requires the operator to certify that the well has been cased and cemented according to the requirements of 25 Pa. Code Chapter 78. Well Record and Completion Report forms that do not contain this certification will not be accepted by the Department. Additional copies of this form can be obtained from the Department's eLibrary at http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-9841

3. Pursuant to Section 212(a) of the Oil and Gas Act, a report specifying the well status and production on the most well-specific basis available is to be provided to the Department. Section 78.121 of Chapter 78 details the reporting time frames required for various well types, waste reporting, and the acceptable format for the **Well and Waste Production Report** submissions.

4. Also note that pursuant to Section 212(b) of the Oil and Gas Act, the Department has the authority to request and does hereby request you submit a digital copy on CD of **ALL Well Logs** (temperature, electrical, radioactive, gamma ray, neutron, induction, resistivity, multi-arm caliper, acoustic, optical, etc.) that have been run on this well.

The above records and logs are to be submitted to the Department of Environmental Protections, Oil and Gas Management, 230 Chestnut St., Meadville, Pa 16335-3481 to the attention of the Regional Oil and Gas Manager.

Thank you for your cooperation in this matter.

Sincerely,

S. Craig Lobins
Regional Manager
Oil and Gas Management

Authorization Search Details

Search again

Authorization ID:	841481
Permit number:	127-20011
Site:	STOCKPORT ASSN 1
Client:	PENNSWOOD OIL & GAS LLC
Authorization type:	Drill & Operate Well Permit
Application type:	Renewal
Authorization is for:	FACILITY
Date received:	07/06/2010
Status:	Issued 07/20/2010

Sub-Facilities for Authorization

Sub-Facility ID	Sub-Facility Name	Description	eMap PA Location
994272	STOCKPORT ASSN 1	Well	View Map in eMapPa (IE-only)

Log in to DEP's eNOTICE to track this permit with automatic email updates

Authorization Search Details

Search again

Authorization ID:	796670
Permit number:	127-20011
Site:	STOCKPORT ASSN 1
Client:	PENNSWOOD OIL & GAS LLC
Authorization type:	Drill & Operate Well Permit
Application type:	New
Authorization is for:	FACILITY
Date received:	06/15/2009
Status:	Issued 07/22/2009

Sub-Facilities for Authorization

Sub-Facility ID	Sub-Facility Name	Description	eMap PA Location
994272	STOCKPORT ASSN 1	Well	View Map in eMapPa (IE-only)

Log in to DEP's eNOTICE to track this permit with automatic email updates

Authorization Search Details

Search again

Authorization ID:	792478
Permit number:	127-20010
Site:	PRESTON 38 LLC OG WELL
Client:	PENNSWOOD OIL & GAS LLC
Authorization type:	Drill & Operate Well Permit
Application type:	New
Authorization is for:	FACILITY
Date received:	05/15/2009
Status:	Issued 07/29/2009

Sub-Facilities for Authorization

Sub-Facility ID	Sub-Facility Name	Description	eMap PA Location
991872	PRESTON 38 LLC	Well	View Map in eMapPa (IE-only)

Log in to DEP's eNOTICE to track this permit with automatic email updates

Authorization Search Details

Search again

Authorization ID:	841478
Permit number:	127-20010
Site:	PRESTON 38 LLC OG WELL
Client:	PENNSWOOD OIL & GAS LLC
Authorization type:	Drill & Operate Well Permit
Application type:	Renewal
Authorization is for:	FACILITY
Date received:	07/06/2010
Status:	Issued 07/20/2010

Sub-Facilities for Authorization

Sub-Facility ID	Sub-Facility Name	Description	eMap PA Location
991872	PRESTON 38 LLC	Well	View Map in eMapPa (IE-only)

Log in to DEP's eNOTICE to track this permit with automatic email updates

5500-FM-OG0001 . 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Permittee's eFACTS ID: 261535	Auth ID: 715410
Watershed Name:	Quality:

WELL PERMIT

Permittee	OGO.#	Permit Number	Date Issued
STONE ENERGY CORPORATION	OGO-66630	37-127-20007-00	04/28/2008

Address	Farm Name & Well Number	Well Serial #
PO BOX 5280	GEUTHER 1	
	Municipality: Clinton / County: Wayne	
LAFAYETTE, LA 70506	7½' Quadrangle Name: Forest City	Map Section #: 5

Phone	Project #	Latitude	Longitude
(337) 237-0410		41-41-3.7400	-75-26-10.8600

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
2210 feet	8150 feet	GS	South 8,703 feet West 5377 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/28/2009** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

RB KARLINSEY	P O Box 673, Coudersport, PA 16915-0673	814-274-3611
and Gas Inspector	Address	Telephone

5500-PM-OG0001 Rev. 9/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 1198	Amount $ 350.00

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY			
Notes	OGO # 666630	Objection Date - Do not issue before: 4-17-08	Well Permit # 127-20007
	Bond # 11503		Special Cond. A B C D E F
	C: 3 biologist & AD 4/18/08	Date Approved: 2r	Watershed Name:
	INV: 4-28-08		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
STONE ENERGY CORPORATION		337-237-0410	337-237-0426	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
P.O. Box 5280	Lafayette	LA	70506	

(Well) Farm Name	Well #	Serial #
Geuther	1	

County	Municipality	Project # (from DEP)
WAYNE	CLINTON	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled**, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE Check one.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ Other (specify)

TYPE OF WELL Check one.
- ☒ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☐ Other (specify)

APPLICATION FEE Check one.
- ☒ $ 350 (Gas; Comb.; Coal Meth; Storage)
- ☐ $ 250 (Oil; Inj– Rec)
- ☐ $ 150 (Injection – Waste Disposal)
- ☐ $ 100 (Redrill, Drill Deeper, Alter a Well, or Change Use)
- ☐ $ 0 (Rehab orphan)

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active gas **storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet **of a wetland or in a wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "**Coordination of a Well Location with Public Resources**" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☐	☒
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres?	☐	☒

DEP USE ONLY
Date Stamps/Notes
Auth 715410
Site 702466
Clnt 261535
APS 639350
Acct 614142

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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: Eric W. Rankinen Title: Regional Landman	Date
Eric W. Rankinen			2/13/2008

Application Preparer/Contact: FOX AND FOX, INC. Phone: 814-745-2861

Forest City

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP Application Tracking #	DSH 639350 SS 4-18-08
Permit #	127-20007 C:
Project #	

Well is located on topo map 8703 feet south of latitude 41 ° 42 ' 30 "

Well is located on topo map 5377 feet west of longitude 75 ° 25 ' 00 "

⊞ Denotes location of well on topo map.

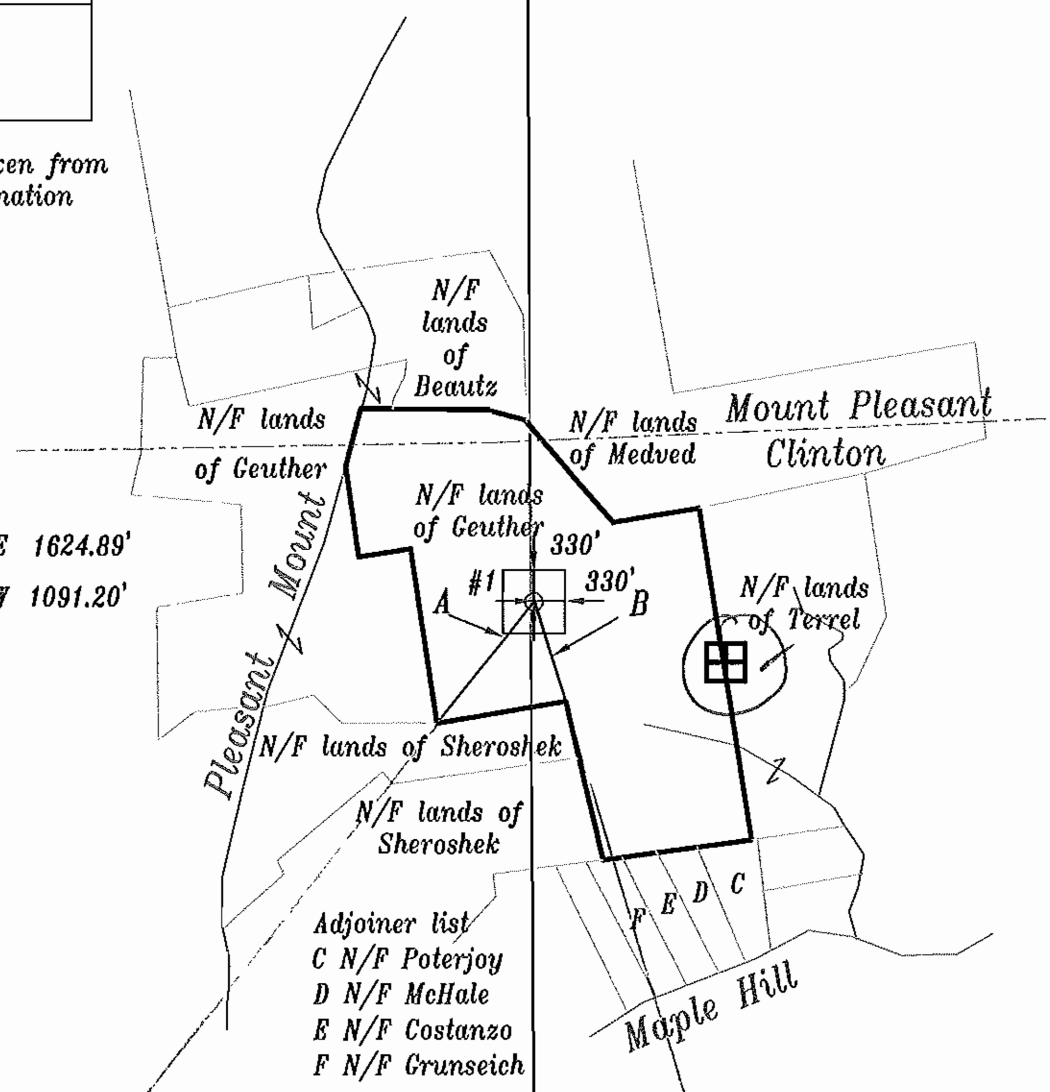
True Latitude: NORTH
41° 41' 03.74"

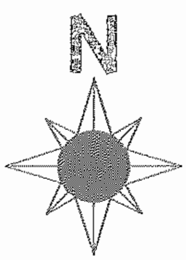
True Longitude: WEST
75° 26' 10.86"

parcel lines taken from tax map information

x 561411.86
y 2631916

A N 38°52'59" E 1624.89'
B N 17°59'20" W 1091.20'





D. Michael Canada

Surveyor or Engineer	Phone #	Dwg. #	Date	Scale	Tract Acreage
D. Michael Canada Pa. Lic. # 029272 E	(716) 379-7918	6669	Rev. Mar. 3, 2008 January 30, 2008	1" = 2000'	261

Lat. & Long Metadata Method Static GPS Accuracy ± 10 ft. Datum NAD 27	Elevation Metadata Method Scaled Accuracy ± 10 ft. Datum USGS Quad Survey Date 1/30/2008
Applicant / Well Operator Name: Stone Energy Corporation	Well (Farm) Name: Geuther; Well # #1; Serial #
Address: PO Box 5280 Lafayette, LA 70506	County - Code: Wayne; Municipality: Clinton
Surface Landowner: Robert Geuther	USGS 7 1/2 Quadrangle Map Name: Forest City; Map Section 5
Surface Lessor	Angle & Course of Deviation (Drilling): Vertical 0; Surface Elevation 2210 ft.; Anticipated Total Depth 8150 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated

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NORTHWEST REGIONAL OFFICE

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 826657
Watershed Name: Shehawken Rattlesnake Creek	Quality: HQ

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20013-	04/23/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E STE 2020	DL TEEPLE 1 1	
	Municipality: Manchester	County: Wayne
HOUSTON, TX 770602424	7½ ' Quadrangle Name: Long Eddy	Map Section #: 1

Phone	Project #	Latitude	Longitude
(281) 847-6031		41-49-39.9000	-75-11-53.3300

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1516 feet	8350 feet	GS	South 2304 feet West 8580 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/23/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Stacie Gustafson for S. Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

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APR 29 2010
OIL & GAS

5500-PM-OG0001 Rev. 10/2009

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 106345	Amount $ 1500.00

A1250 + 250 A1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes: Vertical Test Well	OGO # 67425	Objection Date - Do not issue before: 4/5/10	Well Permit # 127-20013
	Bond # 2382		Special Cond. A B C D E F
	C: 3/11/10 dlc G: 4/5/10 dlc	Date Approved: 4/20/10 JS	Watershed Name: Shehawken Rattlesnake Creek
	INV: 4-22-10		Designation: (HQ) EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address.
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	☐
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
D.L. Teeple	1-1	

County	Municipality	Project # (from DEP)
WAYNE	MANCHESTER	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and enter **date drilled**, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☒ Other (specify)

vertical test well

APPLICATION FEE
Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, Is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in e **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, Is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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NORTHWEST REGIONAL OFFICE

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "**Coordination of a Well Location with Public Resources**" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

DEP USE ONLY
Date Stamps/Notes
Auth 826650
Site 731937
Clnt 277879
APS 715262
Acct 674710
PF 728625
SF 1010226

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date
Donald F. Sleeth II			3-5-10

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: ACO 4/19/10
	Permit # 127-20013	C:
	Project #	

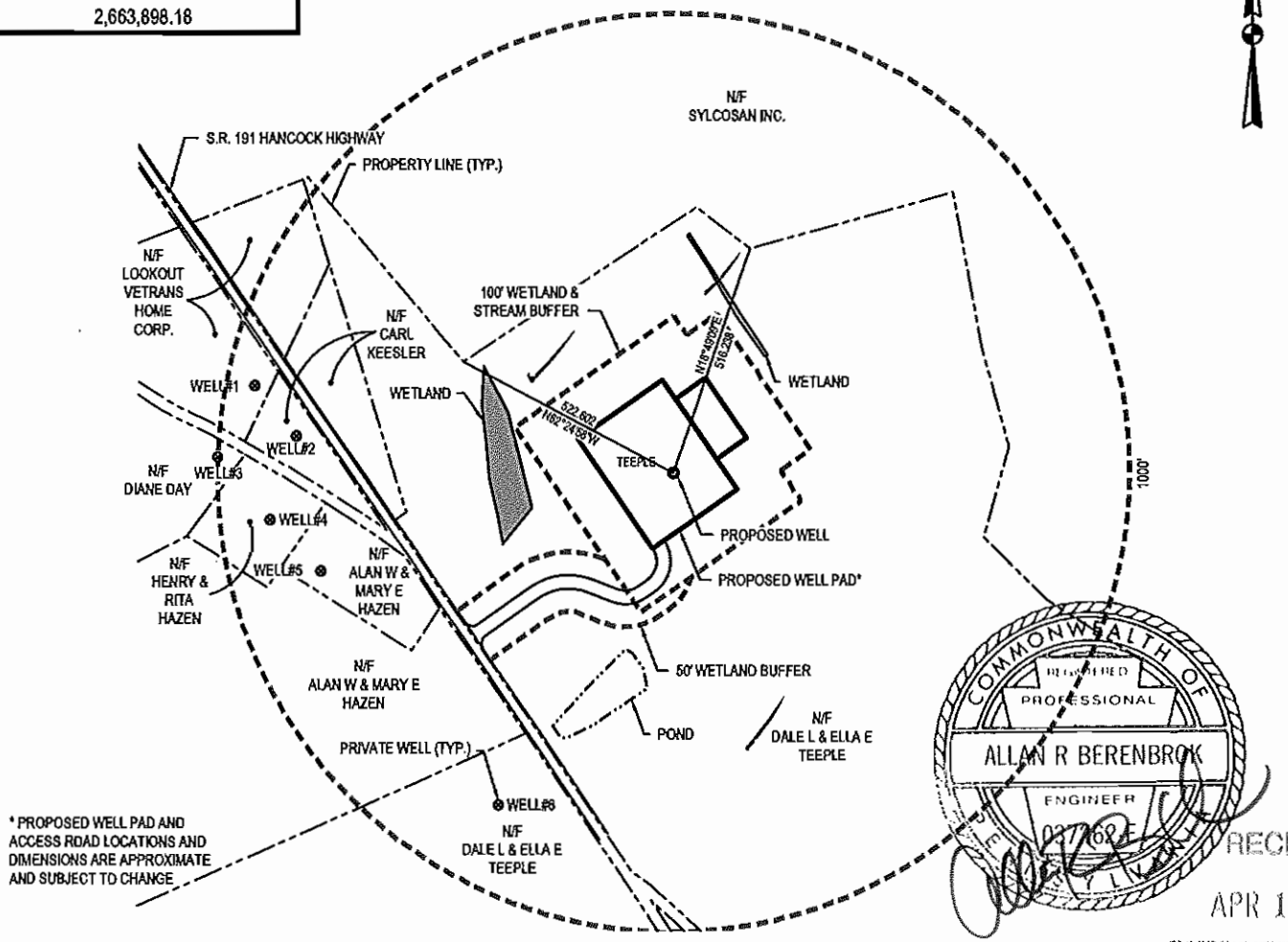
Denotes location of well on topo map.

Well is located on topo map 2,034 feet south of latitude 41 ° 50 ' 00 "

True Latitude: NORTH	41 ° 49 ' 39.90 "
True Longitude: WEST	75 ° 11 ' 53.33 "
WELL NORTHING - Y	615,470.64
WELL EASTING - X	2,663,898.18

HQ WATERSHED She hawken Rattlesnake Creek

Well is located on topo map 8,580 feet west of longitude 75 ° 10 ' 00



COMMONWEALTH OF REGISTERED PROFESSIONAL ALLAN R BERENBROK ENGINEER 027682 E

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APR 19 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1 | Date: 4/16/2010 | Scale: 1" = 400' | Tract Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well(Farm) Name: D.L. Teeple	Well # 1-1 / Serial #
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne / Municipality: Manchester	Well Type: Vertical Test
Surface Landowner / Lessor: Dale and Ella Teeple		USGS 7½ Quadrangle Map Name: Long Eddy, NY 0444	Map Section: 5 / Surface Elevation: 1516 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth: TVD 8,350 TMD 8,350

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp.	N78d 20' 44"W 938'	N/A	N/A
Carl Keesler	N84d 27' 43"W 832'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 818'	N/A	N/A
Alan W Mary E Hazen	S74d 33' 6"W 802'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/16/2010 12:43:02 PM

NEWFIELD

April 1, 2010

PADEP Oil & Gas Management
230 Chestnut St.
Meadville, PA 16335

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APR 02 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Subject: Newfield Appalachia PA LLC – DEP ID# 277879
D.L. Teeple Well #1-1

To Whom It May Concern:

Please include this letter of clarification as part of our permit application associated with the above captioned well.

This permit is to develop a well which is intended solely for exploratory purposes. A core is to be taken from several formations throughout the drilling process of this well and additional scientific study is to be performed on multiple formations including, but not limited to, geophysical logs, micro-seismic studies and fluid sampling. As permitted and configured, this well is not to be completed for production, not to be hydraulically fractured and is not to produce gas. In the future, this wellbore will either be plugged and abandoned per PADEP regulations, converted to inactive status and utilized as a monitoring well, or reconfigured and converted to a production well. Prior to either plugging and abandonment, conversion to inactive status or reconfiguration and conversion to production, we acknowledge that additional permitting will be necessary with approvals from the PADEP and other regulatory bodies with jurisdiction.

Sincerely,

Donald F. Sleeth
Drilling Manager

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 134188	Auth ID: 720872
Watershed Name:	Quality:

Permittee	OGO.#	Permit Number	Date Issued
KEVIN E SCHRADER	OGO-66800	37-127-20009-00	03/05/2009

Address	Farm Name & Well Number	Well Serial #
PO BOX 262	B & E WELLS 1	01
	Municipality: Preston	County: Wayne
LAKE COMO, PA 18437	7½ ' Quadrangle Name: Lake Como	Map Section #

Phone	Project #	Latitude	Longitude
(570) 798-0337		41-50-38.3	75-20-18.1

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1640 feet	8000 feet	GS	South 11,100 feet West 1,450 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

The permittee shall not drill the well until the permittee submits to the Department and the Department has approved the method by which the permittee will withdraw, use, store, distribute, process and dispose of water for well drilling and hydraulic fracturing purposes. ("Water Management Plan").

This permit expires 03/05/2010 unless drilling is commenced on or before that date and prosecuted with due diligence.

Regional Oil and Gas Program Manager

HERB KARLINSEY
Oil and Gas Inspector

P O Box 673, Coudersport, PA 16915-0673
Address

814-274-3611
Telephone

5500-PM-OG0002 Rev. 6/2008

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	
	Permit #: 127-2009	
	Project #:	

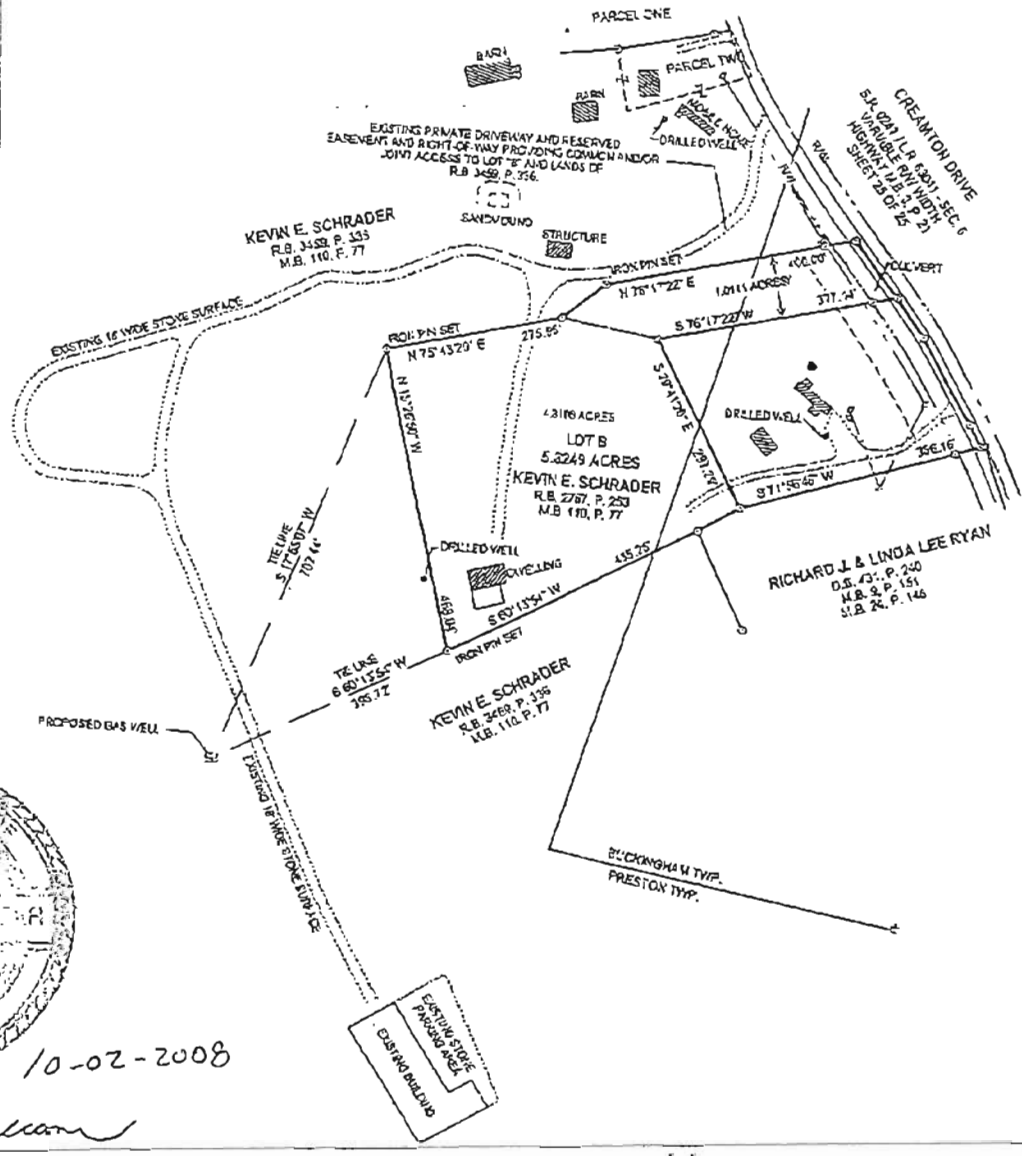
Denotes location of well on topo map.

True Latitude: NORTH
41 ° 50 ' 38.3 "

True Longitude: WEST
75 ° 20 ' 18 . 1 "

Well is located on topo map 1100 feet south of latitude 41 ° 52 ' 30 "

Well is located on topo map 1450 feet west of longitude 75 ° 20 ' 00 "



COMMONWEALTH OF PENNSYLVANIA
ALFRED K. BUCCONEAR
LAND SURVEYOR
PENNSYLVANIA

10-02-2008

Alfred K. Buccanear

REVISED 10/2/08

Surveyor or Engineer	Phone #	Dwg #:	Date	Scale	Total Acreage
ALFRED K. BUCCONEAR	(570) 488-6847		7/25/08	1" = 300'	177.28±

Lat & Long Metadata	Elevation Metadata	Survey Date
Method HANDHELD GPS Accuracy 13'± ft. Datum	Method HANDHELD GPS Accuracy 13'± ft. Datum	3/19/08

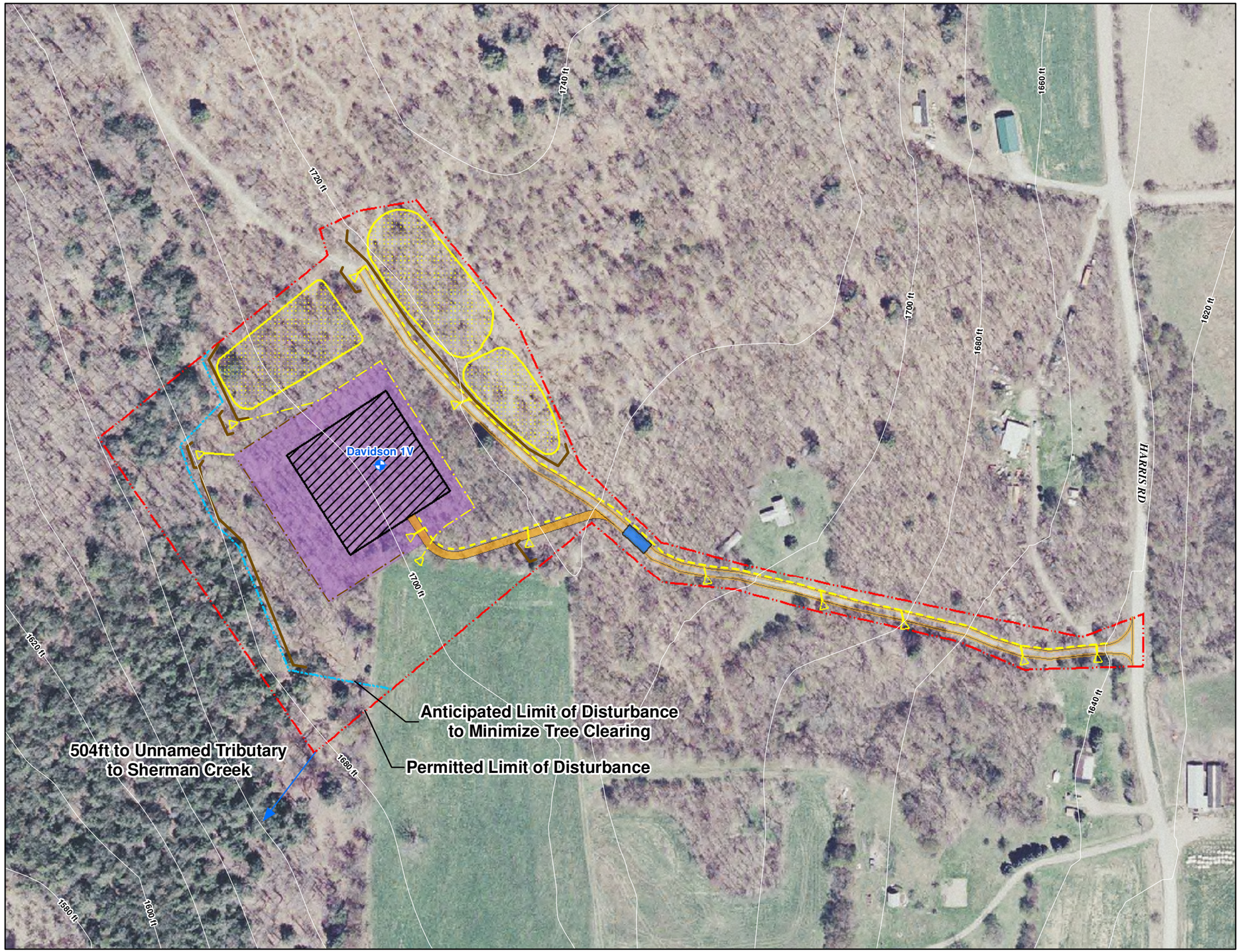
Applicant / Well Operator Name	DEP ID#	Well (Farm) Name	Well #	Serial #
KEVIN E. SCHRADER		B & E WELLS	1	

Address	County	Municipality	Well Type
3230 CREAMTON DR. BOX 262 LAKE COMO PA. 18437	WAYNE	PRESTON	GAS

Surface Landowner / Lessor	USGS 7½' Quadrangle Map Name	Map Section
SAME AS ABOVE	LAKE COMO, PA.-NY	SECTION 1

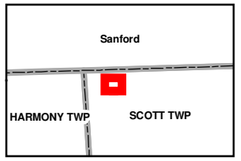
Target Formation(s)	Angle & Course of Deviation (Drilling)	Surface Elevation	Anticipated Total Depth
Marcellus Shale formation.	VERTICAL	1640 ft.	8000 ft.

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Kevin Schrader	300'		



Legend

- Vertical Well Location
- Cross Drain Culverts w/ Rip-Rap Apron
- Compost Filter Sock
- Roadside Ditch
- Diversion Ditch
- Containment Berm
- 20ft Contour Interval
- Construction Entrance w/ Tire Wash Rack
- Stockpile Area (Topsoil, Excess Soil & Vegetation)
- Proposed Access Road
- Existing Access Road
- Restored Vertical Well Pad (200'x200')
- Construction Vertical Well Pad (300'x300')
- Anticipated Limit of Disturbance
- Permit Limit of Disturbance



Key Map
Not to Scale

N

NAD 1983 State Plane
Pennsylvania North FIPS 3701
Projection: Lambert Conformal Conic
Linear Unit: Foot US

0 85 170 340 Feet

1 inch = 170 feet

URS

Davidson 1V Well Site
Hess Marcellus Shale Exploration

Wayne County, Pennsylvania

Prepared By: VP	Checked By: RW
Job:19998485.00001	Date: 07/12/2010

Q:\GIS_Data\HESS\MARCELLUS\Projects\DRBCPresentation2010July\Davidson-1V.mxd

Hess Corporation Marcellus Shale Exploration Regional Extent

2574592 2586592 2598592 2610592 2622592 2634592

680148 668148 656148 644148 632148

Davidson 1V

Approved Before June 14th 2010

SCOTT

HARMONY

STARRUCCA

THOMPSON

PRESTON

BUCKINGHAM

Delaware River Basin

Susquehanna River Basin

Hammond 1V

Funke 1V

Approved After June 14th 2010

SHERMAN RD
SCOTT CENTER RD
MAPLE GROVE RD
STARRUCCA CREEK RD
LITTLE ICELAND RD
SHADIGEE CREEK RD
KINGHILL RD
FLEASANT VALLEY RD
DIXIE HWY
ROSE HILL RD
COMO RD
WRIGHTER LAKE RD
JACKSON ST
MAIN ST

Legend

- Vertical Well Location
- 1000' Radius PADEP Limit of Liability
- Baseline Water Sample 5000' Radius
- PA Unpaved Roads
- PA Local Roads
- PA State Roads
- Rivers and Streams
- Susquehanna and Delaware River Basins Boundary
- National Wetlands Inventory
- Municipal Boundaries

URS Corporation
July 2010

Source:
2006 1M Natural Color NAIP
PA State Municipal Boundaries
DRBC Watershed Boundaries
Parcel Data from Wayne County Municipalities

NAD 1983 StatePlane Pennsylvania North
FIPS 3701 U.S. Feet
Projection: Lambert Conformal Conic
False Easting: 1968500.000000
False Northing: 0.000000
Central Meridian: -77.750000
Latitude Of Origin: 40.166667

GCS North American 1983

N

0 2,000 4,000 8,000 Feet

1 inch = 2,000 feet (when printed as ANSI E-Size)

URS

5500-PM-OG0002-DXF Rev. 11/2003

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking # 636450	# 3/11/08
	Permit # 127-20006	
	Project #	C:

Denotes location of well on topo map.

True Latitude: NORTH 41° 41' 06.39"

True Longitude: WEST 75° 21' 58.21"

Well is located on topo map 8436 feet south of latitude 41° 42' 30"

Well is located on topo map 8968 feet west of longitude 75° 20' 00"

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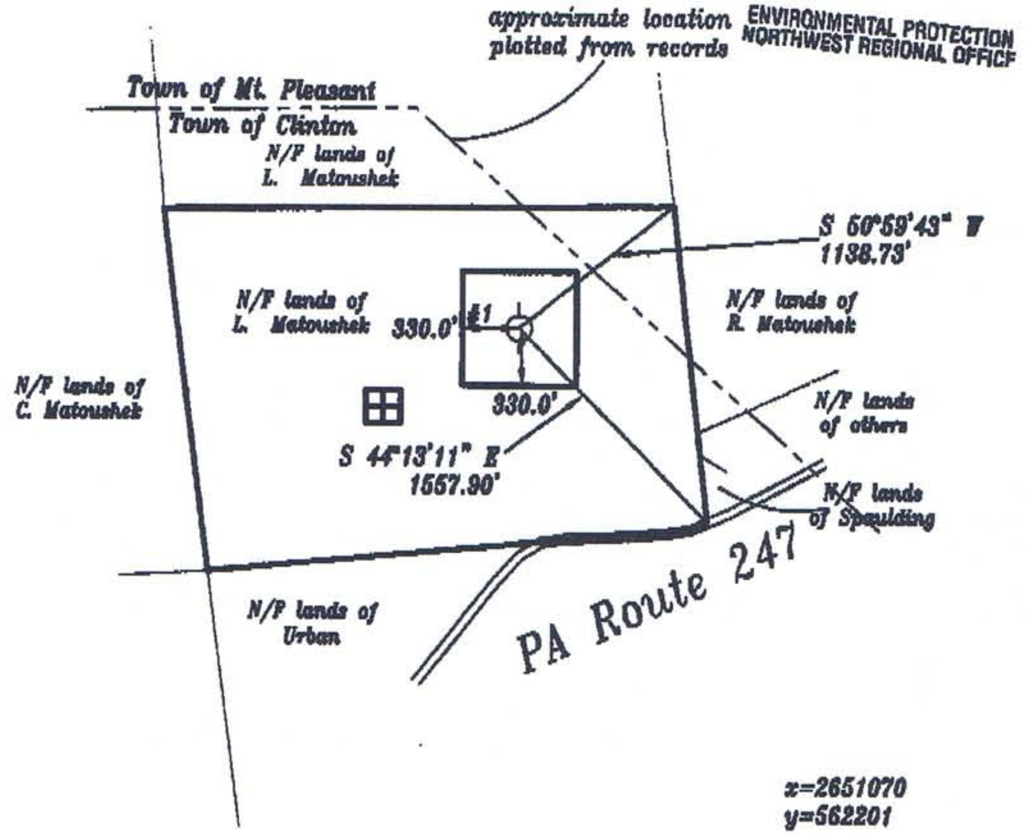
MAR 06 2008
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE



Surveyor or Engineer	Phone #	Dwg. #	Date	Scale	Tract Acreage
D. Michael Canada, Pa. Lic. # 029272 E	(716) 379-7818	6669	Rev. 3/3/08; December 12, 2007	1" = 1000'	133.45 AC

Lat. & Long Metadata: Method Static GPS, Accuracy ± 10 ft., Datum NAD 27	Elevation Metadata: Method Scaled, Accuracy ± 10 ft., Datum USGS Quad; Survey Date Dec. 11, 2007
Applicant / Well Operator Name: Stone Energy Corporation	Well(Farm) Name: Matoushek; Well # #1; Serial #
Address: PO Box 5280 Lafayette, LA. 70506	County - Code: Wayne; Municipality: Clinton / Mt. Pleasant
Surface Landowner: Louis Matoushek	USGS 7 1/2 Quadrangle Map Name: Aldenville; Map Section 4
Surface Lessor	Angle & Course of Deviation (Drilling); Surface Elevation 1545 ft.; Anticipated Total Depth 8150' ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

AC

DEP Application Tracking #	2DSH 639350	4-18-08
Permit #	127-20007	C.
Project #		

Denotes location of well on topo map.

Well is located on topo map 8703 feet south of latitude 41 ° 42 ' 30 "

Well is located on topo map 5377 feet west of longitude 75 ° 25 ' 00 "

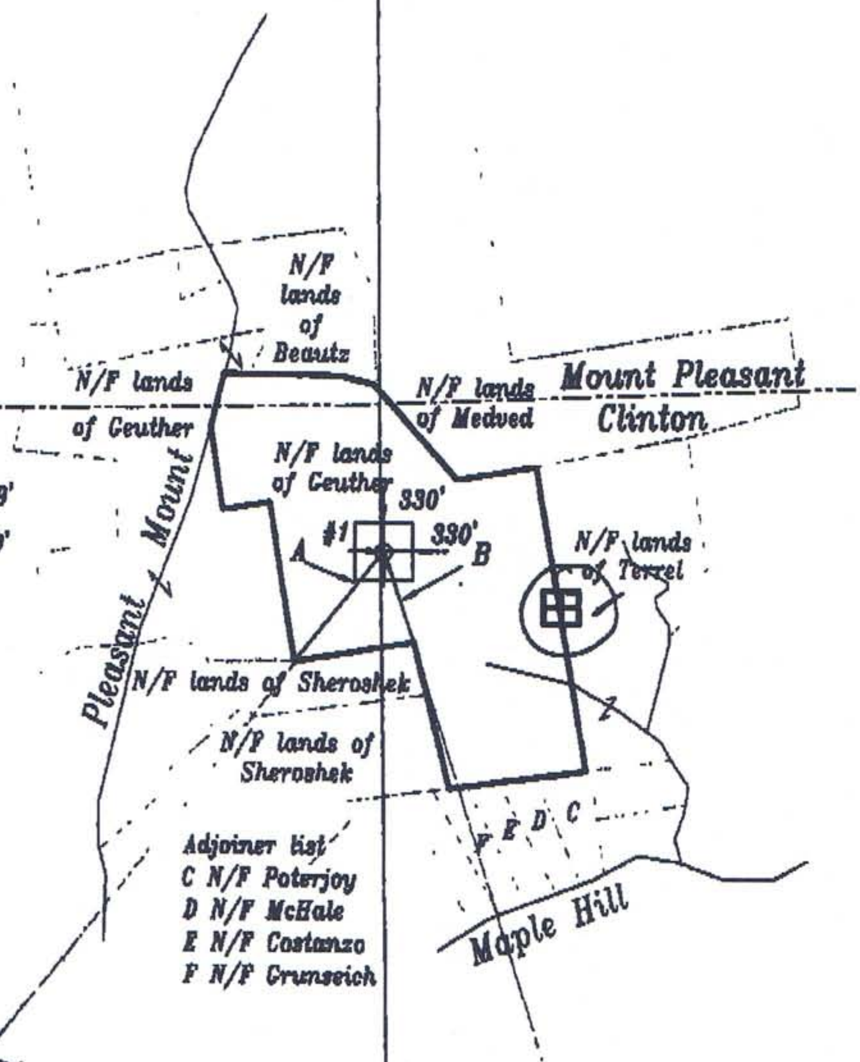
True Latitude: NORTH
41° 41' 03.74"

True Longitude: WEST
75° 26' 10.86"

parcel lines taken from tax map information

x 561411.86
y 2631916

A N 38°52'59" E 1624.89'
B N 17°59'20" W 1091.20'



N

D. Michael Canada

Surveyor or Engineer: D. Michael Canada, Pa. Lic. # 029272 E
Phone # (716) 379-7919
Dwg. # 6669
Date Rev. Mar. 3, 2008 January 30, 2008
Scale 1" = 2000'
Tract Acreage 261

Lat. & Long Metadata Method: State GPS Accuracy: ± 10 ft. Datum: NAD 27		Elevation Metadata Method: Scaled Accuracy: ± 10 ft. Datum: USGS Quad	Survey Date 1/30/2008
Applicant / Well Operator Name: Stone Energy Corporation		Well (Farm) Name: Geuther	Well # 1 / Serial #
Address: PO Box 5280 Lafayette, LA 70506		County - Code: Wayne	Municipality: Clinton
Surface Landowner: Robert Geuther		USGS 7 1/2 Quadrangle Map Name: Forest City	Map Section 5
Surface Lessor		Angle & Course of Deviation (Drilling): Vertical 0	Surface Elevation 2210 ft. / Anticipated Total Depth 8150 ft.
[illegible]			Lessee, or Operator

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APR 17 2008

ENVIRONMENTAL PROTECTION

DOCKET NO. D-2009-13-1

DELAWARE RIVER BASIN COMMISSION

Special Protection Waters

Stone Energy Corporation
Surface Water Withdrawal for Natural Gas Exploration and Development Projects
West Branch Lackawaxen River Withdrawal Site
Mount Pleasant Township, Wayne County, Pennsylvania

PROCEEDINGS

This docket is issued in response to an Application submitted to the Delaware River Basin Commission (DRBC or Commission) by Stone Energy Corporation (Stone) on March 5, 2009 for review of a surface water withdrawal from the West Branch of the Lackawaxen River (WBLR). The withdrawal will be used to support Stone's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) in the Commonwealth of Pennsylvania.

The Application was reviewed for approval under Section 3.8 of the *Delaware River Basin Compact*. The Wayne County Planning Commission and the Township of Mount Pleasant, Wayne County, Pennsylvania has been notified of pending action on this docket. A public hearing on this project was held by the DRBC on February 24, 2010.

A. DESCRIPTION

1. Purpose. The purpose of this project is to withdraw up to 0.7 million gallons per day (mgd) of surface water from the WBLR to support Stone's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the DRB in the Commonwealth of Pennsylvania.

2. Location. The Stone surface water withdrawal (WBLR withdrawal site) is located on private property under lease agreement with Stone in Mount Pleasant Township, Wayne County, Pennsylvania. The withdrawal point is located in the WBLR watershed. The WBLR is classified by Pennsylvania Department of Environmental Protection (PADEP) as a high quality (HQ)-Cold Water Fishery (CWF) stream. Specific latitude and longitude location information of the withdrawal point has been withheld for security reasons.

3. Area/Wells Served. The surface water withdrawals from the WBLR withdrawal site shall only be used to support Stone's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the DRB in the

Commonwealth of Pennsylvania. For the purpose of this docket, natural gas development and extraction activities include or are associated with: mud rotary/air rotary natural gas well drilling, hydraulic fracturing well stimulation, mixing cement for well construction, mixing drilling mud/fluid, support vehicle tire cleaning, dust control and site construction and reclamation on associated well pad sites and access roads within Stone's lease holdings in the Pennsylvania portion of the DRB. Subject to the limitations in this docket, the surface water withdrawals under this docket shall only to be used to support Stone's natural gas development and extraction activities at sites targeting shale formations within the drainage area of Special Protection Waters within the DRB in the Commonwealth of Pennsylvania that have the applicable approvals by the DRBC and the Pennsylvania Department of Environmental Protection (PADEP) (See discussion in Findings section and Conditions in the Decision section of the docket). For the purpose of defining Area Served, the Application is also incorporated herein by reference consistent with conditions contained in the Decision section of this docket and without expanding the limitations or service area as set forth above.

4. Physical Features. The docket holder estimates that the majority of the withdrawn surface water will be used to stimulate horizontal and/or vertical natural gas wells by hydraulic fracturing. The remaining withdrawn water will be used for mixing cement for well construction, mixing drilling mud/fluid, support vehicle tire cleaning, dust control and site construction and reclamation on associated well pad sites and access roads within Stone's lease holdings in the Pennsylvania portion of the DRB.

a. Surface Water Source Design Criteria. Proposed facilities at the WBLR withdrawal site will consist of up to eight 6-inch diameter floating intake screens (Megator Dolphin Floating Suction Strainers) on the end of flexible suction line attached to a portable Prime Series pump. The floating suction strainers shall be tethered to the stream bank using nylon rope or steel cable. The pump will have an intake capacity of 1,040 gallon per minute (gpm) (see Condition n in the Decision section of the docket). A duplicate back-up pump unit may also be stored at the site. Water withdrawn from the WBLR will be distributed directly into a maximum of ten (10), 500-barrel capacity (21,000 gallon) mobile storage tanks located within a fenced-in and gated staging area approximately 0.5 acres in size. Water will be pumped from the storage tanks into the tanks of the water trucks via pumps carried on the hauling vehicles. The water trucks will be filled within the staging area. The pumps will also be located within the fenced in staging area. The staging area shall be constructed with coarse stone aggregate underlain where necessary by a geosynthetic liner. The withdrawal location will have restricted access, through use of fencing and signage. The withdrawal location will be restricted to the operations associated with the function of water withdrawal. Prior to construction, the docket holder will submit final plans and specifications for the WBLR withdrawal site to the Commission. No construction shall commence at the WBLR site until the final plans and specifications have been submitted to the Commission and approval by the Executive Director in accordance with Condition e. in the Decision section of the docket

The withdrawn water and equipment in contact with that water shall be managed and treated in accordance with the Invasive Species Control Plan (if determined to be applicable) and

the Operation Plan (Conditions r and s respectively in the Decision section of the docket) to prevent the spread of invasive species.

The water storage tanks located on site shall only be used to store and distribute surface water from the WBLR. The docket holder will meter, record, and report the volume of surface water withdrawn from the WBLR as it is distributed to the storage tanks as described in Section B. FINDINGS, below and in the Decision section of the docket. Records of the volume of water distributed from the storage tanks to the hauling vehicles will be maintained and reported as part of the required transportation records as described in Section B. FINDINGS, below and in the Decision section of the docket.

Portions of the project site are located in the 100 year flood plain as delineated on the Federal Emergency Management Agency maps. Facilities at the WBLR site shall be designed and constructed in accordance with Commission Flood Plan Regulations (FPR) (e.g. lowest operating floor of such facility is above the Flood Protection Elevation (as defined in the FPR), or the facility is flood proofed according to plans approved by the Commission nor unless emergency plans and procedures for action to be taken in the event of flooding are prepared). (See Condition d. in the Decision section.)

The water system on this site will not be interconnected with any public or private water supply system and withdrawn water will only be used for the purposes defined in Section A.3 Area/Wells Served.

b. **Cost.** The overall cost of this project is estimated to be $18,700. This cost includes planning design, and construction of the surface water withdrawal intake, staging area, and associated appurtenances.

B. FINDINGS

This docket was prepared by Commission staff in response to an Application submitted to the Delaware River Basin Commission (DRBC or Commission) by Stone on March 5, 2009 for review of a surface water withdrawal from the WBLR to be used to support Stone's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the DRB in the Commonwealth of Pennsylvania.

The Commission provided public notice in regards to this docket application in the Federal Register on February 19, 2010. The Commission also notified parties on the Interested Parties List for this application and posted the draft Stone WBLR Withdrawal Site docket on the Commission website on February 9, 2010. On February 24, 2010, a public hearing was held at the Best Western Inn in Matamoras, Pennsylvania. Due to public interest in the project, the comment period was extended from March 12, 2010 until April 12, 2010. During the hearing, which lasted over 7 hours, oral and written comments were received. Including the comments and written materials submitted at the February 24, 2009 hearing and during the extended public

comment period, the Commission received over 2,000 letters, emails, and supporting materials during the public comment period. A copy of the transcript of the February 24, 2010 hearing and a list of the commenters that submitted comments during the hearing is available from the Commission.

Comments were received from the public, local governments, various organizations, federal and state agencies industry representatives, and the project sponsor. A significant number of comments were received from the public and other sources. While the majority of comments were in opposition to the Commission proceeding with the approval of the docket, there were also comments in favor of the proposed Commission action. Federal and state agency comments were more specifically related to docket and site requirements.

On May 5, 2010, the Commissioners directed Commission staff to draft regulations for natural gas well pad projects in shale formations in the Delaware River Basin. The Commissioner's also indicated that it will consider specific natural gas well pad applications after the new regulations are in place. The Commissioners also indicated that applications for water withdrawals associated with natural gas well pad applications activities targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) should continue to be processed since such applications are similar to water withdrawal applications for other uses in the DRB.

Commission staff's review of Stone's Matoushek 1 natural gas well pad application is suspended. Comments that were received during the public hearing and comment period concerning Stone's Matoushek 1 natural gas well pad docket are not addressed in the attached document. Stone's WBLR application indicated that the water withdrawal would be used for Stone's natural gas well pad activities targeting shale formations in Pennsylvania within the drainage area of Special Protection Waters within DRB. In addition, Stone indicated that it wants the processing of the WBLR application to be completed, despite the suspension of the processing of natural gas well pad applications.

After review of the comments and testimony received in preparation for the July 14, 2010 Commission meeting, Commission staff provided the Commissioners with:

- DRBC staff memo dated July 2, 2010 recommending that the Commissioners approve the attached Stone Energy docket No. D -2009-013-1 at the July 14, 2010 Commission meeting.
- DRBC staff response document to the major issues/comments received during the public comment period and public hearing concerning the Stone Energy Corporation draft Docket No. D-2009-0013- 1.
- A revised draft docket.

The Commission staff does not consider these revisions substantial and therefore does not recommend re-noticing of the draft docket or reopening the public comment period. The notice

announcing that the Commission will consider this docket at the Commission's July 14, 2010 meeting was published in the Federal Register on June 29, 2010. Commission staff sent notices to the parties on the Interested Parties List on June 30, 2010.

Public comments were not requested at the July 14, 2010 Commission meeting since: an individual public hearing was held on the draft docket; the public comment period closed on April 12, 2010; and, no substantial changes have been made to the draft docket. During the July 14, 2010 business meeting, the Commissioners' approved the docket for the project withdrawal.

This docket restricts the sites to which the water withdrawn from the WBLR withdrawal site may be transported to and used at (the receiving sites), but does not address the limitations needed to conform activities at these receiving sites to the Commission's Comprehensive Plan. This docket does not approve nor should it imply the Commission determinations of the natural gas development and extraction receiving sites or the activities conducted at those sites. The Delaware River Basin Commission (DRBC) at its May 5, 2010 public business meeting directed commission staff to draft regulations for natural gas well pad projects in shale formations in the Delaware River Basin. The Commissioners will consider specific natural gas well pad applications after the new regulations are in place. The Commissioners also indicated that the review of pending or future proposed water withdrawals to be used to supply water to natural gas extraction projects, including Stone Energy's proposed water withdrawal from the West Branch Lackawaxen River in Mount Pleasant Township, Wayne County, Pa., will proceed in accordance with existing DRBC regulations. In proceeding with the project under this docket, the docket holder is proceeding at its own risk relative to the Commission determinations yet to be made at such receiving sites.

In the review of this Application, Commission staff has also considered the following on and off-site natural gas development and extraction site activities:

a. **Off-site Natural Gas Development and Extraction Activities.** The recommendation to approve the water allocation under this docket is based on the docket holder's projected water demand to support Stone's natural gas development and extraction activities within the DRB in the Commonwealth of Pennsylvania. Condition k. in the Decision section of this docket requires that surface water withdrawals from the Stone WBLR Withdrawal Site shall only be used to support Stone's natural gas development and extraction activities in the drainage area to Special Protection Waters in the Pennsylvania portion of the DRB for natural gas wells targeting shale formations. The condition also requires that such sites must have been approved by the Commission and also the PADEP. Condition m. in the Decision section provides that no water withdrawal from the WBLR shall commence until the docket holder has received approval of the Commission and PADEP for natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) in the Commonwealth of Pennsylvania.

Off-site Non-Point Source Pollution Control Plans. In the case of off-site natural gas well

development and extraction activities targeting shale formations, a separate NPSPCP will be a requirement within a Commission approval for those sites

Off-site Wastewater Generation and Disposal. The Commission's review of all water withdrawal requests includes an evaluation of the wastewaters generated from the approved withdrawals to ensure that the wastewater will be adequately treated and disposed. No water that is withdrawn from the WBLR withdrawal site (see Condition q. in the Decision section of this docket) may be discharged within the DRB, except as provided for in this docket or in accordance with future Commission issued natural gas development and extraction site approvals. Stone must demonstrate that all water withdrawn from the WBLR withdrawal site that becomes wastewater as a result of natural gas development and extraction site activities (e.g. domestic or hydro-fracturing flow-back water and produced water from gas well drilling that cannot be used in the well stimulation process) shall be conveyed to treatment and disposal facilities approved by the DRBC (if in the DRB and subject to Commission approval) as well as by the applicable state/Federal agency (if inside or outside of the DRB). The docket holder is encouraged to use the flow-back water for well stimulation in accordance with Condition w in the Decision section.

To date, the Commission has not approved any in-basin disposal facilities to accept non-domestic related wastewater from natural gas development and extraction activities. In support of its application, the docket holder indicated that it currently intends to transport the wastewaters generated from this water withdrawal to approved treatment facilities outside the DRB. The docket holder has provided the Commission with the names and addresses of these facilities. This list is available for review upon written request or at the Commission's office. Commission staff is satisfied that plans exist for treatment of wastewaters generated as a result of this withdrawal approval. The determination that any of these facilities or alternative facilities can accept the volume and quality of the wastewaters from natural gas development and extraction site activities will also be reviewed when natural gas well site specific applications are submitted to the Commission. Specific conditions for wastewater disposal will be included in any docket that may be issued for natural gas well site development and extraction activities.

On-site Findings

Special Protection Waters

The project is located in the area of the Delaware River Basin that is designated by the Commission as Special Protection Waters as set forth in the DRBC *Water Quality Regulations* (WQR). The SPW designation and associated regulations are designed to protect waters with exceptional value including without limitations existing high water quality in applicable areas of the Delaware River Basin. Article 3.10.3A.2.e.1). and 2). of the *WQR, Administrative Manual* -

Part III, requires that projects subject to review under Section 3.8 of the Compact that are located in the drainage area of Special Protection Waters must submit for approval a Non-Point Source Pollution Control Plan (NPSPCP) that controls the new or increased non-point source loads generated within the portion of the docket holder's service area which is also located within the drainage area of Special Protection Waters. One exception to the NPSPCP requirement is for projects that are located above major surface water impoundments listed in Section 10.3.A.2.g.5) where time of travel and relevant hydraulic and limnological factors preclude a direct impact on Special Protection Waters (Section 10.3.A.2.e.1. c)

The docket holder's surface water withdrawal point is located within the drainage area to Special Protection Waters. The NPSPCP plan requirement is applicable to this project. This project includes the construction of a surface water intake, staging area, and associated appurtenances. The docket holder submitted a general NPSPCP with the Application. However, no site construction activities or water withdrawals approved by this docket shall take place at the WBLR withdrawal site until a site specific NPSPCP including measures to control stormwater both during and post construction on the site has been submitted to the Commission and approved by the Executive Director (Condition i. and any other necessary federal, state, and local authorizations have been issued.

Withdrawal Site and Operations

The intake proposed at the WBLR withdrawal site shall be constructed in accordance with a design approved by PAF&BC, USACE and U.S. Fish & Wildlife Service that in the agencies' view minimizes to the greatest extent possible, impingement and entrainment impacts in the vicinity of the withdrawal site (Condition p. in the Decision section of the docket).

Surface water withdrawal is restricted to the intake structure to be located in the WBLR as provided for in this docket and as described in the Application and supporting materials. All surface water shall be conveyed directly to the water storage tanks and then to the hauling vehicles. Surface water withdrawals from the WBLR withdrawal site shall be metered through a metering plan designed to meet the DRBC metering, recording and reporting requirements of the Commission's Water Code, this docket, and the docket holder's approved Operations Plan described below. The volume of water withdrawn from the WBLR withdrawal site shall be metered and recorded by means of an automatic continuous recording device, or flow meter, and shall be measured to within 5% of actual flow (Condition t. in the Decision section of the docket). The docket holder shall report average daily withdrawal rate and daily and monthly totals of the withdrawal to the Commission on a monthly basis beginning with the 5th calendar day of the month following the month in which the water withdrawals commence in accordance with Condition t. in the Decision section of the docket. Any withdrawals that exceed the allocation provided for in Condition n. of the Decision section of the docket will be reported to the Commission within 48 hours of the exceedance in accordance with Condition ee. of the Decision section of the docket.

A control box located at the withdrawal location, combined with a metering system shall be used to control pump operations. The water storage tanks located on site shall only be used to store and distribute surface water from the WBLR withdrawal site. The docket holder shall meter, record, and report the volume of surface water withdrawn from the WBLR withdrawal site before it is distributed to the storage tanks as described in Section B. FINDINGS, below and in the Decision section of the docket.

The amount of water withdrawn from the WBLR withdrawal site shall be automatically metered and recorded daily and shall be available for inspection. The proposed WBLR surface water withdrawal pump controls shall restrict the surface water withdrawal rate to an instantaneous flow not to exceed 1,040 gpm or a total of 0.7 million gallons (MG) during any day from the river whichever is less. A "day" is defined as the 24-hour period between 12:00 AM and 12:00 AM the following day. At any time during the day, when the total volume withdrawn from the WBLR reaches 0.7 MG, the pump shall automatically shut off, not permitting any additional withdrawals from the source until the start of the following day. A pump operator will be onsite to supervise and monitor all pumping operations.

In addition to the metering and recording above, the docket holder shall maintain water transportation records for all water transferred from the WBLR withdrawal site. There shall be no direct transfer of water from the WBLR withdrawal site to a water hauling vehicle without metering and recording. Records maintained by the docket holder and kept at the WBLR withdrawal site (or at an alternative site approved in writing by the Executive Director) will include the trucking company name, license plate, name of the driver, amount of water transferred, date and time of transfer and destination of the transported water. Surface water withdrawals from the WBLR withdrawal site shall only be used to support Stone's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the DRB in the Commonwealth of Pennsylvania (Condition k. in the Decision section of this docket).

All water withdrawn from the WBLR withdrawal site shall be treated to prevent the spread of potentially invasive, harmful, or nuisance species from entering other watersheds in the DRB as required in the approved Invasive Species Control Plan (ISCP) described in Condition r. in the Decision section of this docket.

Unused surface water from any of the docket holder's Commission approved natural gas development and extraction site activities targeting shale formations in the DRB may be transported to and used at other Commission and state-approved well pads targeting shale formations controlled by the docket holder in the DRB, with the written approval of the Executive Director. Such transfers shall also be reported to the Commission. The Commission encourages the reuse of recovered fracturing fluids (flow back and production fluids), however reuse must be in accordance with the terms and conditions contained in natural gas well pad dockets that may be issued within the DRB. Any reuse shall also be reported to the Commission.

No recovered fracturing fluids shall be used for any purpose other than hydraulic fracturing at natural gas wells targeting shale formations.

No water, fresh or otherwise (e.g. cement mixer wash-out, truck wash water, etc) shall be discharged to waters of the DRB except in accordance with written approvals from the Commission and/or the appropriate state agency (Condition q. in the Decision section of this docket).

The withdrawal location will have restricted access, through use of fencing, signage or other similar means. The WBLR withdrawal site location will be restricted to operations associated with the function of water withdrawal. These areas will not be used as staging areas for chemical additives, except as necessary as part of the ISCP, or fuels above what is likely needed to run an emergency generator if one is used.

Pass-by Flow

The withdrawal shall allow at all times of the year, a minimum flow of water in the WBLR to pass-by as measured below the intake at the WBLR withdrawal site. The WBLR withdrawal site shall be fitted by the docket holder with a gage (the Stone WBLR gage) or another gage or other instrumentation approved by the Executive Director and calibrated to the downstream Aldenville gage station flow data. The installed gage shall be a real-time monitoring and recording gage. For the period of record from 1987 to 2007, the average daily flow statistic calculated for the 40.6 square mile drainage area at the Aldenville gage is 84.1 cubic feet per second (cfs). The proportional average daily flow statistic for the 11.5 square mile drainage area at the Stone WBLR withdrawal site is 23.7 cfs. The pass-by flow, which is based on 25 percent of the average daily flow, shall be a minimum of 5.9 cfs as measured at the Stone WBLR gage. Daily withdrawal rates shall be reduced as appropriate to ensure that a minimum of 5.9 cfs passes by the Stone WBLR gage (Condition o). Withdrawals shall cease entirely if the 24-hour average flow at the Stone WBLR gage, less the withdrawal, is 5.9 cfs or less. The pumps shall be shut off, not permitting any additional withdrawals from the WBLR until the flow as measured at the Stone WBLR gage is at least 8.2 cfs for a 24 hour period. The monitoring and metering of the withdrawal activities at the WBLR withdrawal site shall be described in the Operations Plan. Pass-by flows for the WBLR withdrawal site are summarized in the table below:

STREAM IDENTITY	NEAREST USGS STREAM GAGE	25% OF AVERAGE DAILY FLOW AT ALDENVILLE GAGE (DATA YEARS 1987-2007)	INTAKE PUMP CAPACITY	MINIMUM PASS-BY FLOW REQUIRED AT WITHDRAWAL SITE
West Branch Lackawaxen River Intake	Aldenville Gage #1428750	21 cfs	1,040 gpm	5.9 cfs

The pass-by flow is established from readily available data from the Aldenville gage station operated by the United States Geologic Survey (USGS). The gauge is located approximately 4.0-miles downstream of the proposed WBLR withdrawal site location.

The Stone WBLR gage shall be periodically calibrated by the docket holder. The calibration schedule will be based on the same frequency used by the USGS to re-calibrate its gage station. The Operations Plan shall establish the calibration schedule. The data from the Stone WBLR gage will be converted to daily average flow data for reporting and pass-by flow compliance monitoring. The docket holder shall compare the Stone WBLR gage and the USGS Aldenville gage station no less than once per week through direct observation and real time flow measurements provided by the USGS website when the flow measured at the Stone WBLR gage is 10 cfs or more. When the 24 hour average flow at the Stone WBLR gage is less than 10 cfs the docket holder shall compare the USGS Aldenville gage station and the Stone WBLR gage no less than once per day to ensure compliance with the 5.9 cfs pass-by flow. The Stone WBLR gage must be checked at the minimum intervals set forth above on days when water is withdrawn and also a minimum of 24 hours prior to the initiation of withdrawal to establish that the pass-by flow meets the minimum requirement. No water withdrawal may be initiated at the WBLR withdrawal site until an operating gage is established and a monitoring and reporting program is in effect in accordance with the requirements of the Operations Plan and conditions of this docket.

Operations Plan

In accordance with Condition t. of the Decision section of the docket, at least 90 days prior to the scheduled initiation of any site clearing or construction at the WBLR withdrawal site, the docket holder shall submit an Operations Plan (OP) for the WBLR withdrawal site to the Executive Director. The OP shall include the specifics of the site operations, which shall including, at a minimum, the procedures necessary to comply with the conditions in the Decision section of this docket. In accordance with Condition s. in the Decision section of the docket, no withdrawal of surface water from the WBLR withdrawal site is permitted until the OP is approved by the Executive Director in writing and all systems and equipment required to comply with this docket are operational.

The project is designed to conform to the requirements of the *Water Code* and *WQR* of the DRBC. Commission staff has imposed requirements and limitations to protect the water resources of the basin. For on-site water withdrawal actions and activities related to the water withdrawal actions, Commission staff has included conditions in the Decision section of this docket.

The DRBC estimates that the project withdrawals will result in a consumptive use of 100 percent of the total water withdrawn from the WBLR. The DRBC definition of consumptive use is defined in Article 5.5.1.D of the *Administrative Manual – Part III – Basin Regulations – Water Supply Charges*. This withdrawal is not at present subject to water supply charges as the

point of withdrawal is located above the USGS stream gaging station at Montague, NJ. The docket holder shall be subject to any future water supply charges applicable to withdrawals located above the Montague gaging station resulting from any changes to the DRBC's existing water supply regulations.

The project does not conflict with the Comprehensive Plan and is designed to prevent substantial adverse impact on the water resources related environment, while sustaining the current and future water uses and development of the water resources of the Basin.

C. DECISION

I. Effective on the approval date for Docket No. D-2009-13-1 below the project and appurtenant facilities as described in Section A "Description" are approved pursuant to Section 3.8 of the *Compact*, subject to the following conditions:

a. The project and the appurtenant facilities described in Section A "Description" shall be added to the Natural Gas Well & Withdrawal Database maintained by the DRBC.

b. Docket approval is subject to all conditions, requirements, and limitations imposed by the PADEP, and such conditions, requirements, and limitations are incorporated herein, unless they are less stringent than the Commission's.

c. Nothing herein shall be construed to exempt the docket holder from obtaining all necessary permits and/or approvals from other State, Federal or local government agencies having jurisdiction over this project or activities associated with this project.

d. No new construction, addition or modification shall be permitted unless the lowest operating floor of such facility is above the Flood Protection Elevation, or the facility is flood proofed according to plans approved by the Commission, nor unless emergency plans and procedures for action to be taken in the event of flooding are prepared. Plans shall be filed with the Delaware River Basin Commission and the concerned state or states. The emergency plans and procedures shall provide for measures to prevent introduction of any pollutant or toxic material into the flood water or the introduction of flood waters into potable supplies.

e. Final construction plans and specifications must be submitted by the docket holder and be approved by the Executive Director of the DRBC before any water withdrawal, site clearing, site preparation, or construction commences at the withdrawal site.

f. Upon completion of construction of the approved project, the docket holder shall submit a statement to the DRBC, signed by the docket holder's engineer or other responsible agent, advising the Commission that the construction has been completed in compliance with the approved plans, and stating the final construction cost of the approved project and the date the project is placed in operation.

g. This docket approval shall expire three years from Approval Date set fourth below unless prior thereto the docket holder has commenced operation of the subject project or has expended substantial funds (in relation to the cost of the project) in reliance upon this docket approval.

h. The docket holder shall follow sound practices of excavation, backfill and reseeding at the WBLR withdrawal site to minimize erosion and prevent non-point source pollutants from leaving the site. The docket holder shall abide by all state and local erosion and sediment control, state stream bank disturbance permits, local floodplain development requirements and post-construction storm water management control requirements.

i. The docket holder shall submit a Non-Point Source Pollution Control Plan (NPSPCP) for the WBLR withdrawal site in accordance with Section 3.10.3.A.2.e, of the DRBC Water Quality Regulations to the Executive Director of the DRBC at least 45 working days prior to the scheduled initiation of any site clearing or construction at the site. The NPSPCP and erosion and sedimentation control plan shall be designed in accordance with the more stringent of Commission and PADEP requirements. Prior to commencing any site clearing or construction work at the WBLR withdrawal site, the docket holder shall obtain Executive Director's written approval for the NPSPCP, as well as, any other necessary federal, state, and local authorizations. The NPSPCP shall describe erosion and sedimentation controls to be implemented at the site and shall include measures to control stormwater both during and post construction. The post-construction portion of the plan shall describe the final site conditions including a pre- and post-construction project hydrograph analysis, permanent facilities, equipment, access roads, and all sediment and erosion and stormwater control structures necessary after final site restoration has been achieved.

j. Nothing herein shall be construed to grant the docket holder Commission approval or permission to commence any natural gas well development and extraction activities in the Delaware River Basin targeting shale formations including, but not limited to; preparing any natural gas well sites, drilling any natural gas well, stimulating any natural gas well, or storing, transporting, or disposing of any natural gas well hydro-fracturing or flow-back fluid.

k. This surface water withdrawal shall only be used in support of the docket holder's natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) in the Commonwealth of Pennsylvania for which both the Commission and the PADEP have issued approvals as more fully described in Section A.3 Area/Wells Served in the Description section of this docket. The docket holder must obtain the Commission modification of this docket before using any water withdrawn from the Stone WBLR Withdrawal Site beyond the locations and/or outside of the scope of activities described in Section A.3. Area/Wells Served.

l. The docket holder shall make the surface water withdrawal location, associated natural gas well pad sites, associated natural gas wells, and operational records associated with any water withdrawal at the WBLR withdrawal site (or at an alternative site approved in writing

by the Executive Director) available at all times for inspection by the DRBC and PADEP as appropriate.

m. No water withdrawal from the WBLR shall commence until the docket holder has received approval of the Commission and PADEP natural gas development and extraction activities targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) in the Commonwealth of Pennsylvania.

n. Total surface water withdrawals from the project Intake No. 001 shall not exceed 0.7 mgd. The instantaneous rate of withdrawal from Intake No. 001 shall not exceed 1,040 gpm. Withdrawals are subject to the limitations in Condition I.m. below. A "day" is defined as the 24-hour period between 12:00 AM and 12:00 AM the following day.

o. The project withdrawal must not cause the streamflow in the WBLR to be less than 5.9 cfs at the point of taking at the Stone WBLR gage. The WBLR withdrawal site shall be fitted by the docket holder with a gage (the Stone WBLR gage) or another gage or other instrumentation approved by the Executive Director and calibrated to the downstream Aldenville gage station flow data. The installed gage shall be a real-time monitoring and recording gage. Daily withdrawal rates shall be reduced as appropriate to ensure that the project withdrawal does not cause the stream flow in the WBLR to be less than 5.9 cfs as measured at the Stone WBLR gage. Whenever the 24-hour average stream flow at the Stone WBLR gage, less the Stone WBLR water withdrawal, is less than or equal to this amount, no withdrawal shall be made and the entire stream flow must be allowed to pass. Withdrawal from the WBLR at the WBLR withdrawal site shall not resume until the flow as measured the Stone WBLR gage is at least 8.2 cfs for a 24 hour period. Whenever the flow at the Stone WBLR gage is 10 cfs or more, the docket holder shall check the Stone WBLR gage and the USGS Aldenville gage station a minimum of once per week through direct observation and real time flow provided by the USGS website. Whenever the 24-hour average flow at the Stone WBLR gage is less than 10 cfs the docket holder shall check the Aldenville gaging station and Stone WBLR gage on a daily basis to ensure compliance with the 5.9 cfs pass-by flow. The docket holder is required to check the flow gages at the intervals set forth above only on days when water is withdrawn and shall also check the flow gages a minimum of 24 hours prior to the withdrawal to establish that the pass-by flow meets the minimum requirements.

p. Before commencing construction on the surface water withdrawal intake at the WBLR withdrawal site, the docket holder shall first obtain the approval of the intake design from the Commission, PAF&BC, the USACE and U.S. Fish & Wildlife Service. The intake shall be designed to minimize to the greatest extent possible, impingement and entrainment impacts in the vicinity of the withdrawal site. The docket holder shall provide the Commission with a copy of the intake design, and shall provide the Commission with copies of all correspondence between the docket holder and the other government agencies reviewing the intake design at the time the correspondence is sent or received.

q. Water withdrawn from the Stone's WBLR withdrawal site shall only be transported in water hauling tanks that are free of contaminates (except for the chemicals added as part of the Invasive Species Control Plan (ISCP)). Prior to the transfer of any water to a water hauling vehicle, the onsite pump operator shall verify that the water tank interior is clean and that the tank is dedicated for the use of hauling of fresh water.

r. The docket holder shall not allow any unused water withdrawn from the WBLR withdrawal site, fresh or otherwise, to be discharged to waters of the DRB without the advance written approval of the DRBC and the appropriate state agency or outside the DRB without the written approval of the appropriate state agency. The docket holder shall convey all wastewater created as a result of natural gas development and extraction activities undertaken with water withdrawn from the WBLR withdrawal site to treatment and disposal facilities approved by the DRBC and by the appropriate state and or federal agency (if in the DRB and subject to Commission approval), or if outside the DRB, by the appropriate state and/or federal agency.

s. If determined to be applicable, the docket holder shall submit to the DRBC an Invasive Species Control Plan (ISCP) with the Operation Plan required in Condition t. below. The ISCP shall include the management and treatment program that the docket holder will implement to ensure that all water withdrawn from the Stone WBLR Withdrawal Site prior to distribution to the transportation vehicles is managed or treated to prevent the spread of potentially invasive, harmful, or nuisance species from entering other watersheds in the DRB. The docket holder shall comply with the ISCP approved by the Executive Director.

t. At least 90 days prior to the scheduled initiation of any site clearing or construction and prior to commencement of any withdrawal operations at the Stone WBLR withdrawal site, the docket holder shall submit an Operation Plan to the DRBC. No withdrawal, site clearing or construction shall commence until the docket holder has received the Executive Director's written approval of the Operation Plan. The docket holder shall comply with the Operation Plan approved by the Executive Director. The Operation Plan shall include a procedures for metering, recording, and reporting the pass-by flow and for complying with the pass-by flow requirements, as well as, procedures for monitoring, reporting and recording the usage, transport, and destination of all water withdrawn from the site. The Executive Director may require real time monitoring, reporting and recording as part of the Operation Plan.

u. The docket holder shall meter the project surface water withdrawals with an automatic continuous recording device that measures to within 5 percent of actual flow. An exception to the 5 percent performance standard, but no greater than 10 percent, may be granted if maintenance of the 5 percent performance is not technically feasible or economically practicable. A record of average daily flow rate and daily and monthly totals of the withdrawal shall be maintained. Unless the approved Operation Plan provides otherwise, the docket holder shall at a minimum, submit an electronic copy of this record to the Commission by the 5th calendar day of the month following the month in which the operations occurred beginning with the month that water withdrawal operations commence. In addition the docket holder shall make such record(s) available at any time to the Commission or the PADEP if requested by the

Executive Director. The docket holder shall also submit a record of monthly withdrawal use totals to the PADEP annually. The docket holder shall register with the PADEP all surface water sources described in this docket in accordance with the Pennsylvania Regulations (Title 25 - Environmental Protection, [25 PA. CODE CH. 110], Water Resources Planning).

v. Unless the approved Operation Plan provides otherwise, the docket holder shall meter, record, and report the volume of surface water withdrawn from the on-site storage tanks as it is distributed to the hauling vehicles. Records maintained by the docket holder shall be kept at the WBLR withdrawal site (or at an alternative site approved in writing by the Executive Director). The records shall include the trucking company name, license plate number, name of the driver, amount of water transferred, date and time of transfer and destination of the transported water. Daily records of the amounts of the water withdrawals shall be automatically metered and recorded by the flow meter. The docket holder shall report this information to the Commission at the same frequency as provided in Condition u. above. In addition the docket holder shall make the WBLR withdrawal site records available at any time to the Commission and PADEP for inspection, if requested by the Executive Director.

w. In accordance with DRBC Resolution No. 87-6 (Revised), the docket holder shall continue to implement to the satisfaction of the DRBC, the systematic program to monitor and control leakage within the water supply system. The program shall at a minimum include: periodic surveys to monitor leakage, enumerate unaccounted-for water and determine the current status of system infrastructure; recommendations to monitor and control leakage; and a schedule for the implementation of such recommendations. The docket holder shall proceed expeditiously to correct leakages and unnecessary usage identified by the program.

x. The docket holder shall implement to the satisfaction of the Commission, the continuous program to encourage water conservation in all types of use within the facilities served by this docket approval. This includes the reuse and recycling of flow-back waters for well stimulation activities to the greatest extent economically and technically feasible at natural gas well drilling sites targeting shale formations within the drainage area of Special Protection Waters within the Delaware River Basin (DRB) in the Commonwealth of Pennsylvania. The docket holder shall report annually to the Commission on the actions taken pursuant to this program and the impact of those actions.

y. A complete application for the renewal of this docket, or a notice of intent to cease the operations (withdrawal, discharge, etc.) approved by this docket by the expiration date, must be submitted to the DRBC, to the attention of the Project Review Section, at least 12 months prior to the expiration date below (unless written permission has been granted by the Executive Director for submission at a later date), using the appropriate DRBC application form. In the event that a timely and complete application for renewal has been submitted and the DRBC is unable, through no fault of the docket holder, to reissue the docket before the expiration date below, the terms and conditions of this docket will remain fully effective and enforceable against the docket holder pending the grant or denial of the application for docket approval.

z. The issuance of this docket approval shall not create any private or proprietary rights in the water of the Basin, and the Commission reserves the rights to amend, alter or rescind any actions taken hereunder in order to insure the proper control, use and management of the water resources of the Basin.

aa. Drought Plan - At least 90 days prior to the scheduled initiation of any site clearing or construction and prior to commencement of any withdrawal operations at the WBLR withdrawal site, the docket holder shall submit a drought emergency plan to the DRBC.

bb. Drought Emergencies - For the duration of any drought emergency declared by either Pennsylvania or the Commission, water service or use by the docket holder pursuant to this approval shall be subject to the prohibition of those nonessential uses specified by the Governor of Pennsylvania, the Pennsylvania Emergency Management Council, PADEP, or the Commonwealth Drought Coordinator to the extent that they may be applicable, and to any other emergency resolutions or orders adopted hereafter by the Commission.

cc. The Commission has determined that the review of the reports and submissions developed under the above docket conditions, inspections and any amendments or changes thereto will continue to cause the Commission to expend exceptional efforts and costs. As such, Commission staff will continue to maintain a record of all time and expenses associated with the post-docket approval reviews of the project and associated deliverables. A fee in the amount of 100% of these costs will be assessed on a quarterly basis and the docket holder shall pay the amount assessed within thirty days of the date of the assessment. In the event of a docket amendment or renewal, the larger of actual project review costs or the calculated project review fee will be charged.

dd. The docket holder and any other person aggrieved by a reviewable action or decision taken by the Executive Director or Commission pursuant to this docket may seek an administrative hearing pursuant to Articles 5 and 6 of the Commission's *Rules of Practice and Procedure*, and after exhausting all administrative remedies may seek judicial review pursuant to Article 6, section 2.6.10 of the *Rules of Practice and Procedure* and section 15.1(p) of the Commission's *Compac*t.

ee. Failure to comply with any of the terms and conditions of this docket may result in sanctions by the Commission in accordance with Section 14.17 of the Compact and the Commission’s regulations including without limitation its Rules of Practice and Procedure.

ff. The docket holder shall report to the Commission Project Review Section Supervisor any violation of the docket conditions within 48-hours of the occurrence or upon the docket holder becoming aware of the violation. In addition, the docket holder shall report in writing any violations of the pass by requirements, the daily or monthly water allocations, the approved operations plan or any other docket conditions to the DRBC Project Review Section Supervisor within three days of the violation. The docket holder shall also provide a written explanation of the causes of the violation within 30 days of the violation and shall set forth the

action(s) the docket holder has taken to correct the violation and protect against a future violation.

gg. If the surface water withdrawal operations associated with this docket approval significantly affects or interferes with any domestic or other existing wells or surface water supplies, or if the docket holder receives a complaint by any user of wells or surface water supplies, the docket holder shall immediately notify the Executive Director of any such affects, interferences or complaints and unless excused by the Executive Director, shall investigate such affects, interferences or complaints. The docket holder shall also advise the complainants that they may also direct their phone call notifications of potential interference complaints to the DRBC Project Review Section at 609-883-9500, extension 216. Oral notification by the docket holder must always be followed up in writing or via email directed to the Executive Director. In addition, the docket holder shall provide written notification to all complainants of the docket holder's responsibilities under this condition. Any well or surface water supply which is substantially adversely affected, or otherwise rendered unusable as a result of the docket holder's project withdrawal, shall be repaired, replaced or otherwise mitigated at the expense of the docket holder. The docket holder shall prepare a report of investigation and/or mitigation plan prepared by a qualified professional and shall submit the report to the Executive Director as soon as practicable or as directed by the Executive Director. The Executive Director shall make the final determination, subject to the right of appeal, regarding the validity of such complaints, the scope or sufficiency of such investigations, and the extent of appropriate mitigation measures, if required.

hh. The Executive Director may modify or suspend this approval or any condition thereof, or require mitigating measures pending additional review, if in the Executive Director's judgment such modification or suspension is required to protect the water resources of the Basin.

ii. The docket holder shall pay any water supply charges that become applicable to the withdrawal authorized by this Docket as a result of any change to the Commission's water supply charge regulations.

BY THE COMMISSION

APPROVAL DATE: July 14, 2010

EXPIRATION DATE: July 14, 2015

Subject:
From: "Randis, Thomas" <trandis@state.pa.us>
Date: Fri, 05 Feb 2010 07:57:37 -0500
To: "'David.Kovach@drbc.state.nj.us'" <David.Kovach@drbc.state.nj.us>
CC: "Hawley, Robert" <rhawley@state.pa.us>, "Miller, Chad (DEP)" <chadmiller@state.pa.us>, "Engle, David" <daengle@state.pa.us>

Good Morning Dave,

Valley Joint SA was contacted regarding the acceptance of this top-hole water. The Authority is adamant that they have not taken any further drilling water/wastewater/fluids since DEP sent them a letter in April 2009 requesting a permit amendment if they want to continue accepting these types of wastewaters. It is possible that they accepted this material prior to this date. If Stone Energy is insistent that the top-hole water was disposed of at this facility, either it was prior to April 2009 or there is a disconnect in disposal sites. Thanks Tom

Thomas Randis | Environmental Group Manager
Department of Environmental Protection
208 West Third Street, Suite 101, Williamsport, PA 17701
Phone: (570) 327-3781 | Fax: (570) 327-3565
www.depweb.state.pa.us

----Original Message-----
From: David Kovach [mailto:David.Kovach@drbc.state.nj.us]
Sent: Thursday, February 04, 2010 10:16 AM
To: Miller, Chad (DEP)
Subject: Valley Joint Sewer Authority in Athens, PA

Hi Chad,
Are you aware that the Valley Joint Sewer Authority in Athens, PA apparently accepted water produced during the drilling of the Stone Energy, Matoushek 1 natural gas well. Most of the water was fresh tophole water with potassium chloride as a drilling additive totalling approximately 270,000 gallons. Was the authority approved to take this water? Is there any concerns with accepting these types of wastes. Any help would be appreciated.
Thanks,
Dave

--
David Kovach, P.G.
Geologist, Project Review Section
Delaware River Basin Commission
(p) 609-883-9500 ext 264
(f) 609-883-9522
(e) david.kovach@drbc.state.nj.us

Subject: DRBC Data request
From: "Stiles, Kevin" <StilesEK@StoneEnergy.com>
Date: Mon, 25 Jan 2010 14:07:44 +0000
To: "'david.kovach@drbc.state.nj.us'" <David.Kovach@drbc.state.nj.us>

David:

My technical staff has assembled the information below to answer your questions of last Thursday 1.21. Please let us know if you require any additional information. Looking forward to seeing you at our hearing in February.

Best Regards/Kevin

Kevin Stiles
Appalachia Manager
Stone Energy
6000 Hampton Center Suite E
Morgantown WV 26505
337-291-7783
304-216-1083 Cell
StilesEK@StoneEnergy.com

Matoushek #1 top hole drilling summary:

- Drilled 24" hole from surface to 60'
- 0 – 50', till/gravel/pebbles, drilled on air, hole damp
- 50' – 60', bedrock, drilled on air, hole dry
- 24" conductor pipe set at 60'
- Drilled 17-1/2" hole from 60' to 710'
- 60' – 650', gray shale/siltstone, drilled on air/mist, hole damp
- **650' – 665', significant FW zone**, ~3000 bbls FW to surface (aka 3000 bbls of tophole water)
- 665' – 710', gray shale/siltstone, drilled on air/mist, hole wet from above FW zone
- 13-3/8" conductor casing set at 710' (cemented to surface)
- Drilled 12-1/4" hole from 710' to 1964'
- 710' – 1964', gray shale/siltstone, drilled on air/mist, hole damp, gained 1 to 1.5 bbl/hr water while drilling (~50 bbls FW to surface / tophole water)
- Note: since the hole was damp and "making water" just below the 13-3/8" shoe, the ~50 bbls of water came from near the shoe
- **Note: no significant FW or salt water zones were encountered while drilling the 12-1/4" hole**
- 9-5/8" surface casing set at 1964' (cemented to surface)
- Drilled 8-3/4" hole below 1964', drilled on air/dusted, hole dry, no water zones encountered

1) Depth of all fresh water horizons:
   - 0 – 50', till/gravel/pebbles, hole damp
   - 50' – 650', gray shale/siltstone, hole damp
   - **650' – 665', significant FW zone (~3000 bbls of tophole water)**
   - 665' – approximately 750', gray shale/siltstone, hole wet (~50 bbls of tophole water)
2) Depth of all salt water horizons:
   - No significant salt water horizons were encountered
3) Disposal of salt water in 2) above:

- No significant salt water horizons were encountered

8000-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 246326	Auth ID: 760352
Watershed Name: Holbert Creek	Quality: HQ

Permittee: CHESAPEAKE APPALACHIA, LLC	OGO.#: OGO-65420	Permit Number: 37-127-20008-00	Date Issued: 02/26/2009
Address: 900 PENNSYLVANIA AVE		Farm Name & Well Number: ROBSON 627528 1	Well Serial #:
		Municipality: Oregon	County: Wayne
CHARLESTON, WV 25302		7½ ' Quadrangle Name: Galilee	Map Section #: 8
Phone: (304) 353-5120	Project #:	Latitude: 41-37-39.5200	Longitude: -75-12-11.6000
Surf Elev at Site: 1493 feet	Anticipated Total Depth: 8898 feet / Well Type: GS	Offset distances referenced to NE corner of map section.	South 14207 feet West 9985 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **02/26/2010** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

HERB KARLINSEY	P O Box 673, Coudersport, PA 16915-0673	814-274-3611
Oil and Gas Inspector	Address	Telephone

5500-PM-OG0001 Rev. 9/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 6860001212	Amount $ 350.00

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY			
Notes	OGO # 65420	Objection Date - Do not issue before: 2/19/09	Well Permit # 127-20008
	Bond # 10611		Special Cond. A B C D E F
	C: 1/20/09 del G: 2/19/09	Date Approved:	Watershed Name: HOLBERT CREEK
	INV: 2-25-09		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Chesapeake Appalachia L.L.C.	246326	304-353-5120	304-353-5231	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
900 Pennsylvania Avenue	Charleston	WV	25302	

(Well) Farm Name	Well #	Serial #
Robson (627528)	1	

County	Municipality	Project # (from DEP)
Wayne	Oregon Township	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled**, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE Check one.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ Other (specify)

TYPE OF WELL Check one.
- ☒ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☐ Other (specify)

APPLICATION FEE Check one.
- ☒ $ 350 (Gas; Comb.; Coal Meth; Storage)
- ☐ $ 250 (Oil; Inj– Rec)
- ☐ $ 150 (Injection – Waste Disposal)
- ☐ $ 100 (Redrill, Drill Deeper, Alter a Well, or Change Use)
- ☐ $ 0 (Rehab orphan)

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☐	☒
b. Does the location fall within an area covered by a spacing order?	☐	☐
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

RECEIVED
JAN 13 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

DEP USE ONLY
Date Stamps/Notes
Auth 160352
Site 716805
Clnt 246326
APS 667547
Acct 634818
PF 715590
SF 984685

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the **"Coordination of a Well Location with Public Resources"** form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres?	☐	☒

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	*(Print or Type)*	Name of Signer: Michael John Title: Vice President	Date 1/9/09

Application Preparer/Contact: Rachelle A. King Phone: 304-391-5588

5500-PM-OG0001 Rev. 9/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Robson 1 (627528)	
Applicant Name	DEP ID#
Chesapeake Appalachia L.L.C.	246326
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

12-7-2008

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Christopher and Betty Robson	Address: 45 Ripple Lane Honesdale, PA 18431	X								12/2/08	12/5/08		12/7/08
Name: David S. & Diane L. Richter	Address: 455 Fox Hill Road Honesdale, PA 18431							X					
Name: James II & Beverly Ludwig	Address: 434 Fox Hill Road Honesdale, PA 18431							X					
Name: Anthony J & Judy Novena	Address: 404 Fox Hill Road Honesdale, PA 18431							X					
Name: Mark P. Leunes	Address: 240 Brill Rd Honesdale, PA 18431							X					
Name:	Address:												
Name:	Address:												

RECEIVED
JAN 13 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

RECEIVED
FEB 05 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date 12/2/08	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date 12/7/08	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #		
Robson 1	(627528)	
Applicant Name		DEP ID#
Chesapeake Appalachia L.L.C.		246326
DEP USE ONLY	APS #	

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

127-2008

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Christopher and Betty Robson	Address: 45 Ripple Lane Honesdale, PA 18431	X											
Name: David S. & Diane L. Richter	Address: 455 Fox Hill Road Honesdale, PA 18431							X		12/2/08	12/4/08		✓
Name: James II & Beverly Ludwig	Address: 434 Fox Hill Road Honesdale, PA 18431							X					
Name: Anthony J & Judy Novena	Address: 404 Fox Hill Road Honesdale, PA 18431							X					
Name: Mark P. Leunes	Address: 240 Brill Rd Honesdale, PA 18431							X					
Name:	Address:												
Name:	Address:												

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JAN 13 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

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FEB 05 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☒ Water Purveyor or ☒ Landowner with water supply within 1,000 ft.	Date 12/4/08 David S. Richter	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☒ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date 12/4/08 Diane L. Richter	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Robson 1 (627528)	
Applicant Name	DEP ID#
Chesapeake Appalachia L.L.C.	246326
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

12-1-2008 Y

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates: Sent	Notification: Certified Mail Dates: Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Christopher and Betty Robson	Address: 45 Ripple Lane Honesdale, PA 18431	X											
Name: David S. & Diane L. Richter	Address: 455 Fox Hill Road Honesdale, PA 18431							X					
Name: James II & Beverly Ludwig	Address: 434 Fox Hill Road Honesdale, PA 18431							X		12/2/08	12/8/08		✓
Name: Anthony J & Judy Novena	Address: 404 Fox Hill Road Honesdale, PA 18431							X					
Name: Mark P. Leunes	Address: 240 Brill Rd Honesdale, PA 18431		RECEIVED JAN 13 2009 ENVIRONMENTAL PROTECTION NORTHWEST REGIONAL OFFICE					X		RECEIVED FEB 05 2009 ENVIRONMENTAL PROTECTION NORTHWEST REGIONAL OFFICE			
Name:	Address:												
Name:	Address:												

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☒ Landowner with water supply within 1,000 ft.	Date James R. Ludwig 12-15-08	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☒ Landowner with water supply within 1,000 ft.	Date Beverly Ludwig 12-15-08	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Robson 1 (627528)	
Applicant Name	DEP ID#
Chesapeake Appalachia L.L.C.	246326
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

127-20008

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Christopher and Betty Robson	Address: 45 Ripple Lane Honesdale, PA 18431	X									RECEIVED FEB 05 2009 ENVIRONMENTAL PROTECTION NORTHWEST REGIONAL OFFICE		
Name: David S. & Diane L. Richter	Address: 455 Fox Hill Road Honesdale, PA 18431							X					
Name: James II & Beverly Ludwig	Address: 434 Fox Hill Road Honesdale, PA 18431							X					
Name: Anthony J & Judy Novena	Address: 404 Fox Hill Road Honesdale, PA 18431		RECEIVED JAN 13 2009 ENVIRONMENTAL PROTECTION NORTHWEST REGIONAL OFFICE					X		12/2/08	12/5/08		✓
Name: Mark P. Leunes	Address: 240 Brill Rd Honesdale, PA 18431							X					
Name:	Address:												
Name:	Address:												

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft. Anthony + Judith Novena 12-10-08	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	2/19/09 G: JR
	Permit #: 127-20008	
	Project #:	C:

Denotes location of well on topo map. SEE NOTE 1

True Latitude: NORTH NAD 83
41 ° 37 ' 39.52 "

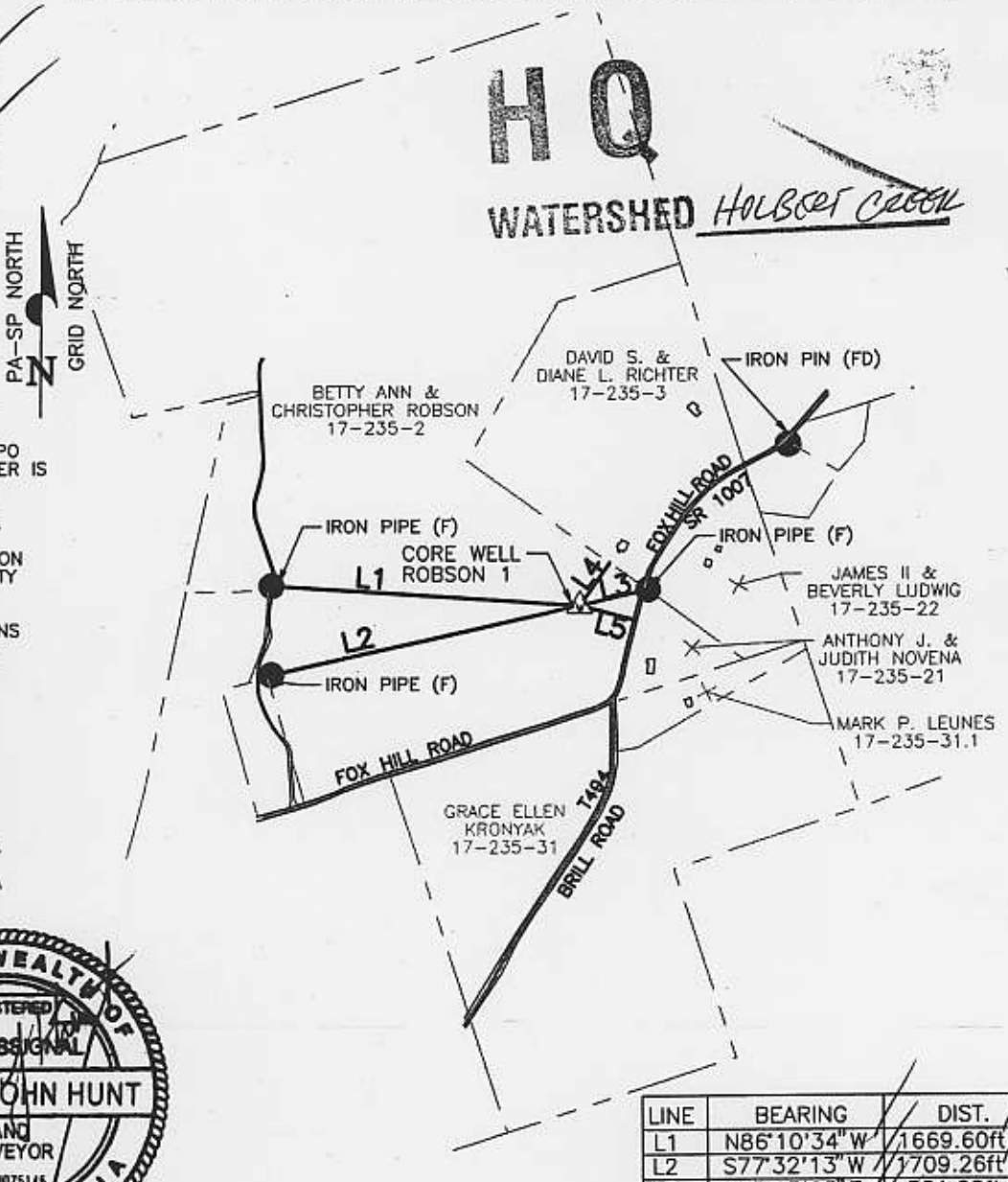
True Longitude: WEST
75 ° 12 ' 11.60 "

True Latitude: NORTH NAD 27
41.62756°

True Longitude: WEST
75.203625°

Well is located on topo map 14,207 feet south of latitude 41 ° 40 ' 00 "

Well is located on topo map 9,985 feet west of longitude 75 ° 10 ' 00 "



LINE	BEARING	DIST.
L1	N86°10'34" W	1669.60ft
L2	S77°32'13" W	1709.26ft
L3	N77°13'05" E	381.28ft
L4	N35°43'07" E	282± ft
L5	S74°51'27" E	311± ft

NOTES:

1. WELL LOCATION POSITION ON A 7.5', 1:24,000 USGS TOPO QUAD WHEN THIS SHEET BORDER IS ADJUSTED TO SCALE AND OVERLAYED AND ORIENTED TO THE RESPECTIVE SECTION GRID.

2. PLAN INFORMATION SHOWN ON THIS PLAT IS BASED ON COUNTY TAX PARCELS, DEED PLOTS, AND BASE DATA FROM PASDA AND USGS. SURVEYED LOCATIONS WERE SOLVED USING DUAL FREQUENCY GPS (L1/L2) THAT WAS POST-PROCESSED WITH THE NGS OPUS SERVICE.

3. THIS PLAT IS FOR WELL LOCATION PURPOSES ONLY. IT IS NOT A BOUNDARY RETRACEMENT SURVEY. TIES TO PINS OR PIPES FOUND IS PROVIDED FOR GAS WELL RE-LOCATION PURPOSES ONLY.

4. BASE STATION CONTROL DATA IS AVAILABLE UPON REQUEST.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH JOHN HUNT
LAND SURVEYOR
No. SU075145

Surveyor or Engineer: JOSEPH J. HUNT, P.L.S., P.E. | Phone #: 610-858-6790 | Dwg #: 2008-CHK-003 | Date: 11/25/2008, 2/18/09 | Scale: 1" = 1,000' | Tract Acreage: 190±

Lat & Long Metadata: Method GPSOF(L1,L2)RTK | Accuracy 0.033' ft | Datum NAD 83

Elevation Metadata: Method GPSOF(L1,L2)RTK | Accuracy 0.069 ft. | Datum NAVD '88 | Survey Date 11/07/2008

Applicant / Well Operator Name: CHESAPEAKE APPALACHIA, L.L.C | DEP ID#: 246326

Well (Farm) Name: ROBSON | Well #: | Serial #:

Address: P.O. BOX 6070, CHARLESTON, WV 25362-0070

County: WAYNE | Municipality: OREGON TOWNSHIP | Well Type: NATURAL GAS

Surface Landowner / Lessor: ROBSON, BETTY ANN & CHRISTOPHER

USGS 7½ Quadrangle Map Name: GALILEE | Map Section: 8 | Surface Elevation: 1493.3 ft.

Target Formation(s): ORISKANY

Angle & Course of Deviation (Drilling): 0°

Anticipated Total Depth ft. TVD 8898 TMD

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
DAVID S. & DIANE L. RICHTER	N36°15'35"E 402± ft		
JAMES II & BEVERLY LUDWIG	N69°54'35"E 777± ft		
ANTHONY J. & JUDITH NOVENA	S50°13'52"E 502± ft		

5500-PM-OG0002 Rev. 9/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	G.
	Permit # 127-20008	
	Project #:	C.

Denotes location of well on topo map. SEE NOTE 1

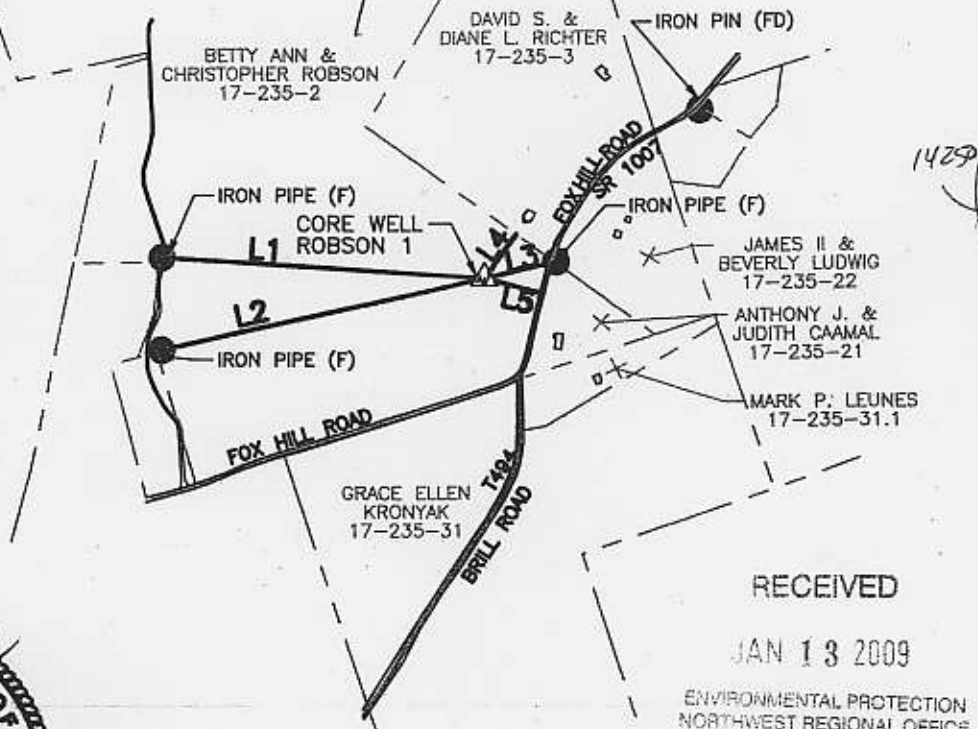
Well is located on topo map 14,207 feet south of latitude 41 ° 40 ' 00 "

Well is located on topo map 1,838 feet west of longitude 75 ° 12 ' 30 "

41 37 39.20
75. 12 13.05

True Latitude: NORTH NAD 83	41 ° 37 ' 39.52 "
True Longitude: WEST	75 ° 12 ' 11.68 "
True Latitude: NORTH NAD 27	41.62756°
True Longitude: WEST	75.203625°

PA-SP NORTH GRID NORTH



NOTES:

1. WELL LOCATION POSITION ON A 7.5', 1:24,000 USGS TOPO QUAD WHEN THIS SHEET BORDER IS ADJUSTED TO SCALE AND OVERLAYED AND ORIENTED TO THE RESPECTIVE SECTION GRID.

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COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH JOHN HUNT
LAND SURVEYOR
No. SU075145

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LINE	BEARING	DIST.
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L4	N35°43'07" E	282± ft
L5	S74°51'27" E	311± ft

Surveyor or Engineer	Phone #	Dwg #	Date	Scale	Tract Acreage
JOSEPH J. HUNT, P.L.S., P.E.	610-858-6790	2008-CHK-003	11/25/2008 REV. 5 12/16/2008	1" = 1,000'	190±

Lat & Long Metadata Method: GPSOF(L1,L2)RTK Accuracy: 0.033' ft. Datum: NAD 83		Elevation Metadata Method: GPSOF(L1,L2)RTK Accuracy: 0.069 ft. Datum: NAVD '88	Survey Date: 11/07/2008
Applicant / Well Operator Name: CHESAPEAKE APPALACHIA, L.L.C	DEP ID#: 246326	Well (Farm) Name: ROBSON (627528)	Well #: 1 / Serial #:
Address: P.O. BOX 6070, CHARLESTON, WV 25362-0070		County: WAYNE / Municipality: OREGON TOWNSHIP	Well Type: NATURAL GAS
Surface Landowner / Lessor: ROBSON, BETTY ANN & CHRISTOPHER		USGS 7½ Quadrangle Map Name: GALILEE 0544	Map Section: 8 / Surface Elevation: 1493.3 ft
Target Formation(s): ORISKANY		Angle & Course of Deviation (Drilling): 0°	Anticipated Total Depth ft: TVD / TMD

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
DAVID S. & DIANE L. RICHTER	N36°15'35" E 402± ft		
JAMES II & BEVERLY LUDWIG	N69°54'35" E 777± ft		
ANTHONY J. & JUDITH CAAMAL	S50°13'52" E 502± ft		

NOVEMA 2. on PG 2.

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

DEP USE ONLY	Auth ID #:	G:
	Permit # 127-20008	
	Project #:	C:

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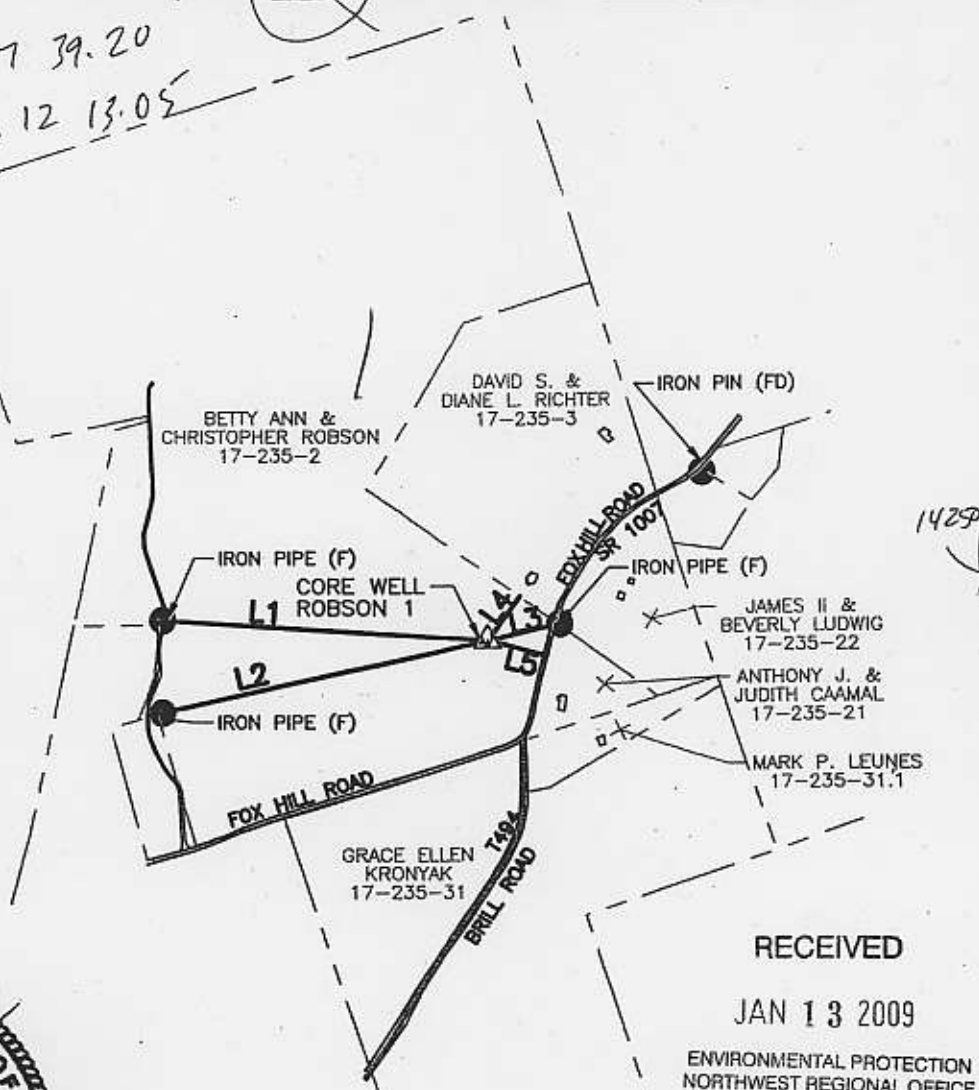
Well is located on topo map 1,838 feet west of longitude 75 ° 12 ' 30 "

True Latitude: NORTH NAD 83	41 ° 37 ' 39.52 "
True Longitude: WEST	75 ° 12 ' 11.68 "
True Latitude: NORTH NAD 27	41.62756°
True Longitude: WEST	75.203625°

41 37 39.20
75. 12 13.05

PA-SP NORTH
GRID NORTH
N



NOTES:

1. WELL LOCATION POSITION ON A 7.5', 1:24,000 USGS TOPO QUAD WHEN THIS SHEET BORDER IS ADJUSTED TO SCALE AND OVERLAYED AND ORIENTED TO THE RESPECTIVE SECTION GRID.

2. PLAN INFORMATION SHOWN ON THIS PLAT IS BASED ON COUNTY TAX PARCELS, DEED PLOTS, AND BASE DATA FROM PASDA AND USGS. SURVEYED LOCATIONS WERE SOLVED USING DUAL FREQUENCY GPS (L1/L2) THAT WAS POST-PROCESSED WITH THE NGS OPUS SERVICE.

3. THIS PLAT IS FOR WELL LOCATION PURPOSES ONLY. IT IS NOT A BOUNDARY RETRACEMENT SURVEY. TIES TO PINS OR PIPES FOUND IS PROVIDED FOR GAS WELL RE-LOCATION PURPOSES ONLY.

4. BASE STATION CONTROL DATA IS AVAILABLE UPON REQUEST.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH JOHN HUNT
LAND SURVEYOR
No. SU075145

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LINE	BEARING	DIST.
L1	N86°10'34" W	1,669.60ft
L2	S77°32'13" W	1709.26ft
L3	N77°13'05" E	381.28ft
L4	N35°43'07" E	282± ft
L5	S74°51'27" E	311± ft

Surveyor or Engineer: JOSEPH J. HUNT, P.L.S., P.E. | Phone #: 610-858-6790 | Dwg #: 2008-CHK-003 | Date: 11/25/2008 REV. 5 12/16/2008 | Scale: 1" = 1,000' | Tract Acreage: 190±

Lat & Long Metadata Method GPSOF(L1,L2)RTK Accuracy 0.033' ft. Datum NAD 83		Elevation Metadata Method GPSOF(L1,L2)RTK Accuracy 0.069 ft. Datum NAVD '88	Survey Date 11/07/2008
Applicant / Well Operator Name: CHESAPEAKE APPALACHIA, L.L.C	DEP ID#: 246326	Well (Farm) Name: ROBSON (627528)	Well #: 1 / Serial #:
Address: P.O. BOX 6070, CHARLESTON, WV 25362-0070		County: WAYNE / Municipality: OREGON TOWNSHIP	Well Type: NATURAL GAS
Surface Landowner / Lessor: ROBSON, BETTY ANN & CHRISTOPHER		USGS 7½ Quadrangle Map Name: GALILEE 0544	Map Section: 8 / Surface Elevation: 1493.3 ft
Target Formation(s): ORISKANY		Angle & Course of Deviation (Drilling): 0°	Anticipated Total Depth ft. TVD / TMD

Surface Owner or Water Purveyor with a Water Supply within 1000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
DAVID S. & DIANE L. RICHTER	N36°15'35" E 402± ft		
JAMES II & BEVERLY LUDWIG	N69°54'35" E 777± ft		
ANTHONY J. & JUDITH CAAMAL	S50°13'52" E 502± ft		

NOVENA 2. on DG 2.

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	Auth ID #: 127-20008

Use only if you need additional space for listings.

Applicant / Well Operator Name	DEP ID#	Well (Farm) Name	Well #	Serial #
CHESAPEAKE APPALACHIA, L.L.C	246326	ROBSON	1	

Surface Owner or Water Purveyor with a Water Supply within 1000 feet	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased or Operated
MARK P. LEUNES	S48°12'41"E 790±ft		

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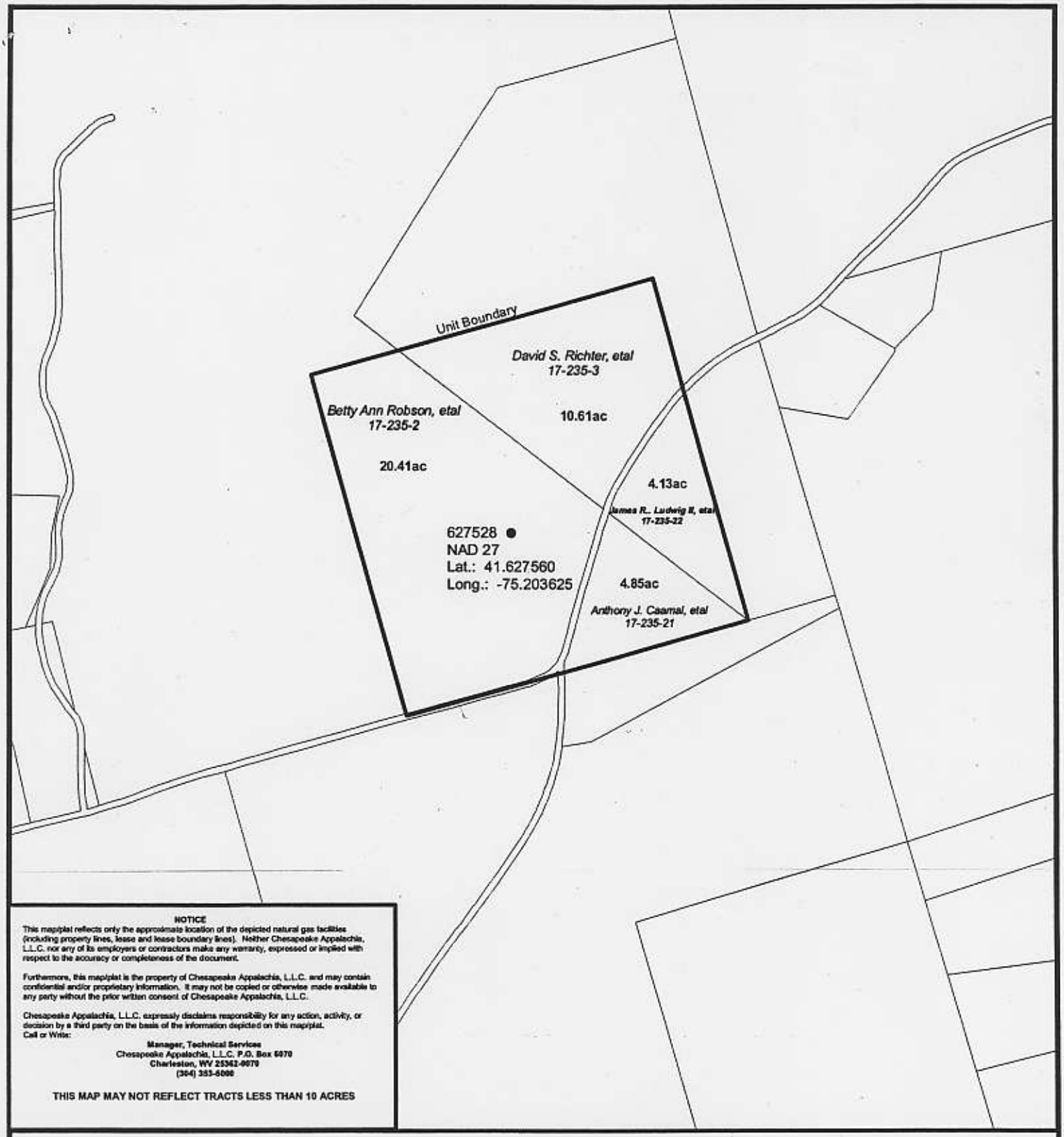

NOTICE

This map/plat reflects only the approximate location of the depicted natural gas facilities (including property lines, lease and lease boundary lines). Neither Chesapeake Appalachia, L.L.C. nor any of its employers or contractors make any warranty, expressed or implied with respect to the accuracy or completeness of the document.

Furthermore, this map/plat is the property of Chesapeake Appalachia, L.L.C. and may contain confidential and/or proprietary information. It may not be copied or otherwise made available to any party without the prior written consent of Chesapeake Appalachia, L.L.C.

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Call or Write:

Manager, Technical Services
Chesapeake Appalachia, L.L.C. P.O. Box 6070
Charleston, WV 25362-6070
(304) 353-5000

THIS MAP MAY NOT REFLECT TRACTS LESS THAN 10 ACRES

UNIT EXHIBIT

WELL 627528 (Robson 1)
Oregon Twp., Wayne Co., PA

1 inch = 500 feet

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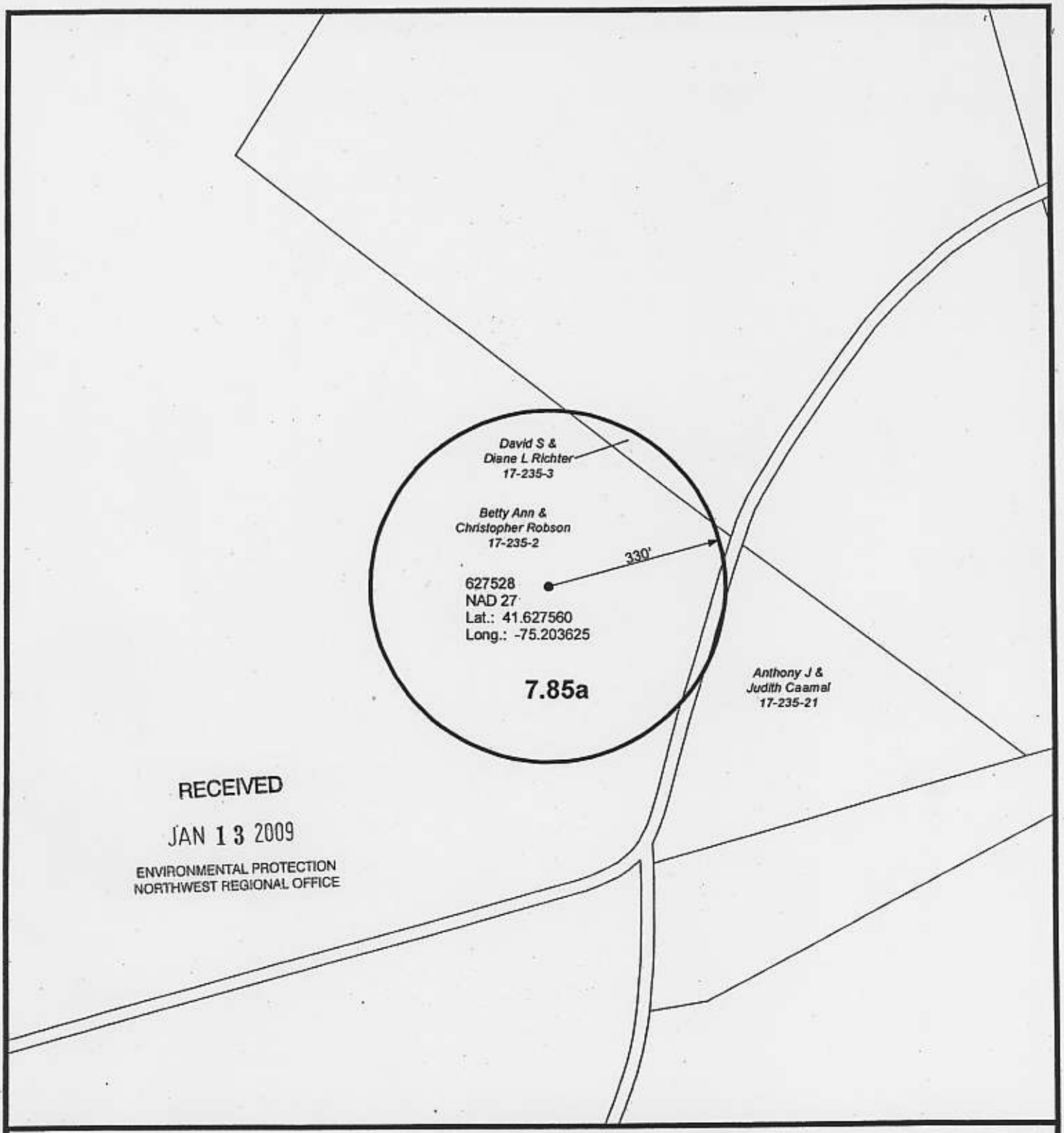
Chesapeake ENERGY

● CHK Well Location 627528

▭ Robson 1 Unit - 40.00ac

Printing Date: January 7, 2009 W:\Unit Exhibits\2009\PA\627528 ROBSON 1-RMS\627528_Robson1.mxd



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1 inch equals 250 feet

UNIT EXHIBIT

WELL 627528 (Robson 1)
Oregon Twp., Wayne Co., PA

Call or Write:

Manager, Technical Services
Chesapeake Appalachia, L.L.C. P.O. Box 6070
Charleston, WV 25362-0070
(304) 353-5000

THIS MAP MAY NOT REFLECT TRACTS LESS THAN 10 ACRES

● CHK Well Location

▭ Robson 1 Unit - 7.85a

Chesapeake ENERGY

Printing Date: January 7, 2009 - File: W:\Unit Exhibits\2009\PA\627528 ROBSON 1-RMS\627528_Robson1_330.mxd

Chesapeake ENERGY

Tim Smith
Manager – Regulatory
Northern Districts
Office: (304) 353-5065
Cell: (304) 382-8783
tim.smith@chk.com

January 9, 2009

Mr. Robert Gleeson
Commonwealth of Pennsylvania
Department of Environmental Protection
Oil and Gas Management Program
230 Chestnut Street
Meadville, PA 16335-3481

Re: Robson 1 (627528) - Permit Application for Drilling a Well
Wayne County, Oregon Township

Dear Mr. Gleeson:

Chesapeake Appalachia, L.L.C. submits the enclosed *Permit Application for Drilling or Altering a Well* for its proposed Robson 1 (627528) well located in Wayne County, Oregon Township.

If you should have any questions or require additional information, please do not hesitate to contact me.

Sincerely,

Chesapeake Appalachia, L.L.C.

Tim Smith

Tim Smith

Enclosures

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Mr and Mrs. Anthony J Novena
404 Fox Hill Road
Honesdale PA 18431

PS Form 3800, A

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- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr and Mrs. Anthony J Novena
404 Fox Hill Road
Honesdale PA 18431

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X J Novena
☐ Agent
☐ Addressee

B. Received by (Printed Name) Anthony Novena
C. Date of Delivery
HONESDALE PA 18431
DEC 05 2008
USPS

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
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4. Restricted Delivery? *(Extra Fee)* ☐ Yes

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Mr. Mark P. Leunes
240 Brill Rd
Honesdale, PA 18431

PS Form 3800

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- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Mark P. Leunes
240 Brill Rd
Honesdale, PA 18431

COMPLETE THIS SECTION ON DELIVERY

A. Signature
x Michelle Ryan ☐ Agent ☐ Addressee

B. Received by (Printed Name) Michelle Ryan C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7008 0150 0001 4928 0320

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NORTHWEST REGIONAL OFFICE

CONSOLIDATION OF LEASE
Robson 1 Unit

KNOW ALL MEN BY THESE PRESENTS that the undersigned, Chesapeake Appalachia, L.L.C., with its principal place of business at P. O. Box 6070, 900 Pennsylvania Avenue, Charleston, WV 25362-0070, owner and holder as Lessee of the oil and gas leases described herein, does hereby select to consolidate the lands shown on the attached plat and covered by each of said leases set forth, to form an oil and gas development unit of forty and No/100 (40.00) acres, more or less, for a well or wells located upon the lands of any of the leases hereinafter described, which leases cover land in Oregon Township, Wayne County, Pennsylvania, incorporated herein by reference as follows:

LESSOR	DATE	RECORDED	ACRES	ACRES IN UNIT
Betty Ann Theobald & Christopher D. Robson	05/18/08	DBV 3547/310	175.21	20.51/40.00
David S. Richter & Diane L. Richter	06/27/08	DBV 3574/199	34.00	10.61/40.00
James R. Ludwig, II & Beverly A. Ludwig	05/03/08	DBV 3550/62	13.00	4.13/40.00
Anthony J Novena & Judith C. Novena aka Judith Caamal	01/23/09		4.85	4.85/40.00

In accordance with the terms and conditions of each of such leases, such one-eighth (1/8) royalty as therein provided shall be payable to and in the following proportions:

NAME	ADDRESS	ROYALTY
Betty Ann Theobald & Christopher D. Robson	45 Ripple Lane, Honesdale, PA 18431-7852	20.51/40.00
David S. Richter & Diane L. Richter	455 Fox Hill Road, Honesdale, PA 18431-7848	10.61/40.00
James R. Ludwig, II & Beverly A. Ludwig	434 Fox Hill Road, Honesdale, PA 18431-7848	4.13/40.00
Anthony J Novena & Judith C. Novena aka Judith Caamal	404 Fox Hill Road, Honesdale, PA 18431-7848	4.85/40.00

Under the terms and conditions of each such lease as herein consolidated, the lands covered hereby shall be consolidated as a single tract of land for the purpose of drilling, and a well commenced upon any of the lands herein consolidated shall have the same effect as though such well were commenced upon the premises described in each such oil and gas lease, provided that only the owner of the lands on which such well is located shall have the privilege of taking gas for use on said lands in accordance with and subject to the provisions of the lease covering said land.

IN WITNESS WHEREOF, we sign this 30th day of January, 2009.

WITNESS

CHESAPEAKE APPALACHIA, L.L.C.

By: _____
Marty Byrd

Its: Vice President Land – Eastern Division

gmw

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STATE OF WEST VIRGINIA)
) SS
COUNTY OF KANAWHA)

On this the 30th day of January, 2009, before me, a Notary Public, the undersigned officer, personally appeared Marty Byrd, who acknowledged himself to be the Vice President Land – Eastern Division of Chesapeake Appalachia, L.L.C., a Limited Liability Corporation, and that as such, being authorized to do so, executed the foregoing instrument for the purposes therein contained by signing the name of said Limited Liability Corporation to himself as Vice President Land – Eastern Division.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Brenda J. Flesher
Notary Public

My Commission Expires: February 7, 2011

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Total Postage & Fees	$

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Mr. and Mrs. James Ludwig II
434 Fox Hill Road
Honesdale, PA 18431

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Total Postage & Fees	$

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Mr. and Mrs. David S. Richter
455 Fox Hill Road
Honesdale, PA 18431

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- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. and Mrs. David S. Richter
455 Fox Hill Road
Honesdale, PA 18431

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Beth Richter ☐ Agent ☐ Address

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

HONESDALE PA 18431 DEC 04 2008

3. Service Type
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☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7008 0150 0001 4928 0313

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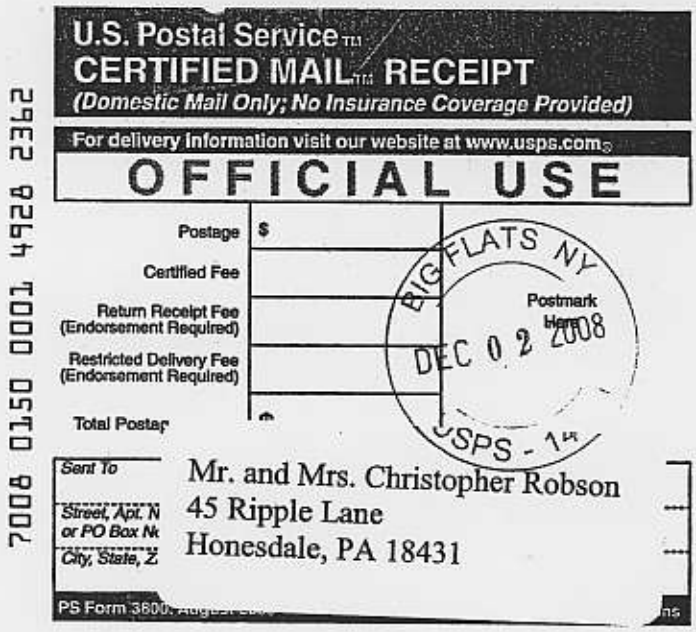

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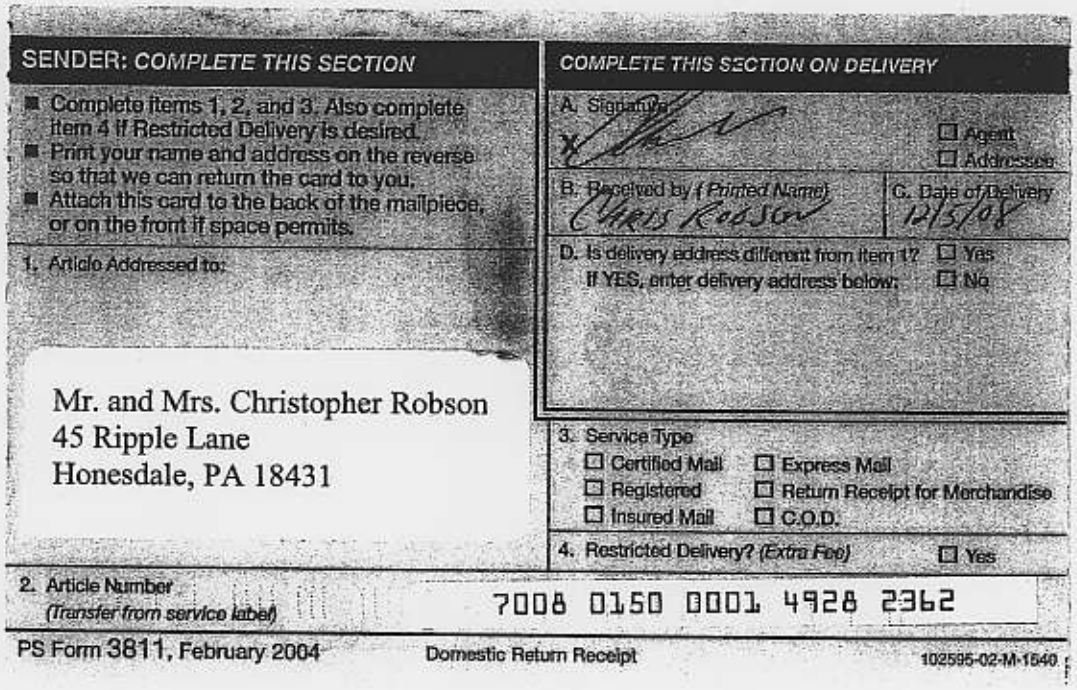
City, State, Z

Mr. and Mrs. Christopher Robson
45 Ripple Lane
Honesdale, PA 18431

PS Form 3800, August



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- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. and Mrs. Christopher Robson
45 Ripple Lane
Honesdale, PA 18431

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X
☐ Agent
☐ Addressee

B. Received by (Printed Name) Chris Robson
C. Date of Delivery 12/5/08

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7008 0150 0001 4928 2362

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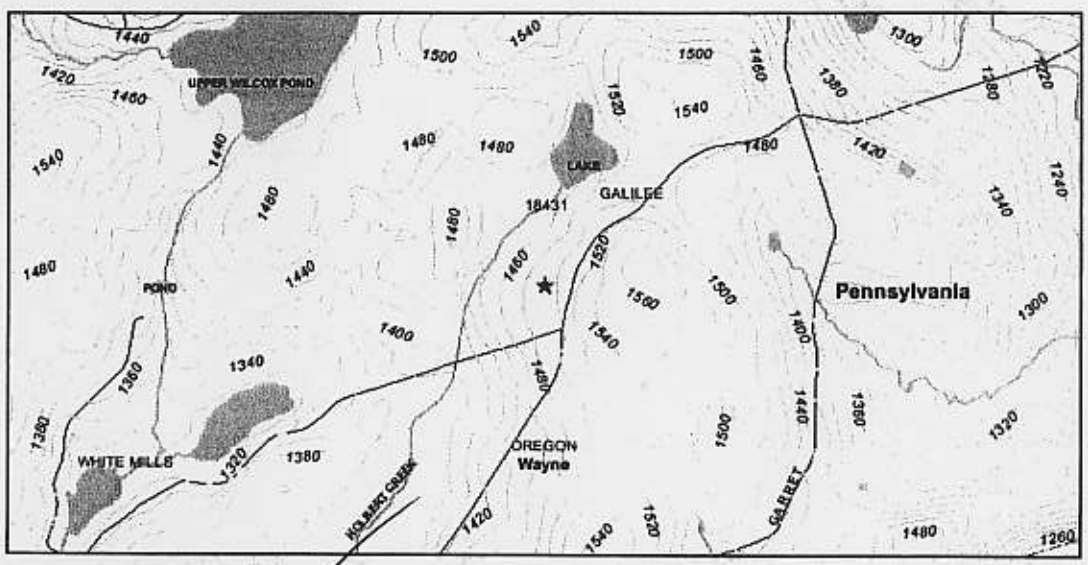
PNDI Project Environmental Review Receipt
Project Search ID: 20081204169530
Project Name: ROBSON 1
Date: 12/4/2008 9:06:10 AM

Project Location



Location Accuracy

Project locations are assumed to be both precise and accurate for the purposes of environmental review. The creator/owner of the Project Review Receipt is solely responsible for the project location and thus the correctness of the Project Review Receipt content.

0 Known Impacts

Under the Following Agencies' Jurisdiction:
None

Project Name: ROBSON 1
On Behalf Of: Self
Project Search ID: 20081204169530
Date: 12/4/2008 9:06:02 AM
# of Potential Impacts: 0
Jurisdictional Agency:
Project Category: Energy Storage, Production, and Transfer,Energy Production (generation),Oil or Gas - new wells, expansion of well field
Project Location
Decimal Degrees: 41.627644 N, -75.203244 W
Degrees Minutes Seconds: 41° 37' 39.52" N, 75° 12' 11.68" W
Lambert: 764519.15554522, 969550.47783612 ft
ZIP Code: 18431
County: Wayne
Township/Municipality: OREGON
USGS 7.5 Minute Quadrangle ID: 138
Quadrangle Name: GALILEE
Project Area: N/A

APPLICANT INITIALS: RAK

PNDI Project Environmental Review Receipt

Project Search ID: 20081204169530
Project Name: ROBSON 1
Date: 12/4/2008 9:06:10 AM

Pennsylvania Natural Diversity Inventory (PNDI) records do **NOT** indicate any known impacts on special concern species and resources within the project area. DEP requires a signed copy of this receipt with permit applications being submitted as indication that an environmental review has been conducted and completed. See DEP PNDI policy at www.naturalheritage.state.pa.us for more information.

Based on the information you provided, no further coordination is required by the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, or the Pennsylvania Department of Conservation and Natural Resources with regard to special concern species, natural communities, or outstanding geologic features. This response does not reflect potential agency concerns regarding impacts to other ecological resources, such as wetlands.

Based on the project-specific information you provided, no impacts to federally listed, proposed, or candidate species are anticipated. Therefore, no further consultation under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* is required with the U.S. Fish and Wildlife Service. Because no take of federally listed species is anticipated, none is authorized. For a list of species that could occur in your project area (but have not been documented in PNDI), please see the county lists of threatened, endangered, and candidate species. A field visit or survey may reveal previously undocumented populations of one or more threatened or endangered species with a project area. If it is determined that any federally listed species occur in your project area, the U.S. Fish and Wildlife Service requires that you initiate consultation to identify and resolve any conflicts. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

These determinations were based on the project-specific information you provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the information you provided does not accurately reflect this project, or if project plans change, DEP and the jurisdictional agencies require that another PNDI review be conducted.

This response represents the most up-to-date summary of the PNDI data files and is good for one(1) year from the date of this PNDI Project Environmental Review Receipt.

DISCLAIMER

The PNDI environmental review website is a preliminary environmental screening tool. It is not a substitute for information obtained from a field survey of the project area conducted by a biologist. Such surveys may reveal previously undocumented populations of species of special concern. In addition, the PNDI only contains information about species occurrences that have actually been reported to the Pennsylvania Natural Heritage Program.

TERMS OF USE

Upon signing into the PNDI environmental review website, and as a condition of using it, you agreed to certain terms of use. These are as follows:

The web site is intended solely for the purpose of screening projects for potential impacts on resources of special concern in accordance with the instructions provided on the web site. Use of the web site for any other purpose or in any other way is prohibited and subject to criminal prosecution under federal and state law, including but not limited to the following: Computer Fraud and Abuse Act of 1986, as amended, 18 U.S.C. Â§ 1030; Pennsylvania Crimes Code, Â§ 4911 (tampering with public records or information), Â§ 7611 (unlawful use of computer and other computer crimes), Â§ 7612 (disruption of service), Â§ 7613 (computer theft), Â§ 7614 (unlawful duplication), and Â§ 7615 (computer trespass).

APPLICANT INITIALS: PAK

PNDI Project Environmental Review Receipt

Project Search ID: 20081204169530
Project Name: ROBSON 1
Date: 12/4/2008 9:06:10 AM

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The PNHP reserves the right at any time and without notice to modify or suspend the web site and to terminate or restrict access to it.

The terms of use may be revised from time to time. By continuing to use the web site after changes to the terms have been posted, the user has agreed to accept such changes.

This review is based on the project information that was entered. The jurisdictional agencies and DEP require that the review be redone if the project area, location, or the type of project changes. If additional information on species of special concern becomes available, this review may be reconsidered by the jurisdictional agency.

PRIVACY and SECURITY

This web site operates on a Commonwealth of Pennsylvania computer system. It maintains a record of each environmental review search result as well as contact information for the project applicant. These records are maintained for internal tracking purposes. Information collected in this application will be made available only to the jurisdictional agencies and to the Department of Environmental Protection, except if required for law enforcement purposesâ€"see paragraph below.

This system is monitored to ensure proper operation, to verify the functioning of applicable security features, and for other like purposes. Anyone using this system consents to such monitoring and is advised that if such monitoring reveals evidence of possible criminal activity, system personnel may provide the evidence to law enforcement officials. See Terms of Use.

Print this Project Review Receipt using your Internet browser's print function and keep it as a record of your search.

Signature: Rachelle M King

Date: 1/8/08

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NORTHWEST REGIONAL OFFICE

Project applicant on whose behalf this search was conducted:

APPLICANT

Contact Name: Chesapeake Appalachia LLC
Address: 900 Pennsylvania Ave
City, State, Zip: Charleston, WV 25302
Phone: (304) 391-5588
Email: rachelle.king@chk.com

PERSON CONDUCTING SEARCH (if not applicant)

Contact Name: _____
Address: _____
City, State, Zip: _____
Phone: _____
Email: _____

The following contact information is for the agencies involved in this Pennsylvania Natural Diversity Inventory environmental review process. Please read this entire receipt carefully as it contains instructions for how to contact these agencies for further review of this particular project.

APPLICANT INITIALS: RMK

PNDI Project Environmental Review Receipt
Project Search ID: 20081204169530
Project Name: ROBSON 1
Date: 12/4/2008 9:06:10 AM

APPLICANT INITIALS: BAK

Pennsylvania Department of Environmental Protection

230 Chestnut Street
Meadville, PA 16335-3481
January 21, 2009

Northwest Regional Office

814-332-6869
Fax: 814-332-6121

TIM - [redacted]
37-085-20172

Tim Smith
Manager – Regulatory, Northern Districts
Chesapeake Energy Corporation – Eastern Division
P.O. Box 6070
Charleston, WV 25362-0070

- CALL 1/26/09 LEFT MESSAGE ABOUT VINITIZATION - NEED TO BREAK OUT AREA.

Re: Technical Deficiency Letter
Chesapeake Energy Corporation
Robson 1 – Permit Application for Drilling a Well
Wayne County, Oregon Township

Dear Mr. Smith:

The Department has reviewed your application and has determined that the following significant deficiencies exist:

Plat problems

Plats are to be accurately prepared as required by the Oil and Gas Act-section 201(b) and Title 25-Chapter 78.15(b) of the PA Code.

Latitude-Longitude, topo mark and topo mark offsets do not correspond to the same location. Additionally, no "anticipated total depth" figure has been provided.

Page 2 & plat differ

The plat submitted with application does not correspond with the information provided on Page 2 of the application. Permit applications are to be accurately prepared as required by the Oil and Gas Act-section 201(b) and Title 25-Chapter 78.15(b) of the PA Code.

Plat indicates Anthony J. & Judith Caamal as surface owners with water supply, Page 2 and associated notifications indicate Anthony J. & Judith Novena as surface owners with water supply.

Unit Agreement

The application plat shows the intended well site to be within 330' of a property line boundary for a neighboring land parcel.

Wells that are subject to the Oil and Gas Conservation Law need be located at least 330 feet from the outside lease or unit boundary as required by the Oil and Gas Conservation Law-section 6(a) and Title 25-Chapter 79.11(b) of the PA Code.

Provided Affidavit of Unitization does not declare a unit, nor does it define the distribution of the unit for those individuals included in the unit. Affidavit of Unitization text defines a 660' x 660' square foot area (resulting in a 10 acre area), Permit application exhibit shows a 660' diameter area (resulting in a 7.85 acre area). Please review attached example of a unit agreement.

See attached Notice of Incomplete Application for these significant deficiencies and other deficiencies if they have been identified.

Should you have any questions regarding the identified deficiencies, please contact me to discuss your concerns or to schedule a meeting. The meeting must be scheduled within the sixty (60) day period allotted for your reply, unless otherwise extended by the Department. Upon receipt of your submission the department will continue its evaluation of your application. You will be notified later if deficiencies remain in your application. You will have a final opportunity to correct any deficiencies, which will be in a pre-denial letter, before the Department makes a final determination. In accordance with the department's Money Back Guarantee Program, the clock tracking the elapsed time for review of your application has stopped while you prepare a response to this letter. The clock will start again when you provide the requested information.

If you believe the stated deficiencies are not significant, you have the option of declining and asking the Department to make a decision based on the information you have already made available.

If you choose this option, you should explain and justify how your current submission satisfies the deficiencies noted above. Please keep in mind that if you ignore this request or fail to respond by March, 22, 2009, you're application will be denied.

If you have any questions concerning this matter, please contact our office.

Sincerely,

Joseph F. Lichtinger, P.G.
Oil and Gas Management

Chesapeake ENERGY

Tim Smith
Manager – Regulatory
Northern Districts
Office: (304) 353-5065
Cell: (304) 382-8783
tim.smith@chk.com

February 3, 2009

UPS OVERNIGHT MAIL

Mr. Joseph F. Lichtinger, P.G.
Pennsylvania Department of Environmental Protection
Oil and Gas Management Program
230 Chestnut Street
Meadville, PA 16335-3481

Re: Deficiency Response for Robson 1 (627528) Well Permit Application

Dear Mr. Lichtinger:

Please find enclosed the corrections that have been made to the above-mentioned well permit application that was returned to Chesapeake due to the deficiencies found within this application as indicated below:

1. Plat – Latitude & Longitude, the topographic mark and the offsets have been corrected to correspond that the location is the same. Also, the anticipated total depth has been included on the corrected plat.
2. Page 2 & Plat Differ – The name that is shown on Page 2 is the correct name of the surface landowner with a water supply, Anthony J. & Judith Novena. The well plat has been corrected to show the correct name so it corresponds with Page 2 of the Permit Application.
3. Unit Agreement – The well site is within 330 feet of a property boundary for a neighboring land parcel and subject to the Oil and Gas Conservation Law. A corrected Unit Exhibit and Affidavit of Unitization have been included to provide the Department what is required.

If you should have any questions or require additional information, please do not hesitate to contact me.

Sincerely,

Chesapeake Appalachia, L.L.C.

Tim Smith

Tim Smith
Enclosures

Phone Contact Log

Date: 2/9/09 **Tracking Number:** 127-20009

Time: 9:25 **Farm Name:** Robson

Number Called: 304-353-3065 **Well Number:** 1

Company Called: CHESAPEAKE

Person Contacted: TIM SMITH

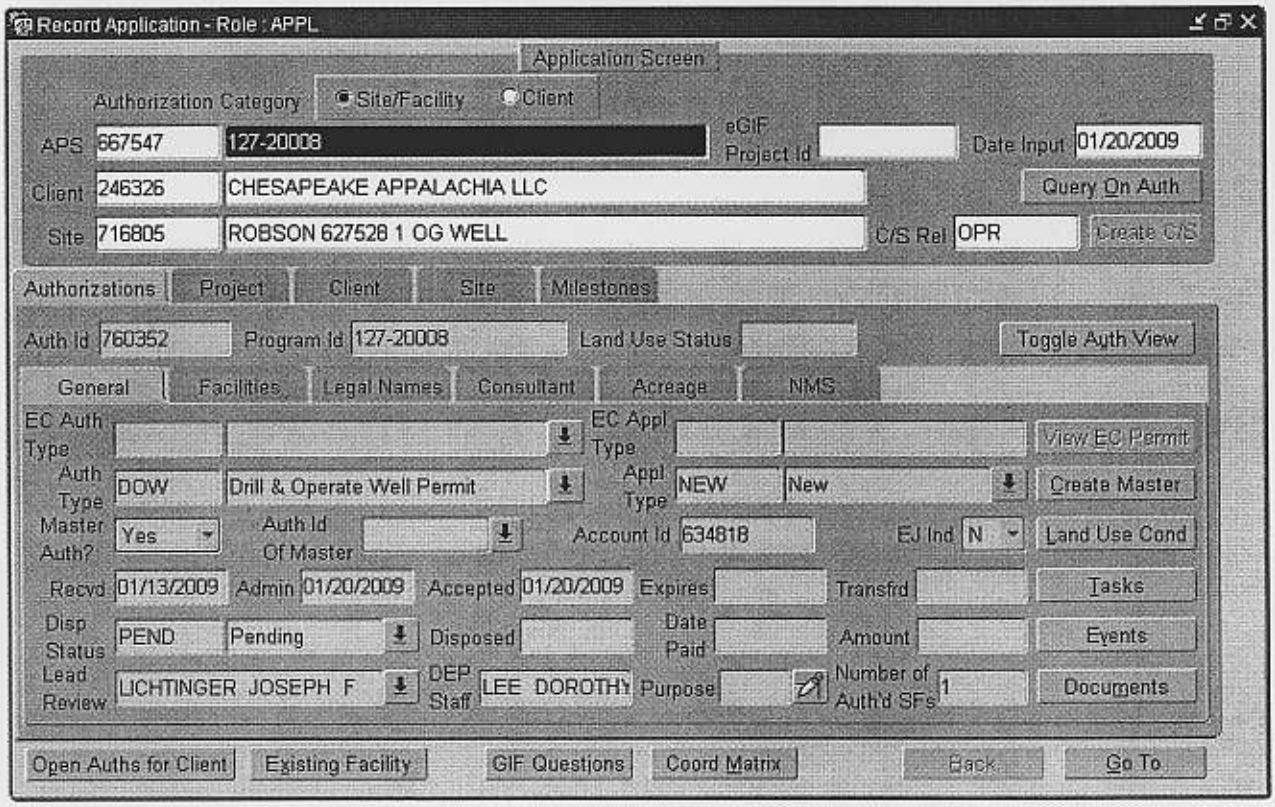
Deficiencies Addressed:

1. TOPO MAP @ INCORRECT LOCATION

REPLY - LEFT MESSAGE.

CALLED AGAIN 2/11/09 ON CELL - LEFT MESSAGE

2/17/09 CALLED SURVEYOR. HE WILL SEND NEW COPY.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EC Appl Type
View EC Permit
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Drill & Operate Well Permit
Appl Type NEW
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Auth Id Of Master
Account Id 634818
EJ Ind N
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Recvd 01/13/2009
Admin 01/20/2009
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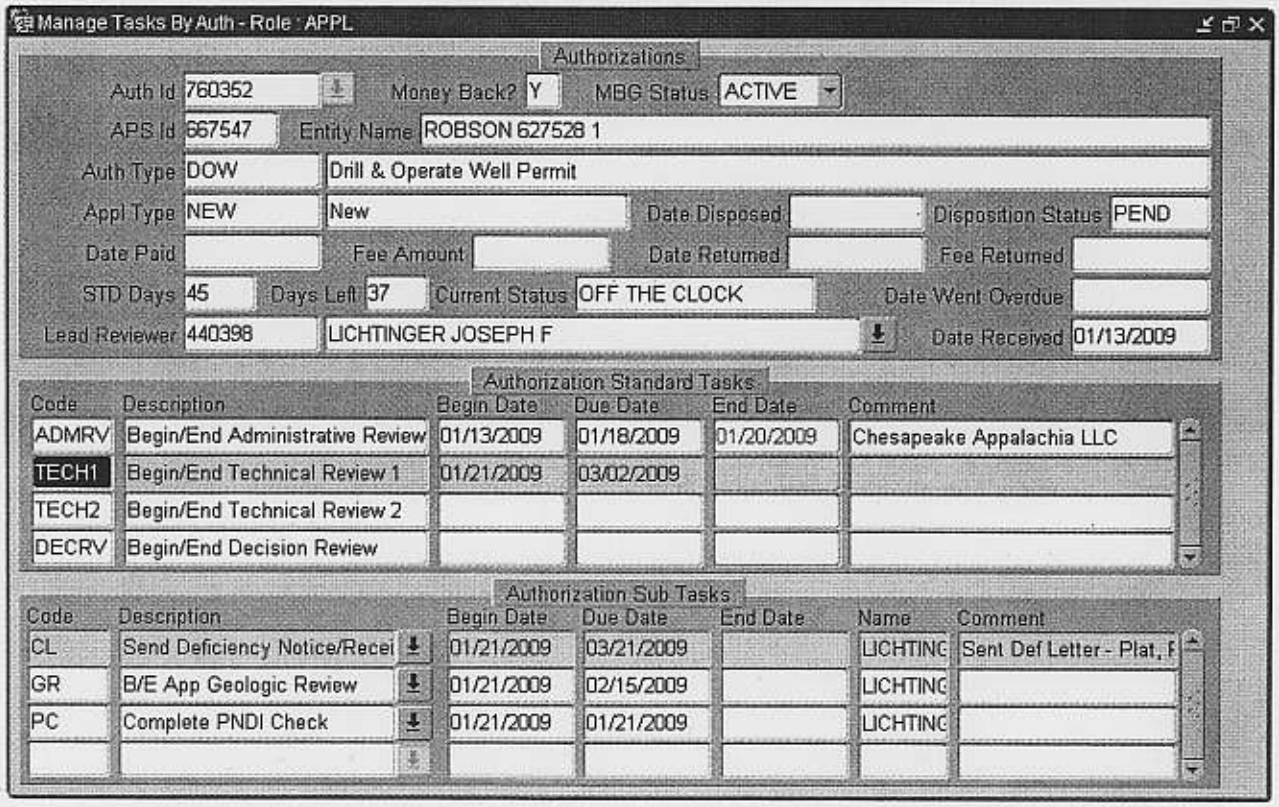
Existing Facility
GIF Questions
Coord Matrix
Back
Go To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Appl Type NEW
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Disposition Status PEND
Date Paid
Fee Amount
Date Returned
Fee Returned
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Days Left 37
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Date Went Overdue
Lead Reviewer 440398
LICHTINGER JOSEPH F
Date Received 01/13/2009
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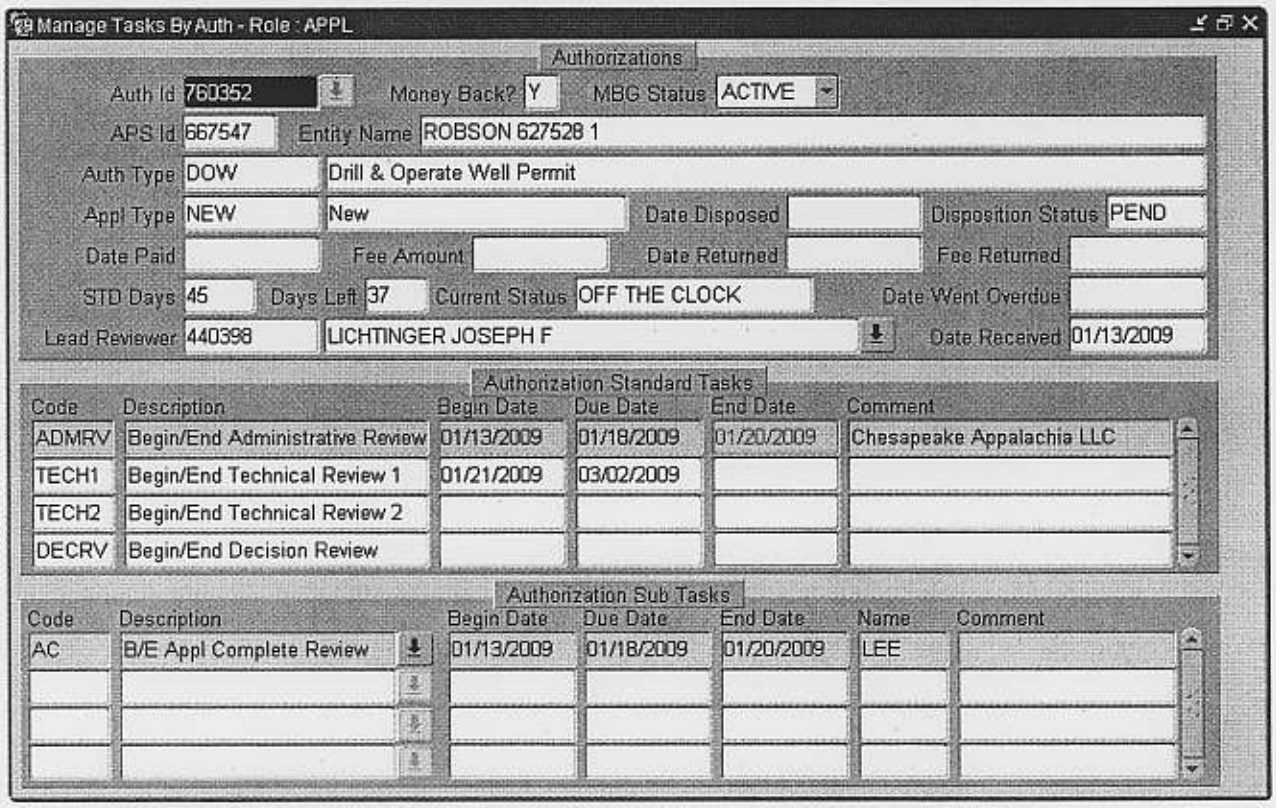
TECH1 Begin/End Technical Review 1 01/21/2009 03/02/2009
TECH2 Begin/End Technical Review 2
DECRV Begin/End Decision Review
Authorization Sub Tasks
Code Description Begin Date Due Date End Date Name Comment
CL Send Deficiency Notice/Recei 01/21/2009 03/21/2009 LICHTING Sent Def Letter - Plat, F
GR B/E App Geologic Review 01/21/2009 02/15/2009 LICHTING
PC Complete PNDI Check 01/21/2009 01/21/2009 LICHTING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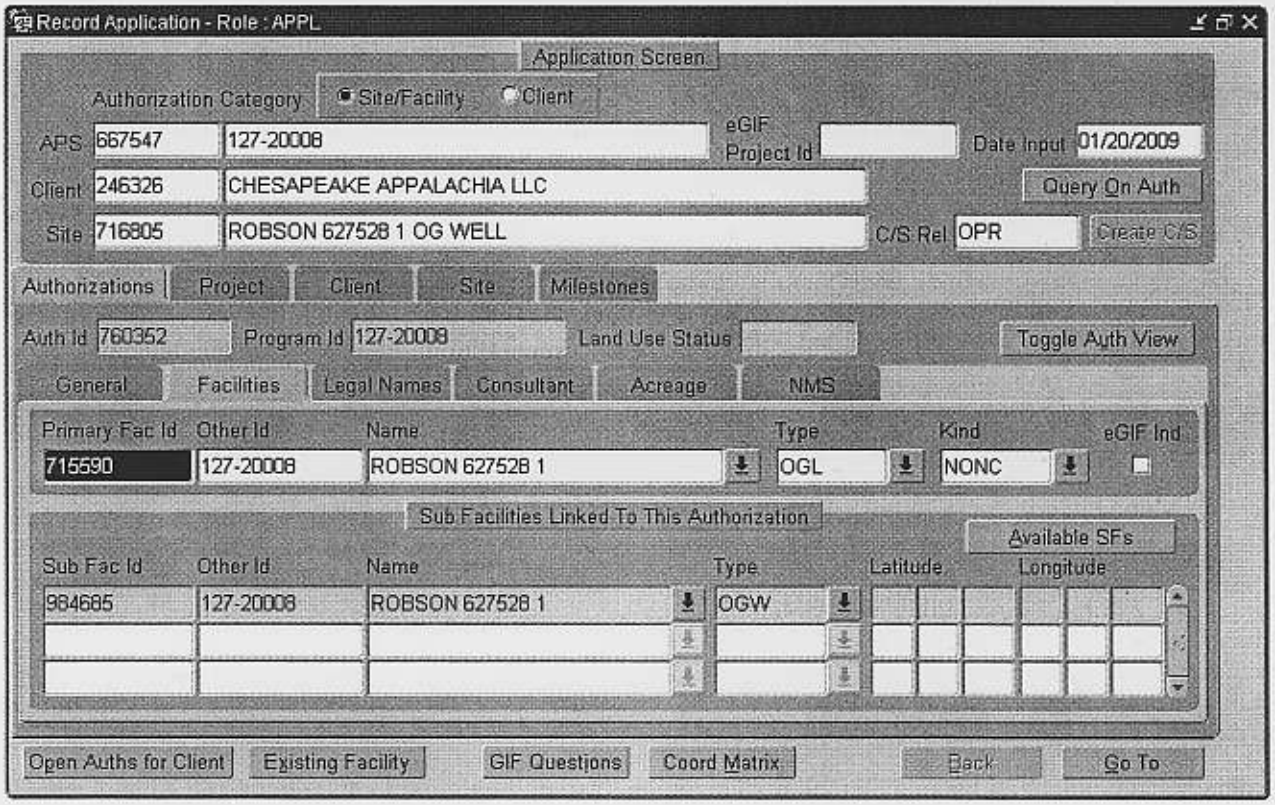
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ROBSON 627528 1 OG WELL
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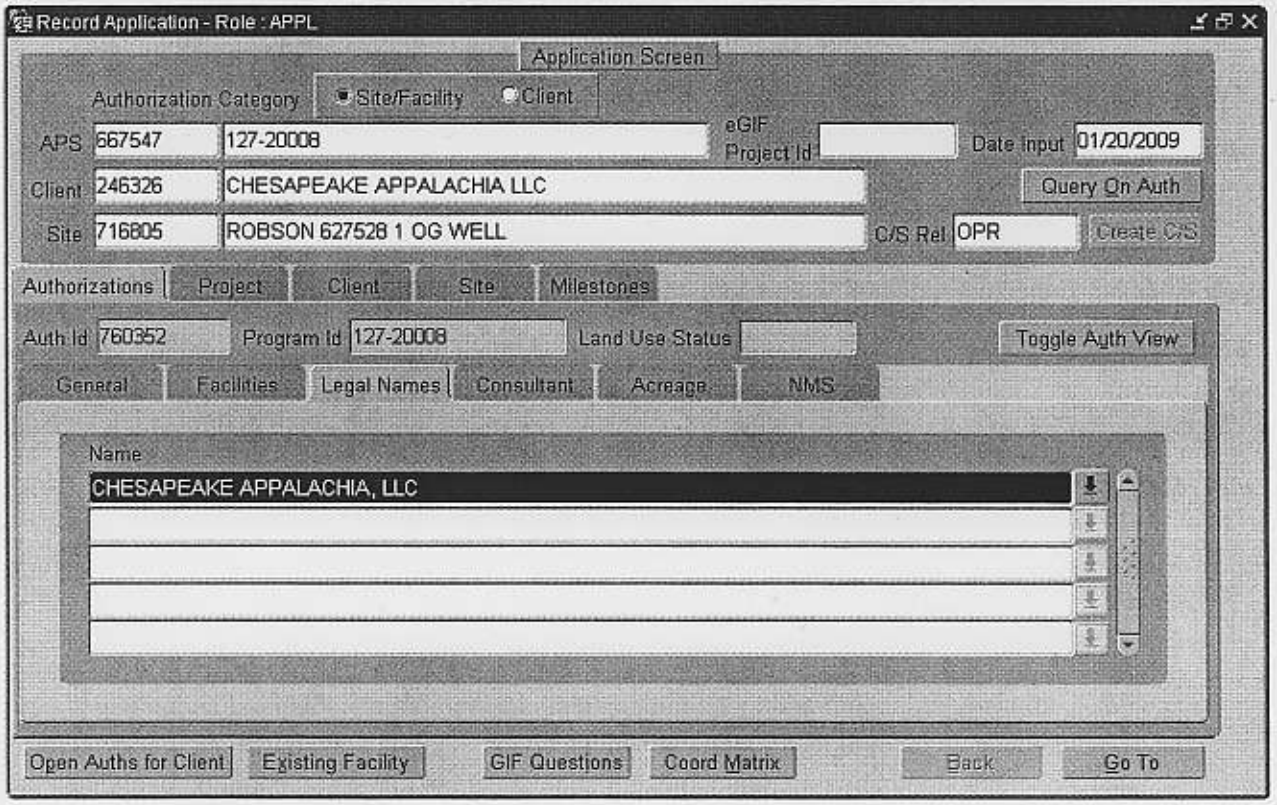
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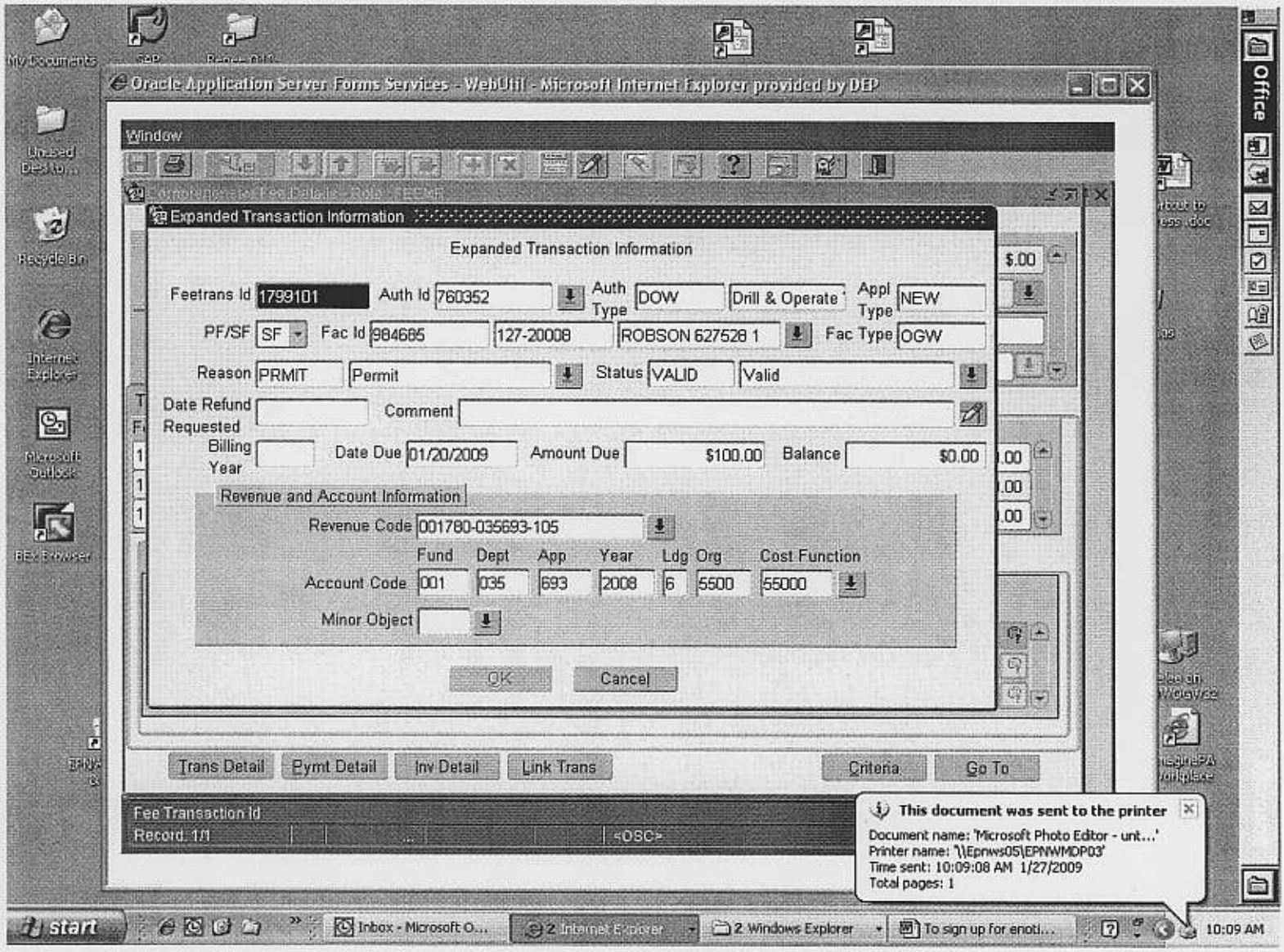
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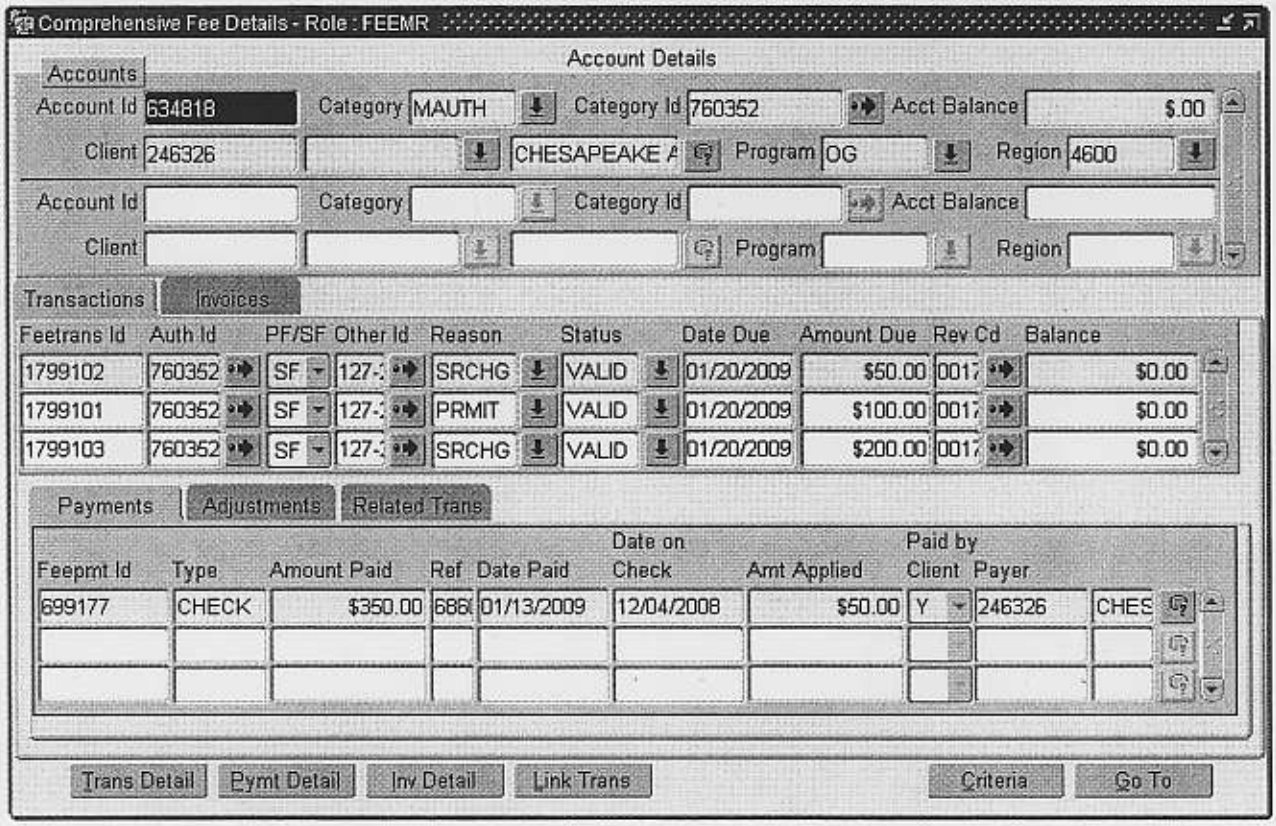
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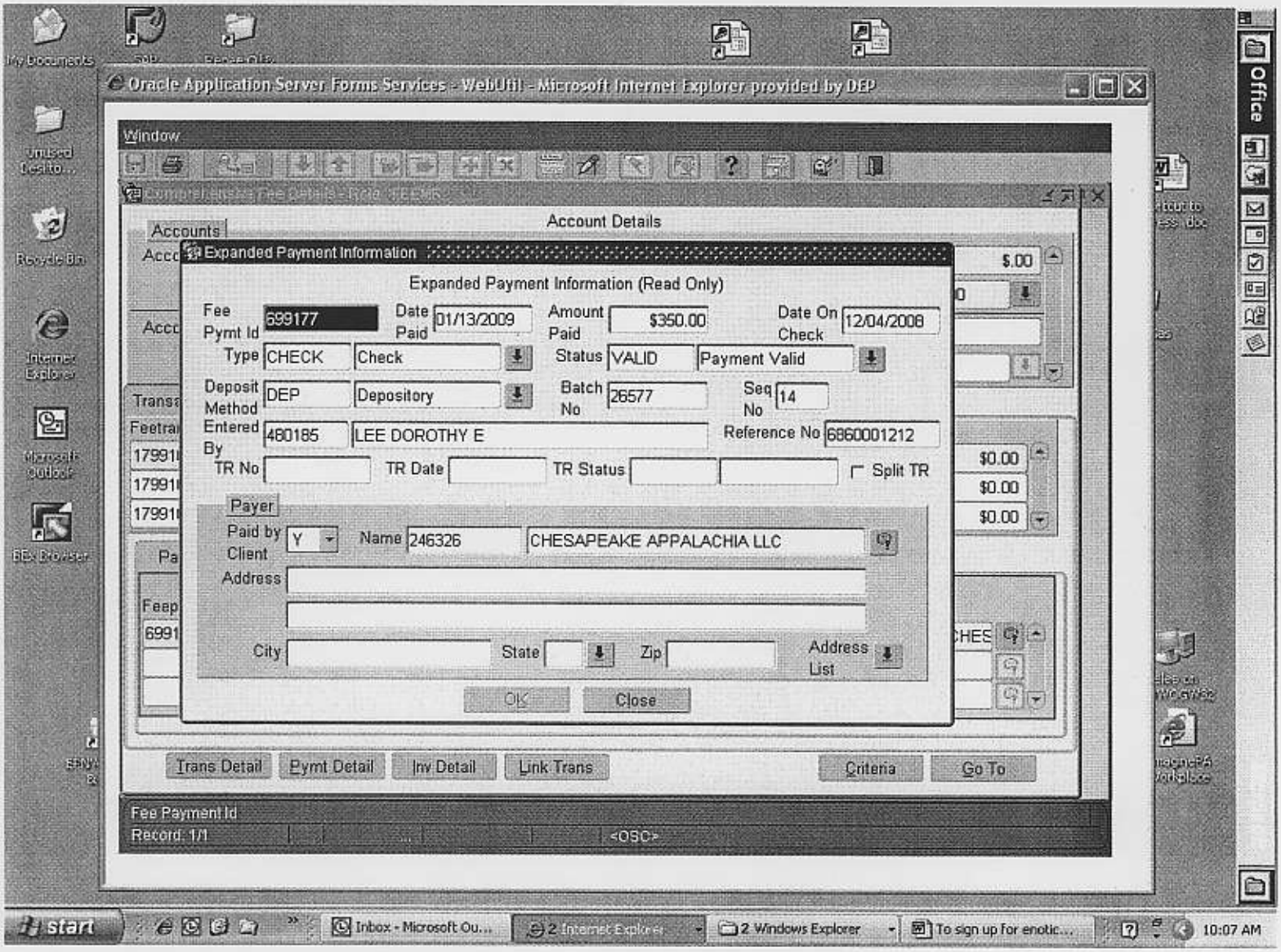
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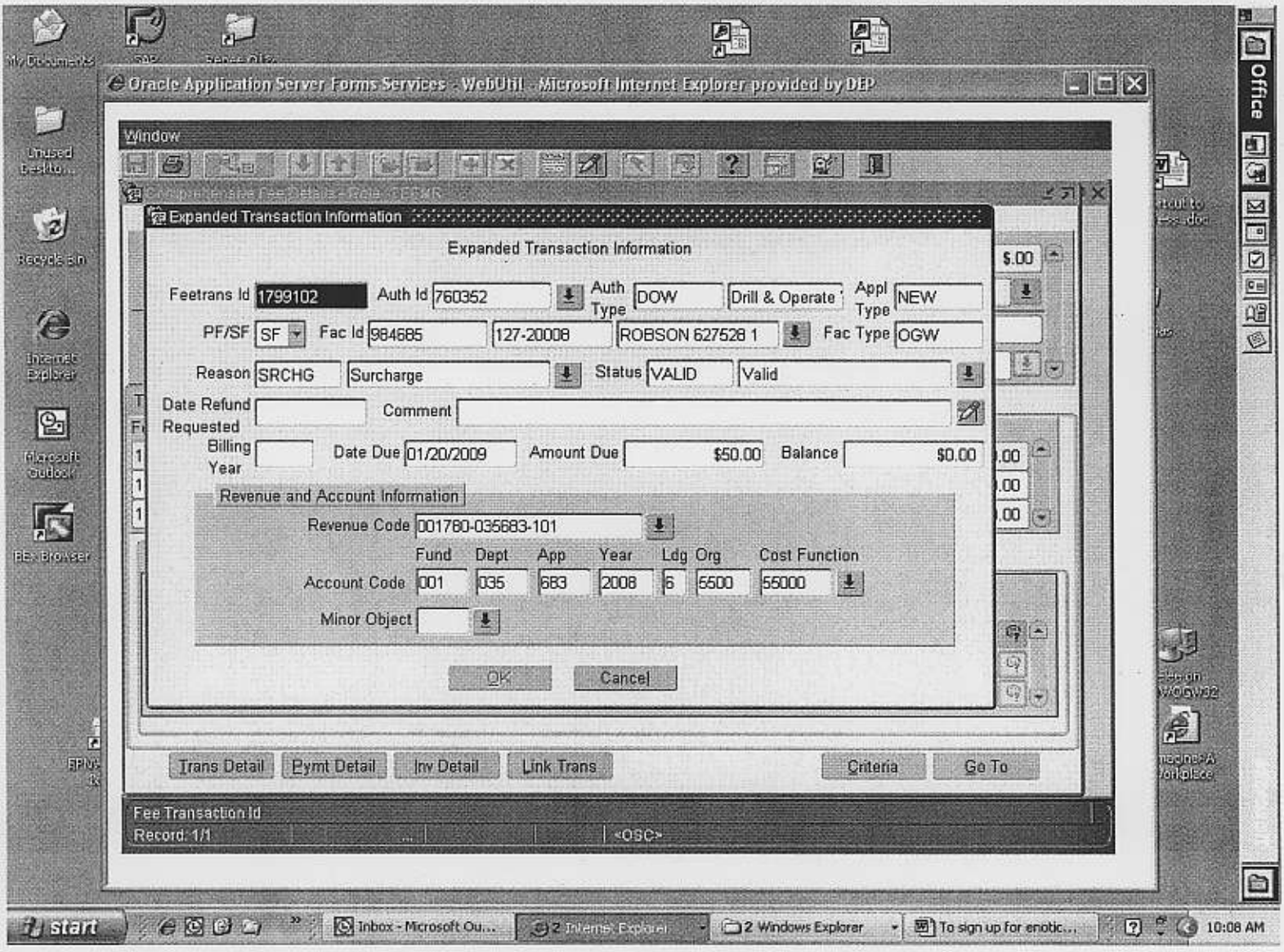
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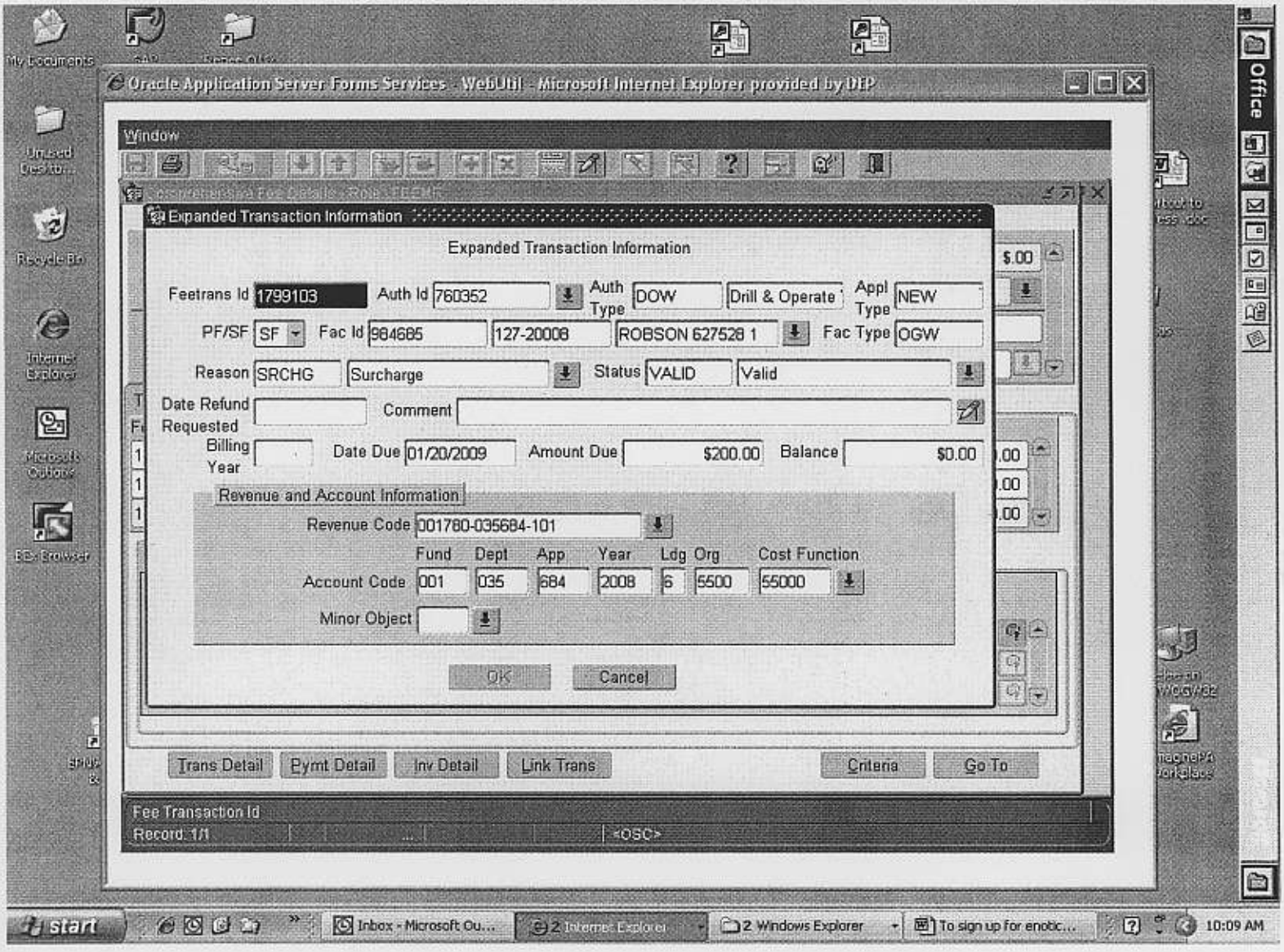
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5500-PM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 830993
Watershed Name: Salt River Brook	Quality: HQ

Permittee	OGO.#	Permit Number	Date Issued
NEWFIELD APPALACHIA PA LLC	OGO-67425	37-127-20018-00	05/25/2010

Address	Farm Name & Well Number	Well Serial #
363 N SAM HOUSTON PKWY E	DL TEEPLE 1 2H	
SUITE 2020	Municipality: Manchester	County: Wayne
HOUSTON, TX 77060-2424	7½' Quadrangle Name: Long Eddy	Map Section #: 5

Phone	Project #	Latitude	Longitude
(281) 674-2501		41-49-23.1900	-75-11-39.3900

Surf Elev at Site	Anticipated Total Depth	Well Type	Offset distances referenced to NE corner of map section.
1438 feet	8140 feet	GS	South 3725 feet West 7525 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

The permittee shall not withdraw or use water from water sources within the Commonwealth of Pennsylvania, for well fracing activities, unless the permittee does so in accordance with a Water Management Plan approved by the Department.

Permittee shall obtain a permit or Environmental Assessment approval from the Department prior to the construction of any dam, reservoir, water obstruction, and/or encroachment for which a permit or Environmental Assessment approval is required by 25 Pa. Code Chapter 105. Any dam embankment including centralized dam embankments utilized to impound freshwater or frac water associated with well fracing not requiring a permit pursuant to 25 Pa. Code Chapter 105 will be constructed in accordance with requirements of 25 Pa. Code §§ 78.56-78.63 and Department guidelines 5500-PM-OG0085 entitled, Design, construction and maintenance standards for dam embankments associated with impoundments for oil and gas wells.

Prior to fracturing the well, as part of its Preparedness, Prevention and Contingency Plan the permittee shall implement a Control and Disposal Plan for the control and disposal of fluids and residual wastes in accordance with 25 Pa. Code § 78.55. The Control and Disposal Plan shall identify the control and disposal methods and practices utilized to prevent pollutants from directly or indirectly reaching waters of the Commonwealth during the impoundment, production, processing and transportation of pollutants, including identification of the permitted processing or disposal facilities where residual wastes will be processed or disposed, in accordance with 25 Pa. Code §§ 78.55 and 91.34.

Prior to transport of the residual wastewater off site, chemical analysis and characterization of the waste shall be conducted and provided to the processing or disposal facility intended for acceptance of the waste in accordance with 25 Pa. Code § 287.54.

The Operator shall run a complete angular deviation survey of the intentionally deviated well. The deviation survey is to be obtained by a responsible well surveying company and shall be filed with the Department within thirty (30) days after well drilling together with other regularly required reports.

This permit expires **05/25/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-PM-OG0001 Rev. 10/2009

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

ESM10-127-0001

DEP USE ONLY	
AUTH #	NC
Check # 1067827	Amount $ 3650.00

1067826 $500.00

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes	OGO # 607425	Objection Date - Do not issue before:	Well Permit # 127-20018 NC
	Bond # 12382	4/26/10	Special Cond. A B C D E F
	C: 4/13/10 mjs; 4/26/10 JR	Date Approved: 5/21/10	Watershed Name: SALT RIVER BROOK
	INV: 5-24-10		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-674-2501	281-674-2902	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
D.L. Teeple	1-2H	

County	Municipality	Project # (from DEP)
WAYNE	MANCHESTER	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled,** if known:_____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☒ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☒ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☐ Other (specify)

APPLICATION FEE
Check applicable.
- ☒ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☐ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☒ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☐ Vertical: Length ____ ft.
- ☒ Marcellus: Length 13,548.8 ft.
- ☐ Non-Vertical: Length ____ ft.

Total Application Fee $ 4,150

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law?** If "No," go to 2).	☐	☒
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☐	☐
b. Does the location fall within an area covered by a spacing order?	☐	☐
2. Will the well penetrate a **workable coal seam?** If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam,** and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine,** or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill?**	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland?**	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply?**	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "**Coordination of a Well Location with Public Resources**" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. See Attached Module	☒	☐

DEP USE ONLY
Date Stamps/Notes
Auth 830993
Site 733332
Clnt 277879
APS 717984
Acct 1616140
PF 729789
SF 1012170

Signature of Applicant

The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	*(Print or Type)*	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date
Donald F. Sleeth			4-12-10

Application Preparer/Contact: ANDREW STRASSNER Phone: 412-862-7963

5500-PM-OG0001 Rev. 10/2009

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
Name: Dale L & Ella E Teeple	Address: 13 Teeple Road Equinunk, Pa 18417-3514	X					X						X
Name: Roger D & Patricia A Hazen	Address: 3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Name: Granville W & Charlene Teeple	Address: 24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Name: Cynthia F Rowe	Address: 3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-27-10		
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft. Dale L Teeple Ella E. Teeple	Date 3-31-10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location Dale L Teeple 3-31-10	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location Ella E. Teeple 3-31-10	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

8100E-L61

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 — Record of Notification / Written Consent

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Name: Dale L & Ella E Teeple	Address: 13 Teeple Road Equinunk, Pa 18417-3514	X					X						X
Name: Roger D & Patricia A Hazen	Address: 3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Name: Granville W & Charlene Teeple	Address: 24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Name: Cynthia F Rowe	Address: 3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-29-10		
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Roger D. Hazen 03/30/2010	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Patricia A. Hazen 3/30/2010	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#:
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

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		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification: Certified Mail Dates Sent	Notification: Certified Mail Dates Return Receipt	Notification: Address Affidavit	Notification: Written Consent
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Name: Roger D & Patricia A Hazen	Address: 3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Name: Granville W & Charlene Teeple	Address: 24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Name: Cynthia F Rowe	Address: 3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-27-10		
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

8100-LG1

Acct-676745

5500-PM-OG0001a 3/2009
Application

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF OIL AND GAS MANAGEMENT

DEP USE ONLY	
APS # 717984	Site # 733332
Permit # 127-20018	Auth ID # 830995

Erosion, Sediment and Stormwater Control MODULE

ESM10-127-0001

Please complete this section if your earth disturbance activities will disturb 5 acres or greater.

1. Project Site Information.

   a. Attach topographic map of proposed location.

   b. Location of surface waters which may receive runoff and the waters classification, pursuant to Chapter 93 and the "statewide existing use listing":

   Receiving Waters/Watershed Name
   Salt River Brook / Little Equinunk Creek

   Chapter 93 Designated Use or Existing Use Stream Classification
   (High Quality) Exceptional Value Other _____

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   NORTHWEST REGIONAL OFFICE

2. Erosion and Sediment Control authorization for Earth Disturbance Associated with Oil and Gas Activities filing fee of $500 payable to: Commonwealth of Pennsylvania, Clean Water Fund.

3. **Compliance History**

   Is the applicant in violation of any existing permit, regulation, order or schedule of compliance issued by the Department? If yes, provide the permit number or facility name, a brief description of the violation, the compliance schedule (including dates and steps to achieve compliance) and the current compliance status.

   Yes (No)

   (Attach on a separate sheet, if needed)

4. **Erosion & Sediment Control and Site Restoration Plan**

   At least fourteen days before the commencement of earth disturbance activities, or earlier in accordance with applicable Chapter 105 permitting requirements, the applicant shall provide the appropriate DEP Regional Oil and Gas Program Office with the following:

   A. An Erosion and Sediment Control and Site Restoration Plan that meets the requirements of 25 Pa. Code Chapters 78 and102, and in the Department's *Erosion and Sediment Pollution Control Manual*, No. 363-2134-008, as amended and updated and the Department's *Oil and Gas Operator's Manual*, No. 550-0300-001.

   B. The Site Restoration Plan shall include PCSM BMPs designed and implemented to meet the requirements of 25 Pa. Code Chapter 93, and consistent with the *Pennsylvania Stormwater Best Management Practices Manual*, No. 363-0300-002, as amended and updated.

   Both the E&S and Site Restoration Plan shall minimize the accelerated erosion and sedimentation and shall eliminate the net change in post construction stormwater runoff as compared to the amount of preconstruction stormwater runoff. This shall be accomplished first through the use of site design and nonstructural BMP approaches, and if necessary structural filtration, infiltration, and runoff control BMPs in accordance with *Erosion and Sediment Pollution Control Manual*, No. 363-2134-008, *Oil and Gas Operator's Manual*, No. 550-0300-001and *Stormwater Best Management Practices Manual*, No. 363-0300-002, as amended and updated. Supporting calculations and measurements for PCSM BMPs are not required unless there will be permanent impervious paved surfaces or above-ground structures or facilities (excluding well-heads and brine storage tanks and other such ancillary equipment. See model plan for further guidance). Crushed rock or gravel roads are not considered impervious.

   Both the E&S and Site Restoration Plan shall be developed and sealed by a licensed professional engineer, surveyor or professional geologist, and shall contain the following certification:

   I do hereby certify to the best of my knowledge, information and belief, that the Erosion and Sediment Control and Site Restoration Plan are true and correct, represent actual field conditions and are in accordance with the 25 Pa. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

   Print Name: _____ Signature: _____

   Company: _____

   Address: _____

   Phone: _____

5. **Area Wide or Phased E&S and Stormwater Management**

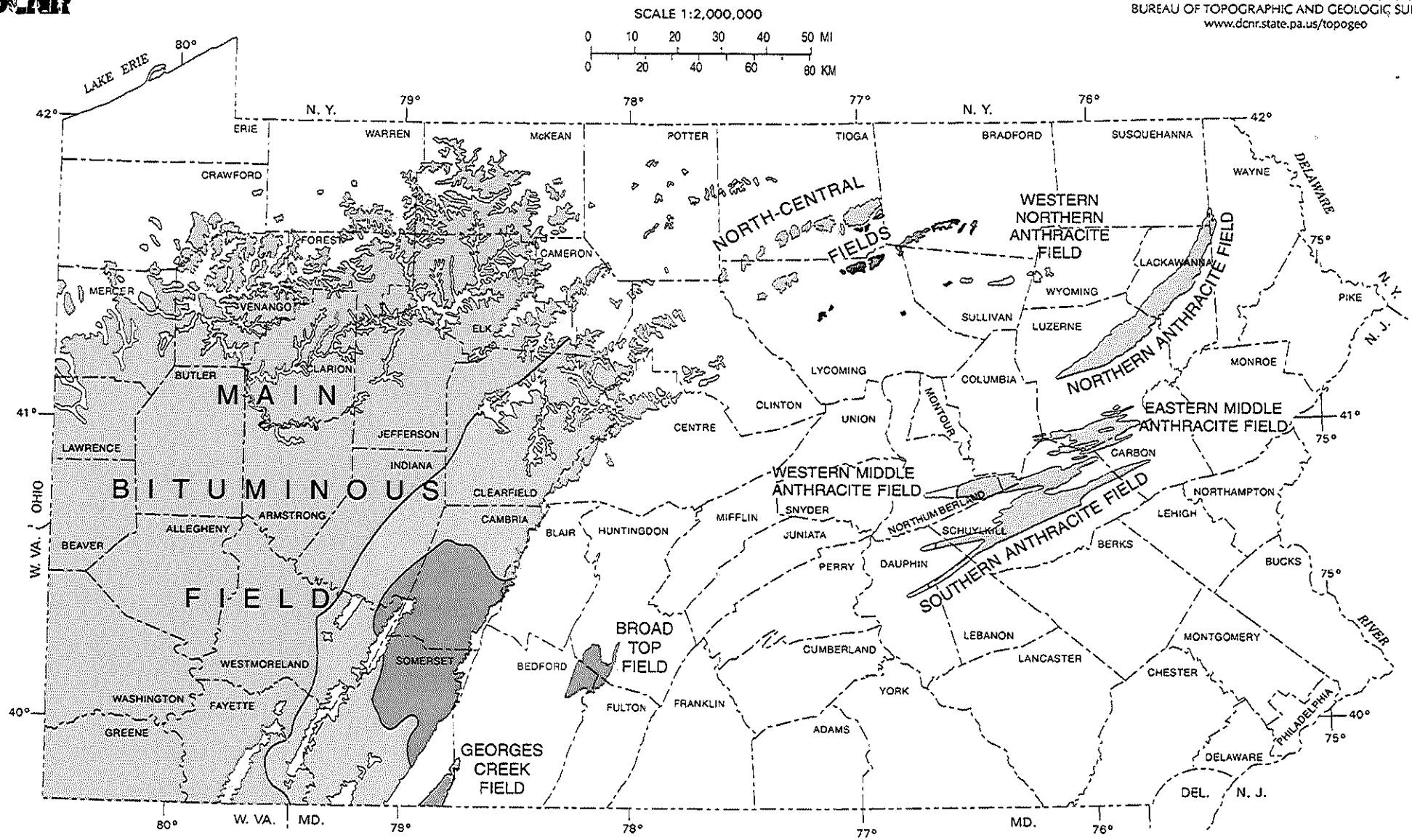
   List the well permit numbers for any other well permit that is or will be included in the E&S and/or Site Reclamation Plan for this project:

   _____

MAP 11

DISTRIBUTION OF PENNSYLVANIA COALS

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF
CONSERVATION AND NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
www.dcnr.state.pa.us/topogeo



EXPLANATION

BITUMINOUS FIELDS

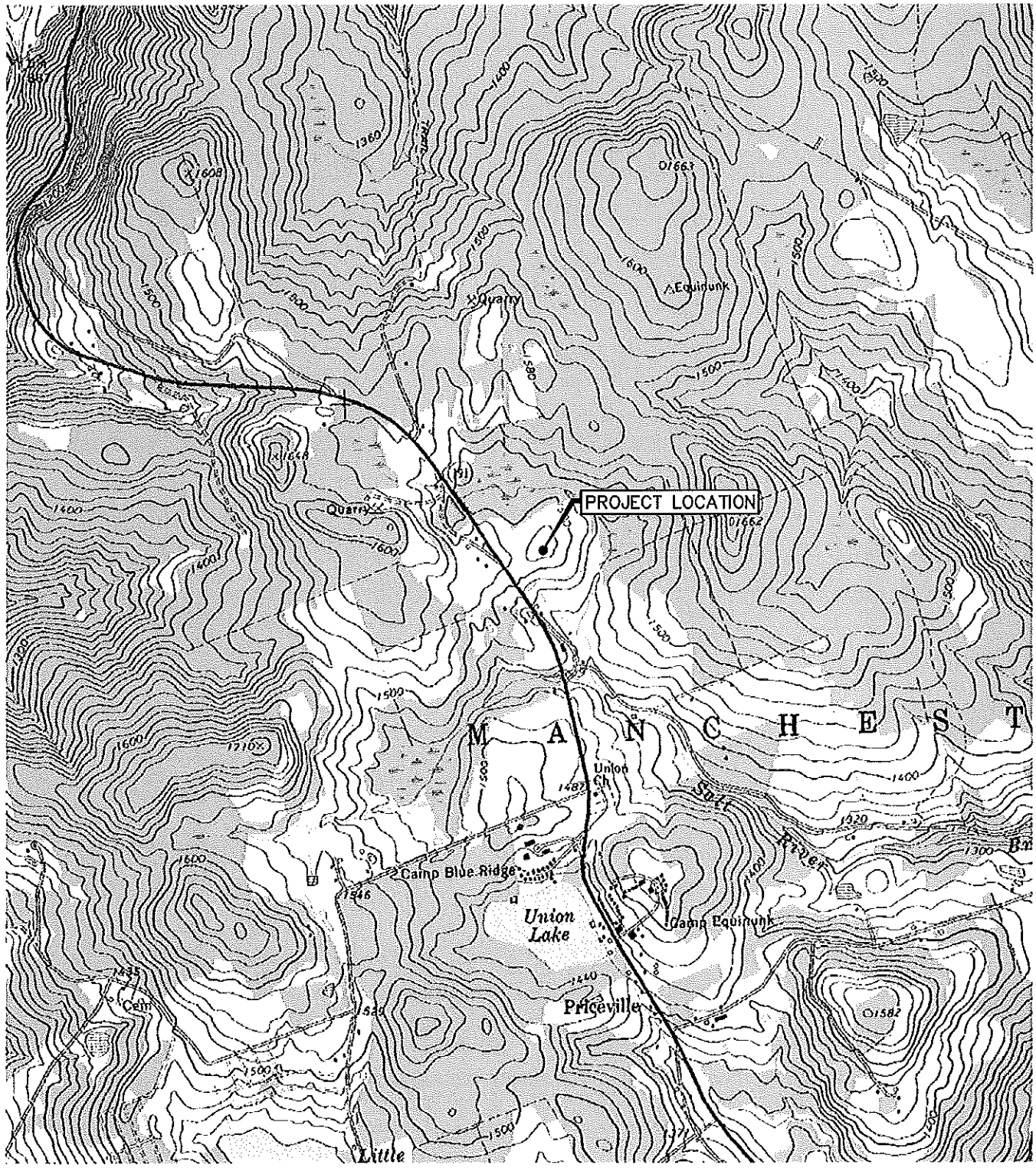
- High-volatile bituminous coal
- Medium-volatile bituminous coal
- Low-volatile bituminous coal

ANTHRACITE FIELDS

- Semi-anthracite
- Anthracite

Prepared by Bureau of Topographic and Geologic Survey.
Third Edition, Revised, 2000; Third Printing, 2008.

2200-MP-DCNR0855
Printed on Recycled Paper



R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Teeple 1-1\Figures\2568FG001.dwg PIT BEN.HOPPE 3/4/2010 8:49:25 AM

TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

NEWFIELD APPALACHIA PA LLC
WAYNE COUNTY, PENNSYLVANIA

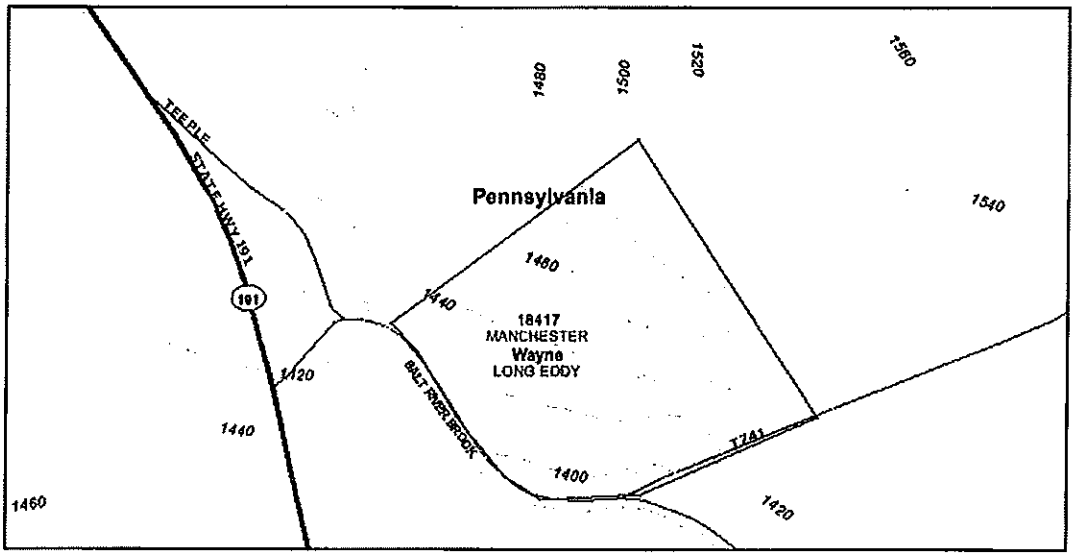
TEEPLE WELL PAD
LOCATION MAP
SCALE: 1" = 2000'

DATE:	3/4/10
PROJECT NO.:	112C02568
DESIGNED BY:	RAL
DRAWN BY:	BH
CHECKED BY:	RAL
SHEET: 1 OF 2	

ATTACHMENT 1

1. PROJECT INFORMATION

Project Name: **D.L. Teeple Well**
Date of review: **3/3/2010 8:00:27 AM**
Project Category: **Energy Storage, Production, and Transfer,Energy Production (generation),Oil or Gas - new wells, expansion of well field**
Project Area: **20.3** acres
County: **Wayne** Township/Municipality: **Manchester**
Quadrangle Name: **LONG EDDY**
ZIP Code: **18417**
Decimal Degrees: **41.82487 N, --75.19285 W**
Degrees Minutes Seconds: **41° 49' 29.5" N, -75° 11' 34.3" W**



2. SEARCH RESULTS

Agency	Results	Response
PA Game Commission	No Known Impact	No Further Review Required
PA Department of Conservation and Natural Resources	No Known Impact	No Further Review Required
PA Fish and Boat Commission	No Known Impact	No Further Review Required
U.S. Fish and Wildlife Service	No Known Impact	No Further Review Required

As summarized above, Pennsylvania Natural Diversity Inventory (PNDI) records indicate no known impacts to threatened and endangered species and/or special concern species and resources within the project area. Therefore, based on the information you provided, no further coordination is required with the jurisdictional agencies. This response does not reflect potential agency concerns regarding impacts to other ecological resources, such as wetlands.

3. AGENCY COMMENTS

Regardless of whether a DEP permit is necessary for this proposed project, any potential impacts to threatened and endangered species and/or special concern species and resources must be resolved with the appropriate jurisdictional agency. In some cases, a permit or authorization from the jurisdictional agency may be needed if adverse impacts to these species and habitats cannot be avoided.

These agency determinations and responses are **valid for one year** (from the date of the review), and are based on the project information that was provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the following change: 1) project location, 2) project size or configuration, 3) project type, or 4) responses to the questions that were asked during the online review, the results of this review are not valid, and the review must be searched again via the PNDI Environmental Review Tool and resubmitted to the jurisdictional agencies. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt.

PA Game Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Department of Conservation and Natural Resources

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Fish and Boat Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

U.S. Fish and Wildlife Service

RESPONSE: No impacts to **federally** listed or proposed species are anticipated. Therefore, no further consultation/coordination under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* is required. Because no take of federally listed species is anticipated, none is authorized. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

4. DEP INFORMATION

The Pa Department of Environmental Protection (DEP) requires that a signed copy of this receipt, along with any required documentation from jurisdictional agencies concerning resolution of potential impacts, be submitted with applications for permits requiring PNDI review. For cases where a "Potential Impact" to threatened and endangered species has been identified before the application has been submitted to DEP, the application should not be submitted until the impact has been resolved. For cases where "Potential Impact" to special concern species and resources has been identified before the application has been submitted, the application should be submitted to DEP along with the PNDI receipt, a completed PNDI form and a USGS 7.5 minute quadrangle map with the project boundaries delineated on the map. The PNDI Receipt should also be submitted to the appropriate agency according to directions on the PNDI Receipt. DEP and the jurisdictional agency will work together to resolve the potential impact(s). See the DEP PNDI policy at

http://www.naturalheritage.state.pa.us.

5. ADDITIONAL INFORMATION

The PNDI environmental review website is a **preliminary** screening tool. There are often delays in updating species status classifications. Because the proposed status represents the best available information regarding the conservation status of the species, state jurisdictional agency staff give the proposed statuses at least the same consideration as the current legal status. If surveys or further information reveal that a threatened and endangered and/or special concern species and resources exist in your project area, contact the appropriate jurisdictional agency/agencies immediately to identify and resolve any impacts.

For a list of species known to occur in the county where your project is located, please see the species lists by county found on the PA Natural Heritage Program (PNHP) home page (www.naturalheritage.state.pa.us). Also note that the PNDI Environmental Review Tool only contains information about species occurrences that have actually been reported to the PNHP.

6. AGENCY CONTACT INFORMATION

PA Department of Conservation and Natural Resources
Bureau of Forestry, Ecological Services Section
400 Market Street, PO Box 8552, Harrisburg, PA. 17105-8552
Fax:(717) 772-0271

U.S. Fish and Wildlife Service
Endangered Species Section
315 South Allen Street, Suite 322, State College, PA. 16801-4851
NO Faxes Please.

PA Fish and Boat Commission
Division of Environmental Services
450 Robinson Lane, Bellefonte, PA. 16823-7437
NO Faxes Please

PA Game Commission
Bureau of Wildlife Habitat Management
Division of Environmental Planning and Habitat Protection
2001 Elmerton Avenue, Harrisburg, PA. 17110-9797
Fax:(717) 787-6957

7. PROJECT CONTACT INFORMATION

Name: Rick Lowry
Company/Business Name: Tetra Tech NUS, Inc
Address: 661 Andersen Drive
City, State, Zip: Pittsburgh, PA 15220
Phone:(412) 921-8375 Fax:(412) 921-4040
Email: Rick.Lowry@Tetra Tech.com

8. CERTIFICATION

I certify that ALL of the project information contained in this receipt (including project location, project size/configuration, project type, answers to questions) is true, accurate and complete. In addition, if the project type, location, size or configuration changes, or if the answers to any questions that were asked during this online review change, I agree to re-do the online environmental review.

(Agent) 03/16/10

applicant/project proponent signature date

Confirmation Services

Package ID: 9171082133393775234354
Destination ZIP Code: 78840
Customer Reference:
Recipient: TCLA and F.H Whitehead
Address: 11 Meadow Ln
Del Rio Texas 78840

E-CERTIFIED
1STCL REGULAR LETTER
PBP Account #: 13945647
Serial #: 4253999
MAR 24 2010 4:58P

Confirmation Services

Package ID: 9171082133393775234361
Destination ZIP Code: 76950
Customer Reference:
Recipient: W.L Whitehead
Address: P.O Box 1508
Sonora, Tx 76950

E-CERTIFIED
1STCL REGULAR LETTER
PBP Account #: 13945647
Serial #: 4253999
MAR 24 2010 4:58P

Confirmation Services

Package ID: 9171082133393775234385
Des
Cus
Rec
Add

Cynthia F. Rowe
3743 Hancock Hwy.
Equinunk, PA 18417

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
MAR 25 2010 2:37P

Confirmation Services

Package ID: 9171082133393775234408
Desti
Custe
Recip
Addr

Granville W. & Charlene Teeple
24 Sault River Rd.
Equinunk, PA 18471

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
MAR 25 2010 2:37P

RECEIVED
APR 13 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Confirmation Services

Package ID: [illegible]
Dest
Cus
Recl
Add

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Granville W. & Charlene Teeple
24 Sault River Rd.
Equinunk, PA 18471

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X G.C Teeple ☐ Agent ☐ Addressee

B. Received by (Printed Name) G.C Teeple
C. Date of Delivery 3-29-10

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 91 7108 2133 3937 7523 4408

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-154

Confirmation Services

Package ID: 9171082133393775234354
Destination ZIP Code: 78840
Customer Reference:
Recipient: TCLA and F.H Whitehead
Address: 11 Meadow Ln
Del Rio Texas 78840

E-CERTIFIED
1STCL REGULAR LETTER
PBP Account #: 13945647
Serial #: 4253999
MAR 24 2010 4:58P

Confirmation Services

Package ID: 9171082133393775234361
Destination ZIP Code: 76950
Customer Reference:
Recipient: W.L Whitehead
Address: P.O Box 1505
Sonora, Tx 76950

E-CERTIFIED
1STCL REGULAR LETTER
PBP Account #: 13945647
Serial #: 4253999
MAR 24 2010 4:58P

Confirmation Services

Package ID: 9171082133393775234385
Des
Cus
Rec
Add

Cynthia F. Rowe
3743 Hancock Hwy.
Equinunk, PA 18417

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
MAR 25 2010 2:37P

Confirmation Services

Package ID: 9171082133393775234408
Desti
Custo
Recip
Addr

Granville W. & Charlene Teeple
24 Sault River Rd.
Equinunk, PA 18471

E-CERTIFIED
1STCL REGULAR FLAT
PBP Account #: 13945647
Serial #: 4253999
MAR 25 2010 2:37P

RECEIVED
APR 13 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Confirmation Services

Package ID: 9171082133393775234415
Dest
Cu
Re
Ad

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete Item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Cynthia F. Rowe
3743 Hancock Hwy.
Equinunk, PA 18417

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Cynthia Rowe
☐ Agent
☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 3/27/10

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 91 7108 2133 3937 7523 4392

PS Form 3811, 2004 Domestic Return Receipt 102595-02-M-1540

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: JR 4/26/10
	Permit # 127-2008	C:
	Project #	

Denotes location of well on topo map.

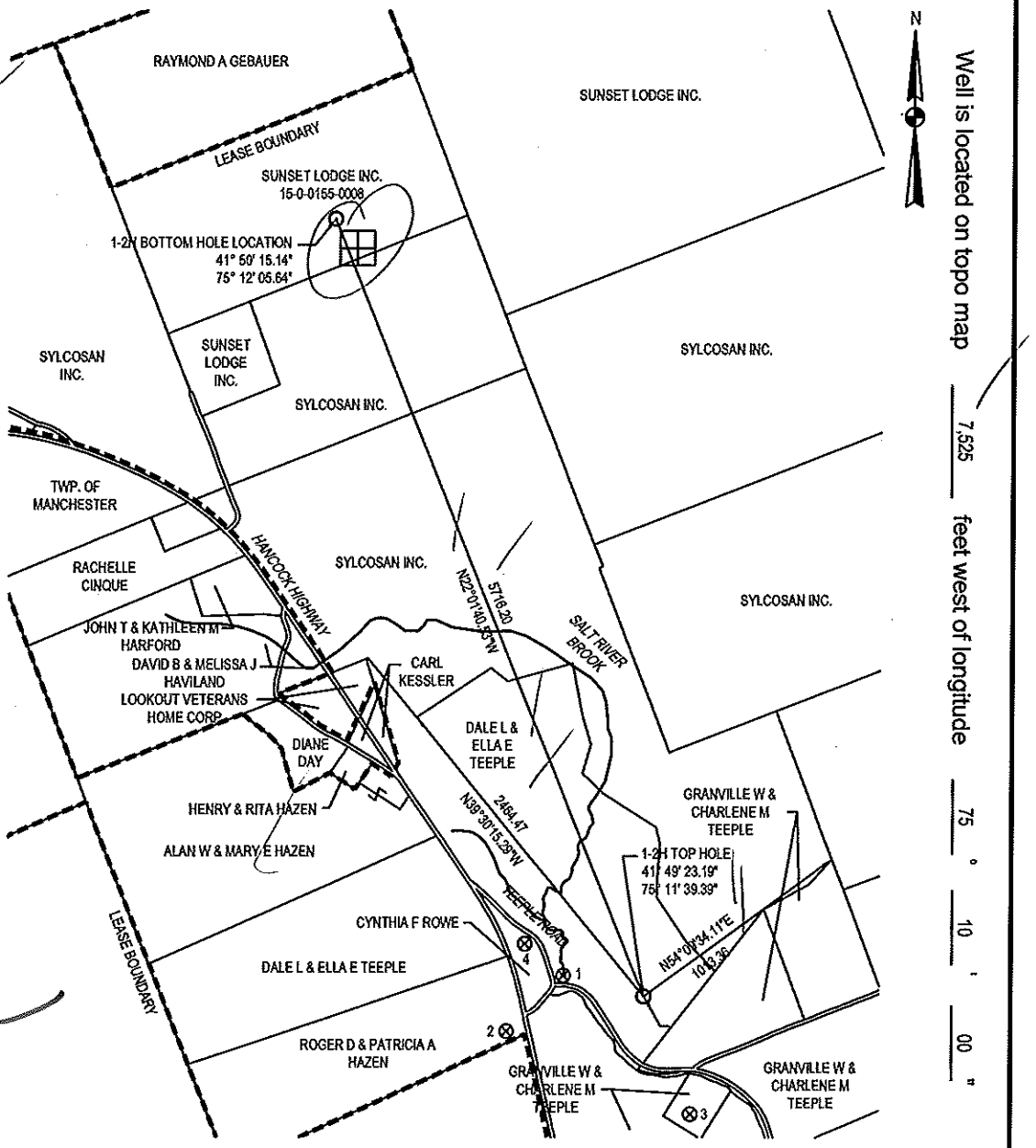
Well is located on topo map 3,725 feet south of latitude 41 ° 50 ' 00 "

True Latitude: NORTH
41 ° 49 ' 23.19 "

True Longitude: WEST
75 ° 11 ' 39.39 "

WELL NORTHING - Y
613,811.1

WELL EASTING - X
2,665,002.7



RECEIVED
APR 13 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
037263-E

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1-2H | Date: 4/7/2010 | Scale: 1"= 1200' | Tract Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83
Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83 Survey Date Jan. 2010

Applicant / Well Operator Name: Newfield Appalachia PA LLC
Well(Farm) Name: D.L. Teeple | Well #: 1-2H | Serial #:

Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060
County - Code: Wayne | Municipality: Manchester | Well Type: Gas

Surface Landowner / Lessor: Dale and Ella Teeple
USGS 7½ Quadrangle Map Name: Long Eddy, NY | Map Section: 5 | Surface Elevation: 1438 ft.

Target Formation(s): Marcellus Shale
Angle & Course of Deviation (Drilling): N22D 01' 40.53"W 5,716.20'
Anticipated Total Depth: TVD 8,140 ft. TMD 13,548.80 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Dale L. and Ella E. Teeple	N75D 34' 24.47"W 568'	N/A	N/A
Roger D. and Patricia A. Hazen	S75d 45' 16.93"W 967'	N/A	N/A
Granville W. and Charlene M. Teeple	S21d 53' 56.41"E 864'	N/A	N/A
Cynthia F. Rowe	N66d 11' 03.82"W 887'	N/A	N/A

WATERSHED SALT RIVER BROOK

Newfield

HALLIBURTON
Sperry Drilling Services

Project: Wayne County, PA (NAD83)
Site: D.L. Teeple
Well: 1-2H
Wellbore: Wellbore #1
Design: Plan #3
Rig: TBD

Surface Location:

US State Plane 1983
Pennsylvania Northern Zone
Elevation: WELL @ 0.00ft (TBD)

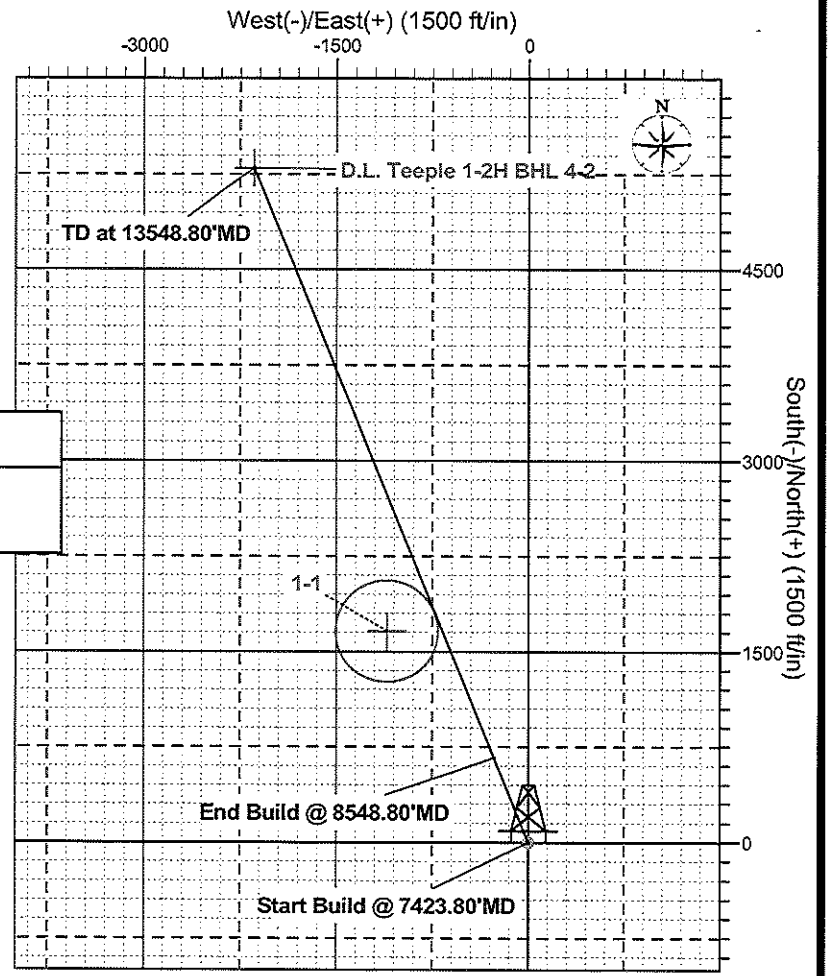
Northing	Easting	Latittude	Longitude
613811.10	2665002.70	41° 49' 23.189 N	75° 11' 39.393 W

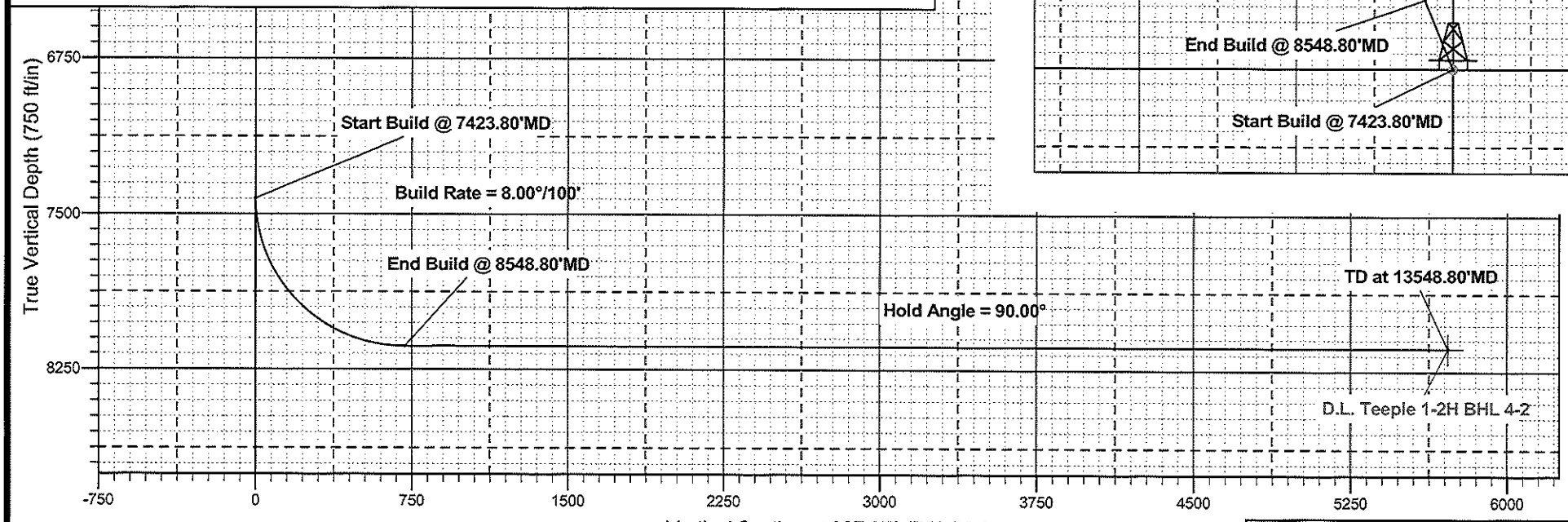
WELLBORE TARGET DETAILS (MAP CO-ORDINATES)

Name	TVD	+N/-S	+E/-W	Northing	Easting	Shape
D.L. Teeple 1-2H BHL 4-2	8140.00	5298.92	-2143.91	619110.02	2662858.79	Point

SECTION DETAILS

MD	Inc	Azi	TVD	+N/-S	+E/-W	DLeg	TFace	VSec	Annotation
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7423.80	0.00	0.00	7423.80	0.00	0.00	0.00	0.00	0.00	Start Build
8548.80	90.00	337.97	8140.00	663.92	-268.62	8.00	337.97	716.20	End Build
13548.80	90.00	337.97	8140.00	5298.92	-2143.91	0.00	0.00	5716.20	TD





Created By: Bianca LaCombeDate: 10:46, April 02 2010

4-7-2010

5500-PM-OG0002 Rev. 9/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL LOCATION PLAT

(Attachment, if needed)

DEP USE ONLY	Auth ID #: 127-20018

Use only if you need additional space for listings.

Applicant / Well Operator Name	DEP ID#	Well (Farm) Name	Well #	Serial #
Newfield Appalachia PA LLC	277879	D.L. Teeple	1-2H	

Surface Owner or Water Purveyor with a Water Supply within 1000 feet	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased or Operated
Cynthia F Rowe	N 66d 11' 3.82" W 866 '	N/A	N/A

DRBC Engagement in Natural Gas Exploration and Development

William J. Muszynski, P.E., Manager
Water Resources Management Branch
Delaware River Basin Commission

Marcellus Shale Meeting
Media, PA
January 19, 2010

Delaware River Basin Commission

Delaware River Basin Commission

- Founded in 1961
- Five Members:
  - Delaware
  - New Jersey
  - Pennsylvania
  - New York State
  - Federal Government

May 19, 2009 Executive Director Determination Natural Gas Well Activates Within the Drainage Area of SPW

- **Shale formations within the drainage area of SPW**
- **Natural gas well activities (NGWA) covered regardless of DRBC thresholds in RPP and Water Code (WC)**
- **RPP Section 2.3.5.B.6. Water Code Section 3.40**
- **NGWA may not commence without obtaining DRBC approval**

DRBC Role in Natural Gas Activities

1. **Water Withdrawal**
2. **Well Site Activities**
3. **Wastewater Storage, Treatment and Disposal.**

Natural Gas Well Wastewater

Wastewater Generated During Development of the Natural Gas Well

- Domestic Wastewater
- Non-domestic Wastewater

Domestic Wastewater

Typical sanitary wastewater generally from on-site septic tanks/portable toilets. Likely to be treated at domestic wastewater treatment plants located near natural gas well sites.

Non-Domestic Wastewater

1. Brine generated during well construction.
2. Drilling fluids
3. Flowback from Well Stimulation
   - Vast majority of wastewater generated.
   - 18% to 30% of stimulation fluids used are expected to return as flowback (estimated 2-3 million gallons per well)
   - Flowback contains water, sand, and chemicals used in stimulation process and absorbed from geologic formation.

Non-Domestic Wastewater Characteristics

Characteristics will vary with well site and geologic formation stimulated.

Total Dissolved Solids (TDS) - may potentially contain 2-300,000 mg/l TDS.

Concentrations of metals, chlorides, and organic chemicals.

Levels of radioactivity contributed by the target geologic formation.

DRBC Regulates at the Well Site

Monitoring and characterization of wastewater generated at site.

Storage, tracking, and transportation of wastewater generated.

Disposal of Wastewater

Wastewater Sources and Treatment and Disposal Sites

Sources of non-domestic wastewater and wastewater treatment and disposal can be:

- Inside of the Delaware River Basin (DRB)
  Only at DRBC/state approved sites.

- Outside of the DRB only at state approved Sites

In-Basin Non-Domestic Wastewater Treatment Facilities

Currently, there are no DRBC approved non-domestic wastewater treatment facilities.

Only one application in house for approval (DELCORA)

Wastewater treatment facilities must receive DRBC/state approval.

Facility must demonstrate compliance with the more stringent of state or DRBC effluent standards or water quality standards (WQS)

Effluent requirements are set for all domestic or industrial wastewater facilities-technology based

WQS

- Basin wide standards
- In-stream specific standards to protect designated use

Critical Demonstration and Effluent Requirements

1. Total Dissolved Solids (TDS)
2. Acute/Chronic Toxicity (in estuary waters)

Demonstration shall be performed for specific discharge location

TDS *Basin-Wide Standard*

Demonstration that discharge will not exceed 133% of background in stream to receive discharge.

OR

Effluent shall not exceed 1,000 mg/l.

Stream specific – Standards may be more restrictive

Estuary Toxicity Standards

Aquatic Health

Human Health

Location Specific

Radioactivity Standards

Stream Specific WQS for Radioactivity

e.g. Zone 4 – Max. 3 pCi/l alpha emitters

1,000 pCi/l beta emitters

DRBC Review/Decision Process

Receipt of Application for Project

Notice to Interested Parties (IP's)

Development and Review of Draft Docket or Recommendation to DRBC Commissioners

Public Notice

- **Generally 10-days prior to Commission hearing of docket**
- **Includes notice to IP's**

Commission Public Hearing

Appeal Provisions

Check in with the Commission early in the process:

Water Resources Management Branch
Project Review Section
Chad Pindar
David Kovach
Eric Engle
609-883-9500 ext. 216

Regulations and applications are available on the Commission's website:

www.drbc.net

Thank you.

Delaware River Basin Commission

Delaware River Basin Commission

Vision Statement

CHARTING THE FUTURE

PREAMBLE

The Delaware River Basin Commission was formed in 1961 by the signatory parties to the Delaware River Basin Compact (Delaware, New Jersey, New York, Pennsylvania, and the United States) to share the responsibility of managing the water resources of the Basin. Since its formation, the Commission has provided leadership in restoring the Delaware River and protecting water quality, resolving interstate water disputes without costly litigation, allocating and conserving water, managing river flow, and providing numerous other services to the signatory parties. The success of the past serves as a promise for the future as the Commission and the region move into the 21st century. In implementing the Compact, we will be guided by our Vision, Mission and Core Values.

VISION OF THE DELAWARE RIVER BASIN COMMISSION

The Commission will be the leader in protecting, enhancing, and developing the water resources of the Delaware River Basin for present and future generations. In performing this leadership role, the Commission will serve as a policy-maker, regulator, planner, manager and mediator on behalf of the Signatories to the Delaware River Basin Compact and the citizens of the Basin.

MISSION

We will:

- **Provide comprehensive watershed management.**
- **Act as stewards of the Basin's water resources particularly with respect to:**
  - **Surface water quality, including both point and nonpoint sources of pollution;**
  - **Ground and surface water quantity, including water demands, water withdrawals, water allocations, water conservation, and protected areas;**
  - **Drought management; and**
  - **In-stream flow management**
- **Promote effective inter-agency coordination to prevent duplication of efforts.**
- **Seek increased public involvement.**

By:

- **Serving primarily basinwide and interstate interests; and national, statewide, regional, and local watershed interests as the need arises.**
- **Resolving interstate disputes through mediation.**
- **Regularly updating the Comprehensive Plan.**
- **Adopting and implementing policies to manage the Basin's water resources in an integrated, planned fashion.**
- **Integrating environmental and economic needs.**
- **Basing decisions on sound science.**
- **Providing meetings, conferences, seminars, and other opportunities for public education, information exchange, involvement, and resolution of issues.**

CORE VALUES

We believe in:

- **Serving the public.**
- **Treating everyone with fairness and respect.**
- **Acting in an open, honest and professional manner.**
- **Listening and responding to our constituents.**
- **Encouraging innovative, creative solutions to water management problems.**
- **Improving our expertise.**
- **Enjoying and respecting the magnificent resource that is the watershed of the Delaware River.**

Hydrologic Info | News Releases | Next DRBC Meeting | Other Meetings | Publications | Basin Facts | Contact Info | Your Comments Welcomed

Commission Member Links: Delaware | New Jersey | Pennsylvania | New York | United States |

DRBC Home Page

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Voice (609) 883-9500 FAX (609) 883-9522
clarke.rupert@drbc.state.nj.us

Recommendations for Pennsylvania's Proposed Changes to Oil and Gas Well Construction Regulations

Report to:

Earthjustice and Sierra Club

Prepared by:

HARVEY CONSULTING, LLC.

Oil & Gas, Environmental, Regulatory Compliance, and Training

March 1, 2010

Email: sharvey@mtaonline.net
Phone: (907) 694-7994
Fax: (907) 694-7995
PO Box 771026
Eagle River, Alaska 99577

Contents

1. Introduction

This analysis responds to a request by Earthjustice and Sierra Club for a review of proposed revisions to the Pennsylvania's regulations governing construction of oil and gas wells [25 Pa.Cod Ch. 78 (Chapter 78)]. The purpose of this review is to examine whether the revisions proposed by the Pennsylvania Department of Environmental Protection (DEP or the Department) are: best practice, protective of human health and the environment, and consistent with DEP's stated goals of: (1) minimizing public concerns associated with gas migration into public drinking water supplies; (2) updating material specifications and performance testing requirements; and (3) revising design, construction, operations, monitoring, plugging, water supply replacement, and gas migration reporting requirements.

Analysis Approach

This analysis examined DEP's proposed changes to Chapter 78 and makes recommendations on whether those proposed changes are best practice and protective of human health and the environment. Additionally, this analysis examined sections of Chapter 78 that DEP did not propose to amend in order to identify further changes that would serve to achieve DEP's stated goals.

Recommendations made in this report are based on 23 years of experience as a Petroleum and Environmental Engineer and are highlighted in blue text boxes.

2. Subchapter A, General Provisions, Definitions § 78.1

Casing Seat. DEP has revised the definition to read:

> *"The depth to which the surface casing or coal protection casing or intermediate casing is set. In wells without surface casing, the casing seat shall be equal to the depth of casing which is typical for properly constructed wells in the area."*

The second sentence in this definition is not consistent with standard industry practice for construction of an oil and gas well. Surface casing, and in some cases an additional string of intermediate casing is used to protect ground water aquifers, provide the structure to support blowout prevention equipment, and provide a conduit for drilling fluids when drilling the subsequent section of the well. The second sentence of this definition should be deleted, or DEP should explain how an oil and gas well could be drilled safely, and protect ground water resources, without surface casing.

Recommendation No. 1: Delete the second sentence of the proposed casing seat definition.

Surface Casing. DEP has revised the definition to read:

> *"Casing used to isolate the wellbore from fresh groundwater and to prevent the escape or migration of gas, oil and other fluids from the wellbore into fresh groundwater. The surface casing is also commonly referred to as the water string or water casing."*

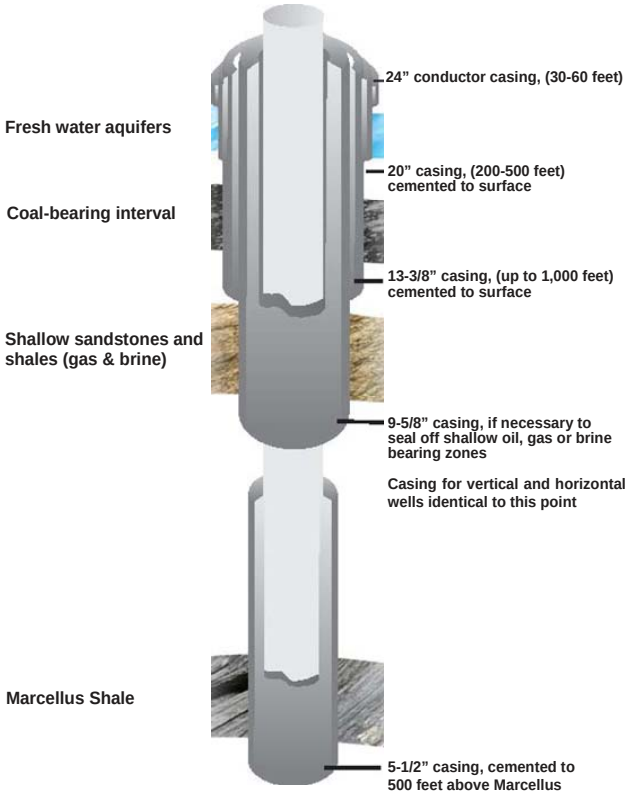
In addition to protecting ground water, surface casing also provides the very important structural support required to install blowout prevention equipment and provides a conduit for drilling fluids when drilling the subsequent section of the well.

Recommendation No. 2: The surface casing definition should clarify that the surface casing also provides the structural support required to install blowout prevention equipment and provides a conduit for drilling fluids when drilling the subsequent section of the well.

Intermediate Casing. DEP has added a new definition that reads:

> *"A string of casing other than production casing that is used in the wellbore to isolate, stabilize or provide well control to a greater depth than that provided by the surface casing or coal protection casing."*

Generalized casing design for a Marcellus Shale gas well to protect the environment



Intermediate casing does play an important role in the structural stability of the wellbore, but it also provides a very important additional protective barrier of pipe and cement across shallow freshwater aquifer zones. In other words, it provides a second protective barrier, in addition to the surface casing and cement, when a well passes through a fresh water aquifer.

Intermediate casing may be set to provide a transition from the surface casing to the production casing for protection of oil, gas, and freshwater zones, and to seal off anomalous pressure zones, lost circulation zones, and other drilling hazards. A drilling engineer may need to set hundreds or thousands of feet of intermediate casing to: isolate unstable hole sections (to prevent collapse); isolate high or low pressure zones; isolate geologic "thief" zones prone to robbing mud from the well bore (lost circulation); put gas or saltwater zones behind pipe before drilling into the production zone; or provide additional wellbore structure. Intermediate casing is typically set prior to drilling through the hydrocarbon-bearing zone, and may be cemented behind the entire casing string from the top of the well to the bottom of the casing shoe if the intermediate casing depth is shallow enough.

Recommendation No. 3: The intermediate casing definition should clarify that intermediate casing also provides a very important additional protective barrier of pipe and cement across shallow freshwater aquifer zones, and provides a transition from the surface casing to the production casing for protection of oil, gas, and freshwater zones, and to seal off anomalous pressure zones, lost circulation zones, and other drilling hazards.

Casing Use Requirement. DEP's regulations at Chapter 78, and definitions at § 78.1, provide latitude in the amount and type of surface casing that can be run. Yet, industry trade groups operating in Pennsylvania recognize the importance of running both surface casing and intermediate casing in areas where freshwater resource protection is of critical importance, to provide a sound structural barrier that contains stimulation fluids when conducting large slickwater fracture treatments (e.g. Marcellus Shale).

For example, a typical wellbore diagram[1] of the casing program recommended by the oil and gas industry and industry trade groups operating in the Marcellus Shale in Pennsylvania[2] is shown on the previous page. Industry recommends three sets of casing (conductor, surface, and intermediate), all cemented to the surface, which puts freshwater behind three layers of casing and cement. Industry also recommends a fourth layer of production casing.

Recommendation No. 4: Consistent with the recommendations of industry trade groups operating in Pennsylvania, DEP regulations should require the use of ***surface*** casing ***and intermediate*** casing in areas where freshwater resource protection is of critical importance. Casing and cement barriers also provide a sound structural barrier that contains stimulation fluids when conducting large slickwater fracture treatments.

Cement. DEP's current definition for cement reads:

> *"A mixture of materials for bonding or sealing that attains a 7-day maximum permeability of 0.01 millidaricies and a 24-hour compressive strength of at least 500 psi in accordance with applicable API standards and specifications."*

DEP's definition for cement sets a 24-hour compressive strength standard of at least 500 psi; however, other states, such as Texas, have found that standard insufficient to prevent vertical migration of fluids or gas behind pipe. Texas requires operators to have knowledge of the location and extent of all usable-quality water zones, and requires a higher cement quality to protect these zones. For example, Texas requires an **additional** 72-hour compressive strength standard of at least 1,200 psi across critical zones of cement. For example, Texas regulations define the critical zone as "all usable-quality water zones," and define the "critical zone of cement" as the bottom 20% of the casing string (at least 300', but no more than 1000').[3] This places a section of high strength cement at the bottom of the casing seat where the highest pressures and stresses are likely to be encountered.

Additionally, Texas requires the API free water separation to average no more than six milliliters per 250 milliliters of cement, tested in accordance with the current API RP 10B. The Texas commission[4] overseeing oil and gas development may require a better quality of cement mixture to be used in any well or any area if evidence of local conditions (which must be provided by the permit applicant) indicates a better quality of cement is necessary to prevent pollution or to provide safer conditions in the well or area.

[1] http://www.pamarcellus.com/images/pdfs/casing_graphic-with_copy.pdf.
[2] http://www.pamarcellus.com/about.php. "Founded in 2008, the Marcellus Shale Committee is an organization committed to the responsible development of natural gas from the Marcellus Shale geological formation in Pennsylvania and the enhancement of the Commonwealth's economy that can be realized by this clean-burning energy source. The members of the committee bring the strength of the Pennsylvania Oil and Gas Association and the Independent Oil and Gas Association of Pennsylvania together to address concerns with regulators, government officials and the people of the Commonwealth about all aspects of drilling and extracting natural gas from the Marcellus Shale formation."
[3] 16 TAC Part 1.
[4] Texas Railroad Commission

Texas cement quality standards read:

> *"Surface casing strings must be allowed to stand under pressure until the cement has reached a compressive strength of at least 500 psi in the zone of critical cement before drilling plug or initiating a test. The cement mixture in the zone of critical cement shall have a 72-hour compressive strength of at least 1,200 psi. … In addition to the minimum compressive strength of the cement, the API free water separation shall average no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B. The commission may require a better quality of cement mixture to be used in any well or any area if evidence of local conditions indicates a better quality of cement is necessary to prevent pollution or to provide safer conditions in the well or area.*[5]
>
> *"Compressive strength tests. Cement mixtures for which published performance data are not available must be tested by the operator or service company. Tests shall be made on representative samples of the basic mixture of cement and additives used, using distilled water or potable tap water for preparing the slurry. The tests must be conducted using the equipment and procedures adopted by the American Petroleum Institute, as published in the current API RP 10B. Test data showing competency of a proposed cement mixture to meet the above requirements must be furnished to the commission prior to the cementing operation. To determine that the minimum compressive strength has been obtained, operators shall use the typical performance data for the particular cement used in the well (containing all the additives, including any accelerators used in the slurry) at the following temperatures and at atmospheric pressure. (i) For the cement in the zone of critical cement, the test temperature shall be within 10 degrees Fahrenheit of the formation equilibrium temperature at the top of the zone of critical cement. (ii) For the filler cement, the test temperature shall be the temperature found 100 feet below the ground surface level, or 60 degrees Fahrenheit, whichever is greater.*[6]*"*

Recommendation No. 5: Revise the cement definition to include a 72-hour compressive strength standard of 1,200 psi for cement mixtures in the zone of critical cement. Also, require conformance with the API free water separation standard of no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B. Provide a provision for the Department to set more stringent local standards if needed for pollution prevention, and establish quantitative temperature limits for water used in cement mixing. The cement definition should clarify that it applies to cement used for surface, intermediate, and production casing.

Cement Ticket. DEP's has added a new definition that reads:

> *"Cement ticket – A written record that documents the procedures and specifications of the cementing operation and the chemical composition of the cement for each cemented casing string. The record shall include the amount and composition of the cement slurry, the amount of cement returned to the surface, if any, the amount and type of additives to the cement slurry mixture. Slurry properties must include weight, yield, density, water requirements, compressive strength, fluid loss. Cementing operation information shall include a description of the stages and sequence of events during the cementing operation, calculations employed, and wellbore and casing information such as casing diameter and depth and hole size and depth and pump time."*

[5] 16 TAC Part 1 §3.13(b)(2)(C)
[6] 16 TAC Part 1 §3.13(b)(2)(D)

DEP's recommendation to add a new definition for cement ticket is useful. However, it is recommended that the definition be expanded to include the recommendations listed below.

Recommendation No. 6: Expand the cement ticket definition to include: (a) a requirement for the operator to test the mixing water pH and temperature and note it on the cement ticket (this is standard industry practice and aids in determining cement quality); (b) a record of the Waiting on Cement [WOC] time, which is the time required to achieve the calculated compressive strength standard before the casing is disturbed in any way [described in the cement definition comments above]; and (c) a certification statement that requires the operator to certify, under penalty of law, that the cement job was completed in compliance with Pennsylvania regulatory requirements.

3. Subchapter C, Environmental Protection, Performance Standards, Protection of Water Supplies, § 78.51

DEP has proposed a number of important revisions to the regulations at § 78.51 to clarify what constitutes an adequately restored or replacement water supply. However, DEP did not recommend any revisions to the portion of § 78.51(c) that sets a timeframe for acting upon a complaint filed by a landowner, water purveyor, or affected person suffering pollution or diminution of a water supply as a result of drilling, altering, or operating an oil or gas well. DEP's regulations at § 78.51(c) currently allow a delay of up to 10 calendar days before an investigation must be completed.

If a violation of DEP standards is suspected, and that violation results in pollution or diminution of a water supply, or has the potential to threaten a water supply, immediate investigation by DEP is essential, not merely response within a 10-day time period. It is recommended that this regulation be revised to require an immediate investigation to commence within 24 hours of notification, and that if DEP's investigation team finds evidence to support the complaint, the noncompliant activity should be immediately shut down. Additionally, all potentially affected users of the water supply should be immediately notified and provided alternative water supplies until the DEP completes a final investigation and a final remedy is resolved with the non-compliant operator. Keep in mind that most wells take 14 - 30 days to drill, depending on depth; and depending on where the operator is within the drilling cycle when the problem begins, drilling rig operations could be completely packed up and moved off location before a DEP investigation team arrives on the site 10 days later. The same holds true for stimulation procedures such as fracture treatments that may take a few hours to a few days, depending on the number of stages and complexity.

It is unlikely that the operator or equipment will be on location, or any evidence can be examined or collected by an investigation team, 10 days after a report of a violation is made. Most importantly, if the agency is notified of a threat to a water supply, immediate action is necessary. A technical team should be sent out into the field without delay to examine the situation and determine whether action is needed to shut down operations. That same initial investigation team can collect the information, records, and evidence required to complete the formal written determination due in at least 45 days.

Recommendation No. 7: Revise § 78.51(c) to read: Within 24 hours of the receipt of the investigation request, the Department will send a technical team to the field site to examine the situation and determine whether immediate action is needed to shut down operations. The technical team will also collect the information, records, and evidence required to complete the investigation. If the technical team finds that there is any potential threat or impact to a water supply, the operator will be ordered to immediately cease operations, and the Department will immediately notify all potential affected users of the water supply and require the operator to provide alternative water supplies until the Department completes a final investigation and a final remedy is resolved with the non-compliant operator.

Within 45 days of receipt of the investigation request, the Department will issue a formal written determination. If the Department finds that pollution or diminution was caused by drilling, alteration, or operation activities, or if it presumes the well operator responsible for polluting the water supply of the landowner or water purveyor under section 208(c) of the act (58 P. S. § 601.208(c)), the Department will issue orders to the well operator necessary to assure compliance with this section.

DEP proposes to add a new requirement at § 78.51(i) that requires a well operator to notify DEP if a water supply contamination complaint has been received from a landowner, water purveyor, or affected person, within 10 calendar days. A 10-day notification period is too long. Notification should be made within 24 hours, followed by a written report via electronic communication or facsimile within a 24-hour period. This way the DEP is promptly notified and can send a technical team to the site to commence the investigation while the factors that may have contributed to the complaint are still present.

Recommendation No. 8: Revise the notification period in § 78.51(i) to 24 hours.

DEP proposes a new regulation § 78.51(e) that clarifies what constitutes an adequate restoration or replacement of a polluted water supply. This regulation is useful. However, the new language proposed for § 78.51(e)(2) appears to include redundant language, as well as language somewhat contradictory to the existing §78.51(d) regulation. It is recommended that these regulatory sections be combined and clarified.

The language proposed at § 78.51(e)(2) could allow an operator to construct a new, replacement water supply at a standard less than the Pennsylvania Safe Drinking Water Act if it were replacing a water source that originally did not meet the Pennsylvania Safe Drinking Water Act. All newly constructed water sources, especially those constructed to remedy a compliance violation, should meet the minimum water quality standards of the Pennsylvania Safe Drinking Water Act.

Recommendation No. 9: Revise § 78.51(e)(2) and § 78.51(d) to meet this stated intent: All ***restored*** water supplies must be at least equal to the quality of the water supply before it was affected by the operator. If the quality of the water supply, before it was affected by the operator, cannot be affirmatively established, the operator shall demonstrate that the concentrations of substances in the restored water supply meet the Pennsylvania Safe Drinking Water Act standards. Any new, ***replacement*** water supply must meet the Pennsylvania Safe Drinking Water Act standards.

4. Subchapter C, Environmental Protection, Performance Standards, Predrilling or Prealteration Survey, § 78.52

DEP regulations allow an operator to obtain water supply samples prior to drilling. The purpose of this "baseline" water quality assessment is to establish whether pollution already exists. The right to conduct the sampling is described in § 78.52(a). DEP's sampling instructions are found at § 78.52(c):

> *"(c) The survey shall be conducted by an independent certified laboratory. A person independent of the well owner or well operator, other than an employee of the certified laboratory, may collect the sample and document the condition of the water supply, if the certified laboratory affirms that the sampling and documentation is performed in accordance with the laboratory's approved sample collection, preservation and handling procedure and chain of custody."*

The sampling instructions at § 78.52(c) do not specify what type of tests must be completed, when the testing must be completed, or what testing procedures must be followed. A standard suite of water quality tests and procedures should be specified and required by DEP. Baseline testing should be completed over a full hydrologic cycle (multiple samples). Additionally, in areas where industrial activity has already occurred; testing should include examination of chemicals used by the oil and gas industry. See additional recommendations on this topic at § 78.122(b)(6).

DEP's reporting instructions are found at § 78.52(e):

> *" (e) The report describing the results of the survey must contain the following information:*
> *(1) The location of the water supply and the name of the surface landowner or water purveyor.*
> *(2) The date of the survey, and the name of the certified laboratory and the person who conducted the survey.*
> *(3) A description of where and how the sample was collected.*
> *(4) A description of the type and age, if known, of the water supply, and treatment, if any.*
> *(5) The name of the well operator, name and number of well to be drilled and permit number if known.*
> *(6) The results of the laboratory analysis."*

The reporting instructions at § 78.52(e)(6) are very generic. DEP only requests the "results of the laboratory analysis" to be provided with no clear instructions on what tests must be reported, at a minimum, or what test methods must be followed, along with evidence that quality control and quality assurance procedures were followed.

The report should include a summary, in layman's terms, verifying whether any contamination was found. If contamination was found, the report should clearly describe the amount of contamination found and by what factor it exceeds Pennsylvania's Safe Drinking Water Act.

This report should be made available to the public, and should be provided to all agencies responsible for ground water protection (e.g. county boards, commissions).

Additionally, DEP should require annual water quality testing (at a minimum) to verify the water supply condition while drilling, completion and production operations continue.

Recommendation No. 10: Revise the sampling instructions at § 78.52(c) to specify the type of tests and testing procedures that must be followed, and when samples must be obtained. A minimum standard suite of water quality tests and procedures should be required. Baseline testing should be completed over a full hydrologic cycle (multiple samples). In areas where industrial activity has already occurred, testing should include examination of chemicals used by the oil and gas industry. Revise the reporting instructions at § 78.52(e)(6) to ensure the report includes: test results; test methods; evidence that quality control and quality assurance procedures were followed; a summary, in layman's terms, verifying whether any contamination was found. If contamination was found, the report should clearly describe the amount of contamination found and by what factor it exceeds Pennsylvania's Safe Drinking Water Act. Require the test reports to be made available to the public, and to be provided to all agencies responsible for ground water protection (e.g. county boards, commissions). Require annual water quality testing (at a minimum) to verify the water supply condition while drilling, completion and production operations continue.

5. Subchapter C, Environmental Protection, Performance Standards, Control and Disposal Plan, § 78.55

DEP did not propose any changes to § 78.55; however, it is recommended that a revision be made to require operators to submit their control and disposal plans to DEP for review and approval. Currently, the plans are prepared by the operator, but there is no agency review for compliance with Pennsylvania Environmental Protection Standards.

Recommendation No. 11: Revise § 78.55 to require well operators to submit a copy of their control and disposal plan for DEP review and approval prior to commencing operations to ensure compliance with Pennsylvania Environmental Protection Standards.

6. Subchapter D, Well Drilling, Operation and Plugging, Use of Safety Devices, Well Casing, § 78.71

DEP proposes to revise § 78.71 (a) to read:

> *"(a) The operator shall equip the well with one or more strings of casing of sufficient cemented length and strength to prevent blowouts, explosions, fires and casing failures during installation, completion and operation."*

DEP's stated goal of revising the well casing requirements to enhance ground water protection and to minimize public concerns associated with gas migration into public drinking water supplies is not reflected in the regulations at § 78.71(a).

Recommendation No. 12: Amend § 78.71(a) to clearly state that sufficient casing and cement must be installed in the well to prevent contamination of ground water resources, in addition to the other purposes already listed.

7. Subchapter D, Well Drilling, Operation and Plugging, Use of Safety Devices, Blowout Equipment, § 78.72

A Blowout Preventer (BOP) cannot be installed until surface casing is set and cemented; therefore a gas flow diverter system should be installed to provide for personnel and public safety during the initial stages of well drilling and setting surface casing. Once surface casing is set, a BOP can be installed to control the well as it is drilled deeper into higher pressure zones. The proposed DEP regulations do not set standards for diverter systems, except later, at § 78.73, which states that excess gas encountered during drilling should be diverted away from the drilling rig in a manner that does not create a hazard to public health or safety. Yet, DEP provides no criteria or standards for what constitutes an acceptable design for a drilling diverter system. Shallow gas hazards are well known in the oil and gas industry to be the root cause of many well blowouts and explosions. Many of these situations could have been prevented by a more rigorous diverter system design. It is recommended that DEP improve the safety device regulations at § 78.72 to include diverter system specifications.

Recommendation No. 13: It is recommended that DEP improve the safety device regulations at § 78.72 to add the following diverter system specifications.

A diverter system should be at least as large as the diameter of the hole that will be drilled, and the system should include a remotely operated annular pack-off device, a full-opening vent line valve, and a diverter vent line with a diameter appropriately sized for geological conditions, rig layout, and surface facility constraints.

The diverter vent line outlet should be located below the annular pack-off device, either as an integral part of the annular pack-off device or as a vent-line outlet spool immediately below it. The actuating mechanism for the vent line valve should be integrated with the actuating mechanism for the annular pack-off device in a fail-safe manner so that the vent line valve automatically opens before full closure of the annular pack-off device. The diverter system vent line should extend at least 100 feet away from any potential sources of ignition and the drilling rig substructure, and should be secured. The diverter system area should be well marked as a "warning zone" at the vent line tip, prohibiting ignition sources, equipment, or personnel in this area.

DEP has revised the applicability standard of § 78.72 to specify the types of wells that are required to install a BOP when drilling. The proposed applicability standard includes four criteria:

1. Marcellus Shale gas wells;
2. wells where an operator anticipates pressures or flows that may result in a blowout;
3. wells drilled in areas where there is no previous pressure data; and
4. wells regulated by the Oil and Gas Conservation Law.

Criteria #1 & #3 are clear. BOPs are required on all Marcellus Shale gas wells and all wells drilled in areas where there is no previous pressure data.

Criterion #2 provides the operator with broad discretion to determine whether wellhead pressures or natural open flows that may occur during drilling operations could pose a threat of blowout. There are no safety or hazard criteria established to guide the operator as to when a BOP is required.

Criterion #4 is clear in that it requires BOPs on all wells regulated by the Oil and Gas Conservation Law, but that law excludes wells that do not penetrate the Onondaga horizon. The law also excludes wells that

do not exceed a depth of 3,800 feet beneath the surface, including wells located in areas where the Onondaga horizon is nearer to the surface than 3,800 feet. Therefore, it is not clear if Criterion #4 conflicts with Criteria #1, #2 or #3.

Industry standard practice is to design, size, and install a BOP to handle wellhead pressures expected to be encountered while drilling (with a sufficient safety factor). Operators that propose to drill wells without BOPs should provide a technical and safety justification to DEP as part of their permit to drill application. This justification should be reviewed and approved by the Department. A BOP should be required on all wells, and BOP waivers should be the exception rather than the rule.

Blowouts are very serious human health, work safety, and environmental situations. Blowouts may result in human injury, fire, explosion, oil spills, gas venting, equipment damage, etc.

Recommendation No. 14: Revise § 78.72 to require all wells to be drilled with a BOP once surface casing is installed and cemented. Allow exceptions to that rule only if the operator submits a sufficient technical and safety justification to warrant drilling without a BOP.

The operator should be required to submit a copy of its blowout preventer (BOP), diverter, and related equipment plans, along with its proposed casing and cementing design plan, to DEP for review and approval, as part of permit to drill applications.

DEP regulations at § 78.72 do not specify the type of BOPs required. Typically for rotary drilling operations with a maximum potential surface pressure of 3,000 psi or less, the BOP must have at least three preventers, including: one equipped with pipe rams that fit the size of the drill pipe, tubing, or casing that is being used; one with blind rams; and one annular type. In rotary drilling rig operations with a maximum potential surface pressure of 3,000 psi or greater, the BOP typically has at least four preventers, including: two equipped with pipe rams that fit the size of the drill pipe, tubing, or casing that is being used; one with blind rams; and one annular type.

Regulations typically specify that the rated working pressure of the BOP and other well control equipment must exceed the maximum potential surface pressure to which it may be subjected. Interestingly, existing DEP regulations at § 78.72 (c) require operators to select the appropriate pressure rating for all pipe fittings, valves, and other connections to the BOPS, but DEP's regulations do not specify that the BOPs themselves must be capable of withstanding the maximum potential surface pressure to which it may be subjected. BOPs come in various sizes and pressure ratings. Larger, higher-pressure rated BOPs are more expensive to purchase and operate; therefore, it is important that this point be specified in regulation.

Recommendation No. 15: Revise § 78.72 to provide specific BOP type and pressure rating criteria.

DEP proposes a new requirement at § 78.72 (c) that reads:

> *"(c) The controls for the blow-out preventer shall be accessible to allow actuation of the equipment in the event of an emergency. Controls for a blow-out preventer with a pressure rating of greater than 3,000 psi should be located a safe distance from the drilling rig."*

This regulation requires BOP controls to be accessible during an emergency; this is logical. However, the second sentence of the proposed regulation, which instructs the operator to place the BOP controls at a

safe distance away from the drilling rig, does not instruct the operator to have BOP controls on the rig itself. BOP controls need to be accessible **both** on the rig and at a location a safe distance away from the drilling rig.

> **Recommendation No. 16**: DEP regulations at § 78.72(c) should be revised to clarify that BOP controls are also needed on the rig.

DEP regulations at § 78.72(d) and (e) require BOPs to be tested; however, the regulations do not specify that a "pass" rate is required to continue drilling operations, although this is surely DEP's intent. It would be useful to clarify that drilling operations must cease if a BOP fails a test. The BOP must be repaired or replaced, and successfully retested, prior to resuming drilling.

> **Recommendation No. 17**: DEP regulations at § 78.72(d) and (e) should be revised to clearly state that drilling operations must cease if a BOP fails a test. The BOP must be repaired or replaced, and successfully retested, prior to resuming drilling.

8. Subchapter D, Well Drilling, Operation and Plugging, General Provisions for Well Construction and Operation, § 78.73

DEP proposes a more stringent casing pressure limitation in the new regulations at § 78.73(c), by adding an additional safety factor, and by expanding that safety factor to include protection at the intermediate casing seat, in addition to the surface casing seat. Both changes are safety and environmental improvements. DEP proposes § 78.73(c) to read:

> *"(c) After a well has been completed, recompleted, reconditioned or altered the operator shall prevent shut-in pressure and producing back pressure at the surface casing seat, coal protective casing seat or intermediate casing seat when the intermediate casing is used in conjunction with the surface casing to isolate fresh groundwater from exceeding 80 percent (80%) of the hydrostatic pressure of the surrounding fresh groundwater system in accordance with the following formula. The maximum allowable shut-in pressure and producing back pressure to be exerted at the casing seat may not exceed the pressure calculated as follows: Maximum pressure = (0.8 x 0.433 psi/foot) multiplied by (casing length in feet)."*

The proposed regulation applies to wells **after** they have been "completed, recompleted, reconditioned or altered." While it is understandable that this requirement does not apply while drilling, casing, and cementing are underway, it is important to clarify that this requirement will be in place during any testing, stimulation, or other well operations.

Most drilling is completed using overbalanced drilling fluid systems of sufficient density to counteract any potential hydrostatic pressures in the wellbore; therefore, it would not be possible to adhere to the proposed pressure limits during these operations. However, once the drilling is "completed" and the casing is set and cemented in place, the pressure limitation should apply to all subsequent operations to protect ground water resources.

The term "completion" is often more broadly defined by industry to include casing, cementing, and well stimulation operations. The regulation should be clear that the pressure limitation will apply to testing and stimulation treatments, and other well operations, because high pressure is exerted on the casing seat during these operations.

Recommendation No. 18: DEP regulations at § 78.73 (c) should be revised to make it clear that the pressure limit will apply to all well activities after the casing is cemented in place.

DEP's revised regulation at § 78.73(d) requires the operator to take action to prevent the migration of gas and other fluids from lower formations into fresh groundwater in the event that the hydrostatic pressure exceeds the newly proposed 80% safety factor, described in § 78.73(c). Requiring the operator to take action in the event that the hydrostatic pressure was exceeded is a good step; yet, the proposed regulations do not provide any instruction on what course of action is required to remedy mechanical defects in the wellbore construction, nor does it require the operator to notify the DEP of the problem, report the resolution, or notify anyone who may be potentially affected (e.g. by groundwater impacts).

Recommendation No. 19: DEP regulations at § 78.73(c) should be revised to require the operator to notify DEP of any pressure exceedance within 24 hours, followed by a written plan of action to be submitted to DEP for review and approval. The regulations should also include a requirement for the operator to work with DEP to notify any potentially affected parties.

DEP proposes a new regulation at § 78.73(e) that requires operators to ensure that excess gas encountered during drilling, completion, or stimulation be flared, captured, or diverted away from the drilling rig in a manner that does not create a public health or safety hazard. The proposed regulation does not mandate or encourage operators to select the most environmentally preferable, lowest impact methods available. While flaring and venting have been commonly used in the oil and gas industry to deal with unwanted, potentially explosive vapors, both federal and state governments have taken steps over the past two decades to enact regulations that limit flaring and venting of natural gas.[7] Initially, the motive was to conserve hydrocarbon resources to maximize federal and state revenue and gas supply. More recently, focus on greenhouse gas (GHG) emission reduction has prompted additional innovation to further reduce flaring and venting. Reducing flaring and venting to the lowest level technically achievable is widely considered best practice.

Drilling & Completions: Flares may be used during well drilling, completion, and testing to safely combust hydrocarbon gases that cannot be collected because gas processing and pipeline systems have not yet been installed. If gas processing equipment and pipeline systems are in place, gas flaring can be avoided in all cases except equipment malfunction.

During the drilling and completion phase of the first well on a well pad, a gas pipeline may not be installed. Gas pipelines are typically not installed until it is confirmed that an economic gas supply is found. Therefore, gas from the first well is often flared or vented during drilling and completion activities because there is not a pipeline to route it to. However, subsequent wells drilled on that same pad would be in a position to implement Reduced Emission Completion (REC), also called "green completion," which involves routing gas to a pipeline. Green completions require equipment to be brought to the well site to process wet gas from the well (during well completion activities) to ensure the gas meets pipeline specifications.

Gas Production: High pressure gas buildup may require gas venting via a pressure release valve, or gas may need to be routed to a flare during an equipment malfunction. At natural gas facilities, continuous flaring or venting may be associated with the disposal of waste streams[8] and gaseous by-product streams[9]

[7] Global Gas Flaring Reduction Partnership (GGFR), Guidance on Upstream Flaring and Venting Policy and Regulation, Washington D.C., March 2009.
[8] For example, acid gas from the gas sweetening process and still-column overheads from glycol dehydrators.

that are uneconomical to conserve.[10] Venting or flaring may also occur during manual or instrumented depressurization events, compressor engine starts, equipment maintenance and inspection, pipeline tie-ins, pigging, sampling activities, and removal of hydrates from pipelines.[11]

Best practices for flaring and venting during gas production should limit flaring and venting to the smallest amount needed for safety. Gas should be collected for sale, used as fuel, or reinjected for pressure maintenance, unless it is proven to be technically and economically unfeasible.

DEP should adopt very clear regulations limiting flaring and venting during gas production operations. If gas collection, use, sale, or reinjection is not possible, DEP should require operators to flare gas as a preferred method over venting. Gas flaring is environmentally preferable over venting because flaring reduces hazardous air pollutants, volatile organic compound emissions, and GHG emissions.[12]

Several states (e.g. Alaska and California) require operators to keep accurate records of gas venting and flaring to ensure that the amount is limited to safety related needs. Some states and the federal government (in the Outer Continental Shelf) require operators to pay royalty and taxes on flared and vented gas not authorized for safety purposes. This encourages investment in gas collection and control devices to conserve natural gas.[13]

Best Practices for Flares: When flare use is necessary for safety, the following best practices should be instituted:

- Minimize the risk of flare pilot blowout by installing a reliable flare system;
- Ensure sufficient exit velocity or provide wind guards for low/intermittent velocity flare streams;
- Ensure use of a reliable ignition system;
- Minimize liquid carry over and entrainment in the gas flare stream by ensuring a suitable liquid separation system is in place; and
- Maximize combustion efficiency by proper control and optimization of flare fuel/air/steam flow rates.

Best Practices for Venting and Fugitive Emissions: Best Practices for controlling venting and fugitive emissions include:

- Leak Detection and Repair (LDAR) programs, including acoustic detectors and infrared technology to detect odorless and colorless leaks;
- Use of low bleed pneumatic instruments,[14] and use of instrument air, electric or solar powered control devices;
- Use of dry centrifugal compressor seals;
- Use of smart automation plunger lifts for liquid unloading;
- Early installation of pipelines; and
- REC methods for gas well completions.

[9] For example: instrument vent gas; stabilizer overheads; and process flash gas.
[10] The Global Gas Flaring Reduction partnership (GGFR) and the World Bank, Guidelines on Flare and Vent Measurement, September 2008.
[11] The Global Gas Flaring Reduction partnership (GGFR) and the World Bank, Guidelines on Flare and Vent Measurement, September 2008.
[12] Fugitive and Vented methane has 21 times the global warming potential as combusted methane gas. Methanetomarkets.org, epa.gov/gasstar.
[13] Global Gas Flaring Reduction Partnership (GGFR), Guidance on Upstream Flaring and Venting Policy and Regulation, Washington D.C., March 2009.
[14] Process controllers, chemical pumps, and glycol pumps often vent pressurized natural gas used for pneumatic actuation.

In most cases these best practices improve safety and collect marketable gas for sale. For example, green completions provide an immediate revenue stream by routing gas that would otherwise be vented to a sale line. Industry has demonstrated that green completions are both best environmental practice and profitable. Green completion equipment has a short economic payout. A green completion requires the operator to bring in gas processing equipment to the well pad to clean up wet gas, improving it to gas pipeline quality. Typically, portable gas dehydration units, gas-liquid-sand separator traps, and additional tanks are required.[15] Most companies report a one-to-two-year payout for investment in their own green completion equipment, and substantial profit thereafter, depending on the gas flow rate.[16] It is also possible for smaller operators to rent green completion equipment. A recent New York State study for the Marcellus Shale found that equipment payouts may be as short as three months, and more than $65 million in profits was made on a national level in 2005 by companies conducting green completions.[17] Natural Gas STAR also provided technical advice to New York State recommending green completions as a technically feasible economic method. The best practice of green completions should be codified in DEP regulation.

Recommendation No. 20: DEP should develop regulations to restrict flaring, venting, and fugitive emissions to the lowest level technically feasible, and require the use of Reduced Emission Completions ("green completions") whenever technically feasible.

DEP proposes a new requirement at § 78.73(f) that reads:

> *"(f) Casing which is attached to a blow-out preventer with a pressure rating of greater than 3,000 psi shall be pressure tested. A passing pressure test shall be holding 120 percent of the highest expected working pressure of the casing string being tested for 30 minutes with not more than a 10 percent change. Certification of the pressure test shall be confirmed by entry and signature of the person performing the test on the driller's log."*

This regulation requires casing to be pressure tested only when it is attached to a BOP of a pressure rating greater than 3,000 psi. Industry standard practice is to pressure test casing whenever a BOP is installed on casing, not just on BOPs with more than a 3,000 psi rating.

Typically the casing must be able to hold a surface pressure at least equal to 50% of the required working pressure of the BOP. Specifying a surface pressure of at least 50% of the working pressure of the BOP is an easily quantifiable, verifiable value.

Pressure testing the casing is a very important step in groundwater protection. A failed pressure test indicates an integrity problem that could potentially provide a conduit from the well to adjacent aquifers.

Recommendation No. 21: DEP regulations at § 78.73(f) should be revised to require pressure testing of all casing at a surface pressure of 50% of the required working pressure of the BOP.

[15] EPA, Green Completion, Partner Reported Opportunities (PROs) for Reducing Methane Emissions, Fact Sheet No. 703, 2004.
[16] Reduced Emissions Completions, Lessons Learned from Natural Gas STAR, Producers Technology Transfer Workshop, Casper Wyoming, August 30, 2005.
[17] DSGEIS, Appendix 25.

9. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Use of Conductor Pipe, § 78.82

DEP proposes to revise § 78.82 to read:

> *"If the operator installs conductor pipe in the well, the following provisions shall apply:*
> *(i) The operator may not remove the pipe.*
> *(ii) Conductor pipe shall be installed in a manner that prevents infiltration of surface water or fluids from the operation into groundwater.*
> *(iii) Conductor pipe shall be made of steel."*

The proposed changes are useful and provide additional instruction on conductor pipe, but should be expanded further. Regulations should provide specific instructions on how an operator should install conductor pipe to prevent infiltration of surface water or fluids from the operation into groundwater.

Most commonly the conductor casing is installed with a cement seal at the surface to prevent groundwater contamination. Cement is placed in the annulus (the space between the outside of the pipe and inside of the hole), to secure the pipe in the hole and ensure there is a continuous barrier. DEP should specify that conductor pipe be cemented from top to bottom and firmly affixed in a central location in the wellbore with a continuous, equally thick layer of cement around the pipe.

Alternatively, if surface geology allows, conductor casing can be driven by mechanical percussion methods into unconsolidated strata. In this case, there is no annulus, and the casing is not cemented. And in this case, a mechanical or cement seal needs to be installed at the surface to prevent the downward migration of surface pollutants.

DEP should also provide instruction on what type of drilling fluids should be used when excavating the conductor casing hole, because this section of the well is being drilled through freshwater resources. Drilling fluids should be limited to air, fresh water, or water-based mud, and exclude oil based muds or use of other chemical lubricants.

Recommendation No. 22: DEP regulations at § 78.82 should include specific instructions on how an operator should install conductor pipe to prevent infiltration of surface water or fluids from the operation into groundwater. DEP should specify that conductor pipe be cemented from top to bottom and firmly affixed in a central location in the wellbore with a continuous, equally thick layer of cement around the pipe. A mechanical or cement seal should be installed at the surface to prevent the downward migration of surface pollutants. Drilling fluids should be limited to air, fresh water, or water-based mud, and exclude oil based muds or use of other chemical lubricants.

10. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Surface and Coal Protective Casing and Cementing Procedures, § 78.83

DEP has proposed a number of important changes to the regulations at § 78.83. Revisions to this section of the regulations are most critical to DEP's stated goal of minimizing public concerns associated with gas migration into public drinking water supplies.

DEP proposes to revise § 78.83 to read:

> *" (a) For wells drilled, altered, reconditioned or recompleted after [effective date], surface casing or any casing functioning as a water protection casing shall not be utilized as production casing except if one of the following applies:*
>
> *(1) In oil wells where the operator does not produce any gas generated by the well and the annulus between the surface casing and the production pipe is left open.*
>
> *(2) The operator demonstrates that the pressure in the wellbore at the casing seat is no greater than the pressure permitted by § 78.73(c) and demonstrates that all gas and fluids will be contained within the well."*

The proposed rule at § 78.83(a) starts off clear and robust. Clearly stated, casing functioning as a water protection casing shall not be utilized as production casing. This approach is logical, and important to groundwater resource protection. Water protection casing should be an ***additional*** string of piping, cemented from top to bottom and firmly affixed in a central location in the wellbore with a continuous, equally thick layer of cement around the pipe. By contrast with the clear initial prohibition, however, the two proposed exceptions to this rule at § 78.83(a)(1)-(2) do not make sense, and serve to compromise the protective barrier that surface casing is intended to create.

As drafted, § 78.83(a)(1) proposes to allow the surface casing to serve as production casing in an oil well where no gas is generated by the well and the annulus between the surface casing and the "production pipe" is left open. The term "production pipe" is not defined in DEP regulation at § 78.1, and it is not clear what piping string DEP is referencing. Is this DEP's term for production tubing? This proposed exemption is not clear or technically supported.

As drafted, § 78.83(a)(2) proposes to allow the surface casing to serve as production casing in all wells if an operator demonstrates that the casing seat pressure does not exceed § 78.73(c) (which the operator is required to do anyway so this is not an incremental requirement) and if the operator demonstrates that all gas and fluids will be contained within the well. Yet DEP sets no criteria or approval process for making this showing. The proposed exemption at § 78.83(a)(2) defeats the purpose of requiring § 78.83(a).

Recommendation No. 23: DEP regulations at § 78.83(a) should be revised to read: Surface casing or any casing functioning as a water protection casing shall not be utilized as production casing.

Exemptions proposed at § 78.83(a)(1)-(2) should be deleted or further technical justification should be provided by DEP to explain why these proposed requirements are more protective of human health and the environment.

DEP's proposed regulations at § 78.83(c) require an operator to set surface casing 50' below the deepest fresh ground water or into consolidated rock, whichever is deeper. The technical basis for selecting a 50' depth is not explained.

New York State has instituted more restrictive Fresh Water Aquifer Supplementary Permit Conditions on permits to drill for wells that pass through primary and principal aquifers, including setting surface casing at least 100' below the deepest fresh water zone and at least 100' into bedrock. Similar to DEP's proposal later at § 78.83(f), NYS allows for this setting depth to be adjusted to ensure the casing seat is set above

any hydrocarbon interval. DEP should provide a technical basis to show how the 50' depth criteria is sufficient to protect water resources, or DEP should increase it to the more protective standard of 100'.

Recommendation No. 24: DEP regulations at § 78.83(c) should be revised to increase the surface casing setting depth to 100' below the deepest fresh water zone and at least 100' into bedrock. Correspondingly, DEP's proposed regulation at § 78.83(f) needs to be adjusted to increase the 50' criterion to 100'.

DEP's proposed regulations at § 78.83(f) reads:

> *"The operator shall permanently cement the surface casing by placing the cement in the casing and displacing it into the annular space between the wall of the hole and the outside of the casing."*

This language does not clearly require a continuous, equally thick layer of cement around the pipe. Nor does this language clarify that cement must be placed behind the casing from the bottom of the casing (casing seat) to the surface.

The most common methods of placing cement behind surface casing are the pump and plug or displacement methods that use sufficient cement to ensure a protective cement bond is achieved from the bottom of the casing to the top of the hole. To ensure that a continuous, equally thick layer of cement is achieved, with no void spaces, industry standard practice is to pump excess cement and verify its return at the surface. Pumping a minimum of 25% excess cement is common. If the excess cement does not return at the surface, a bond was not achieved behind the entire section of surface casing. In this case, steps must be taken to remedy the failed cement job. A common method is to install a cement basket and pump cement down the annulus from the surface. A cement bond log should be run to verify cement integrity prior to proceeding further in the wellbore.

Recommendation No. 25: The following language should be added to DEP regulations at § 78.83(f): Surface casing must be cemented from top to bottom and firmly affixed in a central location in the wellbore with a continuous, equally thick layer of cement around the pipe. Cement must be placed behind surface casing by the pump and plug or displacement method and a sufficient amount of cement (at least 25% excess) must be used to ensure a protective cement bond is achieved from the bottom of the casing to the top of the hole. If the excess cement does not return at the surface, the operator must take steps to remedy the failed cement job, including pumping cement down the annulus from the surface to fill any void spaces. A cement bond log must be run to verify cement integrity prior to proceeding further in the wellbore. If the cement bond long does not verify placement of a continuous, solid layer of cement behind the surface casing from the bottom of the casing to the top of the hole, an additional string of casing must be set pursuant to § 78.83b(a)(1).

DEP's regulations at § 78.83(g) reads:

> *"If additional fresh groundwater is encountered in drilling below the permanently cemented surface casing, the operator shall protect the additional fresh groundwater by installing and cementing a subsequent string of casing or other procedures approved by the Department to completely isolate and protect fresh groundwater. The string of casing may also penetrate zones bearing salty or brackish water with cement in the annular space being used to segregate the*

various zones. Sufficient cement shall be used to cement the casing at least 20 feet into the permanently cemented casing."

This regulation essentially says that if an operator sets surface casing too early,[18] and then continues to drill through freshwater, the operator must set another string of protective casing to "*completely isolate and protect the fresh groundwater*." The requirement to set a second set of casing is appropriate. This second set of casing is called "intermediate casing" and is a defined term in DEP regulations. The regulations should use this term for clarity.

The last line of this regulation requires the operator to place cement only 20' behind the intermediate casing, just above the casing shoe. This amount of cement is inadequate to "*completely isolate and protect the fresh groundwater*."

Depending on the intermediate casing seat depth, it may be possible to place cement behind the entire casing string. As explained above, industry trade groups operating in the Marcellus Shale in Pennsylvania[19] recommend 13-3/8" intermediate casing at depths up to 1,000' be cemented behind the entire section. Intermediate casing provides a second protective barrier across a freshwater aquifer. However, it is not usually possible to cement the entire intermediate casing string if it is more than a few thousand feet deep. In this case, intermediate casing strings are partially cemented in place to secure the lower section of the pipe. Most states specify a minimum number of feet of cement be placed behind intermediate casing (e.g. 500-600'). It is recommended that DEP apply similar standards.

Of note, § 78.83(g) conflicts with the new proposed regulation at § 78.83c for intermediate casing requiring cementing of at least 600' (which is more consistent with current regulatory practices in other states).

Recommendation No. 26: DEP regulation at § 78.83(g) should be revised to remove the last line and replace it with a requirement to install cement behind the entire section of the intermediate casing string, unless the operator can demonstrate it is not technically feasible to circulate cement all the way to the surface due to the depth of intermediate casing. In that case, a minimum of 600' of cement must be placed behind the casing, above the casing shoe. In all cases, the cement must be firmly affixed in the wellbore in a central location with a continuous, equally thick layer of cement around the pipe.

Inconsistencies between regulations at § 78.83(g) and § 78.83c should be remedied, because both seem to be addressing intermediate casing.

DEP's existing regulation at § 78.83(f) reads:

"Where potential oil or gas zones are anticipated to be found at depths within 50 feet below the deepest fresh groundwater, the operator shall set and permanently cement surface casing prior to drilling into a stratum known to contain, or likely containing, oil or gas."

As recommended above at § 78.83 (c) the 50' depth should be increased to 100', and the regulation should be clear that surface casing should stop above any significant pressure zone or hydrocarbon zone, to ensure the blowout preventer can be installed prior to drilling into a pressured zone or hydrocarbon

[18] Or in the in the case that freshwater intervals are separated by intervals of shallow gas requiring multiple casing strings to be set.
[19] *See* note 2, *supra.*

zone; and surface casing needs to be set to provide a protective barrier to prevent hydrocarbons from contaminating freshwater aquifers when the well is drilled deeper (below the surface casing).

Recommendation No. 27: Revise § 78.83(f) to read: Where potential oil or gas zones are anticipated at depths within 100 feet below the deepest fresh groundwater, the operator shall set and permanently cement surface casing prior to drilling into a stratum known to contain, or likely containing, oil or gas, to provide a protective barrier to prevent hydrocarbons from contaminating the fresh water aquifers when the well is drilled deeper. A blowout preventer must be installed prior to drilling into a pressured hydrocarbon zone.

DEP's existing regulation at § 78.83(c) and (h) require the use of centralizers. Centralizers are necessary to center the casing in the hole and ensure that a concentric cement ring is placed around the pipe, sealing the annular space between the wellbore and the casing. Once the casing is set, there is still drilling fluid inside the casing and in the annular space between the casing and the wellbore wall. Drilling mud is displaced out of the hole by pumping cement down the inside of the casing and up the back side of the annulus. Poorly centralized casing will allow the cement to bypass the drilling fluid, following the path of least resistance (usually down the wide side of the annulus), leaving drilling fluid behind the casing on the narrow side of the annulus; if this happens, a section of the annulus is not properly cemented/sealed. Centralizers serve many functions including: centering the casing; preventing drag while casing is run in the hole; minimizing differential sticking; aiding in mud displacement; and reducing mud channeling when cementing is underway. Centralizers need to be installed either on a casing collar or a mechanical stop collar. American Petroleum Institute Specification (API) 10D is the industry standard for proper selection, design, and placement of centralizers. It is recommended that this standard be referenced in the regulations, because the distance between centralizers is only one of the design criteria that should be considered when properly selecting, installing, and running casing centralizers.

Recommendation No. 28: Revise § 78.83(c) and (h) to include American Petroleum Institute Specification (API) 10D standard for centralizers.

DEP has proposed three new regulatory sections at § 78.83, and has labeled them § 78.83a, § 78.83b, and § 78.83c. Presumably these sections also apply to surface and coal protective casing and cementing procedures, although this is not clear and should be stated, or these requirements should just be added by expanding the existing standard at § 78.83 beginning at the letter (l) where the last regulation left off.

This numbering scheme has the potential to cause confusion with existing regulations at § 78.83(a), § 78.83(b) and § 78.83(c) and is not consistent with DEP's numbering scheme. As proposed, DEP's numbering scheme will include regulations labeled § 78.83(a) and § 78.83a(a).

Recommendation No. 29: Revise the § 78.83a, § 78.83b, and § 78.83c numbering scheme for consistency with existing DEP regulation format. DEP should clarify that these new standards apply to surface and coal protective casing and cementing procedures.

DEP has proposed a whole new regulatory section at § 78.83a that requires the operator to prepare and maintain a casing and cementing plan. DEP's proposed regulation at § 78.83a reads:

"§ 78.83a Casing and Cementing Plan
(a) The operator shall prepare and maintain a casing and cementing plan showing how the well will be drilled and completed. The plan shall demonstrate compliance with this subchapter and include the following information:

(1) The anticipated depth and thickness of any producing formation, expected pressures, and anticipated fresh groundwater zones.
(2) Diameter of the well bore,
(3) Casing type, depth, diameter, wall thickness and burst pressure rating.
(4) Cement type, additives and estimated amount.
(5) Estimated location of centralizers.
(6) Alternative methods or materials as required by the Department as a condition of the well permit.

(b) The plan shall be available at the well site for review by the Department.
(c) Upon request, the operator shall provide a copy of the well specific casing and cementing plan to the Department for review and approval.
(d) Any revisions to the plan made as a result of on-site modification must be documented by the operator and be available for review by the Department"

The proposed regulation is unclear. § 78.83a(a) requires the operator to prepare and maintain a casing and cementing plan, but does not require this plan to be submitted to DEP for review or approval.

Since the casing and cementing plan is not reviewed by DEP as part of the well permit (unless per § 78.83a(c) and DEP specifically requests it), how does DEP develop a list of "alternative methods or materials required" for the casing and cementing plan under § 78.83a(a)(6)? And how does DEP include that information in the well permit as described under § 78.83a(a)(6), if it doesn't normally review and approve casing and cementing plans?

Simply put, due to the importance of properly installing casing and cementing to protect groundwater, casing and cementing plans should be submitted to DEP as part of the well permit application, so that DEP can review, approve, and provide informed technical guidance to the operator in advance. Too often, regulators get involved in the tail end of the process, when the casing has been run, and the cement job has failed. Efficient and economic corrections are difficult to achieve at this stage. Advance review and approval is appropriate.

DEP proposes that the casing and cementing plan at § 78.83a(a)(1-6) include specific information. At § 78.83a(a)(3) DEP requests information on the casing burst pressure rating. Pipe strength information should be expanded beyond burst strength, to include collapse resistance and tensile strength, because to design a reliable casing string you must know the strength of the pipe under different load conditions.[20]

At § 78.83a(a)(3) DEP requests information on the casing type. This information should be expanded to include whether the casing is new or used casing, and if used, the date, condition, and location of prior use and prior service history should be recorded. As noted later in comments at §78.84, it is strongly recommended that no used casing be allowed for surface casing or intermediate casing, when its primary function is to protect groundwater. New casing should be used in these cases. However, in cases where used casing may be allowed by DEP (e.g. production casing), it is critical that DEP have a very thorough understanding of the service history and quality prior to allowing reuse.

The casing and cementing plan should include a quality control and quality assurance section that ensures the design specifications established by the engineering team, and approved by DEP, are followed in the field, and cement bond logs and pressure tests are run to verify integrity.

[20] Petroleum Engineering Handbook, Volume II, Drilling Engineering, Society of Petroleum Engineers, 2006.

Recommendation No. 30: Revise § 78.83a(a) to require the operator to prepare and submit a casing and cementing plan to DEP for review and approval as part of the well permit application.

DEP should review and approve a complete well drilling and completion plan application including a casing and cementing plan, as part of the well permitting process, so that appropriate permit stipulations may be placed in the permit.

Expand § 78.83a(a)(3) to include information on the casing's collapse resistance and tensile strength. Also require information on casing age, condition, location of prior use, and prior service history.

The casing and cementing plan should include a quality control and quality assurance section and should demonstrate conformance with the objectives of § 78.71, and procedures and standards of §§ 78.81-87.

The same recommendations regarding excess cement returns made at § 78.83(f) apply here at §78.83b(a).

Recommendation No. 31: Revise § 78.83b(a) to include the recommendations made at § 78.83(f) regarding a minimum 25% excess cement return.

The newly proposed regulations at § 78.83b(a)(1)-(2) and (b) are confusing, inconsistent with best practices for protecting groundwater, and conflict with the newly proposed intermediate casing regulations at § 78.83c(a)-(c).

The newly proposed regulations at § 78.83b(a)(1)-(2) read:

> *" (a) If cement used to permanently cement the surface or coal protective casing is not circulated to the surface, the operator shall do one of the following:*
>
> *(1) Run an additional string of casing at least 50 feet deeper than the surface casing and cement the second string of casing back to the seat of the surface or coal protective casing and vent the annulus of the additional casing string to the atmosphere at all times unless closed for well testing or maintenance.*
>
> *(2) if the additional string of casing is the production casing, the operator shall set the production casing on a packer and vent the annulus of the production casing to the atmosphere at all times unless closed for well testing or maintenance.*
>
> *(a) If cement used to permanently cement the surface or coal protective casing is not circulated to the surface cement, the Department may require the operator to determine the amount of casing that was cemented by logging or other suitable method."*

Under § 78.83b(a) when surface casing is set, if a cement job fails, and another set of casing (called intermediate casing) must be run, the operator would then go to the new section of the regulations at §78.83c(a)-(c) that provides instruction on how to install intermediate casing. This makes the new regulation at § 78.83b(a)(1) unnecessary. And as explained in the earlier recommendations at § 78.83, it may be possible to cement the entire section of intermediate casing, depending on depth. If possible, the entire length should be cemented in place.

§ 78.83b(a)(2), as proposed, does not make sense. It proposes to allow **production casing** to serve as a **groundwater protection** casing in the event surface casing is run, and the cement job fails. The reason this does not make sense is that an operator with a failed surface casing cement job would have to drill into a hydrocarbon bearing zone to set production casing, potentially exposing groundwater to hydrocarbon contamination.

Simply put, production casing cannot serve as groundwater protection casing. **Groundwater protection casing must be set below the groundwater, but above the hydrocarbon zone**, firmly anchored. If the first set of surface casing was not cemented in place properly, a second set (intermediate casing) must be run and cemented in place to ensure groundwater protection, prior to entering the hydrocarbon zone.

The production casing, by DEP's own definition at § 78.1, is: *"A string of pipe other than surface casing and coal protective casing which is run for the purpose of confining or conducting hydrocarbons and associated fluids from one or more producing horizons to the surface."* To set production casing, the operator would have to drill into the hydrocarbon-bearing zone; meanwhile, keep in mind that if the surface casing was not properly cemented, drilling into the production zone creates a potential pathway for hydrocarbons to reach groundwater behind improperly cemented casing.

§ 78.83b(b) is even more perplexing, because after reading § 78.83b(a), where the operator is clearly instructed to run another string of casing after a failed surface casing and cement job, § 78.83b(b) requests the operator to further examine the cement condition by logging or other methods. A more logical progression, and a more common progression, is the one explained above in the surface casing regulations. The surface casing cementing program should be designed with at least 25% excess cement. Excess cement should be observed at the surface. Cement bond logs should be run as a normal suite of quality control and assurance, to verify cement quality prior to proceeding. If necessary, additional cementing may be needed to fill voids (if any). If the cement job cannot be remedied, with routine cementing procedures, it may be necessary to run a string of intermediate casing and cement it in place.

Recommendation No. 32: Revise § 78.83b to clearly state that if surface casing is not properly cemented in place with at least 25% excess cement returns at the surface, intermediate casing must be run and cemented in place following the recommendations made above at § 78.83. Cement bond logs should be run to verify cement quality. The proposal to allow an operator to continue drilling into a hydrocarbon bearing zone to set production casing, in the presence of a known failed surface casing cement job, is technically unsound and environmentally hazardous, and should be deleted.

11. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Casing Standards, § 78.84

DEP's casing standard requirement at § 78.84(a) should include a requirement to design and install casing to withstand the effects of corrosion and erosion, in addition to the other factors listed. This can included using coated piping, higher grade pipe, or thicker walled pipe with a higher corrosion allowance.

Recommendation No. 33: Revise § 78.84(a) to include a requirement to design and install casing to withstand the effects of corrosion and erosion.

DEP has added a new regulation at § 78.84(b) that reads:

> *"(b) Surface casing shall be a string of new pipe with a pressure rating that is at least 20 percent greater than the anticipated maximum pressure. Used casing may be approved for use but must be pressure tested after cementing and before continuation of drilling. A passing pressure test is holding the anticipated maximum pressure for 30 minutes with not more than a 10 percent change in pressure."*

This standard allows the use of new or used surface casing. The quality of intermediate casing is not addressed.

Surface casing should not be constructed of used casing. Surface casing and intermediate casing should be made of new, high-quality piping. Keep in mind that surface casing and intermediate casing both play an important role in: preventing the contamination of freshwater; confining fluids to the wellbore; preventing migration of fluids and hydrocarbons from one stratum to another; ensuring control of well pressures encountered; and providing well control until the next casing is set. Oil and gas wells may be subject to elevated temperatures, pressures, erosion, corrosion, and other factors that reduce the operating life of the casing string, and its ability to protect groundwater supplies. Installation of new piping maximizes public and environmental protection, by extending the life cycle of the well.

Recommendation No. 34: DEP regulation at § 78.84(b) should be revised to read: (b) Surface and intermediate casing shall be a string of new casing with a pressure rating that is at least 20 percent greater than the anticipated maximum pressure.

Similarly, DEP should revise § 78.84(c) to require new welded piping for surface and intermediate casing strings.

The exemption for not obtaining API welder's certification at § 78.84(c)(3) appears to have a typo. Should it be "within **90 days** of the effective date," instead of "within **9** of the effective date"? The justification for the welding certification exemption is not clear. API welder's certifications were developed to improve the quality and consistency of casing and other types of piping welds. There are rigorous training and qualification requirements, and quality control and assurance procedures that must be followed. If a welder is not API certified, DEP should evaluate if there is an equivalent state welding certification training program in Pennsylvania that could be substituted. Alternatively, DEP should consider if a Pennsylvania certification program could be developed to test and certify those with existing experience, to validate their training, experience, and quality control and quality assurance procedures.

The technical basis for grandfathering in welders with 10 years or more experience is not clear. While these welders may have many years of welding experience, the concern is that they may not be familiar with the new quality control and quality assurance procedures that have been developed. Certification programs provide continuing education opportunities and information on new techniques as they are developed.

Recommendation No. 35: Revise § 78.84(c) to require new welded piping for surface and intermediate casing strings and API welder's certification. Alternatively, consider substitution of the API certification with an equivalent state welding certification training program. Allow a reasonable transition period to allow welders time to obtain this new certification.

12. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Cement Standards, § 78.85

DEP's revised cement standard at § 78.85 (a) reads:

> *"(a) The operator shall use cement that meets or exceeds the ASTM International C 150, type I, II or II standard. The cement shall also:*
> *(1) Secure the casing in the well bore,*
> *(2) Isolate the wellbore from fresh groundwater,*
> *(3) Contain any pressure from drilling, completion and production,*
> *(4) Protect the casing from corrosion, and*
> *(5) Resist degradation by the chemical and physical conditions in the well.*
> *(6) Prevent gas migration"*

The proposed language at § 78.85 (a) appears to have a few typos: type II is listed twice; in subsection (4), the word "and" should be deleted; in subsection (5), the period should be replaced with a comma, followed by the word "and"; and subsection (6) should close with a period.

In addition to preventing gas migration, as noted at § 78.85 (a)(6), cement should also prevent migration of fluids and hydrocarbons from one stratum to another.

Recommendation No. 36: Revise § 78.85(a) to correctly reference the ASTM International Standard for Portland Cement. Correct the typographical errors in Revise § 78.85 (a)(4)-(6). Revise § 78.85(a)(6) to read: Prevent migration of fluids and hydrocarbons, including gas, from one stratum to another.

DEP's existing regulation at § 78.85(b) includes a 350 psi compressive strength standard. As recommended, and described in detail in the comment on the definition of "cement" at § 78.81, DEP should consider a higher compressive strength standard to protect groundwater, especially in the critical zone of cement.

Recommendation No. 37: Revise § 78.85(b) to increase the compressive strength standard, consistent with the recommendations made at § 78.81.

13. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Mechanical Integrity of Operating Wells, § 78.88

DEP has proposed a new section of regulations for operating wells at § 78.88. The proposed regulations at § 78.88(a) require quarterly well inspections to verify the operating condition of the well, identify maintenance and repair needs, and take corrective action. Routine well integrity monitoring is best practice. Quarterly inspections, however, are too infrequent. Daily, or at least weekly, inspections are recommended.

Recommendation No. 38: Revise § 78.88(a) to increase the operating well inspection frequency to daily, or at least weekly.

DEP's proposed regulation at § 78.88(b)(3) requires the operator to determine if gas is escaping from the well, and the amount. DEP's proposed regulation at § 78.88(b)(4) requires the operator to determine if there is evidence of progressive corrosion, rusting, or other signs of equipment deterioration. Yet, DEP does not require the operator to take any action to stop the gas leak or remedy the corrosion, or equipment deterioration, except to take action to meet § 78.73(c) (to minimize pressure at the casing seat) or report the mechanical integrity problem at § 78.88(e).

Recommendation No. 39: Revise §7 8.88 to require wells with mechanical integrity problems to be repaired, shut in, or plugged and abandoned, as appropriate and safe to protect human health and the environment. The annual mechanical integrity report required at § 78.88(e) should summarize both the compliance status of each well and what action was taken to remedy non-compliant wells.

14. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Stray Gas Mitigation Response, § 78.89

DEP has proposed a new section of regulations for stray gas mitigation response at § 78.89. A stray gas mitigation response regulation is an excellent addition; however, the title should be expanded beyond "stray gas" to address the broad range of responses described and anticipated in § 78.89 (a), including "oil" and "other fluids" (presumably chemicals and well stimulation fluids).

Recommendation No. 40: Revise § 78.89 throughout, to address potential leaks and/or contamination from "stray gas," "oil," and/or "other fluids," including but not limited to chemicals and well stimulation fluids.

DEP's proposed regulation at §78.89(b) requires the operator to "immediately" notify DEP and conduct an investigation when the operator becomes aware of a "stray gas incident". Yet there is no timeframe designated for when the operator and DEP need to respond to the situation. The notification requirement and response action obligation should be extended to incidents including "oil" and "other fluids".

Recommendation No. 41: Revise the last sentence of § 78.89(b) to read: The operator, in conjunction with the Department and local emergency response agencies, shall **immediately** take measures to ensure public health, safety, and welfare. The requirements proposed at § 78.89(b) should be extended to oil and other chemicals.

15. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Plugging, § 78.91-98

Properly plugging and abandoning a well is critical to the protection of groundwater resources. In addition to DEP regulations at §§ 78.91-78.98, DEP should consider enhancing the regulations to require longer and additional cement barriers to ensure that hydrocarbons and freshwater are confined to their respective indigenous strata, and are prevented from migrating into other strata or to the surface. For example, while

DEP uses a 50' cement barrier, other states like Alaska require double the protection at 100'.[21] Texas requires an operator to submit a plugging procedure for agency review and approval.[22]

Recommendation No. 42: Revise the regulations at §§ 78.91-78.98 to include the following:

Plugging a wellbore must be performed in a manner that ensures that all hydrocarbons and freshwater are confined to their respective indigenous strata and are prevented from migrating into other strata or to the surface.

All hydrocarbon-bearing strata should be permanently sealed off by installing a cement barrier at least 100 feet below the base to 100 feet above the top of all hydrocarbon-bearing strata.

Plugging of a well must include effective segregation of uncased and cased portions of the wellbore to prevent vertical movement of fluid within the wellbore. A continuous cement plug must be placed from at least 100 feet below to 100 feet above the casing shoe.

The operator is required to submit records to DEP to demonstrate that the well was plugged in compliance with DEP regulations.

16. Subchapter D, Well Drilling, Operation and Plugging, Casing and Cementing, Well Record and Completion Report, § 78.122

DEP regulations at § 78.122(a)(6) should be expanded to include intermediate casing.

Recommendation No. 43: Revise the regulations at § 78.122(a)(6) to include intermediate casing.

DEP regulations at § 78.122(a)(7) should be expanded to include the requirement to submit an electronic copy of the cement bond log to verify cement integrity behind any casing used to protect groundwater resources, including surface and intermediate casing.

Recommendation No. 44: Revise the regulations at § 78.122(a)(7) to require submission of an electronic copy of the cement bond log.

DEP regulations at § 78.122(a) should be expanded to address waste.

Recommendation No. 45: Revise the regulations at § 78.122(a) to require a list of waste generated during drilling and workover operations, and a description of the waste handling and disposal methods and locations.

DEP revised the regulations at § 78.122(b)(6) to require additional information on stimulation procedures. It is recommended that the "composition" of stimulation fluids, including a list of all additives, identifying all chemical components, be reported.

[21] 20 AAC 25.
[22] 16 TAC Part 1§3.14

The lowest environmental impact methods should be considered. Possible methods for further DEP examination include:

1. Waste minimization (drilling mud recycle and reuse when possible);
2. Use of drilling mud additives with lower environmental impact;
3. Beneficial reuse of uncontaminated drilling wastes;
4. Use of closed loop tank systems to transport waste, versus use of reserve pits;
5. Burial (e.g. landfills, or reserve pits);
6. Commercial treatment and disposal facilities; and/or
7. Underground injection.

Recommendation No. 46: Revise the regulations at § 78.122(b)(6) to include information on the chemical additives, including all chemical components. Reported information should include biodegradability, bioaccumulation potential, toxicity, and any detrimental mutagenic or reproductive affects. Best practices would include a requirement to forbid chemicals that have low biodegradability, high bioaccumulation potential, high acute toxicity, or detrimental mutagenic or reproductive affects.

DEP regulations at § 78.122(b) should be expanded to provide a list of all waste generated during well completion operations, and a description of waste handling and disposal methods and locations. See waste management methods for consideration in Recommendation 45 above.

Recommendation No. 47: Revise the regulations at § 78.122(b) to require a list of waste generated during well completion operations, and a description of the waste handling and disposal methods and locations.

17. Copyrighted Standards

DEP should obtain a public access license to all copyrighted standards (e.g. API, ASTM) that are not available in the public domain. Regulations should be available for public review and comment, without having to purchase very expensive copies of copyrighted standards to understand the criteria and requirements that DEP is proposing. It is useful to reference technical standards and best practices when they serve to provide clear instruction; however, the public must be able to read and understand the regulations without an unreasonable financial burden. The cost to obtain a copy of these copyrighted standards can range up to several hundred dollars per standard.

Recommendation No. 48: Ensure that the public has access to all technical standards and criteria referenced in DEP's regulations. A public access version should be made available on the DEP website.

18. Inspection and Enforcement Program

Drafting new regulations to minimize contamination from oil and gas development in Pennsylvania is an important first step. New regulations must be accompanied by a rigorous inspection and enforcement program. It would be very useful for DEP to provide information on how it plans to expand and enhance

its current inspection and enforcement program. DEP should provide more information on the following topics: budget, number of inspectors, inspector qualifications and expertise, frequency of inspections, type of inspections, and enforcement procedures and guidelines.

DEP should demonstrate that it has sufficient resources to oversee, inspect, and enforce the proposed enhanced regulations. This increases public confidence that a plan is not only required, but that DEP will ensure that it is followed.

Recommendation No. 49: DEP should provide information on how it plans to expand and enhance its current inspection and enforcement program to ensure regulatory compliance.

Federal Register

Wednesday,
January 14, 2009

Part II

Securities and Exchange Commission

17 CFR Parts 210, 211 et al.
Modernization of Oil and Gas Reporting; Final Rule

SECURITIES AND EXCHANGE COMMISSION

17 CFR Parts 210, 211, 229, and 249

[Release Nos. 33–8995; 34–59192; FR–78; File No. S7–15–08]

RIN 3235–AK00

Modernization of Oil and Gas Reporting

AGENCY: Securities and Exchange Commission.

ACTION: Final rule; interpretation; request for comment on Paperwork Reduction Act burden estimates.

SUMMARY: The Commission is adopting revisions to its oil and gas reporting disclosures which exist in their current form in Regulation S–K and Regulation S–X under the Securities Act of 1933 and the Securities Exchange Act of 1934, as well as Industry Guide 2. The revisions are intended to provide investors with a more meaningful and comprehensive understanding of oil and gas reserves, which should help investors evaluate the relative value of oil and gas companies. In the three decades that have passed since adoption of these disclosure items, there have been significant changes in the oil and gas industry. The amendments are designed to modernize and update the oil and gas disclosure requirements to align them with current practices and changes in technology. The amendments concurrently align the full cost accounting rules with the revised disclosures. The amendments also codify and revise Industry Guide 2 in Regulation S–K. In addition, they harmonize oil and gas disclosures by foreign private issuers with the disclosures for domestic issuers.

DATES: *Effective Date:* January 1, 2010.

Comment Date: Comments on the Paperwork Reduction Act Analysis should be received on or before February 13, 2009.

ADDRESSES: Comments may be submitted by any of the following methods:

Electronic Comments

- Use the Commission's Internet comment form (*http://www.sec.gov/rules/proposed.shtml*); or
- Send an e-mail to *rule-comments@sec.gov*. Please include File Number S7–15–08 on the subject line; or
- Use the Federal e-Rulemaking Portal *http://www.regulations.gov*. Follow the instructions for submitting comments.

Paper Comments

- Send paper submissions in triplicate to Secretary, Securities and Exchange Commission, 100 F Street, NE., Washington, DC 20549–1090.

All submissions should refer to File Number S7–15–08. This file number should be included on the subject line if e-mail is used. To help us process and review your comments more efficiently, please use only one method. The Commission will post all comments on the Commission's Internet Web site (*http://www.sec.gov/rules/concept.shtml*). Comments also are available for public inspection and copying in the Commission's Public Reference Room, 100 F Street, NE., Washington, DC 20549, on official business days between the hours of 10 a.m. and 3 p.m. All comments received will be posted without change; we do not edit personal identifying information from submissions. You should submit only information that you wish to make available publicly.

FOR FURTHER INFORMATION CONTACT: Ray Be, Special Counsel, Office of Chief Counsel at (202) 551–3500; Dr. W. John Lee, Academic Petroleum Engineering Fellow, or Brad Skinner, Senior Assistant Chief Accountant, Office of Natural Resources and Food at (202) 551–3740; Leslie Overton, Associate Chief Accountant, Office of Chief Accountant for the Division of Corporation Finance at (202) 551–3400, Division of Corporation Finance; or Mark Mahar, Associate Chief Accountant, Jonathan Duersch, Assistant Chief Accountant, or Doug Parker, Professional Accounting Fellow, Office of the Chief Accountant at (202) 551–5300; U.S. Securities and Exchange Commission, 100 F Street, NE., Washington, DC 20549–3628.

SUPPLEMENTARY INFORMATION: We are adopting amendments to Rule 4–10 [1] of Regulation S–X [2] and Items 102, 801 and 802 [3] of Regulation S–K.[4] We also are adding new Subpart 1200, including Items 1201 through 1208, to Regulation S–K.

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[1] 17 CFR 210.4–10.

[2] 17 CFR 210.

[3] 17 CFR 229.102, 17 CFR 229.801, and 17 CFR 229.802.

[4] 17 CFR 229.

I. Introduction

A. Background

On June 26, 2008, the Commission issued a proposing release (Proposing Release) seeking public comment on proposed amendments to the disclosure requirements regarding oil and gas companies.[5] These proposals encompassed issues that were previously addressed more generally in a concept release that the Commission issued on December 12, 2007 (Concept Release),[6] which solicited comment on possible revisions to the oil and gas reserves disclosure requirements specified in Rule 4–10 of Regulation S–X[7] and Item 102 of Regulation S–K.[8] The Proposing Release also contained proposals not addressed by the Concept Release related to the updating and codification of Industry Guide 2.

We initially adopted our oil and gas disclosure requirements in 1978 and 1982.[9] Since that time, there have been significant changes in the oil and gas industry and markets, including technological advances, and changes in the types of projects in which oil and gas companies invest their capital.[10] Prior to our issuance of the Concept Release and the Proposing Release, many industry participants had expressed concern that our disclosure rules are no longer in alignment with current industry practices and therefore limit their usefulness to the market and investors.[11]

[5] Release No. 33–8935 (June 27, 2008) [73 FR 39181].

[6] Release No. 33–8870 (Dec. 12, 2007) [72 FR 71610].

[7] 17 CFR 210.4–10. See Release No. 33–6233 (Sept. 25, 1980) [45 FR 63660] (adopting amendments to Regulation S–X, including Rule 4–10). The precursor to Rule 4–10 was Rule 3–18 of Regulation S–X, which was adopted in 1978. See Accounting Series Release No. 253 (Aug. 31, 1978) [43 FR 40688]. See also Accounting Series Release No. 257 (Dec. 19, 1978) [43 FR 60404] (further amending Rule 3–18 of Regulation S–X and revising the definition of proved reserves).

[8] Item 102 of Regulation S–K [17 CFR 229.102]. In 1982, the Commission adopted Item 102 of Regulation S–K. Item 102 contains the disclosure requirements previously located in Item 2 of Regulation S–K. See Release No. 33–6383 (March 16, 1982) [47 FR 11380]. The Commission also ''recast * * * the disclosure requirements for oil and gas operations, formerly contained in Item 2(b) of Regulation S–K, as an industry guide.'' See Release No. 33–6384 (Mar. 16, 1982) [47 FR 11476].

[9] The disclosure requirements were introduced pursuant to a directive in the Energy Policy and Conservation Act of 1975 (the ''EPCA''). The EPCA directed the Commission to ''take such steps as may be necessary to assure the development and observance of accounting practices to be followed in the preparation of accounts by persons engaged, in whole or in part, in the production of crude oil or natural gas in the United States.'' See 42 U.S.C. 6201–6422.

[10] See, for example, Daniel Yergin and David Hobbs: ''The Search for Reasonable Certainty in Reserves Disclosure,'' Oil and Gas Journal (July 18, 2005).

[11] See, for example, Greg Courturier, ''Standard & Poor's Urges SEC to Change Disclosure Rules,'' International Oil Daily (Dec. 3, 2007); Steve Levine, ''Tracking the Numbers: Oil Firms Want SEC to Loosen Reserves Rules,'' Wall Street Journal Online (Feb. 7, 2006); Christopher Hope, ''Oil Majors Back Attack on SEC Rules,'' The Daily Telegraph (London) (Feb. 24, 2005); Barrie McKenna, ''Rules undervalue reserves report says: Volumes buried in Canada's oil sands not counted by SEC's measure,'' The Globe & Mail (Canada) (Feb. 24, 2005); and ''Deloitte Calls on Regulators to Update Rules for Oil and Gas Reserves Reporting,'' Business Wire Inc. (Feb. 9, 2005).

B. Issuance of the Concept Release

The Concept Release addressed the potential implications for the quality, accuracy and reliability of oil and gas disclosure if the Commission were to:

- Revise the definition of ''proved reserves'' in our rules, in particular, the criteria used to assess and quantify resources that can be classified as proved reserves; and
- Expand the categories of resources that may be disclosed in Commission filings to include resources other than proved reserves.

In addition, the Concept Release questioned whether our revised disclosure rules should be modeled on any particular resource classification framework currently being used within the oil and gas industry. We also asked how any revised disclosure rules could be made flexible enough to address future technological innovation and changes within the oil and gas industry. The Concept Release sought further comment on whether the Commission should require independent third-party assessments of reserves estimates that a company includes in its filings.

In response to the Concept Release, commenters submitted 80 comment letters.[12] We received comment letters from a variety of industry participants such as accounting firms, engineering consulting firms, domestic and foreign oil and gas companies, federal government agencies, individuals, law firms, professional associations, public interest groups, and rating agencies. We considered these comments and addressed many of them in issuing the Proposing Release.

C. Overview of the Comment Letters Received on the Proposing Release

The Proposing Release sought significantly more detailed comment on issues raised in the Concept Release, as well as proposed amendments to the disclosure items in our rules and Industry Guide 2. In response to the Proposing Release, we received 65 comment letters, again from a variety of constituents with interests in oil and gas industry disclosure.

[12] The public comments we received are available for inspection in the Commission's Public Reference Room at 100 F St., NE., Washington, DC 20549 in File No. S7–29–07. They are also available on-line at *http://www.sec.gov/comments/s7-29-07/s72907.shtml*.

Almost all commenters supported some form of revision to the current oil and gas disclosure requirements, particularly given the length of time that has elapsed since the requirements were initially adopted.[13] Commenters provided significantly more detailed comments on the Proposing Release than on the Concept Release, which did not include specific proposed regulatory text. We discuss those comments in detail in the relevant sections of this release. However, in general, commenters focused on several key issues raised by the Proposing Release. These issues included the following:

- The proposal to permit disclosure of probable and possible reserves;
- The proposed use of average historical prices to represent existing economic conditions to determine the economic producibility of oil and gas reserves for disclosure purposes while continuing to use a single day year-end price to determine the economic producibility of reserves for accounting purposes;
- The proposed inclusion of bitumen, oil shales, and other resources in the definition of ''oil and gas producing activities'';
- The proposed provision to broaden the types of technology that a company may use to establish reserves estimates and categories;
- The proposed change in the definition of proved undeveloped reserves to eliminate the ''certainty'' requirement; and
- The increased detail of disclosure that would be required as a result of our proposed definition of ''geographic location.''

II. Revisions and Additions to the Definition Section in Rule 4–10 of Regulation S–X

A. Introduction

The revisions and additions to the definition section in Rule 4–10(a) of Regulation S–X [14] update our reserves definitions to reflect changes in the oil and gas industry and markets and new technologies that have occurred in the decades since the current rules were adopted. Many of the definitions are designed to be consistent with the Petroleum Resource Management System (PRMS).[15] Among other things, the revisions to these definitions address four issues that have been of particular interest to companies, investors, and securities analysts:

- The use of single-day year-end pricing to determine the economic producibility of reserves;
- The exclusion of activities related to the extraction of bitumen and other ''non-traditional'' resources from the definition of oil and gas producing activities;
- The limitations regarding the types of technologies that an oil and gas company may rely upon to establish the levels of certainty required to classify reserves; and
- The limitation in the current rules that permits oil and gas companies to disclose only their proved reserves.

The revisions of, and additions to, the Rule 4–10 definitions attempt to address these issues without sacrificing clarity and comparability, which provide protection and transparency to investors. In addition, to the extent appropriate, we have revised our proposals so that the final definitions are more consistent with terms and definitions in the PRMS to improve compliance and understanding of our new rules.

B. Pricing Mechanism for Oil and Gas Reserves Estimation

1. 12-Month Average Price

The final rules define the term ''proved oil and gas reserves'' in part as ''those quantities of oil and gas, which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be economically producible—from a given date forward, from known reservoirs, and under existing economic conditions, operating methods, and government regulations—prior to the time at which contracts providing the right to operate expire, unless evidence indicates that renewal is reasonably certain, regardless of whether deterministic or probabilistic methods are used for the estimation.'' The definition states that the economic producibility of a reservoir must be based on existing economic conditions. It specifies that, in calculating economic producibility, a company must use a 12-month average price, calculated as the unweighted arithmetic average of the first-day-of-the-month price for each month within the 12-month period prior to the end of the reporting period, unless prices are defined by contractual arrangements, excluding escalations based upon future conditions.[16]

Most commenters supported the use of a 12-month average price to serve as a proxy for existing economic conditions to determine the economic producibility of reserves.[17] Some noted that a 12-month average price is considered to reflect ''current economic conditions'' by PRMS.[18] They noted that the use of an average price would reduce the effects of short term volatility [19] and seasonality,[20] while

[13] See letters from American Association of Petroleum Geologists (''AAPG''), American Clean Skies Foundation (''American Clean Skies''), American Petroleum Institute (''API''), AngloGold Ashanti Ltd. (''AngloGold''), Apache Corporation (''Apache''), BHP Billiton Petroleum (''BHP''), BP Plc. (''BP''), Brookwood Petroleum Advisors, Ltd. (''Brookwood''), Canadian Association of Petroleum Producers (''CAPP''), Canadian Natural Resources Ltd. (''Canadian Natural''), Center for Audit Quality (''CAQ''), Center for Corporate Policy (''CCP''), CFA Institute Centre for Financial Market Integrity (''CFA''), Chesapeake Energy Corporation (''Chesapeake''), Chevron Corporation (''Chevron''), Coeur d'Alene Mines Corporation (''Coeur''), Cunningham, Peter (''Cunningham''), Davis, Polk & Wardwell (''Davis Polk''), Deloitte & Touche (''Deloitte''), Devon Energy Corporation (''Devon''), EnCana Corporation (''EnCana''), Energen Corporation (''Energen''), Energy Information Administration (of DOE) (''EIA''), Eni S.p.A. (''Eni''), Equitable Resources, Inc. (''Equitable''), Ernst & Young (''E&Y''), Evolution Petroleum Corporation (''Evolution''), ExxonMobil Corporation (''ExxonMobil''), Federal Energy Regulatory Commission (''FERC''), Graff Consulting Group LLC (''Graff Consulting''), Grant Thornton (''Grant Thornton''), Imperial Oil Ltd. (''Imperial''), Independent Petroleum Association of America (''IPAA''), KPMG (''KPMG''), Luscher, Brian (''Luscher''), Magoto, Joseph (''Magoto''), McMoRan Exploration Co. (''McMoRan''), Newfield Exploration Company (''Newfield''), Nexen, Inc. (''Nexen''), Peabody Energy Corporation (''Peabody''), Petro-Canada (''Petro-Canada''), Petroleo Brasileiro S.A. (''Petrobras''), Petroleos Mexicanos (''PEMEX''), PRA International Ltd. (''PRA''), PriceWaterhouseCoopers (''PWC''), Questar Market Resources (''Questar''), RepsolYPF, S.A. (''Repsol''), Ross Petroleum Ltd. (''Ross''), Ryder Scott Company, L.P. (''Ryder Scott''), Sasol Ltd. (''Sasol''), Senator Robert Menendez, Senator Russell D. Feingold, and Senator Bernard Sanders, U.S. Senate (''Three Senators''), Shearman & Sterling (''Shearman & Sterling''), Shell International B.V. (''Shell''), Society of Exploration Geophysicists (''SEG''), Society of Petroleum Engineers (''SPE''), Society of Petroleum Evaluation Engineers (''SPEE''), Southwestern Energy Production Company (''Southwestern''), Standard Advantage (''Standard Advantage''), StatoilHydro (''StatoilHydro''), Swift Energy Company (''Swift''), Talisman Energy Inc. (''Talisman''), Total, S.A. (''Total''), van Wyk, Mike (''van Wyk''), Wagner, Robert (''Wagner''), Zakaib, Geoff (''Zakaib'').

[14] 17 CFR 210.4–10(a).

[15] The Petroleum Resources Management System is a widely accepted standard for the management of petroleum resources developed by several industry organizations. See Society of Petroleum Engineers, the World Petroleum Council, American Association of Petroleum Geologists, and the Society of Petroleum Evaluation Engineers, *Petroleum Resources Management System,* SPE/WPC/AAPG/SPEE (2007).

[16] See Rule 4–10(a)(22)(v) [17 CFR 210.4–10(a)(22)(v)].

[17] See letters from AngloGold, Apache, API, BHP, BP, Canadian Natural, CAPP, Chesapeake, Chevron, Devon, EIA, EnCana, Equitable, Evolution, ExxonMobil, Newfield, Nexen, Petrobras, Petro-Canada, PWC, Questar, Repsol, Ryder Scott, Sasol, Shell, Southwestern, SPE, Total, and Wagner.

[18] See letters from AngloGold, BHP, Equitable, Ryder Scott, and SPE.

[19] See letters from Apache, API, BHP, BP, Canadian Natural, CAPP, Chesapeake, EIA, EnCana, Equitable, Evolution, ExxonMobil, Imperial, IPAA, Newfield, Petrobras, Petro-Canada, Repsol, Ryder Scott, SPE, Total, and Wagner.

[20] See letters from Apache, Canadian Natural, Devon, EnCana, Evolution, IPAA, Petro-Canada, Repsol, and Ryder Scott.

maintaining comparability of disclosures among companies.[21]

Seven commenters recommended the use of first-of-the-month prices[22] instead of the proposed use of end-of-the-month prices because the use of first-of-the-month prices would provide companies with more time to estimate their reserves[23] and they thought that these prices better reflect the actual price received under typical natural gas contracts.[24] Conversely, six commenters recommended the use of a 12-month daily average price[25] because they thought that a daily average price would be more appropriate than a monthly average price. These commenters noted that oil sales contracts often are based on daily averages.[26] Two commenters expressed concern that end-of-the-month prices are not representative of actual prices because commodity traders often ''clear their books'' at the end of the month.[27]

One commenter opposed the use of average prices stating that, conceptually, the use of average prices is poor regulatory policy and may encourage the market to pressure standard setters to use historical average prices for financial instruments and other assets and liabilities associated with volatile markets.[28] It noted that volatility reflects the underlying economics of the oil and gas industry.[29]

The objective of reserves estimation is to provide the public with comparable information about volumes, not fair value, of a company's reserves available to enable investors to compare the business prospects of different companies. The use of a 12-month average historical price to determine the economic producibility of reserves quantities increases comparability between companies' oil and gas reserve disclosures, while mitigating any additional variability that a single-day price may have on reserve estimates. Although oil and gas prices themselves are subject to market-based volatility, the estimation of reserves quantities based on any historical price assumption determines those reserves quantities as if the oil or gas already has been produced, even though they have not, and these measures do not attempt to portray a reflection of their fair value. If the objective of reserve disclosures were to provide fair value information, we believe a pricing system that incorporates assumptions about estimated future market prices and costs related to extraction could be a more appropriate basis for estimation.

In order to provide disclosures which are more consistent with the objective of comparability, the amendments state that the existing economic conditions for determining the economic producibility of oil and gas reserves include the 12-month average price, calculated as the unweighted arithmetic average of the first-day-of-the-month price for each month within the 12-month period prior to the end of the reporting period.[30] For example, a company with a reporting year end of December 31 would determine its reserves estimates for its annual report based on the average of the prices for oil or gas on the first day of every month from January through December. Therefore, the use of a 12-month average price provides companies with the ability to efficiently prepare useful reserve information without sacrificing the objective of comparability. We believe that the revised definition of the term ''proved oil and gas reserves'' will provide investors with improved reserves information thereby enhancing their ability to analyze the disclosures.

2. Prices Used for Disclosure and Accounting Purposes

A proposal that resulted in significant comment was the use of a 12-month average price to estimate reserves for disclosure purposes, but a single-day, year-end price for accounting purposes.[31] All commenters addressing the issue of using different prices to determine reserves for disclosure and accounting opposed the proposal.[32] We are not adopting this aspect of the proposal. Instead, we are revising both our disclosure rules and our full-cost accounting rules related to oil and gas reserves to use a single price based on a 12-month average.[33] We also will continue to communicate with the FASB staff to align their accounting standards with these rules.

Commenters pointed out that the use of two different prices for disclosure and accounting purposes could:

- Confuse investors and other users of financial statements.[34]
- Create misleading information;[35]
- Harm comparability;[36]
- Decrease transparency;[37]
- Increase costs and burden significantly;[38]
- Increase the complexity of disclosures;[39]
- Double recordkeeping burden;[40]
- Require more disclosure to explain the differences in reserves estimates; and[41]
- Break the connection between disclosures and accounting.[42]

Some commenters noted that the disclosure and accounting rules and guidance do not use a different pricing method in other situations.[43] In addition, several commenters believed that changing to the use of an average price to estimate proved reserves would have a minimal impact on depreciation and net income.[44] We believe that changing the rules to use a 12-month average price in reserves estimations is

[21] See letters from BHP, Canadian Natural, CAPP, Deloitte, Devon, IPAA, Newfield, Petro-Canada, Total, and Wagner.

[22] See letters from Apache, BP, Chesapeake, Chevron, Devon, Repsol, and Shell.

[23] See letters from Chesapeake, Devon, and Shell.

[24] See letters from Apache, Newfield, and Repsol.

[25] See letters from Canadian Natural, CAPP, EnCana, Nexen, Petro-Canada, and Repsol.

[26] See letter from Newfield.

[27] See letters from Apache and Shell.

[28] See letter from CFA.

[29] See letter from CFA.

[30] See new Rule 4–10(a)(22)(v) of Regulation S–X [17 CFR 210.4–10(a)(22)(v)].

[31] Currently, companies use a single-day, year-end price to determine the quantity of its proved reserves. From an accounting perspective, the quantity of those reserves, while not included on the balance sheet, is used to determine the depreciation, depletion and amortization of certain capitalized costs included on the balance sheet. If the final rule retained a single-day, year-end price for determining reserves for accounting purposes (i.e. , for determining depreciation, depletion and amortization), then companies would effectively be required to calculate reserves twice, using two different pricing assumptions—once for disclosure purposes and once for accounting purposes. Similarly, under the full cost rules, the full cost ceiling test, as described in Section III of this release, would have similar implications.

[32] See letters from Apache, API, Audit Quality, BHP, BP, Canadian Natural, CAPP, CFA, Chesapeake, Chevron, Deloitte, Devon, E&Y, EnCana, Energen, Eni, Equitable, Evolution, ExxonMobil, Grant Thornton, Imperial, KPMG, McMoRan, Newfield, Nexen, PEMEX, Petrobras, Petro-Canada, PWC, Questar, Repsol, Ross, Ryder Scott, Sasol, Shell, Southwestern, SPEE, StatoilHydro, Swift, Talisman, Total, and Wagner.

[33] See Rule 4–10.

[34] See letters from Audit Quality, BHP, Canadian Natural, CAPP, Chesapeake, Deloitte, Devon, Evolution, ExxonMobil, Imperial, Newfield, Nexen, Petrobras, Petro-Canada, PWC, Questar, Repsol, Ryder Scott, Shell, Swift, Talisman, Total, and Wagner.

[35] See letters from BP, CFA, Devon, Eni, Nexen, Repsol, and Wagner.

[36] See letters from Apache, Canadian Natural, CAPP, Questar, StatoilHydro, and Wagner.

[37] See letters from Canadian Natural, CAPP, ExxonMobil, Shell, Swift, and Wagner.

[38] See letters from Apache, Audit Quality, BHP, Canadian Natural, CAPP, Chevron, Deloitte, Devon, Eni, Equitable, Evolution, ExxonMobil, Imperial, McMoRan, Newfield, Nexen, Petrobras, Questar, Petro-Canada, PWC, Ryder Scott, Shell, Swift, Total, and Wagner.

[39] See letters from CAPP, CFA, and Devon.

[40] See letters from Apache, Chesapeake, Eni, Equitable, and Imperial.

[41] See letters from CAPP, Devon, Eni, ExxonMobil, Imperial, and Wagner.

[42] See letters from Apache, Audit Quality, CAPP, CFA, Deloitte, E&Y, Energen, Eni, ExxonMobil, Imperial, KPMG, Newfield, PWC, Repsol, and Total.

[43] See letters from API, CAPP, and Shell.

[44] See letters from API, Canadian Natural, EnCana, ExxonMobil, and Total.

not inconsistent with the principles and objectives of financial reporting in authoritative accounting guidance.

With respect to accounting pronouncements that currently make reference to a single-day pricing regime with respect to oil and gas reserves, we are communicating with the FASB staff to align the standards used in its pronouncements with the 12-month average price used in our new rules, as several commenters recommended.[45] As discussed in more detail below, we are adopting a compliance date that will provide sufficient time to coordinate such activities with the FASB. However, as we discuss our revisions with the FASB, we will consider whether to delay the compliance date further.

3. Alternate Pricing Schemes

Some commenters on the Proposing Release believed that oil and gas futures prices, or management's forecast of future prices, would better represent the value of the reserves[46] and be better aligned with fair value of the reserves.[47] They indicated that management uses futures prices, not historical prices, in its planning and day-to-day decision making.[48] They suggested that the use of futures prices, combined with disclosure of how management made the estimates, would provide greater transparency[49] and comparability of disclosure.[50] One noted that historical prices have little to do with a company's future investments and values.[51] Another commenter noted that differentials can be calculated through established accounting procedures under SFAS 157.[52]

However, other commenters argued that futures prices are not available for all reserves locations[53] and that applying differentials to prices would require subjective estimates and reduce comparability among companies.[54] Two commenters noted that standard prices are not consistently available in some geographic regions.[55] Similarly, two commenters were concerned that futures price estimates would have to be accompanied by estimates of future costs, which they thought would be very subjective and not comparable for determining future economic conditions.[56] One commenter asserted that the use of future prices would require companies to document assumptions about future costs, or else the disclosure would be very inconsistent among reporting companies.[57] Three commenters believed that futures prices are more subject to market perceptions than market realities and are seldom used in actual physical trading of oil and gas.[58]

We share the concerns of many of these commenters that determinations of expected future prices could require significant estimations which could fall into a wide, albeit reasonable, range. For example, in many situations and parts of the world, natural gas is sold through longer term contracts where observable market inputs are not widely available. As a result, there could be less comparability among different companies depending on their assumptions, which are inherent in determining futures prices. Difference in assumptions between companies could reduce the comparability of reserves information between those companies.

We believe that the purpose of disclosing reserves estimates is to provide investors with information that is both meaningful and comparable. The reserves estimates in our disclosure rules, however, are not designed to be, nor are they intended to represent, an estimation of the fair market value of the reserves. Rather, the reserves disclosures are intended to provide investors with an indication of the relative quantity of reserves that is likely to be extracted in the future using a methodology that minimizes the use of non-reserves-specific variables. By eliminating assumptions underlying the pricing variable, as any historical pricing method would do, investors are able to compare reserves estimates where the differences are driven primarily by reserves-specific information, such as the location of the reserves and the grade of the underlying resource. We recognize that energy markets are continuing to develop. Therefore, we are not adopting a rule that requires companies to use futures prices to estimate reserves at this time.

4. Time Period Over Which the Average Price Is To Be Calculated

Numerous commenters on the Proposing Release recommended that the 12-month period used to calculate the average price for estimating reserves should not coincide with the fiscal year, as we proposed.[59] Most of these commenters recommended a 12-month period running from the beginning of the fourth quarter of the prior fiscal year through the end of the third quarter of the present fiscal year. For example, for a company with a fiscal year end of December 31, the relevant 12-month period would span from October 1 of the prior year to September 30 of the fiscal year covered by the annual report.[60] Several commenters suggested that we provide a two-month buffer between the end of the measurement period and the end of the company's fiscal year so that reserves estimates would be based on prices from November 1 through October 31 by a company with a fiscal year ending on December 31.[61] Commenters attributed the need for a buffer period to the accelerated filing dates for annual reports[62] and stated that they expected that the additional time would result in better, more accurate disclosure.[63] Others noted that some agreements, like production sharing contracts and other complex concession agreements, can make calculations difficult.[64] One commenter also noted that shifting the relevant measurement period so that it ends three-months prior to the fiscal-year end would align economic calculations with technical calculations, which typically occur at the end of the third quarter.[65]

As noted above, we have considered all of these recommendations. We are adopting a pricing formula based on the average of prices at the beginning of each month in the 12-month period prior to the end of the reporting period. A number of commenters believed that the use of first-of-the-month prices essentially would provide companies with one month more to prepare the reserves disclosures,[66] while still

[45] See letters from Apache, BHP, Canadian Natural, CAPP, CFA, Deloitte, McMoRan, Newfield, Nexen, Questar, Southwestern, Talisman, and Total.

[46] See letters from CFA, Deloitte, Grant Thornton, and McMoRan.

[47] See letters from CFA and Deloitte.

[48] See letters from CFA, Grant Thornton, and McMoRan.

[49] See letter from Deloitte.

[50] See letters from Deloitte and McMoRan.

[51] See letter from McMoRan.

[52] See letter from CFA.

[53] See letters from ExxonMobil and Wagner.

[54] See letters from EnCana, Evolution, ExxonMobil, Newfield, Ryder Scott, and Total.

[55] See letters from Ryder Scott and Total.

[56] See letters from SPE and Total.

[57] See letter from SPE.

[58] See letters from Evolution, Ryder Scott, and Wagner.

[59] See letters from Apache, API, BP, Canadian Natural, CAPP, EnCana, Eni, ExxonMobil, PEMEX, Petro-Canada, Repsol, Ryder Scott, Sasol, Shell, Total, van Wyk, and Wagner.

[60] See letters from Apache, API, BP, Canadian Natural, CAPP, Devon, Eni, ExxonMobil, PEMEX, Petro-Canada, Repsol, Ryder Scott, Sasol, Shell, Total, van Wyk, and Wagner.

[61] See letters from Canadian Natural, CAPP, Eni, Nexen, and Petro-Canada.

[62] See letters from API, Canadian Natural, CAPP, Devon, Evolution, PEMEX, Petrobras, Ryder Scott, Sasol, Shell, Total, and Wagner.

[63] See letters from Canadian Natural, CAPP, Nexen, Petrobras, Petro-Canada, Ryder Scott, Sasol, and Wagner.

[64] See letters from API and Shell.

[65] See letter from Shell.

[66] See letters from API, Devon, Eni, Evolution, ExxonMobil, PEMEX, Petrobras, PWC, Repsol, and Total.

aligning the time period with the fiscal year.[67] We agree with the commenters that such an average will provide companies more time to prepare more accurate disclosure, while still tying the pricing formula to the period covered by the annual report.

C. Extraction of Bitumen and Other Non-Traditional Resources

1. Definition of ''Oil and Gas Producing Activities''

Our current definition of ''oil and gas producing activities'' explicitly excludes sources of oil and gas from ''non-traditional'' or ''unconventional'' sources, that is, sources that involve extraction by means other than ''traditional'' oil and gas wells.[68] These other sources include bitumen extracted from oil sands, as well as oil and gas extracted from coal and shales, even though some of these resources are sometimes extracted through wells, as opposed to mining and surface processing. However, such sources are increasingly providing energy resources to the world due in part to advancements in extraction and processing technology.[69] Therefore, the rules we adopt today revise the definition of ''oil and gas producing activities'' to include such activities.[70]

All commenters on this issue supported including the extraction of unconventional resources as oil and gas producing activities.[71] They believed that such inclusion would greatly improve the quality and completeness of the disclosures.[72] Eight commenters noted that inclusion would better align disclosure with the way that companies view their operations.[73] Some noted that, although the distinction was reasonable decades ago when traditional resources dominated oil and gas production, the reality of today is that such unconventional resources are mainstream and companies invest significant amounts of capital to develop these resources.[74]

The revised definition of ''oil and gas producing activities'' that we adopt today includes the extraction of the non-traditional resources described above.[75] This amendment is intended to shift the focus of the definition of ''oil and gas producing activities'' to the final product of such activities, regardless of the extraction technology used. The amended definition states specifically that oil and gas producing activities include the extraction of saleable hydrocarbons, in the solid, liquid, or gaseous state, from oil sands, shale, coalbeds, or other nonrenewable natural resources which are intended to be upgraded into synthetic oil or gas, and activities undertaken with a view to such extraction.[76]

Currently, two types of natural resources pose a unique problem to establishing oil and gas reserves. Coal and, to a lesser degree, oil shale are used both as direct fuel and as feedstock to be converted into oil and gas. In response to our request for comment on how best to treat these resources, several commenters recommended that the extraction of coal[77] and oil shale[78] be categorized based on the final product. One commenter noted that investment decisions are based on the value and disposition of the final product.[79] We agree with these commenters and have revised the proposal to require a company to include coal and oil shale that is intended to be converted into oil and gas as oil and gas reserves. The adopted rules also, however, prohibit a company from including coal and oil shale that is not intended to be converted into oil and gas as oil and gas reserves.

2. Disclosure by Final Products

We proposed that disclosure of reserves would be organized based on the pre-processed resource extracted from the ground. For example, under the proposal, a company that extracted bitumen and processed that bitumen into synthetic crude oil in its own processing plant would have had to base its reserves disclosure on the amount of bitumen that was economically producible, not taking into account the economics of the processing plant. This proposal was consistent with our traditional separation of ''upstream'' activities such as drilling and producing oil and gas from ''downstream'' activities such as refining. Distinguishing between traditional resources and unconventional resources can be significant to investors because unconventional resources often involve significantly different economics and company resources than oil and gas from traditional wells.

Several commenters disagreed with our proposal, recommending that the determining factor should be the final product.[80] They believed that a company should be able to consider the prices of self-processed resources when estimating oil and gas reserves because the economics of the processing plant are critical to the registrant's evaluation of the economic producibility of the resources.[81] One commenter was concerned that distinguishing bitumen or other intermediate product from traditional oil and gas creates a false and misleading sense of comparability because producers that upgrade bitumen and sell synthetic crude do not face the same risks and rewards as do producers who sell the bitumen itself.[82]

We are persuaded by these commenters. However, we believe that the distinction between a company's traditional and unconventional activities is an important one from an investor's perspective because many of the unconventional activities are costlier and, therefore, have a much higher threshold of economic producibility. Therefore, we are revising the proposed table in Item 1202 to require separation of reserves based on final product, but distinguishing between final products that are traditional oil or gas from final products of synthetic oil or gas. We believe that with this separate disclosure, investors will be able to identify resources in projects that produce synthetic oil or gas that may be more sensitive to economic conditions from other resources.

In addition, as proposed, we are amending the definition of ''oil and gas producing activities'' to include activities relating to the processing or upgrading of natural resources from which synthetic oil or gas can be

[67] See letters from Devon and ExxonMobil.

[68] See Rule 4–10(a)(1)(ii)(D) [17 CFR 210.4–10(a)(1)(ii)(D)].

[69] Commenters noted that unconventional resources currently represent 45% of natural gas production in the U.S. See letters from American Clean Skies and IPAA.

[70] See Rule 4–10(a)(16) [17 CFR 210.4–10(a)(16)].

[71] See letters from American Clean Skies, Apache, API, Canadian Natural, CAPP, CAQ, CFA, Davis Polk, Devon, E&Y, EnCana, ExxonMobil, FERC, Imperial, IPAA, KPMG, Nexen, Petrobras, Petro-Canada, PRA, PWC, Repsol, Ryder Scott, Sasol, Shell, SPE, StatoilHydro, Talisman, Total, and Wagner.

[72] See letters from API, CAPP, CAQ, ExxonMobil, Imperial, PWC, Repsol, Ryder Scott, Total, and Wagner.

[73] See letters from API, CAQ, E&Y, ExxonMobil, Imperial, Petro-Canada, PWC, and Total.

[74] See letters from Imperial, IPAA, Repsol, and Total.

[75] See Rule 4–10(a)(16) [17 CFR 210.4–10(a)(16)].

[76] A hydrocarbon product is saleable if it is in a state in which it can be sold even if there is no ready market for that hydrocarbon product in the geographic location of the project. The absence of a market does not preclude the activity from being considered an oil and gas producing activity. However, in order to claim reserves for that hydrocarbon product from a particular location, there must be a market, or a reasonable expectation of a market, for that product.

[77] See letters from CAPP, ExxonMobil, Ryder Scott, Sasol, Shell, StatoilHydro, and Wagner.

[78] See letters from CAPP, ExxonMobil, Shell, StatoilHydro, and Wagner.

[79] See letter from ExxonMobil.

[80] See letters from Apache, Nexen, Petrobras, and Ryder Scott.

[81] See letters from Apache, CAQ, and Nexen.

[82] See letter from Nexen.

extracted. However, the definition would continue to exclude:

- Transporting, refining, processing (other than field processing of gas to extract liquid hydrocarbons by the company and the upgrading of natural resources extracted by the company other than oil or gas into synthetic oil or gas) or marketing oil and gas;
- The production of natural resources other than oil, gas, or natural resources from which synthetic oil and gas can be extracted; and
- The production of geothermal steam.

D. Proved Oil and Gas Reserves

We proposed to significantly revise the definition of ''proved oil and gas reserves.'' We are adopting that definition, substantially as proposed.[83] However, as noted above, we have decided to base the price used to establish economic producibility on the average price during the 12-month period prior to the ending date of the period covered by the report, determined as an unweighted arithmetic average of the first-day-of-the-month price for each month within such period.

One commenter recommended against using an average price to calculate existing economic conditions if the price is set by contractual arrangements.[84] We agree that under such circumstances, the appropriate price to use for establishing economic producibility is the price set by those contractual arrangements. Therefore, we have revised the definition to reflect that situation.[85]

The existing definition of the term ''proved oil and gas reserves'' incorporates certain specific concepts such as ''lowest known hydrocarbons'' which limit a company's ability to claim proved reserves in the absence of information on fluid contacts in a well penetration,[86] notwithstanding the existence of other engineering and geoscientific evidence.[87] We proposed revisions to the definition that would permit the use of new reliable technologies to establish the reasonable certainty of proved reserves. The proposed revisions to the definition of ''proved oil and gas reserves'' also included provisions for establishing levels of lowest known hydrocarbons and highest known oil through reliable technology other than well penetrations. We are adopting those revisions as proposed.

We also are adopting, as proposed, revisions that permit a company to claim proved reserves beyond those development spacing areas that are immediately adjacent to developed spacing areas if the company can establish with reasonable certainty that these reserves are economically producible.[88] These revisions are designed to permit the use of alternative technologies to establish proved reserves in lieu of requiring companies to use specific tests. In addition, they establish a uniform standard of reasonable certainty that applies to all proved reserves, regardless of location or distance from producing wells.

E. Reasonable Certainty

Both the existing definition of the term ''proved oil and gas reserves,'' and the definition of that term that we are adopting in this release, rely on the term ''reasonable certainty,'' which previously was not defined in Rule 4–10. In the Proposing Release, we proposed to define the term ''reasonable certainty'' as ''much more likely to be achieved than not'' to avoid ambiguity in that term's meaning. However, several commenters recommended that the rules mirror the PRMS definition more closely.[89] Four commenters were concerned that a different definition from the PRMS would cause confusion. They recommended using the PRMS standard of ''high degree of confidence that the quantities will be recovered.'' [90] One commenter recommended that, because the proposed definition is new, the Commission should adopt a safe harbor, to avoid potential uncertainty until a court interprets the phrase.[91] But others believed that the proposed definition is consistent with the PRMS definition.[92] One commenter opined that the concept of estimated ultimate recovery (EUR) is appropriate to establish proved oil and gas reserves.[93]

We believe that the terms ''high degree of confidence'' from the PRMS and ''much more likely to be achieved than not'' in our proposal have the same meaning. Our proposed language was not intended to change the level of certainty required to establish reasonable certainty. However, we agree that the use of terminology that is consistent with the PRMS will assist in the understanding of those terms. Therefore, we are adopting the ''high degree of confidence'' standard that exists in the PRMS. We also are clarifying that having a ''high degree of confidence'' means that a quantity is ''much more likely to be achieved than not, and, as changes due to increased availability of geoscience (geological, geophysical, and geochemical), engineering, and economic data are made to estimated ultimate recovery (EUR) with time, reasonably certain EUR is much more likely to increase or remain constant than to decrease'' to provide elaboration to the definition of reasonable certainty.

We are adopting a definition of ''reasonable certainty'' that addresses, and permits the use of, both deterministic methods and probabilistic methods for estimating reserves, as proposed. Nine commenters supported permitting the use of either deterministic methods or probabilistic methods.[94] One commenter believed that each method may be more appropriate for different situations.[95] Other commenters also supported the proposed alignment of the definitions of those terms with the definitions in the PRMS definitions.[96] The definition that we are adopting states that, if deterministic methods are used, reasonable certainty means a high degree of confidence that the quantities will be recovered.[97] Consistent with the PRMS definition, if probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate.

F. Developed and Undeveloped Oil and Gas Reserves

We proposed to revise the definitions of the terms ''proved developed oil and gas reserves'' and ''proved undeveloped oil and gas reserves.'' One commenter noted that the terms ''developed'' and ''undeveloped'' are not restricted to proved oil and gas reserves, but could apply to all classifications of reserves, including probable and possible reserves.[98] We agree with that

[83] See Rule 4–10(a)(22) [17 CFR 210.4–10(a)(22)].

[84] See letter from SPE.

[85] See Rule 4–10(a)(22)(v) [17 CFR 210.4–10(a)(22)(v)].

[86] In certain circumstances, a well may not penetrate the area at which the oil makes contact with water. In these cases, the company would not have information on the fluid contact and must use other means to estimate the lower boundary depths for the reservoir in which oil is located.

[87] See previous Rule 4–10(a)(2)(i) [17 CFR 210.4–10(a)(2)(i)].

[88] See Rule 4–10(a)(22) [17 CFR 210.4–10(a)(22)]. See Section II.G for a more detailed discussion regarding this provision.

[89] See letters from EIA, ExxonMobil, and Zakaib.

[90] See letters from Apache, EIA, Energen, and SPE.

[91] See letter from Evolution.

[92] See letters from EnCana, ExxonMobil, Petrobras, and Ryder Scott.

[93] Total.

[94] See letters from Apache, Devon, Evolution, Petro-Canada, Ryder Scott, Shell, SPE, Total, and Wagner.

[95] See letter from Wagner.

[96] See letters from AAPG, SPE, and Southwestern.

[97] See Rule 4–10(a)(24) [17 CFR 210.4–10(a)(24)].

[98] See letter from SPE. We note that with respect to oil and gas reserves, the term ''classification'' is

commenter. Although the development of a prospect may provide the company with more information and data to determine reserves amounts more accurately, companies may estimate proved, probable, and possible volumes regardless of the development stage. In the past, these terms were linked to the concept of proved reserves because our disclosure rules permitted the disclosure only of proved reserves. In light of our revision to allow disclosure of probable and possible reserves, the final rules define the terms ''developed oil and gas reserves'' and ''undeveloped oil and gas reserves'' to indicate that the development status of the reserves is relevant to all classifications of oil and gas reserves.[99]

1. Developed Oil and Gas Reserves

Other than the change discussed above to eliminate ''proved'' from the term being defined, we are adopting a definition of ''developed oil and gas reserves'' substantially as proposed. We proposed to define the term ''proved developed oil and gas reserves'' as proved reserves that:

- In projects that extract oil and gas through wells, can be expected to be recovered through existing wells with existing equipment and operating methods; and
- In projects that extract oil and gas in other ways, can be expected to be recovered through extraction technology installed and operational at the time of the reserves estimate.

Two commenters suggested that, consistent with the PRMS, reserves should be considered developed if the cost of any required equipment is relatively minor compared to the cost of a new well or the installed equipment.[100] Again, we agree that consistency with PRMS would improve compliance with our rules. In addition, such a revision is consistent with our existing definition of the term ''proved undeveloped reserves'' which includes reserves on which a well exists, but a relatively ''major'' expenditure is required for recompletion.[101] Therefore, the final rules provide that reserves also are developed if the cost of any required equipment is relatively minor compared to the cost of a new well.[102]

2. Undeveloped Oil and Gas Reserves

In the Proposing Release, we proposed a significantly revised definition of the term ''proved undeveloped oil and gas reserves.'' The most significant aspect of the proposed revision was the replacement of the existing ''certainty'' test for areas beyond one offsetting drilling unit[103] from a productive well with a ''reasonable certainty'' test. Currently, the definition of the term ''proved undeveloped reserves'' imposes a ''reasonable certainty'' standard for reserves in drilling units immediately adjacent to the drilling unit containing a producing well and a ''certainty'' standard for reserves in drilling units beyond the immediately adjacent drilling units.[104] All commenters on this issue supported the proposal.[105] Three commenters noted that a single standard-reasonable certainty-should apply to all proved reserves.[106] We are adopting this aspect of the definition as proposed.

Many commenters opposed the proposed language that would have imposed a five-year limit on maintaining undeveloped reserves unless ''unusual'' circumstances existed.[107] They asserted that large projects, projects in remote areas, and projects in continuous accumulations, such as oil sands, typically take more than five years to develop, but they do not view such projects as ''unusual.''[108] One commenter noted that the proposed rule is not consistent with the PRMS, which uses the term ''specific circumstances,'' rather than ''unusual circumstances.''[109] Other commenters suggested that we require the company to explain why it has not developed any undeveloped reserves for more than five years.[110] The intent of the proposal was not to exclude projects that typically take more than five years to develop from being considered reserves. We agree that the rule should allow the recognition of reserves in projects that are expected to run more than five years, regardless of whether ''unusual'' circumstances exist. Therefore, we have revised the rule to replace the term ''unusual'' with the term ''specific.''[111] We note that, as proposed, Item 1203 of Regulation S–K would require disclosure regarding why such undeveloped reserves have not been developed.[112]

We also proposed to broaden the definition of the term ''proved undeveloped reserves'' to permit a company to include, in its undeveloped reserves estimates, quantities of oil that can be recovered through improved recovery projects and to expand the technologies that a company can use to establish reserves. Under the existing definition, a company can include such quantities only if techniques have been proved effective by actual production from projects in the area and in the same reservoir. As proposed, we are expanding this definition of the term ''undeveloped oil and gas reserves'' to permit the use of techniques that have been proved effective by actual production from projects in the same reservoir or an analogous reservoir or ''by other evidence using reliable technology that establishes reasonable certainty.''[113]

We also are making other, less substantive revisions to the definition of ''undeveloped oil and gas reserves.'' First, commenters suggested that we use the term ''development spacing''[114] or ''drainage areas''[115] instead of ''drilling units'' because the term ''drilling units'' is only relevant in jurisdictions that establish such units. They noted that many foreign jurisdictions do not establish such units. We concur with those commenters and have replaced the term ''drilling units'' with the term ''development spacing areas.''

One commenter also noted that the PRMS guidance on the use of analogs for improved recovery projects does not limit such use to ''within the immediate area'' and recommended that we delete this phrase from the definition.[116] Again, we agree that consistency with PRMS would be beneficial in this instance and have deleted that phrase

used to indicate the level of certainty that estimated amounts will be recovered. Thus, although the terms ''developed'' and ''undeveloped'' may be considered means in which to generically ''classify'' reserves, for clarity, we use that term to be consistent with industry usage.

[99] See Rules 4–10(a)(6) and (31) [17 CFR 210.4–10(a)(6) and (31)].

[100] See letters from SPE and Total.

[101] See previous Rule 4–10(a)(4) [17 CFR 210.4–10(a)(4)].

[102] See Rule 4–10(a)(6) [17 CFR 210.4–10(a)(6)].

[103] As noted later in this section of the release, we are replacing the term ''drilling unit'' with the term ''development spacing area'' in the final rules. However, for purposes of discussing the proposal and the existing rules, we continue to use the term ''drilling unit'' because that is the term used in the proposal and the existing rules.

[104] See previous Rule 4–10(a)(4) [17 CFR 210.4–10(a)(4)]. A drilling unit refers to the spacing between wells required by some local jurisdictions to prevent wasting resources and optimize recovery.

[105] See letters from American Clean Skies, Apache, API, Canadian Natural, CAPP, Chesapeake, Devon, Evolution, ExxonMobil, McMoRan, Petro-Canada, Questar, Repsol, Southwestern, Shell, SPE, Total, and Wagner.

[106] See letters from Devon, EnCana, and Equitable.

[107] See letters from American Clean Skies, Apache, CAPP, Chesapeake, EnCana, ExxonMobil, Luscher, Newfield, Nexen, Petrobras, Petro-Canada, Ryder Scott, Shell, SPE, and Total.

[108] See letters from American Clean Skies, CAPP, Chesapeake, EnCana, ExxonMobil, Newfield, Nexen, Petrobras, Petro-Canada, Ryder Scott, Shell, and Total.

[109] See letter from SPE.

[110] See letters from Devon, Ryder Scott, and Wagner.

[111] See Rule 4–10(a)(31) [17 CFR 210.4–10(a)(31)].

[112] See Item 1203(d) [17 CFR 229.1203(d)].

[113] See Rule 4–10(a)(31) [17 CFR 210.4–10(a)(31)].

[114] See letter from Total.

[115] See letter from SPE.

[116] See letter from SPE.

from the definition. We also have eliminated two paragraphs of the proposed definition because they were largely repetitive of other aspects of the definition and were unnecessary.[117]

G. Reliable Technology

1. Definition of the Term ''Reliable Technology''

We are adopting, substantially as proposed, a new definition of ''reliable technology'' that would broaden the types of technologies that a company may use to establish reserves estimates and categories. All commenters on this topic supported the proposed principles-based definition for reliable technology.[118]

The current rules limit the use of alternative technologies as the basis for determining a company's reserves disclosures. For example, under the current rules, a company must use actual production or flow tests to meet the ''reasonable certainty'' standard necessary to establish the proved status of its reserves.[119] Similarly, the current rules provide bright line tests for determining fluid contacts, such as lowest known hydrocarbons and highest known oil, which establish the volume of the hydrocarbons in place.

We recognize that technologies have developed, and will continue to develop, improving the quality of information that can be obtained from existing tests and creating entirely new tests that we cannot yet envision. Thus, the new definition of the term ''reliable technology'' permits the use of technology (including computational methods) that has been field tested and has demonstrated consistency and repeatability in the formation being evaluated or in an analogous formation. This new standard will permit the use of a new technology or a combination of technologies once a company can establish and document the reliability of that technology or combination of technologies.

We are adopting certain revisions to our proposed definition of the term ''reliable technology.'' The proposal also would have required reliable technology to be ''widely accepted.'' However, some commenters were concerned that this requirement would exclude proprietary technologies that companies develop internally that have proven to be reliable.[120] We concur with these commenters and have removed the ''widely accepted'' requirement from the final rule.

We also proposed to define the term ''reliable technology,'' expressed in probabilistic terms, as technology that has been proven empirically to lead to correct conclusions in 90% or more of its applications. Several commenters expressed concern that this proposed 90% threshold would be difficult to verify and support on an ongoing basis.[121] We agree that a bright line test would be difficult to apply to a particular technology or mix of technologies to determine their reliability. Therefore, we are not adopting the 90% threshold as part of the definition.

2. Disclosure of Technologies Used

The proposal would have required a company to disclose the technology used to establish reserves estimates and categories for material properties in a company's first filing with the Commission and for material additions to reserves estimates in subsequent filings because, under the proposal, a company would be able to select the technology or mix of technologies that it uses to establish reserves. Two commenters supported the proposal because they believed that disclosure of the technologies used is reasonable if the definition of ''reliable technology'' is principles-based.[122] However, many other commenters were concerned that the proposed requirement to disclose the technologies used to establish levels of certainty for reserves estimates would lead to very complex, technical disclosures that would have little meaning to investors.[123] Others were concerned that disclosure of the technology, or the mix of technologies, might cause competitive harm.[124]

As an alternative, some commenters recommended that the rule require a more general overview of the technologies used.[125] We are clarifying that the required disclosure would be limited to a concise summary of the technology or technologies used to create the estimate.[126] A company would not be required to disclose proprietary technologies, or a proprietary mix of technologies, at a level of specificity that would cause competitive harm. Rather, the disclosure may be more general. For example, a company may disclose that it used a combination of seismic data and interpretation, wireline formation tests, geophysical logs, and core data to calculate the reserves estimate. As noted, however, the Commission's staff, as part of the review and comment process, may continue to request companies to provide supplemental data, consistent with current practice,[127] which, under the new rules, may include information sufficient to support a company's conclusion that a technology or mix of technologies used to establish reserves meets the definition of ''reliable technology.''

Two commenters supported the proposal to limit the disclosures to technologies used to establish reserves in a company's first filing with the Commission and material additions to reserves.[128] We are adopting this limitation as proposed.[129] If the company has not previously disclosed reserves estimates in a filing with the Commission or is disclosing material additions to its reserves estimates, the company must disclose the technologies used to establish the appropriate level of certainty for reserves estimates from material properties included in the total reserves disclosed and the particular properties do not need to be identified. We believe that requiring such disclosure when reserves, or material additions to reserves, are reported for the first time will discourage the use of questionable technologies to establish reserves. However, we do not believe it is necessary to require a company to disclose the technology or technologies

[117] These paragraphs would have clarified (1) in a conventional accumulation, offsetting productive units must lie within an area in which economic producibility has been established by reliable technology to be reasonably certain and (2) proved reserves can be claimed in a conventional or continuous accumulation in a given area in which engineering, geoscience, and economic data, including actual drilling statistics in the area, and reliable technology show that, with reasonable certainty, economic producibility exists beyond immediately offsetting drilling units. We do not believe that these statements, based on the terms ''conventional accumulation'' and ''continuous accumulation'' which are no longer being defined continue to serve a helpful purpose. See Section II.J.5 of this release.

[118] See letters from AAPG, American Clean Skies, Apache, CFA, Davis Polk, Devon, EnCana, ExxonMobil, Petrobras, Ryder Scott, Sasol, Shell, SPE, Southwestern, and Wagner.

[119] However, in the past, the Commission's staff has recognized that flow tests can be impractical in certain areas, such as the Gulf of Mexico, where environmental restrictions effectively prohibit these types of tests. The staff has not objected to disclosure of reserves estimates for these restricted areas using alternative technologies.

[120] See letters from Chesapeake, ExxonMobil, Shell, and Total.

[121] See letters from AAPG, Apache, EIA, Evolution, Ryder Scott, Shell, SPE, and Wagner.

[122] See letters from Davis Polk and Sasol.

[123] See letters from API, Devon, Eni, ExxonMobil, PEMEX, Petro-Canada, Questar, Repsol, Ryder Scott, Shell, Southwestern, StatoilHydro, and Total.

[124] See letters from API, Devon, Evolution, ExxonMobil, Ryder Scott, StatoilHydro, and Total.

[125] See letters from EnCana, Eni, Evolution, Ryder Scott, and Shell.

[126] See Item 1202(a)(6) [17 CFR 229.1202(a)(6)].

[127] Currently, the Commission's staff requests supplemental data pursuant to Instruction 4 to Item 102 of Regulation S–K [17 CFR 229.102], Rule 418 [17 CFR 230.418], and Rule 12b–4 [17 CFR 240.12b–4]

[128] See letters from Southwestern and Wagner.

[129] See Item 1202(a)(6) [17 CFR 229.1202(a)(6)].

relied upon to establish reserves previously disclosed under our rules because the permitted technologies have been limited to those permitted by our existing rule. In addition, we believe that ongoing disclosure of the technologies used to establish all of a company's reserves would become unnecessarily cumbersome.

H. Unproved Reserves—''Probable Reserves'' and ''Possible Reserves''

As discussed more fully in Section IV.B.3 of this release addressing the disclosure requirements of new Subpart 1200, we are adopting the proposal to permit disclosure of probable and possible reserves. Therefore, we are adopting the proposed definitions of the terms ''probable reserves'' and ''possible reserves'' as proposed.

When producing an estimate of the amount of oil and gas that is recoverable from a particular reservoir, a company can make three types of estimates:

- An estimate that is reasonably certain;
- An estimate that is as likely as not to be achieved; and
- An estimate that might be achieved, but only under more favorable circumstances than are likely.

These three types of estimates are known in the industry as (1) proved, (2) proved plus probable, and (3) proved plus probable plus possible reserves estimates.

1. Probable Reserves

We are adopting the definition of the term ''probable reserves'' as proposed. It states that ''probable reserves'' are those additional reserves that are less certain to be recovered than proved reserves but which, in sum with proved reserves, are as likely as not to be recovered.[130] This definition provides guidance for the use of both deterministic and probabilistic methods. The definition clarifies that, when deterministic methods are used, it is as likely as not that actual remaining quantities recovered will equal or exceed the sum of estimated proved plus probable reserves. Similarly, when probabilistic methods are used, there must be at least a 50% probability that the actual quantities recovered will equal or exceed the proved plus probable reserves estimates. This definition was derived from the PRMS definition of the term ''probable reserves.'' Several commenters agreed with the proposed definition of this term, noting that it is roughly consistent with PRMS.[131]

2. Possible Reserves

We also are adopting the definition of the term ''possible reserves'' as proposed. The new definition states that possible reserves include those additional reserves that are less certain to be recovered than probable reserves.[132] It clarifies that, when deterministic methods are used, the total quantities ultimately recovered from a project have a low probability to exceed the sum of proved, probable, and possible reserves. When probabilistic methods are used, there must be at least a 10% probability that the actual quantities recovered will equal or exceed the sum of proved, probable, and possible estimates. Several commenters noted that our proposed definition of the term ''possible reserves'' was consistent with PRMS, which also uses a 10% threshold.[133] One commenter recommended that the threshold for ''possible reserves'' should be a 25% likelihood of recovery because that percentage would be more meaningful than 10%.[134] We believe that a definition consistent with the PRMS will provide the most certainty and clarity for companies and investors.

I. Reserves

We proposed to add a definition of the term ''reserves'' to our rules. The proposed definition would have described the criteria that an accumulation of oil, gas, or related substances must satisfy to be considered reserves (of any classification), including non-technical criteria such as legal rights. Specifically, we proposed to define reserves as the estimated remaining quantities of oil and gas and related substances anticipated to be recoverable, as of a given date, by application of development projects to known accumulations based on:

- Analysis of geoscience and engineering data;
- The use of reliable technology;
- The legal right to produce;
- Installed means of delivering the oil, gas, or related substances to markets, or the permits, financing, and the appropriate level of certainty (reasonable certainty, as likely as not, or possible but unlikely) to do so; and
- Economic producibility at current prices and costs.

The proposed definition also would have clarified that reserves are classified as proved, probable, and possible according to the degree of uncertainty associated with the estimates. We are not adopting the definition as proposed. Four commenters recommended clarification that the term ''legal right to produce'' extends beyond the initial term of an oil and gas concession if there is a reasonable expectation that the concession will be renewed, consistent with the PRMS and current staff position.[135] We are adopting a definition of the term ''reserves'' that more closely parallels the PRMS definition of that term.

Our final rules define the term ''reserves'' as the estimated remaining quantities of oil and gas and related substances anticipated to be economically producible, as of a given date, by application of development projects to known accumulations.[136] In addition, there must exist, or there must be a reasonable expectation that there will exist, the legal right to produce or a revenue interest in the production of oil and gas, installed means of delivering oil and gas or related substances to market, and all permits and financing required to implement the project.

A note to the definition clarifies that reserves should not be assigned to adjacent reservoirs isolated by major, potentially sealing, faults until those reservoirs are penetrated and evaluated as economically producible and that reserves should not be assigned to areas that are clearly separated from a known accumulation by a non-productive reservoir (*i.e.*, absence of reservoir, structurally low reservoir, or negative test results). Such areas may contain prospective resources (*i.e.*, potentially recoverable resources from undiscovered accumulations).[137]

One notable difference between our final definition of ''reserves'' and the PRMS definition is that our definition is based on ''economic producibility'' rather than ''commerciality.'' One commenter believed that reserves must be ''commercial,'' as stated in the PRMS definition.[138] However, commerciality introduces a subjective aspect to the price used to establish existing economic conditions by factoring in the rate of return required by a particular company before it will commit resources to the project. This rate of return will vary among companies, reducing the comparability among disclosures. Therefore, the adopted definition of the term ''reserves'' relies on economic producibility, as proposed.

[130] See Rule 4–10(a)(18) [17 CFR 210.4–10(a)(18)].

[131] See letters from Devon, EnCana, SPE, and StatoilHydro.

[132] See Rule 4–10(a)(17) [17 CFR 210.4–10(a)(17)].

[133] See letters from Devon, EnCana, SPE, and StatoilHydro.

[134] See letter from Evolution.

[135] See letters from API, CAQ, Grant Thornton, and KPMG.

[136] See Rule 4–10(a)(26) [17 CFR 210.4–10(a)(26)].

[137] See Note to Rule 4–10(a)(26) [17 CFR 210.4–10(a)(26)].

[138] See letter from StatoilHydro.

J. Other Supporting Terms and Definitions

We also proposed to define several other terms primarily to support and clarify the definitions of the key terms. We are adopting most of those supporting definitions as discussed in further detail below.

1. Deterministic Estimate

A company can derive two different types of reserves estimates depending on the method used to calculate the estimates. These two types of estimates are known as ''deterministic estimates'' and ''probabilistic estimates.'' [139] In the Proposing Release, we proposed to define the term ''deterministic estimate'' as an estimate based on a single value for each parameter (from the geoscience, engineering, or economic data) in the reserves calculation that is used in the reserves estimation procedure. We are adopting that definition as proposed.

2. Probabilistic Estimate

We are adopting a new definition of the term ''probabilistic estimate'' substantially as proposed. The new rule defines the term ''probabilistic estimate'' as an estimate that is obtained when the full range of values that could reasonably occur from each unknown parameter (from the geoscience and engineering data) is used to generate a full range of possible outcomes and their associated probabilities of occurrence.[140] In response to a comment received, however, we revised the definition so that it does not include the application of a range of values with respect to economic conditions because those conditions, such as prices and costs, are based on historical data, and therefore are an established value, rather than a range of estimated values.[141]

3. Analogous Reservoir

We proposed a definition of the term ''analogous formation in the immediate area.'' As noted above, we received comment indicating that the use of appropriate analogs should not be limited to the immediate area in which the reserves are being estimated.[142] Therefore, we have changed the defined term to ''analogous reservoir.'' [143] In addition, based on commenters' remarks, we are defining the term ''analogous reservoir'' in a manner that is more consistent with the PRMS, which addresses more specifically the types of reservoirs that may be used as analogues. The new definition of the term ''analogous reservoir'' states that analogous reservoirs, as used in resources assessments, have similar rock and fluid properties, reservoir conditions (depth, temperature, and pressure) and drive mechanisms, but are typically at a more advanced stage of development than the reservoir of interest and thus may provide concepts to assist in the interpretation of more limited data and estimation of recovery.[144] When used to support proved reserves, an ''analogous reservoir'' refers to a reservoir that shares the following characteristics with the reservoir of interest:

- Same geological formation (but not necessarily in pressure communication with the reservoir of interest);
- Same environment of deposition;
- Similar geological structure; and
- Same drive mechanism.

As proposed, the new definition includes an instruction that clarifies that reservoir properties must, in the aggregate, be no more favorable in the analog than in the reservoir of interest. The new definition also clarifies that, although an analogous reservoir must be in the same geological formation as the reservoir of interest, it need not be in pressure communication with the reservoir of interest.

4. Definitions of Other Terms

We received no comment with regard to several of the proposed supporting definitions. We are adopting those definitions substantially as proposed without material changes. They include the following terms:

- ''Condensate''; [145]
- ''Development project''; [146]
- ''Economically producible''; [147]
- ''Estimated ultimate recovery,'' [148]
- ''Exploratory well''; [149]
- ''Extension well''; [150] and
- ''Resources.'' [151]

Most of these supporting terms and their definitions are based on similar terms in the PRMS. The definition of ''resources'' is based on the Canadian Oil and Gas Evaluation Handbook (COGEH).

In the Proposing Release, we solicited comment on whether we should adopt any other supporting definitions. One commenter submitted an appendix to its letter containing numerous other terms that it thought we should adopt.[152] We have decided not to adopt those additional definitions because we feel that they are unnecessary at this time. However, we have decided to adopt a definition for the term ''bitumen.'' We believe that providing a definition for this term will lead to more consistency among disclosures because there currently are several competing definitions of that term used in the industry.

We are defining the term ''bitumen'' as ''petroleum in a solid or semi-solid state in natural deposits. In its natural state, it usually contains sulfur, metals, and other non-hydrocarbons. Bitumen has a viscosity greater than 10,000 centipoise measured at original temperature in the deposit and atmospheric pressure, on a gas free basis.'' [153] This definition is similar to the PRMS definition of ''natural bitumen.''

5. Proposed Terms and Definitions Not Adopted

We proposed definitions for the terms ''continuous accumulations'' and ''conventional accumulations'' to assist companies in disclosing segregated reserves based on these two types of accumulations. As noted elsewhere in this release, the final rules do not require disclosure based on the type of accumulation in which the reserves are found.[154] Therefore, there is no need to define these terms and we are not adopting the proposed definitions.

Similarly, we proposed a definition for the term ''sedimentary basin'' because it would have been part of our definition of the term ''by geographic area.'' As noted elsewhere in this release, we have substantially revised the definition of the term ''by geographic area'' [155] and the term ''sedimentary basin'' is no longer needed, so we are not adopting this proposed term and definition.

As noted above, one commenter recommended that we adopt a large glossary of terms and definitions that correspond with the PRMS definitions.[156] Rather than defining an extensive glossary of terms in our rules

[139] See Rules 4–10(a)(5) and (a)(19) [17 CFR 210.4–10(a)(5) and (a)(19)]. These definitions are based on the Canadian Oil and Gas Evaluation Handbook (COGEH). This handbook was developed by the Calgary Chapter of the Society of Petroleum Evaluation Engineers and the Petroleum Society of CIM to establish standards to be used within the Canadian oil and gas industry in evaluating oil and gas reserves and resources.

[140] See Rule 4–10(a)(19) [17 CFR 210.4–10(a)(19)].

[141] See letter from Shell.

[142] See letter from SPE.

[143] See Rule 4–10(a)(2) [17 CFR 210.4–10(a)(2)].

[144] See Rule 4–10(a)(2) [17 CFR 210.4–10(a)(2)].

[145] See Rule 4–10(a)(4) [17 CFR 210.4–10(a)(4)].

[146] See Rule 4–10(a)(8) [17 CFR 210.4–10(a)(8)].

[147] See Rule 4–10(a)(10) [17 CFR 210.4–10(a)(10)].

[148] See Rule 4–10(a)(11) [17 CFR 210–4–10(a)(11)].

[149] See Rule 4–10(a)(13) [17 CFR 210.4–10(a)(13)].

[150] See Rule 4–10(a)(14) [17 CFR 210.4–10(a)(14)].

[151] See Rule 4–10(a)(28) [17 CFR 210.4–10(a)(28)].

[152] See letter from SPE.

[153] See Rule 4–10(a)(3) [17 CFR 210.4–10(a)(3)].

[154] See Section III.B.3.c.

[155] See Section III.B.2.a.

[156] See letter from SPE.

and attempting to constantly update those definitions, we advise companies to look to definitions that are commonly accepted within the oil and gas industry to the extent such definitions are not in, or inconsistent with, our rules.

K. Alphabetization of the Definitions Section of Rule 4–10

We are alphabetizing the definitional terms in Rule 4–10(a) because we are adding a significant number of defined terms to this section.

III. Revisions to Full Cost Accounting and Staff Accounting Bulletin

As we noted in Section II.B.2 of this release, commenters unanimously opposed our proposal to use different prices for disclosure and accounting purposes. We agree with those commenters and are revising our proposal to use a 12-month average price for accounting purposes. These revisions primarily will appear under the full cost accounting method described in Rule 4–10(c) [157] of Regulation S–X. The full cost accounting method permits certain oil and gas extraction costs to accumulate on a company's balance sheet subject to a limitation test or a ''ceiling'' as described in Rule 4–10(c)(3)(4). Like reserve disclosures, these capitalized costs and the related limitation test are not fair value based measurements. Rather the capitalized costs represent the accumulated historical acquisition, exploration and development costs (net of any previously recorded depletion, amortization or ceiling test write downs) incurred for oil and gas producing activities, limited to a standardized mathematical calculation (the full cost ceiling) adopted over 25 years ago. Costs that do not exceed the limitation are deferred and amortized over time. The limitation test calculation on capitalized costs is not designed or intended to represent a fair valuation of the related oil and gas assets.[158]

Similar to the single-day, year-end pricing used under the successful efforts method,[159] the application of the full cost method of accounting in Rule 4–10(c) has used ''current prices,'' interpreted as single-day, year-end prices, as the basis for calculating the limitation on costs that may be capitalized under the full cost method. In order to further the objective of providing comparable oil and gas reserve quantities, our final rule clarifies that the term ''current prices'' as used in Rule 4–10(c) is consistent with the 12-month average price as calculated in Rule 4–10(a)(22)(v).[160]

However, since these calculations are not designed to result in a calculation of fair value and since the change to the full cost accounting method would effectively eliminate the anomalies caused by the single-day, year-end price currently used in the limitation test, the SEC staff will eliminate portions of Staff Accounting Bulletin (SAB) Topic 12:D.3.c that permit consideration of the impact of price increases subsequent to the period end on the ceiling limitation test.

The combination of adopting a 12-month average pricing mechanism and eliminating portions of SAB Topic 12:D.3.c could have the effect of requiring a company using the full cost accounting method to record a ceiling test write-down in income during periods of rising oil and gas prices. In that situation, it is possible that using a 12-month average price in the ceiling test calculation might result in a write-down that would not otherwise have been required had the full cost company been permitted to use the single-day, year-end price. Conversely, it is also possible that in periods of declining oil and gas prices, the application of this rule could result in the deferral of ceiling test write-downs. In that situation, it is possible that using a 12-month average price in the ceiling limitation test calculation might not result in a write-down in situations where a write down would have otherwise been required had the full cost company been required to use a single-day, year-end price in its ceiling limitation test calculation.

Because the application of the ceiling limitation test is not a fair-value-based calculation but rather a limit on the amount of certain oil and gas related exploration costs that can be capitalized, portions of which would have resulted in write-downs in prior periods under other methods of accounting, we believe the benefits of using a single pricing mechanism justify the potential changes to the timing of those ceiling test write-downs or amortizations amounts. However, as discussed in Section V of this release, we believe that the company should discuss such situations, if material, particularly when pricing trends indicate the possibility of future write-downs, in Management's Discussion and Analysis and, where appropriate, the notes to the financial statements.

IV. Update and Codification of the Oil and Gas Disclosure Requirements in Regulation S–K

The Proposing Release proposed to update and codify Securities Act and Exchange Act Industry Guide 2: Disclosure of Oil and Gas Operations (Industry Guide 2).[161] Industry Guide 2 currently sets forth most of the disclosures that an oil and gas company provides regarding its reserves, production, property, and operations. Regulation S–K references Industry Guide 2 in Instruction 8 to Item 102 (Description of Property), Item 801 (Securities Act Industry Guides), and Item 802 (Exchange Act Industry Guides). However, Industry Guide 2 itself does not appear in Regulation S–K or in the Code of Federal Regulations. The rules that we adopt today codify the contents of Industry Guide 2 in a new Subpart 1200 of Regulation S–K.

A. Revisions to Items 102, 801, and 802 of Regulation S–K

The instructions to Item 102 of Regulation S–K, as well as Items 801 and 802 of Regulation S–K, currently reference the industry guides. Because we are codifying the Industry Guide 2 disclosures in a new Subpart 1200 of Regulation S–K, we are revising the instructions to Item 102 to reflect this change.[162] We also are eliminating the references in Items 801 and 802 to Industry Guide 2 because that industry guide will cease to exist upon effectiveness of the amendments we adopt today.[163]

In addition, Instruction 5 to Item 102 of Regulation S–K currently prohibits the disclosure of reserves other than proved oil and gas reserves. Because we are adopting rules to permit disclosure of probable and possible oil and gas reserves, we are revising Instruction 5 to limit its applicability to extractive enterprises other than oil and gas producing activities, such as mining activities.[164] Similarly, Instruction 3 of

[157] 17 CFR 210.4–10(c).

[158] While not intended to represent fair value, costs that are written down because they exceed the ceiling limitation are accounted for in the same manner as impairments recognized under accounting generally. That is, once the asset is written down, it becomes the new historical cost basis and cannot be reinstated for subsequent increases in the ceiling. See Rule 4–10(c)(4)(i) of Regulation S–X [17 CFR 210–4–10(c)(4)(i)].

[159] The accounting guidance refers to our definition of proved reserves under existing Rule 4–10(a)(2), which currently uses a single-day, year-end price to establish reserves amounts.

[160] See Rule 4–10(c)(8) [17 CFR 210.4–10(c)(8)].

[161] Exchange Act Industry Guide 2 merely references, and therefore is identical to, Securities Act Industry Guide 2.

[162] See revised Instructions 4 and 8 to Item 102 [17 CFR 229.102].

[163] See revised Item 801 and 802 [17 CFR 229.801 and 802].

[164] See revised Instruction 5 to Item 102 [17 CFR 229.102]. Extractive enterprises include enterprises such as mining companies that extract resources from the ground.

Item 102, regarding production, reserves, locations, development and the nature of the company's interests, will no longer apply to oil and gas producing activities, so we also are limiting that instruction to mining activities.[165]

Finally, we are eliminating Instruction 4 to Item 102 regarding the ability of the Commission's staff to request supplemental information, including reserves reports. This instruction is duplicative of Securities Act Rule 418 [166] and Exchange Act 12b–4,[167] regarding the staff's general ability to request supplemental information.

B. Proposed New Subpart 1200 to Regulation S–K Codifying Industry Guide 2 Regarding Disclosures by Companies Engaged in Oil and Gas Producing Activities

1. Overview

We are adding a new Subpart 1200 to Regulation S–K that codifies the disclosure requirements related to companies engaged in oil and gas producing activities. This new subpart largely includes the existing requirements of Industry Guide 2. However, we have revised these requirements to update them, provide better clarity with respect to the level of detail required in oil and gas disclosures, including the geographic areas by which disclosures need to be made, and provide formats for tabular presentation of these disclosures. In addition, Subpart 1200 contains the following new disclosure requirements, many of which have been requested by industry participants:

- Disclosure of reserves from non-traditional sources (*e.g.*, bitumen, shale, coal) as oil and gas reserves;
- Optional disclosure of probable and possible reserves;
- Optional disclosure of oil and gas reserves' sensitivity to price;
- Disclosure of the development of proved undeveloped reserves;
- Disclosure of technologies used to establish additions to reserves estimates;
- Disclosure of a company's internal controls over reserves estimation and the qualifications of the business entity or individual preparing or auditing the reserves estimates; and
- Disclosure based on a new definition of the term ''by geographic area.''

We discuss each of these proposed new Items below.

2. Item 1201 (General Instructions to Oil and Gas Industry-Specific Disclosures)

We are adding new Item 1201 to Regulation S–K. This item sets forth the general instructions to Subpart 1200. The new item contains three paragraphs that perform the following tasks:

- Instruct companies for which oil and gas producing activities are material to provide the disclosures specified in Subpart 1200; [168]
- Clarify that, although a company must present specified Subpart 1200 information in tabular form, the company may modify the format of the table for ease of presentation, to add additional information or to combine two or more required tables;
- State that the definitions in Rule 4–10(a) of Regulation S–X apply to Subpart 1200; and
- Define the term ''by geographic area.''

a. Geographic Area

We received significant comments regarding the proposed definition of the term ''by geographic area.'' We proposed to require disclosure by continent, country containing 15% of more of the company's reserves, and sedimentary basin or field containing 10% or more of the company's reserves. Several commenters were concerned that the proposed definition would add too much detail to the disclosures, particularly at the basin or field level.[169] They were concerned that this amount of detail would make disclosures too complex and incoherent.[170] They were particularly concerned with the extension of this standard to disclosures other than reserves, such as production, wells, and acreage.[171] Commenters also believed that the disclosures, in particular by field, could cause competitive harm in future property sales transactions, unitization agreements, and other asset transfers.[172]

Some commenters also believed that some of these disclosures may be prohibited by foreign governments.[173] One commenter noted that separate determination of field or basin reserves within a larger production sharing agreement may not be possible due to concession-wide cost sharing terms.[174] Eight commenters recommended that the determination of appropriate geographic disclosure should remain with management, consistent with Statement of Financial Accounting Standard No. 69 (SFAS 69).[175] However, two commenters indicated that a country-by-country breakdown would be adequate.[176]

Four commenters supported the proposed percentage thresholds for geographic disclosure, stating that they would increase understanding of the total energy supply, leading to better decisions by policy makers.[177] One commenter supported the 15% threshold for countries.[178]

As we noted in the Proposing Release, there have been differing interpretations among oil and gas companies as to the level of specificity required when a company is breaking out its reserves disclosures based on geographic area as required by Instruction 3 of Item 102 of Regulation S–K.[179] Some companies currently broadly organize their reserves only by hemisphere or continent. SFAS 69 requires reserves disclosure to be separately disclosed for the company's home country and foreign geographic areas. It defines ''foreign geographic areas'' as ''individual countries or groups of countries as appropriate for meaningful disclosure in the circumstances.'' Since SFAS 69 was issued, the operations of oil and gas companies have become much more diversified globally. For many large U.S. oil and gas producers, the majority of reserves are now overseas, with material amounts in individual countries and even individual fields or basins.

We think that greater specificity than simply disclosing reserves within ''groups of countries'' would benefit investors and, in certain cases, may be necessary to meet the requirements of Item 102 of Regulation S–K. Some countries in which many of these companies operate and may have significant reserves are subject to unique risks, such as political instability.

[165] See revised Instruction 3 to Item 102 [17 CFR 229.102].

[166] 17 CFR 230.418.

[167] 17 CFR 240.12b–4.

[168] This paragraph would maintain the existing exclusion in Industry Guide 2 for limited partnerships and joint ventures that conduct, operate, manage, or report upon oil and gas drilling or income programs, that acquire properties either for drilling and production, or for production of oil, gas, or geothermal steam or water.

[169] See letters from Apache, CAPP, Devon, ExxonMobil, Imperial, Nexen, Repsol, Shell, and StatoilHydro.

[170] See letters from Apache, CAPP, ExxonMobil, Imperial, Nexen, and Repsol.

[171] See letters from ExxonMobil, Imperial, and Total.

[172] See letters from Apache, API, BHP, Canadian Natural, CAPP, Devon, EnCana, Eni, Newfield, Nexen, Petro-Canada, Shell, StatoilHydro, and Total.

[173] See letters from Apache, API, CAPP, Eni, Newfield, Petro-Canada, and Total.

[174] See letter from Apache.

[175] See letters from Apache, API, Canadian Natural, CAPP, Eni, ExxonMobil, Imperial, and Petro-Canada.

[176] See letters from ExxonMobil and Nexen.

[177] See letters from AAPG, CFA, Chesapeake, and E&Y.

[178] See letter from Shell.

[179] 17 CFR 229.102.

However, we recognize that disclosure that is too detailed may detract from the overall disclosure. Thus, we have revised the definition of the term ''by geographic area'' to mean, as appropriate for meaningful disclosure under a company's particular circumstances:

(1) By individual country;

(2) By groups of countries within a continent; or

(3) By continent.[180]

This definition is substantially the same as the definition currently provided in SFAS 69. However, as proposed, we are adopting specific percentage thresholds to the geographic breakdowns of reserves estimates and production. With respect to production, the final rules require disclosure of production in each country or field containing 15% or more of the company's proved reserves unless prohibited by the country in which the reserves are located. We are raising the proposed 10% threshold for field disclosure of production to 15% to make the threshold consistent. However, rather than requiring disclosure based on a percentage of the amount of the company's reserves of an individual product, as proposed, the final rules require disclosure based on a percentage of a company's total global oil and gas proved reserves, based on barrels of oil equivalent.[181]

With respect to reserves estimates, the final rules require disclosure of reserves in countries containing more than 15% of the company's proved reserves. As with the production disclosure, this 15% threshold would be based on the company's total global oil and gas proved reserves, rather than on individual products, as proposed.[182] A registrant need not provide disclosure of the reserves in a country containing 15% or more of the registrant's proved reserves if that country's government prohibits disclosure of reserves in that country.

We are not adopting the requirement that we proposed to disclose reserves by sedimentary basin or field. We share commenters' concerns that there is potential for competitive harm from such disclosure in future property sales transactions, unitization agreements, and other asset transfers. Moreover, we recognize that there may be situations in which a particular field may encompass a significant portion of a company's reserves in a foreign country. To avoid compelling a company to provide, in effect, field disclosure, the rule does not require disclosure of reserves in a country containing 15% of the company's reserves if that country prohibits disclosure of reserves in a particular field and disclosure of reserves in that country would have the effect of disclosing reserves in particular fields.[183] For example, if a company has 25% of its reserves in Country A and Country A's government prohibits disclosure of reserves by field within Country A, if almost all of that company's reserves in Country A are located in a single field, the company would not be required to specify the amount of its reserves located in Country A.

b. Tabular Disclosure

We proposed to require much of the reserves disclosures and other disclosures in Industry Guide 2 to be presented in tabular format. Two commenters encouraged using a standardized table for reserves disclosure.[184] Another believed that companies should be able to reorganize, supplement, or combine tables for better presentation of the company's strategy.[185] However, two commenters believed that the rules should not propose a specified tabular format in general.[186] These commenters believed that companies should have the flexibility to present data in a format that is most relevant and meaningful to investors, whether it is tabular or narrative.[187] We continue to believe that in certain circumstances, the required disclosures lend themselves to a tabular disclosure format. We believe that standardizing such tables will improve the readability and comparability of disclosures among companies. However, in response to comments received, we have made several revisions to the individual disclosure items, including whether the disclosure item must be presented in tabular format. We discuss each below.

3. Item 1202 (Disclosure of Reserves)

Existing Instruction 3 to Item 102 of Regulation S–K requires disclosure of an extractive enterprise's proved reserves. With respect to oil and gas producing companies, we are replacing this Instruction by adding a new Item 1202 to Regulation S–K that contains a similar disclosure requirement regarding a company's proved reserves.[188] However, new Item 1202 expands on the requirements of Item 102 by specifically permitting the disclosure of probable and possible reserves and permitting the disclosure of reserves from non-traditional sources. In addition, because we are no longer distinguishing between types of accumulations, the item contains only one table with separate columns for different final products, specifically, oil, gas, synthetic oil, synthetic gas, and other natural resources sold by the company.

a. Oil and Gas Reserves Tables

New Item 1202 requires disclosure, in the aggregate and by geographic area, of reserves estimates using prices and costs under existing economic conditions, for each product type, in the following categories:

- Proved developed reserves;
- Proved undeveloped reserves;
- Total proved reserves;
- Probable developed reserves (optional);
- Probable undeveloped reserves (optional);
- Possible developed reserves (optional); and
- Possible undeveloped reserves (optional).

A form of this table is set forth below:

SUMMARY OF OIL AND GAS RESERVES AS OF FISCAL-YEAR END BASED ON AVERAGE FISCAL-YEAR PRICES

Reserves category	Reserves				
	Oil (mbbls)	Natural gas (mmcf)	Synthetic oil (mbbls)	Synthetic gas (mmcf)	Product A (measure)
PROVED					
Developed:					
Continent A					

[180] See Item 1201(d) [17 CFR 229.1201(d)].

[181] See Item 1204(a) [17 CFR 229.1204(a)].

[182] See Item 1202(a)(2) [17 CFR 229.1202(a)(2)].

[183] See Instruction 4 to Item 1202(a)(2).

[184] See letters from Devon and Petrobras.

[185] See letter from Petro-Canada.

[186] See letters from Apache and ExxonMobil.

[187] See letters from Apache and ExxonMobil.

[188] See Item 1202 [17 CFR 229.1202].

SUMMARY OF OIL AND GAS RESERVES AS OF FISCAL-YEAR END BASED ON AVERAGE FISCAL-YEAR PRICES—Continued

Reserves category	Reserves				
	Oil (mbbls)	Natural gas (mmcf)	Synthetic oil (mbbls)	Synthetic gas (mmcf)	Product A (measure)
Continent B					
Country A					
Country B					
Other Countries in Continent					
Undeveloped:					
Continent A					
Continent B					
Country A					
Country B					
Other Countries in Continent B					
TOTAL PROVED					
PROBABLE					
Developed					
Undeveloped					
POSSIBLE					
Developed					
Undeveloped					

i. Disclosure by Final Product Sold

The table requires disclosure by final product sold by the company, specifically, oil, gas, synthetic oil, synthetic gas, or other natural resource. Thus, if the company processes a natural resource that it has extracted, such as bitumen, into synthetic oil or gas prior to selling the product, it may include such reserves under the synthetic oil or gas columns. As noted below, we have revised the proposal that would have required disclosure by type of accumulation. In addition, in response to commenters, we have revised the definition of ''oil and gas producing activities'' so that a company can use the price of that synthetic oil or gas to determine the economic producibility of the reserves because the economics of the processing activity are relevant to the determination of whether to extract the underlying resource.[189]

However, if a company extracts a resource other than oil or gas, such as bitumen, and sells the product without processing it into synthetic oil or gas, it must disclose reserves of that other natural resource. Although that company's extractive activities would be considered an oil and gas producing activity under the definition of that term, such a company would not benefit from the economics of processing of that resource because the price that determines whether such a company extracts the resource is the price of the unprocessed resource and therefore the company may not establish reserves estimates based on the price of the upgraded product. Similarly, if the company does not itself extract the natural resource, but purchases the natural resource for processing or is paid to process the natural resource, it may not claim reserves either of the resource or of the processed product.

ii. Aggregation

As proposed, the reserves to be reported in these tables would be aggregations (to the company total level) of reserves determined for individual wells, reservoirs, properties, fields, or projects. Regardless of whether the reserves were determined using deterministic or probabilistic methods, the reported reserves should be simple arithmetic sums of all estimates at the well, reservoir, property, field, or project level within each reserves category. Eight commenters agreed that aggregation should not be permitted beyond the field, property or project level, consistent with PRMS.[190]

iii. Optional Disclosure of Probable and Possible Reserves

A company may, but is not required to, disclose probable or possible reserves in these tables. If a company discloses probable or possible reserves, it must provide the same level of geographic detail as it must with respect to proved reserves and must state whether the reserves are developed or undeveloped. In addition, Item 1202 requires the company to disclose the relative uncertainty associated with these classifications of reserves estimations. By permitting disclosure of all three of these classifications of reserves, our objective is to enable companies to provide investors with more insight into the potential reserves base that managements of companies may use as their basis for decisions to invest in resource development.

Most commenters addressing this issue supported permitting the disclosure of probable and possible reserves in filed documents.[191] They believed that such disclosure would provide a more complete picture of a company's full portfolio of opportunities.[192] One commenter noted that this information often is already available on company Web sites and in press releases.[193] However, several commenters supporting the proposal cautioned that there could be significant variability among disclosures.[194]

Other commenters expressed concern about disclosure of unproved reserves, but conceded that voluntary disclosure would be acceptable.[195] These commenters were concerned that such disclosure may confuse investors and expose companies to increased litigation because of the inherent uncertainty associated with probable and possible reserves.[196] They noted that various

[189] See Section II.C.2 of this release.

[190] See letters from Devon, Evolution, ExxonMobil, Ryder Scott, Shell, SPE, Talisman, and Wagner.

[191] See letters from CFA, Chesapeake, Deloitte, EnCana, Evolution, McMoRan, Newfield, Petrobras, Petro-Canada, Questar, Ryder Scott, Sasol, Ryder Scott, Shell, SPE, Three Senators, Wagner, and Zakaib.

[192] See letters from CFA, Evolution, Petro-Canada, Ryder Scott, and Wagner.

[193] See letter from Evolution.

[194] See letter from EnCana.

[195] See letters from API, ExxonMobil, Imperial, Repsol, and Total.

[196] See letters from API, ExxonMobil, Imperial, and Repsol.

technologies may be used to support these estimates.[197]

Several commenters opposed permitting disclosure of probable and possible reserves in Commission filings for similar reasons.[198] Again, they were concerned that the inherent uncertainty associated with such reserves estimates may lead to investor confusion and misunderstanding.[199] They believed that the broad range of technologies and methods used by companies to support these estimates would lead to inconsistent disclosure among companies.[200]

We note that numerous oil and gas companies already disclose unproved reserves on their Web sites and in press releases. This practice does not appear to have created confusion in the market. However, we understand commenters' concerns that probable and possible reserves estimates are less certain than proved reserves estimates and so may increase litigation risk. By making these disclosures voluntary, a company could exercise its own discretion as to whether to provide the market with this disclosure.

Some commenters were concerned that voluntary disclosure by some companies may raise confusion as to why other companies do not disclose these classifications of reserves.[201] One commenter was concerned that voluntary disclosure may increase market pressure on all companies to disclose probable and possible reserves estimates.[202] Considering the fact that many companies already make these disclosures public, we do not believe that this is an adequate reason for prohibiting from filings disclosure that may be helpful to investors.

iv. Resources Not Considered Reserves

Because we are permitting disclosure of probable and possible reserves, we are revising existing Instruction 5 to Item 102 of Regulation S–K to continue to prohibit disclosure of estimates of oil or gas resources other than reserves, and any estimated values of such resources, in any document publicly filed with the Commission, unless such information is required to be disclosed in the document by foreign or state law.[203] Five commenters recommended that the rules permit disclosure of all categories of resources, including those that do not qualify as reserves.[204] One commenter believed that the prohibition against disclosing all resources deprives public markets of significant information without meaningfully enhancing investor protection and ultimately may harm the efficiency and development of U.S. markets and U.S. companies raising capital.[205] That commenter also thought such a restriction could also encourage companies to form outside of the U.S.[206] Another commenter believed that the uncertainty of resource estimates is best communicated by reporting the full range of estimates.[207] In addition, another commenter believed that clear disclosure would allay concerns about investor misunderstanding of estimates of resources that do not qualify as reserves.[208] That commenter noted that excluding resources that are not reserves is inconsistent with international standards and the fact that these resources are disclosed in the U.S. on Web sites and in press releases.[209] We continue to be concerned that such resources are too speculative and may lead investors to incorrect conclusions. Therefore, we are adopting the proposal to prohibit disclosure of resources other than reserves.

However, consistent with existing Instruction 5, a company may continue to disclose such estimates of non-reserves resources in a Commission filing related to an acquisition, merger, or consolidation if the company previously provided those estimates to a person that is offering to acquire, merge, or consolidate with the company or otherwise to acquire the company's securities.[210] Several commenters recommended that the Commission maintain this exception so that the company's shareholders would not be at an informational disadvantage compared to the counterparty when assessing a merger.[211] We agree with these commenters and have retained the exception in the revised Instruction 5 adopted today.

b. Optional Reserves Sensitivity Analysis Table

The rules that we are adopting require a company to determine whether its oil or gas resources are economically producible based on a 12-month average price. We also proposed, and are adopting, an optional reserves sensitivity table. This table would permit companies to disclose additional information to investors, such as the sensitivity that oil and gas reserves have to price fluctuations. If a company chooses to provide such disclosure, it may choose the different scenario or scenarios, if any, that it wishes to disclose in the table, provided that it also discloses the price and cost schedules and assumptions on which the alternate reserves estimates are based.

Twelve commenters supported permitting such sensitivity analyses.[212] Some believed that this would provide investors with a better view of management's analysis of future prices.[213] One recommended providing a set price change of 10% for the sensitivity analysis.[214] Two other commenters believed that different circumstances may require different types of sensitivity analyses, both with respect to the range of prices used and the format of the presentation.[215] We agree that the appropriate range for a sensitivity analysis may vary depending on the situation, and therefore, as proposed, we are not specifying a range of prices to be used.

However, five commenters specifically opposed requiring such an analysis.[216] They believed that such a requirement would cause confusion and harm comparability.[217] Three commenters opposed such a sensitivity analysis because using different prices could mislead investors.[218] We are adopting this table, as proposed, as a voluntary disclosure rather than a requirement. However, as proposed, the table would require disclosure of the assumptions behind varying estimates. We believe this disclosure will mitigate any investor confusion.

In addition, we remind companies that Item 303 of Regulation S–K (Management's Discussion and Analysis of Financial Condition and Results of Operations)[219] requires discussion of

[197] See letters from API, ExxonMobil, and Imperial.

[198] See letters from Apache, Devon, Energen, Eni, and Southwestern.

[199] See letters from Apache, Devon, Eni, and Southwestern.

[200] See letters from Devon, Eni, and Southwestern.

[201] See letters from Apache and Total.

[202] See letter from Eni.

[203] See Instruction 5 to Item 102 [17 CFR 229.102].

[204] See letters from Davis Polk, Petro-Canada, Shearman & Sterling, SPE, and Zakaib.

[205] See letter from Shearman & Sterling.

[206] *Id.*

[207] See letter from SPE.

[208] See letter from Davis Polk.

[209] See letter from Davis Polk.

[210] *Id.*

[211] See letters from Devon, ExxonMobil, Shell, and Total.

[212] See letters from Canadian Natural, CAPP, CFA, Chesapeake, Deloitte, Devon, Evolution, ExxonMobil, McMoRan, Nexen, Petro-Canada, and Total.

[213] See letters from Chesapeake, Deloitte, and McMoRan.

[214] See letter from CFA.

[215] See letters from Evolution and Total.

[216] See letters from Canadian Natural, CAPP, Devon, EnCana, and ExxonMobil.

[217] See letters from EnCana and Ryder Scott.

[218] See letters from Apache, Petrobras, and Wagner.

[219] See Item 303 of Regulation S–K [17 CFR 229.303].

known trends and uncertainties, which may include changes to prices and costs. A form of this optional reserves sensitivity analysis table is set forth below.

SENSITIVITY OF RESERVES TO PRICES BY PRINCIPAL PRODUCT TYPE AND PRICE SCENARIO

Price case	Proved reserves			Probable reserves			Possible reserves		
	Oil Mbbls	Gas mmcf	Product A measure	Oil mbbls	Gas mmcf	Product A measure	Oil mbbls	Gas mmcf	Product A measure
Scenario 1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Scenario 2	.....	.....	.....	.....	.....	.....	.....	.....	.....

c. Separate Disclosure of Conventional and Continuous Accumulations

Under the proposal, new Item 1202 would have required companies to disclose reserves from conventional accumulations separately from reserves in continuous accumulations. Nine commenters recommended disclosure based on the final product.[220] These commenters opposed segregating disclosure based on the type of accumulation that is involved.[221] They believed that such disclosure would be too complex and detailed and of little use to investors.[222] In addition, seven commenters pointed out that separation may be impossible because some fields contain both conventional and continuous accumulations.[223] This would make allocation of costs arbitrary.[224] However, four commenters supported the definitions and separate disclosure by type of accumulation.[225] One commenter believed that such disclosure would allow investors to assess the impact of unconventional sources on reserves.[226]

Although we agree conceptually that the focus of reserves disclosure should be on the final product, we also recognize that the production of oil and gas from varying sources can have significantly different economics. Extraction of oil and gas from continuous accumulations can be much more labor and resource intensive than extraction of oil and gas from traditional wells. They often require greater ongoing efforts and expense after the initial extraction equipment is in place, making such operations more sensitive to price fluctuations.

We agree with the commenters that disclosure based on the end product sold would provide a more effective basis for distinguishing reserves that disclosure based on the type of accumulation in which the reserves are held. Therefore, we have revised the disclosure to be based on the end product that is sold by the company.[227] However, with respect to the end product, new Item 1202 makes a distinction between oil and gas, on the one hand, and synthetic oil and gas, on the other. Synthetic products require processing of the raw resource material, either while it is still in the ground (''in situ'') or after it is extracted, before it can be used as refinery feedstock or as natural gas. Such processes currently include bitumen upgrading as well as coal liquefaction and gasification. However, resources from some continuous accumulations, such as coalbed methane, do not require such processing and therefore are not associated with the same level of ongoing costs once a well has been drilled because the in-ground resource is already oil or gas (in the case of coalbed methane, the in-ground resource is methane, trapped in a coalbed). Thus, coalbed methane would not be considered a synthetic product.

d. Preparation of Reserves Estimates or Reserves Audits

In the Proposing Release, we proposed to require a company to disclose whether or not the technical person [228] primarily responsible for preparing the reserves estimate possessed certain specified qualifications and was subject to a list of controls for maintaining objectivity. Most commenters addressing the issue opposed this proposed requirement.[229] However, many of these commenters appeared to believe that the disclosure requirement would pertain to every person involved with the estimation process.[230] If adopted, they noted that such disclosure would be voluminous, adding unnecessary complexity to disclosures.[231] Four commenters suggested that we clarify that the disclosure is limited to the chief technical person who oversees the company's overall reserves estimation process,[232] which was the intent of the proposal. Five commenters supported this disclosure because it helps users understand the objectivity and quality of reserves estimates.[233]

It was our intent to limit the disclosure to the technical person primarily responsible for overseeing the reserves estimates. However, there may have been confusion with respect to this point based on a footnote which stated that we sought disclosure about the person who ''is primarily responsible for the actual calculations and estimation or audit.'' By that term, we did not intend to include *any* person making ''actual calculations.'' We recognize that, ultimately, the reserves estimates are overseen by top management, which may or may not have reserves estimation expertise. The focus of the final rule is the primary technical person responsible for overseeing the preparation of the reserves estimation process. We have

[220] See letters from Apache, API, Canadian Natural, CAPP, EnCana, ExxonMobil, Imperial, Petro-Canada, and Total.

[221] See letters from Apache, API, CAPP, Chesapeake, Devon, ExxonMobil, Imperial, Repsol, and Shell.

[222] See letters from Apache, API, BP, CAPP, Chesapeake, Chevron, Devon, E&Y, EnCana, ExxonMobil, Imperial, Petro-Canada, Repsol, and Southwestern.

[223] See letters from BP, Canadian Natural, CAPP, EnCana, Petro-Canada, Ryder Scott, and Talisman.

[224] See letters from EnCana and Ryder Scott.

[225] See letters from Davis Polk, EIA, Petrobras, and Wagner.

[226] See letter from Wagner.

[227] See Item 1202 [17 CFR 229.1202].

[228] With regard to the objectivity of a technical person, the ''person'' could be an individual or an entity, as appropriate. However, with regard to the qualifications of a person, the disclosure would relate to the individual who is primarily responsible for the technical aspects of the reserves estimation or audit. Thus, this individual is not necessarily the individual generally overseeing the estimation or audit, but the individual who is primarily responsible for the actual calculations and estimation or audit.

[229] See letters from Apache, API, Chevron, Energen, Eni, ExxonMobil, Newfield, Nexen, PEMEX, Petro-Canada, Ryder Scott, Shell, and Total.

[230] See letters from Apache, API, ExxonMobil, Newfield, Nexen, PEMEX, Ryder Scott, and Total.

[231] See letters from Apache, API, ExxonMobil, Newfield, Nexen, PEMEX, Repsol, and Total.

[232] See letters from API, ExxonMobil, PEMEX, and Petro-Canada.

[233] See letters from CFA, Devon, EnCana, Southwestern, and Wagner.

revised the language in the rule to clarify this point.[234]

Two commenters noted that it was inconsistent to require such precise disclosure about reserves experts, but not other experts.[235] One of those commenters recommended that the rule require expert language, including clear disclosure of which portion of the reserves estimate the third party is expertising and filed consents.[236] The concept of an expert under the Securities Act is different from the disclosures that we seek regarding the qualifications and objectivity of persons responsible for the preparation or audit of oil and gas reserves. Under the Securities Act, disclosure must be made when the company represents that disclosure is based on the authority of an expert. Although the Securities Act concept of experts will continue to be relevant when the reserves disclosures are in, or incorporated into, a Securities Act filing and the company represents that disclosure is based on the authority of an expert, the new rules requiring disclosure about the reserves preparer or auditor in a company's Exchange Act reports are intended to help investors determine whether reserves estimates, which are highly technical, have been prepared by a qualified, objective person, regardless of whether that person is an employee of the company.

However, we agree with commenters that a prescribed list of qualifications and objectivity requirements may be too rigid for all situations. With respect to technical qualifications, several commenters noted that licensing requirements can vary greatly among jurisdictions.[237] Commenters also believed that disclosure of a person's objectivity was unnecessary because management is required to install appropriate internal controls to ensure the reliability of reserves estimates.[238] In fact, some commenters recommended that we limit the disclosure to a description of a company's internal controls, including the company's technical assessment routine, management and board review and approval processes, the internal audit process, the extent to which the company uses external parties to estimate or audit reserves estimates, and a summary description of the qualifications of the company's typical reserves estimators.[239] We are following these commenters' recommendations and adopting a rule that requires a company to provide a general discussion of the internal controls that it uses to assure objectivity in the reserves estimation process and disclosure of the qualifications of the technical person primarily responsible for preparing the reserves estimates or conducting the reserves audit if the company discloses that such a reserves audit has been performed, regardless of whether the technical person is an employee or an outside third party.[240]

We did not propose, but sought comment on, whether the rules should require a company to retain an independent third party to prepare, or conduct a reserves audit of, the company's reserves estimates. Most commenters urged the Commission not to adopt such a requirement.[241] They believed that a company's internal staff, particularly at larger companies, is generally in a better position to prepare those estimates [242] and that there is a potential lack of qualified third party engineers and other professionals available to conduct the increased work that would result from such a requirement.[243] We agree with these commenters and are not adopting a requirement that an independent third party prepare, or conduct a reserves audit of, the company's reserves estimates.

e. Reserve Audits and The Contents of Third-Party Reports

In the Proposing Release, we proposed that, if a company represents that its estimates of reserves are prepared or audited by a third party, the company must file a report of the third party as an exhibit to the relevant registration statement or report. Two commenters believed that a company description of the third party's report would be sufficient because the reports can contain sensitive information.[244] However, another commenter was concerned that not filing the report may lead to mischaracterizations by the company.[245] This commenter supported the filing of a report by the third party reserves estimator or auditor, but believed that the Commission should determine the contents of such a report.[246] Two commenters supported the filing of the report ''letter'' as an exhibit, but not the full reserves report because it may contain proprietary information.[247]

As proposed, we are adopting a new rule to require that if the company represents that a third party prepared the reserves estimate or conducted a reserves audit of the reserves estimates, the company must file a report of the third party as an exhibit to the relevant registration statement or report.[248] These reports need not be the full ''reserves report,'' which is often very detailed and voluminous. Rather, these reports could be shorter form reports that summarize the scope of work performed by, and conclusions of, the third party. These reports must include the following disclosure, based on the Society of Petroleum Evaluation Engineers's audit report guidelines:

- The purpose for which the report is being prepared and for whom it is prepared;
- The effective date of the report and the date on which the report was completed;
- The proportion of the company's total reserves covered by the report and the geographic area in which the covered reserves are located;
- The assumptions, data, methods, and procedures used to conduct the reserves audit, including the percentage of company's total reserves reviewed in connection with the preparation of the report, and a statement that such assumptions, data, methods, and procedures are appropriate for the purpose served by the report;
- A discussion of primary economic assumptions;
- A discussion of the possible effects of regulation on the ability of the registrant to recover the estimated reserves;
- A discussion regarding the inherent risks and uncertainties of reserves estimates;
- A statement that the third party has used all methods and procedures as it considered necessary under the circumstances to prepare the report; and
- The signature of the third party.

In addition, if the report is related to a reserves audit, it must contain a brief summary of the third party's conclusions with respect to the reserves estimates. Finally, if the disclosures are

[234] See Item 1202(a)(7) [17 CFR 229.1202(a)(7)].

[235] See letters from API and Deloitte.

[236] See letter from Deloitte.

[237] See letters from AAPG, API, Chevron, Eni, Petro-Canada, Questar, and SPE.

[238] See letters from API, Chevron, Energen, ExxonMobil, Newfield, Nexen, Petrobras, Ryder Scott, Shell, StatoilHydro, and Total.

[239] See letters from ExxonMobil, Nexen, Shell, and StatoilHydro.

[240] See Item 1202(a)(7) [17 CFR 229.1202(a)(7)].

[241] See letters from API, BHP, BP, CFA, CNOOC, Denbury, Devon, Eni, Energy Literacy, ExxonMobil, Imperial, R. Jones, D. McBride, Newfield, Nexen, Petro-Canada, Ross, D. Ryder, Sasol, Shell, Talisman, Total, and W. van de Vijver.

[242] See letters from API, Denbury, ExxonMobil, Imperial, Nexen, Shell, and Talisman.

[243] See letters from AAPG, API, BP, Devon, ExxonMobil, Imperial, D. McBride, Newfield, D. Ryder, and Sasol.

[244] See letters from Evolution and Petro-Canada.

[245] See letter from Wagner.

[246] See letter from Wagner.

[247] See letters from Devon and Ryder Scott.

[248] See Item 1202(a)(8) [17 CFR 229.1202(a)(8)].

made in, or incorporated into, a Securities Act registration statement, the company must file a consent of the third party as an exhibit to the filing.

In the Proposing Release, we proposed to define the term ''reserves audit'' as ''the process of reviewing certain of the pertinent facts interpreted and assumptions made that have resulted in an estimate of reserves prepared by others and the rendering of an opinion about the appropriateness of the methodologies employed, the adequacy and quality of the data relied upon, the depth and thoroughness of the reserves estimation process, the classification of reserves appropriate to the relevant definitions used, and the reasonableness of the estimated reserves quantities. In order to disclose that a 'reserves audit' has been conducted, the report resulting from this review must represent an examination of at least 80% of the portion of the registrant's reserves covered by the reserves audit.'' We are substantively adopting the first sentence of this definition as proposed.

However, in response to comments received, we are not adopting the proposed second sentence of the definition of the term ''reserves audit.'' Two commenters supported the proposed 80% threshold regarding the proportion of reserves that a reserves auditor must review in order for the company to characterize that auditor's work as a ''reserves audit.'' [249] Another commenter believed that the 80% threshold was appropriate for preparing reserves estimates.[250] But three commenters believed that an audit should simply disclose the percentage that was audited.[251] One of these noted that it has its reserves audit performed on a rolling basis.[252] We believe that disclosure of the work done in the required third-party report makes a bright-line percentage test unnecessary. If a company conducts its reserves audit on a rolling basis, it is appropriate for its shareholders to be aware of that fact. Therefore, we are not adopting the proposed 80% threshold. We believe that disclosure of the scope of the review will enable investors to assess the significance to attribute to a reserves audit.

f. Process Reviews

In the Proposing Release, we solicited comment regarding whether we should permit a company to disclose that it has hired a third party to perform a process review under the Society of Petroleum Engineers' (SPE's) reserves auditing standards.[253] Those standards define a process review as an investigation by a person who is qualified by experience and training equivalent to that of a reserves auditor to address the adequacy and effectiveness of an entity's internal processes and controls relative to reserves estimation. However, those standards also note that a process review should not include an opinion relative to the reasonableness of the reserves quantities and should be limited to the processes and control system reviewed. The SPE's standards state that, although such reviews may provide value to the entity, an external or internal process review is not of sufficient rigor to establish appropriate classifications and quantities of reserves and should not be represented to the public as being equivalent to a reserves audit.

Five commenters believed that internal process reviews are helpful in promoting accuracy and effectiveness, so companies should be permitted to disclose them.[254] However, one commenter was concerned that, although a process review can be helpful for a company, disclosure may give investors a false sense of security.[255] Two commenters suggested that, if a company discloses that it performed a process review, it should clearly disclose what a process review is.[256]

We agree that a process review can be helpful to the company and ultimately to investors. However, we also agree that if a company discloses that it has hired a third party to perform a process review, it must clearly disclose the details surrounding that process review. As such, the new rules treat a process review similar to a reserves audit. If the company discloses that it has hired a third party to conduct a process review, it must file a report of the third party as an exhibit to the relevant registration statement or report and, if the disclosures are made in, or incorporated into, a Securities Act registration statement, the company must file a consent of the third party as an exhibit to the filing.[257]

4. Item 1203 (Proved Undeveloped Reserves)

We proposed requiring tabular disclosure of the aging of proved undeveloped reserves (PUDs). Proposed Item 1203 would have required an oil and gas company to prepare a table showing, for each of the last five fiscal years and by product type, proved reserves estimated using current prices and costs in the following categories:

- Proved undeveloped reserves converted to proved developed reserves during the year; and
- Net investment required to convert proved undeveloped reserves to proved developed reserves during the year.[258]

Numerous commenters were concerned that the proposed five-year table would be too complex for investors to understand.[259] They expressed concern that the proposed table may mislead investors by not clearly attributing costs to the year in which the corresponding PUDs are converted because much of the costs may have been spent in previous years.[260] In addition, commenters noted that maintenance of such data would be costly [261] and that companies currently do not always capture this type of information because management does not use it to run the business.[262]

Eight commenters suggested an alternative of disclosing (1) the quantity of undeveloped reserves if material, (2) the progress in converting PUDs, and (3) any material changes in the current year.[263] Three U.S. Senators recommended requiring disclosure of development plans in addition to the table.[264] They believed that requiring reporting of investments and planned investments in oil and gas development would provide investors with certainty about companies' intentions to develop the federal lands that they have at their disposal.[265] However, three commenters opposed disclosure of a company's plans to drill and expected capital expenditures because disclosing their business plan may cause competitive harm and might expose them to litigation if results differ from their plan.[266] Six commenters supported the proposed table.[267]

[249] See letters from Evolution and Wagner.

[250] See letter from Ryder Scott.

[251] See letters from Devon, Ryder Scott, and Talisman.

[252] See letter from Talisman.

[253] See SPE Reserves Auditing Standards.

[254] See letters from Devon, ExxonMobil, Petro-Canada, Ryder Scott, and Shell.

[255] See letter from Wagner.

[256] See letters from Devon and Petro-Canada.

[257] See Item 1202(a)(8) [17 CFR 229.1202(a)(8)].

[258] See Item 1204 [17 CFR 229.1204].

[259] See letters from API, BP, Canadian Natural, CAPP, Chevron, Eni, Equitable, ExxonMobil, Nexen, Petrobras, Repsol, Shell, and Wagner.

[260] See letters from API, ExxonMobil, Petrobras, Ryder Scott, Total, and Wagner.

[261] See letters from API, Canadian Natural, CAPP, Chevron, Eni, Equitable, ExxonMobil, Nexen, Petrobras, Southwestern, and Wagner.

[262] See letter from Apache.

[263] See letters from API, Canadian Natural, Chevron, ExxonMobil, Newfield, Nexen, Petrobras, and Ryder Scott.

[264] See letter from Three Senators.

[265] See letter from Three Senators.

[266] See letters from Chesapeake, Devon, and Newfield.

[267] See letters from Chesapeake, Deloitte, Devon, Three Senators, Talisman, and Wagner.

We recognize the concern that the PUD table that we proposed may be confusing to investors because it would not attribute capital expenditures to the corresponding reserves as they are developed. As an alternative to the proposed table, we are adopting rules that require a company to disclose the following in narrative form:

- The total quantity of PUDs at year end;
- Any material changes in PUDs that occurred during the year, including PUDs converted into proved developed reserves;
- Investments and progress made during the year to convert PUDs to proved developed oil and gas reserves; and
- An explanation of the reasons why material concentrations of PUDs in individual fields or countries have remained undeveloped for five years or more after disclosure as PUDs.[268]

These disclosures would have been required under the proposal, but much of it would have been presented in tabular format. We believe that a narrative approach to these disclosures will provide companies with a better vehicle to explain the status of their PUDs and their track record for developing such reserves. Rather than requiring forward-looking information about a company's plans to develop reserves that may lead to exaggeration of a company's capability to actually convert such reserves, we believe that disclosure of a company's verifiable, established track record of converting such reserves, including its ability to obtain financing for such activities, would be a better indication of the likelihood of that company's success in developing reserves in the future. Specific required disclosure regarding a company's failure to develop material concentrations of PUDs for five or more years should address commenters' concerns that the company may have no intention to develop such reserves.

5. Item 1204 (Oil and Gas Production)

We proposed to codify the Industry Guide 2 disclosure regarding oil and gas production as Item 1204 of Regulation S–K, in tabular form and with greater detail. One commenter did not believe that separating production, sales price and production costs based on whether they were related oil wells or gas wells would be valuable to investors.[269] It believed that companies do not use this information to manage their business and do not maintain systems to capture this information on that basis, so tracking such data would require costly changes to their systems.[270] Two commenters also believed that it would not be possible to separate production cost by product because many units extract different products.[271] One commenter also recommended that production not be segregated by type of accumulation.[272]

We have decided not to adopt Item 1204 as proposed. Rather, we are codifying the existing Industry Guide 2 disclosure item with several revisions. Consistent with the Industry Guide 2 disclosure item, the Item 1204, as adopted, requires disclosure, for each of the prior three fiscal years, of production, by final product sold, of oil, gas, and other products. In addition, for the same time period, the company must disclose, by geographical area:

- The average sales price (including transfers) per unit of oil, gas and other products produced; and
- The average production cost, not including ad valorem and severance taxes, per unit of production.

However, unlike the Industry Guide disclosure item, this disclosure must be made by geographical area and for each country and field containing 15% or more of the registrant's proved reserves, expressed on an oil-equivalent-barrels basis.

Similarly, we are codifying the instructions to the Industry Guide 2 item. One commenter recommended that we maintain some of the existing instructions from the Industry Guide.[273] The first instruction codified from the Industry Guide clarifies that net production should include only production that is owned by the registrant and produced to its interest, less royalties and production due others. However, in special situations (*e.g.*, foreign production), net production before any royalties may be provided, if more appropriate. If ''net before royalty'' production figures are furnished, the change from the usage of ''net production'' should be noted.

The second instruction, which is also from the Industry Guide, states that production of natural gas should include only marketable production of natural gas on an ''as sold'' basis. Production will include dry, residue, and wet gas, depending on whether liquids have been extracted before the registrant transfers title. Flared gas, injected gas, and gas consumed in operations should be omitted. Recovered gas-lift gas and reproduced gas should not be included until sold. Synthetic gas, when marketed as such, should be included in natural gas sales.

We are adding a third instruction that was not in the Industry Guide. This instruction states that, if any product, such as bitumen, is sold or custody is transferred prior to conversion to synthetic oil or gas, the product's production, transfer prices, and production costs should be disclosed separately from all other products. This instruction is necessary because the existing Industry Guide 2 disclosure requirement only required separate disclosure based on whether the end product was oil or gas. This instruction merely clarifies that disclosures under this item must be based on the end product, which may not be oil or gas because the amendments will permit the disclosure of reserves of other end products, such as bitumen.

The fourth instruction codified from the Industry Guide states that the transfer price of oil and gas (natural and synthetic) produced should be determined in accordance with SFAS 69. And the fifth instruction codified from the Industry Guide clarifies that the average production cost per unit of production should be computed using production costs disclosed pursuant to SFAS 69. Units of production should be expressed in common units of production with oil, gas, and other products converted to a common unit of measure on the basis used in computing amortization. This instruction also adds products from unconventional sources to the existing disclosure Item in Industry Guide 2.

6. Item 1205 (Drilling and Other Exploratory and Development Activities)

We proposed to codify the Industry Guide 2 disclosure item regarding drilling activities as Item 1205 of Regulation S–K, in tabular form, with several revisions to that Industry Guide 2 disclosure item, including applying a new definition of the term ''geographic area'' and adding two categories of wells:

- Extension wells; and
- Suspended wells.

Three commenters believed that the disclosures required under this proposed Item would become too detailed.[274] One of these commenters also believed that the number of wells being drilled does not provide an accurate picture of a company's drilling

[268] See Item 1203 [17 CFR 229.1203].

[269] See letter from Apache.

[270] See letter from Apache.

[271] See letters from Total and ExxonMobil.

[272] See letter from ExxonMobil.

[273] See letter from ExxonMobil.

[274] See letters from Apache, ExxonMobil, and Total.

activities because of the increased usage of horizontal wells.[275]

Some commenters also did not believe that creating new categories for extension wells and suspended wells would be meaningful.[276] They noted the burden of the added detail would exceed the value of the information to investors.[277] One pointed out that determining whether a well constitutes an extension well would be difficult because of multipurpose drilling.[278]

After considering the above comments, we have decided not to adopt all of the proposed revisions to the existing Industry Guide 2 disclosure. We recognize that, for some companies that use advanced drilling techniques, the proposed disclosure may not be a good indicator of the extent of their exploratory and development activities, although we believe that this disclosure is still important for many companies. Therefore, we have decided to codify the existing disclosures found in Industry Guide 2 related to drilling activities without revision and to not require tabular disclosure.[279] However, as proposed, we are adding a new provision to this Item that requires companies to discuss their exploratory and development activities regarding oil and gas resources that are extracted by mining techniques because we are now including such resources under the definition of ''oil and gas producing activities.''

7. Item 1206 (Present Activities)

Item 1206 codifies existing Item 7 of Industry Guide 2, which calls for disclosure of present activities, including the number of wells in the process of being drilled (including wells temporarily suspended), waterfloods in process of being installed, pressure maintenance operations, and any other related activities of material importance.[280] We are adopting Item 1206 substantially as proposed.

8. Item 1207 (Delivery Commitments)

Item 1207 codifies existing Item 8 of Industry Guide 2, which calls for disclosure of arrangements under which the company is required to deliver specified amounts of oil or gas and how the company intends to meet such commitments.[281] We are not adopting any substantive changes to the disclosure currently called for by Item 8 of Industry Guide 2. However, we are restructuring and rewording the disclosure item to make it easier to understand, including separating embedded lists into separate subparagraphs and making general plain English revisions. As proposed, these revisions are not intended to change the substance of the disclosures.

9. Item 1208 (Oil and Gas Properties, Wells, Operations, and Acreage)

We proposed to codify disclosure about oil and gas properties, wells, operations, and acreage as Item 1208 of Regulation S–K, in tabular form, as well as make several revisions to the existing disclosures, including applying a new definition of the term ''geographic area'' and adding language that better illustrates the types of properties and the types of disclosures for those properties, including the following:

- Identification and description generally of the company's material properties, plants, facilities, and installations;
- Identification of the geographic area in which they are located;
- Indication of whether they are located onshore or offshore; and
- Description of any statutory or other mandatory relinquishments, surrenders, back-ins, or changes in ownership.

Six commenters believed that it is not necessary to enhance this section from Industry Guide 2 because the requirements are already covered by Item 102 of Regulation S–K.[282] Commenters were particularly concerned with the segmentation of this disclosure by product, by type of accumulation, and by geographic location.[283] They believed that this level of detail would not be helpful to investors and would impose added costs on companies because they currently do not collect this detailed information.[284] Moreover, seven commenters thought that the well count disclosure is no longer meaningful because of technologies such as horizontal drilling.[285] They thought that, in light of these new technologies, well count disclosure could be misleading.[286]

As with the case of drilling activities, we agree that the proposed added detail could make the disclosures too cumbersome. In addition, such disclosure may be of less importance to many companies because of new drilling technology. Therefore, we are merely codifying the existing Industry Guide 2 disclosure, without revision.[287]

V. Guidance for Management's Discussion and Analysis for Companies Engaged in Oil and Gas Producing Activities

We proposed to add a new Item 1209, which would have specified topics that a company should address either as part of its Management's Discussion and Analysis of Financial Condition and Results of Operations (MD&A) or in a separate section.[288] Four commenters were concerned that, although the proposed Item was intended to provide more guidance regarding the disclosures required, it would effectively require companies to address all of the issues listed in the Item.[289] One recommended that, instead of a detailed list, the requirement should clarify that companies should address ''material changes due to technology, prices, concession conditions, commercial terms, known trends, demands, commitments, uncertainties and any events that are reasonably likely to have a material effect on reserves estimates and financial condition.'' [290] Similarly, another commenter recommended that the Commission clarify that the Item is limited to material impacts.[291]

We are not adopting the proposed Item as part of Regulation S–K because it is intended to be guidance, rather than a specific disclosure Item. We agree that, if companies were to discuss every issue provided in the list, the disclosure would be too long and detailed to be of much use to most investors. Important issues could be hidden amid unnecessary detail. However, we believe that added guidance would be beneficial to companies regarding the issues that the Commission's staff commented upon in its review of the MD&A section of filings made by oil and gas companies.

To begin, a fundamental premise of MD&A is that the information provided should be related to issues that are material to a company. Although we discuss a list of topics that a company might need to discuss, a company need only discuss a topic if it constitutes, involves, or indicates known trends, demands, commitments, uncertainties, and events that are reasonably likely to have a material effect on the company. These topics include:

[275] See letter from ExxonMobil.

[276] See letters from Apache, API, and Imperial.

[277] See letters from Apache and Southwestern.

[278] See letter from Total.

[279] See Item 1205 [17 CFR 229.1205].

[280] See Item 1206 [17 CFR 229.1206].

[281] See Item 1207 [17 CFR 229.1207].

[282] See letters from API, Chevron, ExxonMobil, Imperial, Shell, and Total.

[283] See letters from Apache, ExxonMobil, Shell, and Total.

[284] See letters from Apache, ExxonMobil, and Petro-Canada.

[285] See letters from API, BP, Chevron, ExxonMobil, Imperial, StatoilHydro, and Total.

[286] See letters from API and Imperial.

[287] See Item 1208 [17 CFR 229.1208].

[288] See Item 303 of Regulation S–K [17 CFR 229.303].

[289] See letters from Chevron, ExxonMobil, Petrobras, and Shell.

[290] See letter from Repsol.

[291] See letter from Total.

- Changes in proved reserves and, if disclosed, probable and possible reserves, and the sources to which such changes are attributable, including changes made due to:
  - Changes in prices;
  - Technical revisions; and
  - Changes in the status of any concessions held (such as terminations, renewals, or changes in provisions);
- Technologies used to establish the appropriate level of certainty for any material additions to, or increases in, reserves estimates, including any material additions or increases to reserves estimates that are the result of any of the final rules adopted in this release;
- Prices and costs, including the impact on depreciation, depletion and amortization as well as the full cost ceiling test;
- Performance of currently producing wells, including water production from such wells and the need to use enhanced recovery techniques to maintain production from such wells;
- Performance of any mining-type activities for the production of hydrocarbons;
- The company's recent ability to convert proved undeveloped reserves to proved developed reserves, and, if disclosed, probable reserves to proved reserves and possible reserves to probable or proved reserves;
- The minimum remaining terms of leases and concessions;
- Material changes to any line item in the tables described in Items 1202 through 1208 of Regulation S–K;
- Potential effects of different forms of rights to resources, such as production sharing contracts, on operations; and
- Geopolitical risks that apply to material concentrations of reserves.

The MD&A is typically presented in a self-contained section of the registration statement or report. However, the disclosure requirements that comprise new Subpart 1200 of Regulation S–K will cause a substantial amount of an oil and gas company's disclosure to appear in tabular format, providing an outline of much of a company's operations. Because the tables will present many of the types of changes that management often discusses in its MD&A, we believe it may be more helpful to investors to locate such discussion close to the tables themselves. Thus, to the extent that any discussion or analysis of known trends, demands, commitments, uncertainties, and events that are reasonably likely to have a material effect on the company is directly relevant to a particular disclosure required by Subpart 1200, the company may include that discussion or analysis with the relevant table, with appropriate cross-references, rather than including it in its general MD&A section.

VI. Conforming Changes to Form 20–F

Form 20–F is the form on which foreign private issuers file their annual reports and Exchange Act registration statements. Currently, Form 20–F contains instructions that are similar to those in Item 102 of Regulation S–K. However, rather than referring to Industry Guide 2 for disclosures regarding oil and gas producing activities, Form 20–F contains its own ''Appendix A to Item 4.D—Oil and Gas'' (Appendix A) that provides guidance for oil and gas disclosures for foreign private issuers.[292] Appendix A is significantly shorter, and provides far less guidance regarding disclosures, than Subpart 1200 or Industry Guide 2. We proposed to revise Form 20–F to eliminate the reference to Appendix A, and rather refer to Subpart 1200, which would expand the disclosures required by foreign private issuers.

Six commenters supported harmonizing the Form 20–F disclosures with Regulation S–K.[293] One noted that the proposal would make disclosure more consistent and comparable among oil companies.[294] It believed the proposal would put all oil companies on a level playing field.[295] However, one commenter recommended that the Commission exempt companies reporting under International Financial Reporting Standards (IFRS).[296] It also recommended that instead of applying the proposed Subpart 1200 to foreign private issuers, the Commission should revise Appendix A to Form 20–F itself, making appropriate limitations for foreign private issuers, such as eliminating the disclosure of wells and acreage.[297] Another commenter was concerned because the proposals may hinder, rather than facilitate, transition to the use of IFRS.[298]

We continue to believe that Subpart 1200 would be appropriate disclosure for all public companies engaged in oil and gas producing activities, including foreign private issuers. The added guidance in Subpart 1200 should promote more consistent and comparable disclosures among oil and gas companies. It is our understanding that many of the larger foreign private issuers already provide disclosure in their filings with the Commission comparable to the disclosure provided by domestic companies. Thus, we are revising Form 20–F to incorporate Subpart 1200 with respect to oil and gas disclosures and delete Appendix A to Item 4.D in that form. We recognize that this requirement may require a foreign private issuer to prepare two different reserves estimates if the rules in their home jurisdiction require a different pricing standard than the 12-month average that we adopt in this release. However, we believe the same conflict would have existed under our previous rule to the extent our pricing method differed from the home jurisdiction's method.

Appendix A currently allows a foreign private issuer to exclude required disclosures about reserves and agreements if its home country prohibits the disclosures. Two commenters suggested that the rule continue to provide an exception for disclosures about reserves and agreements that are prohibited by foreign laws.[299] However, another commenter believed that a company taking advantage of such an exception should be required to disclose the country, the citation of the relevant law or regulation, and the fact that the disclosed estimates do not include amounts from the named country.[300] We are not revising this provision. Rather, because these considerations still apply to such foreign private issuers, we are moving that provision from Appendix A and adopting it as Instruction 2 to Item 4 of Form 20–F, as proposed.[301]

One commenter recommended clarifying that the new disclosures would not apply to foreign private issuers under the Multi-Jurisdictional Disclosure System (MJDS) using Form 40—F that comply with NI 51–101 in Canada because those rules already are broadly consistent with PRMS.[302] We agree with this commenter and believe that such issuers need not provide disclosures beyond those required in Canada.

VII. Impact of Amendments on Accounting Literature

A. Consistency With FASB and IASB Rules

Numerous commenters recommended that the SEC generally coordinate its efforts with the IASB and FASB to create a cohesive whole and not adopt

[292] See Appendix A to Item 4.D—Oil and Gas of Form 20–F [17 CFR 249.220f].

[293] See letters from CAQ, Deloitte, ExxonMobil, KPMG, PWC, and Shell.

[294] See letter from ExxonMobil.

[295] See letter from ExxonMobil.

[296] See letter from Total.

[297] See letter from Total.

[298] See letter from Ross.

[299] See letters from Shell and Total.

[300] See letter from ExxonMobil.

[301] *Id.*

[302] See letter from Deloitte.

competing models.[303] We have begun, and will continue, to work with both of these organizations to ensure a smooth transition to the new reporting rules.

B. Change in Accounting Principle or Estimate

In the Proposing Release, we expressed our view that the change from using single-day year-end price to an average price should be treated as a change in accounting principle, or a change in the method of applying an accounting principle, that is inseparable from a change in accounting estimate. Therefore, this change would be considered a change in accounting estimate pursuant to Statement of Financial Accounting Standard No. 154 ''Accounting Changes and Error Corrections'' (SFAS 154) and would be accounted for prospectively.

Commenters believed that the change would be best described as:

- A change in accounting estimate; [304]
- A change in accounting principle that is inseparable from a change in accounting estimate; or [305]
- A change in accounting estimate effected by a change in accounting principle.[306]

We believe that any accounting change resulting from the changes in definitions and required pricing assumptions in Rule 4–10, should be treated as a change in accounting principle that is inseparable from a change in accounting estimate, which does not require retroactive revision. We note that pursuant to AU 420.13, such a change requires recognition in the independent auditor's report through the addition of an explanatory paragraph.

All commenters on the issue agreed that adoption of the rules should not require retroactive revision of past reserves estimates.[307] Some believed retroactive revision of reserves estimates would be very burdensome or impossible because such data was not maintained.[308] We agree with those commenters and believe that no retroactive revisions will be necessary.

Three commenters recommended that the FASB revise Statement of Financial Accounting Standard No. 19 (SFAS 19) to include unconventional resources currently accounted for as mining activities and also provide guidance that no retroactive revisions would be required in that scenario.[309] We will continue to work with the FASB on this issue.

C. Differing Capitalization Thresholds Between Mining Activities and Oil and Gas Producing Activities

As noted elsewhere in this release, extraction of products such as bitumen now will be considered oil and gas producing activities, and not mining activities. Under current U.S. accounting guidance, costs associated with proven plus probable mining reserves may be capitalized for operations extracting products through mining methods, like bitumen. Under the new rules, bitumen extraction and operations that produce oil or gas through mining methods are included under oil and gas accounting rules, which only permit capitalization of costs associated with proved reserves.[310] Moreover, the mining guidelines do not provide specified percentages for establishing levels of certainty for proven or probable reserves for mining activities. It is possible that these differences could result in changing reserves estimates for these resources during the transition to the new rules.

One commenter believed that the industry would need guidance regarding how to transition operations that are disclosed and accounted for as mining operations to oil and gas disclosure and accounting.[311] It noted that this issue would be relevant not only coincident with the new rules, but could be relevant to future events, such as a coal mining company that in subsequent years changes its operations to in situ coal gasification.[312] That commenter believed that, without guidance, the change from mining treatment to oil and gas treatment could be considered a change in accounting principle which requires retroactive revision.[313] We acknowledge this commenter's concerns. With respect to resources formerly considered mining activities, we view the change from mining treatment to oil and gas treatment as a change in accounting principle that is inseparable from a change in accounting estimate, which does not require retroactive revision.

VIII. Application of Interactive Data Format to Oil and Gas Disclosures

In the Proposing Release, we sought comment on the desirability of rules that would permit, or require, oil and gas companies to present the tabular disclosures in Subpart 1200 in interactive data format in addition to the currently required format. Most commenters addressing the topic supported the use of XBRL for oil and gas disclosures.[314] They believed using interactive data would be very helpful to investors and analysts.[315]

However, they also recommended that the Commission wait until a well-developed taxonomy exists.[316] Some recommended that the Commission implement it in stages, initially with a voluntary program.[317] One commenter recommended that the SEC work with other groups like SPE, IASB, and the United Nations to ensure tags ultimately become the industry standard.[318]

We agree that much of the disclosures regarding oil and gas companies would be conducive to interactive data. We intend to continue to work on developing a taxonomy for such disclosure. Once a well-developed taxonomy is created, we will address this issue further. We are not, however, adopting interactive data requirements in this release. We will continue to consider whether to require interactive oil and gas disclosure filings in the future and, if so, when such filings should be required based on the development status of an oil and gas disclosure taxonomy.

IX. Implementation Date

A. Mandatory Compliance

We proposed to require companies to begin complying with the disclosure requirements for registration statements filed on or after January 1, 2010, and for annual reports on Forms 10–K and 20–F for fiscal years ending on or after December 31, 2009. A company may not apply the new rules to disclosures in quarterly reports prior to the first annual report in which the revised disclosures are required.

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[303] See letters from CAQ, CFA, Eni, Grant Thornton, KPMG, and PWC.

[304] See letters from CAQ, Canadian Natural, CAPP, Deloitte, Devon, KPMG, Petrobras, PWC, Repsol, Shell, and StatoilHydro.

[305] See letter from Deloitte.

[306] See letter from Petro-Canada.

[307] See letters from Apache, CAQ, Canadian Natural, CAPP, Deloitte, Devon, Evolution, ExxonMobil, Petrobras, Petro-Canada, PWC, Repsol, Shell, StatoilHydro, and Total.

[308] See letters from Canadian Natural, Deloitte, Evolution, Petrobras, and Shell.

[309] See letters from CAQ, Petrobras, and PWC.

[310] See Rule 4–10(c) of Regulation S–X [17 CFR 210.4–10(c)].

[311] See letter from KPMG.

[312] See letter from KPMG.

[313] See letter from KPMG.

[314] See letters from Audit Policy, CFA, Deloitte, Devon, E&Y, ExxonMobil, PWC, Shell, Standard Advantage, StatoilHydro, and Zakaib.

[315] See letters from CFA, Devon, E&Y, StatoilHydro, and Zakaib.

[316] See letters from Audit Policy, Deloitte, Devon, E&Y, ExxonMobil, PWC, Shell, StatoilHydro, and Zakaib.

[317] See letters from Audit Policy, Devon, E&Y, PWC, StatoilHydro, and Zakaib.

[318] See letter from Zakaib.

Fifteen commenters agreed that a delayed compliance date would be helpful in allowing companies to familiarize themselves with the new disclosure requirements before having to comply with them.[319] Four commenters supported the proposed January 1, 2010 compliance date of Securities Act filings and Exchange Act filings related to fiscal periods ending on or after December 31, 2009.[320] However, one conditioned this approval upon the adoption of the rules before December 31, 2008.[321] Another suggested one year after adoption of the rules.[322]

Four commenters believed that the proposed compliance date would be too soon.[323] One recommended a compliance date of December 31, 2010 to enable companies to make necessary changes in IT systems and data processing.[324] Another noted the magnitude of the proposed changes, length of time to design, program and implement system changes, and the goal of getting the best possible disclosure.[325] One commenter suggested delaying implementation for two years after adoption.[326]

We continue to believe that the proposed compliance dates are appropriate. However, as we discuss our revisions with the FASB and IASB, we will consider whether to delay the compliance date further.

B. Voluntary Early Compliance

Seven commenters recommended that early compliance not be permitted to maintain consistency and comparability of disclosure among issuers, which could be misleading or confusing to investors.[327] However, one commenter believed that the Commission should permit early adoption of the new rules because companies with different fiscal year ends are not comparable anyway.[328] One commenter suggested that the Commission permit companies to provide the new disclosures supplementally.[329] We agree that voluntary compliance may make disclosures incomparable. Therefore, companies may not elect to follow the new disclosure rules prior to the effective date.

X. Paperwork Reduction Act

A. Background

Our new rules and amendments contain ''collection of information'' requirements within the meaning of the Paperwork Reduction Act of 1995 (''PRA'').[330] We submitted the new rules and amendments to the Office of Management and Budget (OMB) for review in accordance with the PRA.[331] OMB has approved the revisions. The titles for these collections of information are:

(1) ''Regulation S–K'' (OMB Control No. 3235–0071); [332]

(2) ''Industry Guides'' (OMB Control No. 3235–0069);

(3) ''Regulation S–X'' (OMB Control No. 3235–0009);

(4) ''Form S–1'' (OMB Control No. 3235–0065);

(5) ''Form S–4'' (OMB Control No. 3235–0324);

(6) ''Form F–1'' (OMB Control No. 3235–0258);

(7) ''Form F–4'' (OMB Control No. 3235–0325);

(8) ''Form 10'' (OMB Control No. 3235–0064);

(9) ''Form 10–K'' (OMB Control No. 3235–0063); and

(10) ''Form 20–F'' (OMB Control No. 3235–0063).

We adopted all of the existing regulations and forms pursuant to the Securities Act and the Exchange Act. These regulations and forms set forth the disclosure requirements for annual reports [333] and registration statements that are prepared by issuers to provide investors with the information they need to make informed investment decisions in registered offerings and in secondary market transactions. The industry guides supplement the existing regulations and forms and provide guidance with respect to industry-specific disclosures.

Our amendments to these existing forms are intended to modernize and update our reserves definitions to better reflect changes in the oil and gas industry and markets and new technologies that have occurred in the decades since the current rules were adopted, including expanding the scope of permissible technologies for establishing certainty levels of reserves, reserves classifications that a company can disclose in a Commission filing, and the types of resources that can be included in a company's reserves, as well as providing information regarding a company's internal controls over reserves estimation and the qualifications of person preparing reserves estimates or conducting reserves audits. The new rules and amendments also are intended to codify, modernize, and centralize the disclosure items for oil and gas companies in Regulation S–K. Finally, the new rules and amendments are intended to harmonize oil and gas disclosures by foreign private issuers with disclosures by domestic companies. Overall, the new rules and amendments attempt to provide improved disclosure about an oil and gas company's business and prospects without sacrificing clarity and comparability, which provide protection and transparency to investors.

The hours and costs associated with preparing disclosure, filing forms, and retaining records constitute reporting and cost burdens imposed by the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid control number.

Many, but not all, of the information collection requirements related to annual reports and registration statements will be mandatory. There is no mandatory retention period for the information disclosed, and the information will be publicly available on the EDGAR filing system.

B. Summary of Information Collections

The new rules and amendments increase existing disclosure burdens for annual reports on Forms 10–K [334] and

[319] See letters from Apache, Chevron, Davis Polk, Deloitte, ExxonMobil, KPMG, Newfield, Petrobras, Petro-Canada, PWC, Ryder Scott, Shell, Southwestern, Talisman, and Total.

[320] See letters from Davis Polk, ExxonMobil, Shell, and StatoilHydro.

[321] See letter from ExxonMobil.

[322] See letter from Talisman.

[323] See letters from Apache, Petrobras, PWC, and Total.

[324] See letter from Petrobras.

[325] See letter from Apache.

[326] See letter from Devon.

[327] See letters from Davis Polk, Devon, ExxonMobil, Petrobras, Ryder Scott, Shell, and Wagner.

[328] See letter from Evolution.

[329] See letter from Davis Polk.

[330] 44 U.S.C. 3501 *et seq.*

[331] 44 U.S.C. 3507(d) and 5 CFR 1320.11.

[332] The paperwork burden from Regulation S–K and the Industry Guides is imposed through the forms that are subject to the disclosures in Regulation S–K and the Industry Guides and is reflected in the analysis of those forms. To avoid a Paperwork Reduction Act inventory reflecting duplicative burdens, for administrative convenience, we estimate the burdens imposed by each of Regulation S–K and the Industry Guides to be a total of one hour.

[333] The pertinent annual reports are those on Forms 10–K and 20–F.

[334] The disclosure requirements regarding oil and gas properties and activities are in Form 10–K as well as the annual report to security holders required pursuant to Rule 14a–3(b) [17 CFR 240.14a–3(b)]. Form 10–K permits the incorporation by reference of information from the Rule 14a–3(b) annual report to security holders to satisfy the Form 10–K disclosure requirements. The analysis that follows assumes that companies would either provide the proposed disclosure in a Form 10–K or incorporate the required disclosure into the Form 10–K by reference to the Rule 14a–3(b) annual report to security holders if the company is subject to the proxy rules. This approach takes into account the burden from the proposed disclosure

Continued

20–F and registration statements on Forms 10, 20–F, S–1, S–4, F–1, and F–4 by creating the following new disclosure requirements, many of which were requested by industry participants:

- Disclosure of reserves from non-traditional sources (*i.e.*, bitumen, shale, coalbed methane) as oil and gas reserves;
- Optional disclosure of probable and possible reserves;
- Optional disclosure of oil and gas reserves' sensitivity to price;
- Disclosure of the company's progress in converting proved undeveloped reserves into proved developed reserves, including those that are held for five years or more and an explanation of why they should continue to be considered proved;
- Disclosure of technologies used to establish reserves in a company's initial filing with the Commission and in filings which include material additions to reserves estimates;
- The company's internal controls over reserves estimates and the qualifications of the technical person primarily responsible for overseeing the preparation or audit of the reserves estimates;
- If a company represents that disclosure is based on the authority of a third party that prepared the reserves estimates or conducted a reserves audit or process review, filing a report prepared by the third party; and
- Disclosure based on a new definition of the term ''by geographic area.''

In addition, the amendments harmonize the disclosure requirements that apply to foreign private issuers with the disclosure requirements that apply to domestic issuers with respect to oil and gas activities. In particular, foreign private issuers must disclose the information required by Items 1205 through 1208 of Regulation S–K regarding drilling activities, present activities, delivery commitments, wells, and acreage, which previously were not specified in Appendix A to Form 20–F. These disclosure items codify the substantive disclosures called for by Items 4 through 8 of Industry Guide 2, although much of this disclosure may have been disclosed by some companies under the more general discussions of business and property on that form.

C. Revisions to PRA Burden Estimates

For purposes of the PRA, we estimated, in the Proposing Release, the total annual increase in the paperwork burden for all affected companies to comply with our proposed collection of information requirements to be approximately 7,472 hours of in-house company personnel time and to be approximately $1,659,000 for the services of outside professionals.[335] These estimates included the time and the cost of preparing and reviewing disclosure and filing documents. Our methodologies for deriving the above estimates are discussed below.

Our estimates represented the burden for all oil and gas companies that file annual reports or registration statements with the Commission. Based on filings received during the Commission's last fiscal year, we estimate that 241 oil and gas companies file annual reports and 67 oil and gas companies file registration statements. Most of the information called for by the new disclosure requirements, including the optional disclosure items, is readily available to oil and gas companies and includes information that is regularly used in their internal management systems. These disclosures include:

- Disclosure of reserves from non-traditional sources (*i.e.*, bitumen, shale, coalbed methane) as oil and gas reserves;
- Optional disclosure of probable and possible reserves;
- Optional disclosure of oil and gas reserves' sensitivity to price;
- Disclosure of the company's progress in converting proved undeveloped reserves into proved developed reserves, including those that are held for five years or more and an explanation of why they should continue to be considered proved;
- Disclosure of technologies used to establish reserves in a company's initial filing with the Commission and in filings which include material additions to reserves estimates;
- The company's internal controls over reserves estimates and the qualifications of the technical person primarily responsible for overseeing the preparation or audit of the reserves estimates;
- If a company represents that disclosure is based on the authority of a third party that prepared the reserves estimates or conducted a reserves audit or process review, filing a report prepared by the third party; and
- Disclosure based on a new definition of the term ''by geographic area.''

We estimated that, on average, each company would incur a burden of 35 hours to prepare these disclosures in an annual report or registration statement.

The amendments also apply several disclosure items to foreign private issuers that previously did not apply to them. As noted above, many of these disclosure items, such as drilling activities, wells and acreage, require the issuer to provide more specificity about its business and property. Foreign private issuers that do not currently provide such specificity would incur an added burden to present such disclosures in their filings. In the Proposing Release, we estimated that this burden would be 20 hours per foreign private issuer.

We received few comments regarding our estimates. Several large oil companies, and an industry organization that primarily represents large oil companies, believed that the estimates were too low. They believed that the new rules and amendments would increase their burden by 10,000 to 15,000 hours per year. However, these commenters included the initial cost to change their internal systems to provide the new required disclosures in their estimates. Based on conversations with these commenters, the staff understands that they believed that the ongoing burden would be approximately one-third of that estimate. For purposes of its Paperwork Reduction Act estimate, the staff considers the ongoing annual burden and spreads the initial transitional burden of compliance with new rules and regulations over a three-year period.

In addition, these commenters indicated that the two most significant burdens that stemmed from the proposed use of different prices for disclosure and accounting purposes and the increased detail in disclosures that would result from the proposed definition of the term ''geographic area'' and the proposed disclosure by type of accumulation. It should be noted that these commenters have significant reserves spread worldwide. Some of these large companies have as much as 10,000 times the amount of reserves of the median oil and gas company. These large companies likely would be more significantly impacted by the level of detailed disclosure that the proposals would have required compared to the vast majority of oil and gas companies in our reporting system, which do not have such extensive global operations. Therefore, we do not believe that the estimate provided by those large oil and gas companies necessarily would be applicable to most oil and gas companies. However, in response to the concerns that they expressed, the final rules do not require the use of different

requirements that are included in both Form 10–K and Regulation 14A or 14C.

[335] For administrative convenience, the presentation of the totals related to the paperwork burden hours have been rounded to the nearest whole number and the cost totals have been rounded to the nearest thousand.

prices for disclosure and full cost accounting purposes. We also intend to continue to work with the FASB to align the accounting standards with that pricing mechanism. In addition, we have significantly reduced the level of detailed geographic and product disclosure that the rules require. Finally, we are providing for a substantial transition period to allow companies to adjust their systems to comply with the new rules. We believe that these changes will help to mitigate the increased burden of the new rules.

We do, however, believe that our initial burden estimates may have been too low. We are therefore adjusting our burden estimate to reflect an additional increase of 100 hours per company per year. In addition, we are increasing our burden estimate for foreign private issuers by an additional 150 hours per company per year. Consistent with current Office of Management and Budget estimates and recent Commission rulemakings, we estimate that 25% of the burden of preparation of registration statements on Forms S–1, S–4, F–1, F–4, 10, and 20–F is carried by the company internally and that 75% of the burden is carried by outside professionals retained by the issuer at an average cost of $400 per hour.[336] We estimate that 75% of the burden of preparation of annual reports on Form 10–K or Form 20–F is carried by the company internally and that 25% of the burden is carried by outside professionals retained by the company at an average cost of $400 per hour. The portion of the burden carried by outside professionals is reflected as a cost, while the portion of the burden carried by the company internally is reflected in hours. The following tables summarize the additional changes to the PRA estimates:

TABLE 1—CALCULATION OF INCREMENTAL PAPERWORK REDUCTION ACT BURDEN ESTIMATES FOR EXCHANGE ACT PERIODIC REPORTS

Form	Annual responses	Incremental hours/form	Incremental burden	75% Issuer	25% Professional	$400 Professional cost
	(A)	(B)	(C)=(A)*(B)	(D)=(C)*0.75	(E)=(C)*0.25	(F)=(E)*$400
10–K§ [337]	206	100	20,600	15,450	5,150	2,060,000
20–F	35	150	5,250	3,938	1,312	525,000
Total	241		25,850	19,388	6,462	2,585,000

TABLE 2—CALCULATION OF INCREMENTAL PAPERWORK REDUCTION ACT BURDEN ESTIMATES FOR SECURITIES ACT REGISTRATION STATEMENTS AND EXCHANGE ACT REGISTRATION STATEMENTS

Form	Annual re-sponses	Incremental hours/form	Incremental burden	25% Issuer	75% Professional	$400 Professional cost
	(A)	(B)	(C)=(A)*(B)	(D)=(C)*0.25	(E)=(C)*0.75	(F)=(E)*$400
10	5	100	500	125	375	150,000
20–F	2	150	300	75	225	90,000
S–1	38	100	3,800	950	2,850	1,140,000
S–4	17	100	1,700	425	1,275	510,000
F–1	2	150	300	75	225	90,000
F–4	3	150	450	112.5	337.5	135,000
Total	67		7,050	1762.5	5,287.5	2,115,000

D. Request for Comment

We request comment in order to evaluate the accuracy of our estimates of the burden of the revised information collections. Any member of the public may direct to us any comments concerning the accuracy of these burden estimates. Persons who desire to submit comments on the collection of information requirements should direct their comments to the OMB, Attention: Desk Officer for the Securities and Exchange Commission, Office of Information and Regulatory Affairs, Washington, DC 20503, and should send a copy of the comments to Secretary, Securities and Exchange Commission, 100 F Street, NE., Washington, DC 20549–1090, with reference to File No. S7–15–08. Requests for materials submitted to the OMB by us with regard to this collection of information should be in writing, refer to File No. S7–15–08, and be submitted to the Securities and Exchange Commission, Records Management Branch, 100 F Street, NE., Washington, DC 20549–1126. Because OMB is required to make a decision concerning the collections of information between 30 and 60 days after publication, your comments are best assured of having their full effect if OMB receives them within 30 days of publication.

XI. Cost-Benefit Analysis

A. Background

We are adopting revisions to the oil and gas reserves disclosure regime of Regulation S–K and Regulation S–X under the Securities Act of 1933 and the Securities Exchange Act of 1934 and Industry Guide 2. The revisions are intended to modernize and update oil and gas disclosure. The oil and gas industry has experienced significant changes since the Commission initially adopted its current rules and disclosure

[336] In connection with other recent rulemakings, we have had discussions with several private law firms to estimate an hourly rate of $400 as the average cost of outside professionals that assist issuers in preparing disclosures and conducting registered offerings.

[337] The burden estimates for Form 10–K assume that the requirements are satisfied by either including information directly in the annual reports or incorporating the information by reference from the Rule 14a–3(b) annual report to security holders.

regime between 1978 and 1982, including advancements in technology and changes in the types of projects in which oil and gas companies invest. The revisions also are intended to provide investors with improved disclosure about an oil and gas company's business and prospects without sacrificing clarity and comparability.

B. Description of New Rules and Amendments

Currently, Industry Guide 2 specifies many of the disclosure guidelines for oil and gas companies. The Industry Guide calls for disclosure relating to reserves, production, property, and operations in addition to that which is required by Regulation S–K. Generally, the new rules and amendments codify and update the existing Industry Guide 2 disclosures in a new Subpart 1200 of Regulation S–K, clarify the level of detail required to be disclosed, and require reserves disclosure in a tabular presentation. The changes relate primarily to disclosure of the following:

- Disclosure of reserves from non-traditional sources (*e.g.*, bitumen, shale) as oil and gas reserves;
- Optional disclosure of probable and possible reserves;
- Optional disclosure of oil and gas reserves' sensitivity to price;
- Disclosure of the company's progress in converting proved undeveloped reserves into proved developed reserves, including those that are held for five years or more and an explanation of why they should continue to be considered proved;
- Disclosure of technologies used to establish reserves in a company's initial filing with the Commission and in filings which include material additions to reserves estimates;
- The company's internal controls over reserves estimates and the qualifications of the technical person primarily responsible for overseeing the preparation or audit of the reserves estimates;
- If a company represents that disclosure is based on the authority of a third party that prepared the reserves estimates or conducted a reserves audit or process review, filing a report prepared by the third party; and
- Disclosure based on a new definition of the term ''by geographic area.''

The new rules and amendments also make revisions and additions to the definitions section of Rule 4–10 of Regulation S–X. These revisions update and extend reserves definitions to reflect changes in the oil and gas industry and new technologies. In particular, the new and revised definitions:

- Expand the definition of ''oil and gas producing activities'' to include the extraction of hydrocarbons from oil sands, shale, coalbeds, or other natural resources and activities undertaken with a view to such extraction;
- Add a definition of ''reasonable certainty'' to provide better guidance regarding the meaning of that term;
- Add a definition of ''reliable technology'' to permit the use of new technologies to establish proved reserves;
- Define probable and possible reserves estimates; and
- Add definitions to explain new terms used in the revised definitions.

In addition, the amendments harmonize the disclosure requirements that apply to foreign private issuers with the disclosure requirements that apply to domestic issuers with respect to oil and gas activities. In particular, the amendments to Form 20–F will require foreign private issuers to disclose the information required by Items 1205 through 1208 of Regulation S–K regarding drilling activities, present activities, delivery commitments, wells, and acreage, which are not currently specified under Appendix A to Form 20–F, although much of this disclosure is often disclosed by companies under the more general discussions of business and property on that form.

C. Benefits

We expect that the new rules and amendments will increase transparency in disclosure by oil and gas companies by providing improved reporting standards. The revisions to the definitions should align our disclosure rules with the realities of the modern oil and gas markets. For example, we believe that the inclusion of bitumen and other resources from continuous accumulations as oil and gas producing activities is consistent with company practice to treat these operations as part of, rather than separate from, their traditional oil and gas producing activities. Similarly, the expansion of permissible technologies for determining certainty levels of reserves recognizes that companies now take advantage of these technological advances to make business decisions. We expect these new rules and amendments to improve disclosure by aligning the required disclosure more closely with the way companies conduct their business.

Allowing companies to disclose probable and possible reserves is designed to improve investors' understanding of a company's unproved reserves. For those companies that already disclose such reserves on their Web sites, the new rules and amendments permit them to unify such disclosures into a single, filed document. Disclosure of these categories of reserves beyond proved reserves may foster better company valuations by investors, creditors, and analysts, thus improving capital allocation and reducing investment risk. Because some of the disclosure items are optional, the amount of increased transparency will depend on the extent to which companies elect to provide the additional disclosures permitted under the new rules. If companies elect not to provide the optional disclosure, then the benefits from increased transparency would be limited to the extent that the new rules improve the transparency of proved reserves disclosure.

By permitting increased disclosure and promoting more consistency and comparability among disclosures, the new rules and amendments provide a mechanism for oil and gas companies to seek more favorable financing terms through more disclosure and increased transparency. Investors may be able to request such additional disclosure in Commission filings during negotiations regarding bond and debt covenants. Thus, we expect that, as a result of competing factors in the marketplace, the new rules and amendments will result in increased transparency, either because companies elect to voluntarily provide increased disclosure, or because investors may discount companies that do not do so. We believe that the benefits and costs of disclosing unproved reserves ultimately will be determined by market conditions, rather than regulatory requirements.

We expect that permitting companies to disclose probable and possible reserves will increase market transparency, provide investors with more reserves information, and allow for more accurate production forecasts. By relating standards used in deterministic methods to comparable percentage thresholds used in probabilistic methods for establishing a given level of certainty, the new rules and amendments should result in increased standardization in reporting practices which would promote comparability of reserves across companies. The new rules would define the term ''reliable technology'' to permit oil and gas companies to prepare their reserves estimates using new types of technology that companies are not permitted to use under the current rules. This new definition also is designed to encompass new technologies as they are developed in the future, thereby

providing investors and the market with a more comprehensive understanding of a company's estimated reserves.

We expect that replacing the Industry Guide with new Regulation S–K items will provide greater certainty because the disclosure requirements would be in rules established by the Commission. In addition, we believe that disclosure of reserves concentrated in particular countries should provide better information to investors regarding the geopolitical risk to which some companies may be exposed. Overall, we believe that the amendments, as a whole, will provide investors with more information that management uses to make business decisions in the oil and gas industry.

1. Average Price and First of the Month Price

The revision to change the price used to calculate reserves from a year-end single-day price to a historical average price over the company's most recently ended fiscal year is expected to reduce the effects of seasonality. In particular, many commenters suggested the use of a 12-month average price to mitigate the risk of a year-end price affected by short-term price volatility such that it does not reflect the true nature of a company investment, planning, and performance. Our Office of Economic Analysis studied the publicly-available pricing data and found evidence of year-end price volatility. The historical volatility of year-end prices is between 16 percent and 41 percent higher than the volatility of annual average prices depending on the grade and geography of oil or gas prices considered. This difference demonstrates variability in oil and gas prices, likely due to seasonal demands, that does not reflect long term fundamental values, but that cannot be immediately corrected due to the costs of transportation and speed of delivery. Given this variability, it is likely that a 12-month average price will yield better reserves estimates—that reflect management planning and investment to the extent that they discount the short-term component of oil and gas prices—than a year-end spot price.

Many of the commenters to the Proposing Release supported the use of a historical price, even though this approach may be less useful in determining the fair value of a company's reserves compared to a futures market price. We believe investors are concerned not only about the quantity of a company's reserves, but also about the profitability of those reserves. We also recognize that some reserves will be of more value than others due to extraction and transportation costs. As a result, since the new rules and amendments require the use of a single price to estimate reserves and since that price may not be as informative of value as a futures price, the new rules and amendments also gives companies the option of providing a sensitivity analysis and reporting reserves based on additional price estimates.

If companies elect to provide a sensitivity analysis, we expect this to benefit investors by allowing them to formulate better projections of company prospects that are more consistent with management's planning price and prices higher and lower that may reasonably be achieved. In particular, it allows companies the flexibility to communicate how their reserves would change under alternative economic conditions, including those that they may believe better reflect their future prospects. We expect that companies would be more likely to adopt a sensitivity analysis approach if investors and other market participants determine that this information would reduce investment risk, or if companies believe such disclosure will reduce the cost of capital formation. The new rules and amendments should result in increased price stability in determining whether reserves are economically producible. This should mitigate seasonal effects, resulting in reserves estimates that more closely reflect those used by management in planning and investment decisions. We expect this to allow for more accurate company assessments and improve projections of company prospects.

In addition to an average annual price, many of the commenters suggested that the price be computed on the first day of the month. Two reasons were given. First, beginning month prices would allow an additional month of preparation time in calculating reserves for financial reporting. Second, some commenters suggested that month-end, and in particular year-end, prices were subject to additional short-term volatility because many oil and gas financial contracts expire on those days, resulting in higher than normal trading activity. While the staff of the Office of Economic Analysis did not find systematic evidence of increased volatility around month-end or year-end oil and gas prices relative to other days in the month, we agree that additional preparation time is beneficial because reserves estimations require significant time and resources. An additional month would help reduce errors that might otherwise result from the financial reporting time constraints.

Finally, we believe that revising the full cost accounting method to use the same pricing mechanism as the reserves disclosure requirements should provide consistency between the disclosure and accounting presentations. The use of a single pricing method should also minimize the incremental burden placed on companies as a result of the rule changes because they would not be required to prepare two separate estimates.

2. Probable and Possible Reserves

We anticipate that disclosure of probable and possible reserves, if companies elect to do so, will allow investors, creditors, and other users to better assess a company's reserves. In addition, the tabular format for disclosing probable and possible reserves should reduce investor search costs by making it easier to locate reserves disclosures and facilitating comparability among oil and gas companies.

While we recognize that many companies already communicate with investors about their unproved and other reserves through alternative means, such as company Web sites or press releases, some commenters remarked that an objective comparison among companies is difficult because different companies have defined such reserves classifications differently. We believe that permitting disclosure of this information in Commission filings will provide a more consistent means of comparison because disclosure in our filings must comply with our definitions. Although our new rules make disclosure of probable and possible reserves optional, and large oil and gas producers suggested in their comment letters that such disclosure would be of limited benefit because of the relative uncertainty of those estimates, we believe that competitive pressures within the industry might make it beneficial for large producers to disclose this information. Increased disclosure might, for example, improve credit quality and lower the cost of debt financing, or reduce the risk associated with business transactions between the company and its customers or suppliers. Regardless, since the disclosure decision is voluntary, it should occur only to the extent that companies find that the benefits justify the costs of doing so.

We believe that permitting the disclosure of probable and possible reserves will benefit smaller companies, in particular. Larger issuers tend to already have large amounts of proved reserves. The new rules and amendments permit smaller companies,

who often participate in a significant amount of exploratory activity, to better disclose their business prospects. Consequently, we anticipate that the new rules and amendments could lead to efficiencies in capital formation, as more information will be available regarding the prospects of smaller issuers.

3. Reserves Estimate Preparers and Reserves Auditors

We believe that investors would benefit from a greater level of assurance with respect to the reliability of reserve estimates, particularly if companies are allowed to disclose unproved reserves because unproved reserves are inherently less certain than proved reserves. We proposed disclosure requirements relating to whether the person primarily responsible for preparing reserves estimates or conducting a reserves audit, if the company represents that it has enlisted a third party to conduct a reserves audit, met a specified list of qualifications based on the Society of Petroleum Engineers's reserves audit guidelines. However, commenters expressed concern that many of these qualifications such as membership in professional societies were not standardized worldwide. Without control over those standards, the disclosures would not be comparable. We agree with those commenters and, as suggested, have adopted a more principles-based disclosure requirement. Under the adopted rules, a company must disclose its internal controls over reserves estimations and disclose the qualifications of the primary technical person in charge of overseeing the reserves estimations or reserves audit. We believe that disclosure of the individual qualifications, rather than simple acknowledgement of meeting certain criteria, which may differ within countries, will provide investors with better information to compare companies and the qualifications of persons in charge of the reserves estimations and reserves audits, which should enable more accurate assessments of the quality of audit reports. We believe that disclosure of a company's internal controls over reserves estimates will allow investors to assess whether a company has implemented appropriate controls without dictating to companies specified criteria for establishing those controls.

Although we do not expect all companies to undertake a third-party reserves audit because our rules do not require such a reserves audit, third party participation in the estimation of reserves should add credibility to a company's public disclosure. The opinion of an objective, qualified person on the reserves estimates is designed to increase the reliability of these estimates and investor confidence.

4. Development of Proved Undeveloped Reserves

The new rules and amendments also require disclosure of a company's progress in developing undeveloped reserves and the reasons why any PUDs have remained undeveloped for five years or more. We believe that such disclosure supplements our amendments that ease the requirements for recognizing PUDs and thereby should increase the amount of PUDs disclosed in filings, even though the properties representing such proved reserves have not yet been developed and therefore do not provide the company with cash flow. We believe that the disclosure requirements will increase the accountability of companies that disclose reserves for extended periods of time without adequate justification for their failure to develop those reserves.

5. Disclosure Guidance

The release also provides guidance about the type of information that companies should consider disclosing in Management's Discussion and Analysis, and allows companies to include this information with the relevant tables. Providing the additional guidance should assist companies in preparing their disclosure, improving the quality and consistency of this disclosure. Locating this discussion with the tables themselves should benefit investors by simplifying the presentation of disclosure, and providing insight into the information disclosed in the tables.

6. Updating of Definitions Related to Oil and Gas Activities

The new rules and amendments also update the definition of the term ''oil and gas producing activities'' as well as updating or creating new definitions for other terms related to such activities, including ''proved oil and gas reserves'' and ''reasonable certainty.'' We believe that updating these definitions will help companies disclose oil and gas operations in the same way that companies manage and assess those operations. This includes resources extracted from nontraditional sources that companies consider oil and gas activities, which previously were excluded them from the definition of ''oil and gas producing activities.'' In addition, adding definitions for terms like ''reasonable certainty'' (which currently is in the definition of ''proved oil and gas reserves,'' but not defined) will provide companies with added guidance and assist them in providing consistent disclosures between companies.

7. Harmonizing Foreign Private Issuer Disclosure

We believe that the harmonization of foreign private issuer disclosure will help make disclosures of foreign private issuers more comparable with domestic companies. The oil and gas industry has changed significantly since the rules were adopted. Today, many companies have interests that span the globe. In addition, many of these projects are joint ventures between foreign private issuers and domestic companies. Having differing levels of disclosure for companies that may be participating in the same projects harms comparability between investment choices. The harmonization of foreign private issuer disclosure is intended to promote comparability among all oil companies.

D. Costs

We expect that the new rules and amendments will result in initial and ongoing costs to oil and gas companies. These burdens will vary significantly among companies. Based on disclosures in company filings, the largest oil and gas companies can have as much as 10,000 times the reserves of the median reporting oil and gas company. As would be expected, companies that have more reserves and larger operations will have a correspondingly larger amount of information that they must disclose and, therefore, the burden of complying with our disclosure requirements would be greater for larger companies.

Although we are adding a new subpart to Regulation S–K to set forth the disclosure requirements that are unique to oil and gas companies, the subpart, for the most part, codifies the substantive disclosure called for by Industry Guide 2. The disclosure requirements have been updated and clarified, and require the disclosure to be presented in a tabular format, where appropriate.

Although many companies already present this information in tabular form, for companies that do not, this requirement could impose a burden on companies as they transition from a narrative to tabular disclosure format. We expect, however, that any increased preparation costs would be highest in the first year after adoption, but would decline in subsequent years as companies adjust to the new format. We

think this burden is justified because tabular disclosure will increase comparability and facilitate understanding and analysis by investors.

1. Probable and Possible Reserves

Allowing disclosure of probable and possible reserves could create an increased risk of litigation because these categories of reserves estimates are less certain than proved reserves. Companies may choose not to disclose such reserves, in part, because of the risk of incurring litigation costs to defend their disclosures due to the increased uncertainty of these categories. Disclosure of probable and possible reserves may also result in revealing competitive information because it might reveal a company's business strategy, such as the geographic location and nature of its exploration and discoveries. For example, if geographical detail can be inferred from estimates of unproved reserves, this might reveal information about the value of a company's assets to competitors and could put the producer at a competitive disadvantage. We have reduced the level of geographical detail to reduce the burden on companies, while still providing sufficient information to investors regarding concentrations of risk, including political risk.

We expect companies will incur costs in preparing the additional disclosures such as calculating and aggregating the reserve projections in a prescribed format. However, if probable and possible categories of reserves have different extraction cost structures and they are not disclosed separately from proved reserves, this could result in increased uncertainty in an investor's assessment of a company's prospects.

Companies also expressed concern that mandatory disclosure of probable and possible reserves could expose them to increased litigation risk. We believe that making these disclosures voluntary mitigates these concerns. Companies unwilling to bear the added risk can simply opt not to provide this disclosure.

2. Reserves Estimate Preparers and Reserves Auditors

If a company chooses to use a third party to prepare or audit reserve estimates, it will incur costs to hire these outside consultants. The new rules and amendments do not require companies to hire such a person. If enough companies that currently do not use such consultants begin to hire them, we believe that industry wages could potentially increase due to increased demand for reserves calculating specialists unless that demand is compensated by an increase in the supply of such persons. If wages increased, then all companies, not just those employing third party consultants, would incur added costs.

Large companies may be less likely to hire third parties because they tend to have staff to make reserves estimates. However, if such large companies chose to hire third-party consultants, third parties would expend significantly more effort on such projects than for smaller companies because larger companies have more properties to evaluate. Thus, we expect third-party fees, and the time required to conduct such projects, would scale upwards with the quantity of company reserves.

Disclosure of unproved reserves without third-party certification may present a risk with respect to smaller oil and gas producers because smaller companies are likely to have less in-house expertise and ability to accurately estimate such reserves than larger companies. However, we understand that the vast majority of smaller oil and gas companies already hire third parties to estimate their reserves or certify their estimates.

3. Consistency With IASB

Some commenters remarked that the International Accounting Standards Board is currently preparing a set of guidelines for oil and gas extractive activities, including definitions of oil and gas reserves, and recommended that the Commission align its regulations with those guidelines. We intend to monitor this initiative and work with the IASB, but our new rules may differ from the guidelines ultimately established by the International Accounting Standards Board. This could make it more difficult for investors to compare foreign and domestic companies.

4. Change in Pricing Mechanism

We do not anticipate significant costs with the change in pricing mechanisms for established reserves. Companies simply will apply a different price scenario to determine the economic producibility of reserves. It is possible that the use of a 12-month average price may reduce the cost of disclosure because it should reduce the volatility of reserves estimates and therefore reduce the need to make significant adjustments to those estimates on a yearly basis due to daily price swings.

5. Disclosure of PUD Development

The required disclosure of a company's progress in developing PUDs will increase the cost of reporting. However, we believe that companies regularly track their progress in this arena. Until a company develops a property, it cannot begin to realize the cash flows from production and the actual sale of products. Thus, the development of reserves is of utmost importance to an oil and gas company's business.

6. Increased Geographic Disclosure

The requirements to provide increased geographic disclosure of reserves and production, in certain circumstances, may increase the amount of disclosure that a company must present. However, because the threshold that we are adopting in the release is 15% of the company's total reserves, a company would be required to disclose, at most, reserves and production in six countries. Considering the relatively large proportion of reserves that must exist in a country before a company is required to provide country-level disclosure, we believe that such information is readily available to companies. As noted in the body of this release, we have attempted to draft this provision to minimize any competitive harm that such disclosure may cause a company.

7. Harmonizing Foreign Private Issuer Disclosure

The harmonization of foreign private issuer disclosure regarding oil and gas activities may increase the burden on foreign private issuers. However, it is our understanding that the large foreign private issuers already voluntarily provide disclosure comparable to the level required from domestic companies. Much of the added new disclosure relates to the day-to-day business and properties of these companies, including drilling activities, number of wells and acreage. This is information that is central to the activities of oil and gas companies, and therefore is readily known to these companies. We believe that applying Subpart 1200 to these companies could prompt more detailed disclosure regarding these activities, which would cause these companies to incur some cost. The provision permitting foreign private issuers to omit disclosures if prohibited from making those disclosures by their home jurisdiction could mitigate some of these costs.

XII. Consideration of Burden on Competition and Promotion of Efficiency, Competition, and Capital Formation

Securities Act Section 2(b)[338] and Section 3(f) of the Exchange Act[339] require us, when engaging in rulemaking where we are required to consider or determine whether an action is necessary or appropriate in the public interest, to consider, in addition to the protection of investors, whether the action will promote efficiency, competition, and capital formation. Section 23(a)(2) of the Exchange Act[340] requires us, when adopting rules under the Exchange Act, to consider the impact that any new rule would have on competition. In addition, Section 23(a)(2) prohibits us from adopting any rule that would impose a burden on competition not necessary or appropriate in furtherance of the purposes of the Exchange Act.

We expect the new rules and amendments to increase efficiency and enhance capital formation, and thereby benefit investors, by providing the market with better information based on updated technology as well as increased information covering a broader range of reserves classifications held by a company and reserves found in non-traditional sources of oil and gas. Such increased and improved information should permit investors to better assess a company's prospects. In particular, the existing prohibitions against disclosing reserves other than proved reserves, using modern technology to determine the certainty level of reserves, and including resources from non-traditional sources can lead to incomplete disclosures about a company's actual resources and prospects. The new rules and amendments are designed to better align the disclosure requirements with the way companies make business decisions.

We believe that permitting the disclosure of probable and possible reserves will benefit smaller companies, in particular. Larger issuers tend to already have large amounts of proved reserves. The new rules and amendments permit smaller companies, who often participate in a significant amount of exploratory activity, to better disclose their business prospects. Consequently, we anticipate that the new rules and amendments could lead to efficiencies in capital formation, as more information will be available regarding the prospects of smaller issuers.

The effects of the new rules and amendments on competition are difficult to predict, but it is possible that permitting public issuers to disclose probable and possible reserves will lead to a reallocation of capital, as companies that previously could show few proved reserves will be able to disclose a broader range of its business prospects, making it easier for these issuers to raise capital and compete with companies that have large proved reserves. Although our new rules make disclosure of probable and possible reserves optional, and large oil and gas producers suggested in their comment letters that such disclosure would be of limited benefit because of the relative uncertainty associated with such reserves, we believe that competitive pressures within the industry might make it beneficial for large producers to disclose this information. Increased disclosure might, for example, improve credit quality and lower the cost of debt financing, or reduce the risk associated with business transactions between the company and its customers or suppliers.

XIII. Final Regulatory Flexibility Analysis

We have prepared this Final Regulatory Flexibility Analysis in accordance with Section 603 of the Regulatory Flexibility Act.[341] This analysis relates to the modernization of the oil and gas disclosure requirements. An Initial Regulatory Flexibility Analysis (IRFA) was prepared in accordance with the Regulatory Flexibility Act in conjunction with the Proposing Release. The Proposing Release included, and solicited comment on, the IRFA.

A. Reasons for, and Objectives of, the New Rules and Amendments

The Commission adopted the current disclosure regime for oil and gas producing companies in 1978 and 1982, respectively. Since that time, there have been significant changes in the oil and gas industry and markets, including technological advances, and changes in the types of projects in which oil and gas companies invest their capital. On December 12, 2007, the Commission published a Concept Release on possible revisions to the disclosure requirements relating to oil and gas reserves.[342] Prior to our issuance of the Concept Release, many industry participants had expressed concern that our disclosure rules are no longer in alignment with current industry practices and therefore have limited usefulness to the market and investors.

Our new rules and amendments to these existing forms are intended to modernize and update our reserves definitions to reflect changes in the oil and gas industry and markets and new technologies that have occurred in the decades since the current rules were adopted, including expanding the scope of permissible technologies for establishing certainty levels of reserves, reserves classifications that a company can disclose in a Commission filing, and the types of resources that can be included in a company's reserves, as well as providing information regarding the objectivity and qualifications of any third party primarily responsible for preparing or auditing the reserves estimates, if the company represents that it has enlisted a third party to conduct a reserves audit, and the qualifications and measures taken to assure the independence and objectivity of any employee primarily responsible for preparing or auditing the reserves estimates. The amendments also harmonize our full cost accounting rules with the changes that we are adopting with respect to disclosure of oil and gas reserves. The new rules and amendments also are intended to codify, modernize and centralize the disclosure items for oil and gas companies into Regulation S–K. Finally, the new rules and amendments are intended to harmonize oil and gas disclosures by foreign private issuers with disclosures by domestic companies. Overall, the new rules and amendments attempt to provide improved disclosure about an oil and gas company's business and prospects without sacrificing clarity and comparability, which provide protection and transparency to investors.

B. Significant Issues Raised by Commenters

We did not receive comments specifically addressing the impact of the proposed rules and amendments on small entities. However, several of the comments related to burdens that would be placed on all companies affected by the proposals. In particular, commenters believed that the proposal to require the use of different prices for disclosure and accounting purposes would impose a significant burden on all oil and gas companies. We have considered those comments and are adopting amendments to our disclosure rules and the full cost accounting method that will require the use of a single price for both purposes. Similarly, commenters were concerned that certain aspects of

[338] 15 U.S.C. 77b(b).

[339] 15 U.S.C. 78c(f).

[340] 15 U.S.C. 78w(a)(2).

[341] 5 U.S.C. 603.

[342] See Release No. 33–8870 (Dec. 12, 2007) [72 FR 71610].

the proposal, such as the new definition of geographic area and disclosure by accumulation type would increase the detail in the disclosures significantly. We agree with those commenters and have significantly reduced the level of detail required in the disclosure requirements.

C. Small Entities Subject to the New Rules and Amendments

The new rules and amendments affect small entities that are engaged in oil and gas producing activities, the securities of which are registered under Section 12 of the Exchange Act or that are required to file reports under Section 15(d) of the Exchange Act. The new rules and amendments also would affect small entities that file, or have filed, a registration statement that has not yet become effective under the Securities Act and that has not been withdrawn. Securities Act Rule 157 [343] and Exchange Act Rule 0–10(a) [344] define an issuer to be a ''small business'' or ''small organization'' for purposes of the Regulatory Flexibility Act if it had total assets of $5 million or less on the last day of its most recent fiscal year. The new rules and amendments affect small entities that are operating companies and engage in oil and gas producing activities. Based on filings in 2007, we estimate that there are approximately 28 oil and gas companies that may be considered small entities.

D. Reporting, Recordkeeping, and Other Compliance Requirements

The new rules and amendments to Regulation S–K expand some existing disclosures, and eliminate others. In particular, the new disclosure requirements, many of which were requested by industry participants, include the following:

- Disclosure of reserves from non-traditional sources (*e.g.*, bitumen and shale) as oil and gas reserves;
- Optional disclosure of probable and possible reserves;
- Optional disclosure of oil and gas reserves' sensitivity to price;
- Disclosure of the development of proved undeveloped reserves, including those that are held for 5 years or more and an explanation of why they should continue to be considered proved;
- Disclosure of technologies used to establish reserves in a company's initial filing with the Commission and in filings which include material additions to reserves estimates;
- Disclosure of the company's internal controls over reserves estimates and the qualifications the technical person primarily responsible for overseeing the preparation or audit of the reserves estimates;
- If a company represents that disclosure is based on the authority of a third party that prepared the reserves estimates or conducted a reserves audit or process review, filing a report prepared by the third party; and
- Disclosure based on a new definition of the term ''by geographic area.''

There would be no mandatory retention period for the information disclosed, and the information disclosed would be made publicly available on the EDGAR filing system.

E. Agency Action To Minimize Effect on Small Entities

We considered different compliance standards for the small entities that will be affected by the new rules and amendments. In the Proposing Release, we solicited comment regarding the possibility of different standards for small entities. We did not receive comment on this particular issue. However, we believe that such differences would be inconsistent with the purposes of the rules.

The new rules and amendments are designed to modernize the disclosure requirements for oil and gas companies. As such, we believe all oil and gas companies will benefit from the modernization of the rules. Under the new rules and amendments, all companies will be allowed to use modern technologies to establish reserves and include operations in unconventional resources in their oil and gas reserves estimates. Adopting differing standards for disclosure for small entities would significantly reduce the comparability between companies. However, the new rules and amendments do permit companies to disclose probable and possible reserves. We believe the removal of the prohibition against such reserves will enable companies to disclose a broader view of their prospects. We believe this will particularly benefit smaller oil and gas companies that may have significant unproved reserves in their portfolio. Such disclosure may assist smaller companies in raising capital for development projects in those properties.

XIV. Update to Codification of Financial Reporting Policies

The Commission amends the ''Codification of Financial Reporting Policies'' announced in Financial Reporting Release No. 1 (April 15, 1982) [47 FR 21028] as follows:

1. By removing the seven introductory paragraphs before Section 406.01, the last sentence of Section 406.01.c.vi., the first paragraph of Section 406.01.d, the introductory paragraph of Section 406.02.d, and removing and reserving Sections 406.01.a., 406.02.a, 406.02.b., 406.02.d.iii., and 406.02.e.

2. By revising Section 406.01B to read as follows:

The rules in Rule 4–10(b) specify that the application of successful efforts shall comply with SFAS 19. In 2008, the Commission published amendments to the definitions in Rule 4–10(a) that may not align completely with SFAS 19's existing terminology and application. Further, paragraph 7 of SFAS 25 states: ''For purposes of applying this Statement and Statement 19, the definition of proved reserves, proved developed reserves, and proved undeveloped reserves shall be the definitions adopted by the SEC for its reporting purposes that are in effect on the date(s) as of which the reserve disclosures are to be made. Previous reported quantities shall not be revised retroactively if the SEC definitions are changed.'' In any case, the Commission expects the practical application of SFAS 19 will remain unchanged other than incorporating the effects of the new definitions.

3. By removing the first three sentences of Section 406.02.c. and in the fourth sentence replacing the phrase ''this sort of information'' with ''information to assess the impact of oil and gas producing activities on near term cash flows and liquidity''.

4. By adding a new Section 406.03 entitled ''Transition'' and including the text of the 3rd paragraph of Section VII.B and the last sentence of the 2nd paragraph of Section VII.C of this release.

5. By adding a new Section 406.04 entitled ''MD&A Guidance'' and including the text beginning with the last sentence of the 2nd paragraph of Section V of this release through the end of that Section.

The Codification is a separate publication of the Commission. It will not be published in the **Federal Register** or Code of Federal Regulations. For more information on the Codification of Financial Reporting Policies, contact the Commission's Public Reference Room at 202–551–5850.

XV. Statutory Basis and Text of Amendments

We are adopting the amendments pursuant to Sections 3(b), 6, 7, 10 and 19(a) of the Securities Act and Sections 12, 13, 14(a), 15(d), and 23(a) of the Exchange Act, as amended.

[343] 17 CFR 230.157.

[344] 17 CFR 240.0–10(a).

Text of Amendments

List of Subjects

17 CFR Part 210

Accountants, Accounting, Reporting and recordkeeping requirements, Securities.

17 CFR Parts 211, 229 and 249

Reporting and recordkeeping requirements, Securities.

■ For the reasons set out in the preamble, title 17, chapter II of the Code of Federal Regulations is amended as follows:

PART 210—FORM AND CONTENT OF AND REQUIREMENTS FOR FINANCIAL STATEMENTS, SECURITIES ACT OF 1933, SECURITIES EXCHANGE ACT OF 1934, PUBLIC UTILITY HOLDING COMPANY ACT OF 1935, INVESTMENT COMPANY ACT OF 1940, INVESTMENT ADVISERS ACT OF 1940, AND ENERGY POLICY AND CONSERVATION ACT OF 1975

■ 1. The authority citation for part 210 continues to read as follows:

Authority: 15 U.S.C. 77f, 77g, 77h, 77j, 77s, 77z–2, 77z–3, 77aa(25), 77aa(26), 78c, 78j–1, 78*l*, 78m, 78n, 78o(d), 78q, 78u–5, 78w(a), 78*ll*, 78mm, 80a–8, 80a–20, 80a–29, 80a–30, 80a–31, 80a–37(a), 80b–3, 80b–11, 7202 and 7262, unless otherwise noted.

■ 2. Amend § 210.4–10 by:

■ a. Redesignating the subparagraphs in paragraph (a) as follows:

Old paragraph number	New paragraph number
(a)(1)	(a)(16)
(a)(2)	(a)(22)
(a)(5)	(a)(23)
(a)(6)	(a)(32)
(a)(7)	(a)(21)
(a)(8)	(a)(15)
(a)(9)	(a)(27)
(a)(10)	(a)(13)
(a)(11)	(a)(9)
(a)(12)	(a)(29)
(a)(13)	(a)(30)
(a)(14)	(a)(1)
(a)(15)	(a)(12)
(a)(16)	(a)(7)
(a)(17)	(a)(20)

■ b. Removing paragraphs (a)(3) and (a)(4);

■ c. Adding new paragraphs (a)(2), (a)(3), (a)(4), (a)(5), (a)(6), (a)(8), (a)(10), (a)(11), (a)(14), (a)(17), (a)(18), (a)(19), (a)(24), (a)(25), (a)(26), (a)(28), (a)(31), and (c)(8);

■ d. Revising newly redesignated paragraphs (a)(13), (a)(16), (a)(22), and (a)(30); and

■ e. Removing the authority citations following the section.

The additions and revisions read as follows:

§ 210.4–10 Financial accounting and reporting for oil and gas producing activities pursuant to the Federal securities laws and the Energy Policy and Conservation Act of 1975.

* * * * *

(a) Definitions. * * *

* * * * *

(2) *Analogous reservoir.* Analogous reservoirs, as used in resources assessments, have similar rock and fluid properties, reservoir conditions (depth, temperature, and pressure) and drive mechanisms, but are typically at a more advanced stage of development than the reservoir of interest and thus may provide concepts to assist in the interpretation of more limited data and estimation of recovery. When used to support proved reserves, an ''analogous reservoir'' refers to a reservoir that shares the following characteristics with the reservoir of interest:

(i) Same geological formation (but not necessarily in pressure communication with the reservoir of interest);

(ii) Same environment of deposition;

(iii) Similar geological structure; and

(iv) Same drive mechanism.

Instruction to paragraph (a)(2): Reservoir properties must, in the aggregate, be no more favorable in the analog than in the reservoir of interest.

(3) *Bitumen.* Bitumen, sometimes referred to as natural bitumen, is petroleum in a solid or semi-solid state in natural deposits with a viscosity greater than 10,000 centipoise measured at original temperature in the deposit and atmospheric pressure, on a gas free basis. In its natural state it usually contains sulfur, metals, and other non-hydrocarbons.

(4) *Condensate.* Condensate is a mixture of hydrocarbons that exists in the gaseous phase at original reservoir temperature and pressure, but that, when produced, is in the liquid phase at surface pressure and temperature.

(5) *Deterministic estimate.* The method of estimating reserves or resources is called deterministic when a single value for each parameter (from the geoscience, engineering, or economic data) in the reserves calculation is used in the reserves estimation procedure.

(6) *Developed oil and gas reserves.* Developed oil and gas reserves are reserves of any category that can be expected to be recovered:

(i) Through existing wells with existing equipment and operating methods or in which the cost of the required equipment is relatively minor compared to the cost of a new well; and

(ii) Through installed extraction equipment and infrastructure operational at the time of the reserves estimate if the extraction is by means not involving a well.

* * * * *

(8) *Development project.* A development project is the means by which petroleum resources are brought to the status of economically producible. As examples, the development of a single reservoir or field, an incremental development in a producing field, or the integrated development of a group of several fields and associated facilities with a common ownership may constitute a development project.

* * * * *

(10) *Economically producible.* The term economically producible, as it relates to a resource, means a resource which generates revenue that exceeds, or is reasonably expected to exceed, the costs of the operation. The value of the products that generate revenue shall be determined at the terminal point of oil and gas producing activities as defined in paragraph (a)(16) of this section.

(11) *Estimated ultimate recovery (EUR).* Estimated ultimate recovery is the sum of reserves remaining as of a given date and cumulative production as of that date.

* * * * *

(13) *Exploratory well.* An exploratory well is a well drilled to find a new field or to find a new reservoir in a field previously found to be productive of oil or gas in another reservoir. Generally, an exploratory well is any well that is not a development well, an extension well, a service well, or a stratigraphic test well as those items are defined in this section.

(14) *Extension well.* An extension well is a well drilled to extend the limits of a known reservoir.

* * * * *

(16) *Oil and gas producing activities.* (i) Oil and gas producing activities include:

(A) The search for crude oil, including condensate and natural gas liquids, or natural gas (''oil and gas'') in their natural states and original locations;

(B) The acquisition of property rights or properties for the purpose of further exploration or for the purpose of removing the oil or gas from such properties;

(C) The construction, drilling, and production activities necessary to retrieve oil and gas from their natural reservoirs, including the acquisition, construction, installation, and maintenance of field gathering and storage systems, such as:

(*1*) Lifting the oil and gas to the surface; and

(*2*) Gathering, treating, and field processing (as in the case of processing gas to extract liquid hydrocarbons); and

(D) Extraction of saleable hydrocarbons, in the solid, liquid, or gaseous state, from oil sands, shale, coalbeds, or other nonrenewable natural resources which are intended to be upgraded into synthetic oil or gas, and activities undertaken with a view to such extraction.

Instruction 1 to paragraph (a)(16)(i): The oil and gas production function shall be regarded as ending at a ''terminal point'', which is the outlet valve on the lease or field storage tank. If unusual physical or operational circumstances exist, it may be appropriate to regard the terminal point for the production function as:

a. The first point at which oil, gas, or gas liquids, natural or synthetic, are delivered to a main pipeline, a common carrier, a refinery, or a marine terminal; and

b. In the case of natural resources that are intended to be upgraded into synthetic oil or gas, if those natural resources are delivered to a purchaser prior to upgrading, the first point at which the natural resources are delivered to a main pipeline, a common carrier, a refinery, a marine terminal, or a facility which upgrades such natural resources into synthetic oil or gas.

Instruction 2 to paragraph (a)(16)(i): For purposes of this paragraph (a)(16), the term *saleable hydrocarbons* means hydrocarbons that are saleable in the state in which the hydrocarbons are delivered.

(ii) Oil and gas producing activities do not include:

(A) Transporting, refining, or marketing oil and gas;

(B) Processing of produced oil, gas or natural resources that can be upgraded into synthetic oil or gas by a registrant that does not have the legal right to produce or a revenue interest in such production;

(C) Activities relating to the production of natural resources other than oil, gas, or natural resources from which synthetic oil and gas can be extracted; or

(D) Production of geothermal steam.

(17) *Possible reserves.* Possible reserves are those additional reserves that are less certain to be recovered than probable reserves.

(i) When deterministic methods are used, the total quantities ultimately recovered from a project have a low probability of exceeding proved plus probable plus possible reserves. When probabilistic methods are used, there should be at least a 10% probability that the total quantities ultimately recovered will equal or exceed the proved plus probable plus possible reserves estimates.

(ii) Possible reserves may be assigned to areas of a reservoir adjacent to probable reserves where data control and interpretations of available data are progressively less certain. Frequently, this will be in areas where geoscience and engineering data are unable to define clearly the area and vertical limits of commercial production from the reservoir by a defined project.

(iii) Possible reserves also include incremental quantities associated with a greater percentage recovery of the hydrocarbons in place than the recovery quantities assumed for probable reserves.

(iv) The proved plus probable and proved plus probable plus possible reserves estimates must be based on reasonable alternative technical and commercial interpretations within the reservoir or subject project that are clearly documented, including comparisons to results in successful similar projects.

(v) Possible reserves may be assigned where geoscience and engineering data identify directly adjacent portions of a reservoir within the same accumulation that may be separated from proved areas by faults with displacement less than formation thickness or other geological discontinuities and that have not been penetrated by a wellbore, and the registrant believes that such adjacent portions are in communication with the known (proved) reservoir. Possible reserves may be assigned to areas that are structurally higher or lower than the proved area if these areas are in communication with the proved reservoir.

(vi) Pursuant to paragraph (a)(22)(iii) of this section, where direct observation has defined a highest known oil (HKO) elevation and the potential exists for an associated gas cap, proved oil reserves should be assigned in the structurally higher portions of the reservoir above the HKO only if the higher contact can be established with reasonable certainty through reliable technology. Portions of the reservoir that do not meet this reasonable certainty criterion may be assigned as probable and possible oil or gas based on reservoir fluid properties and pressure gradient interpretations.

(18) *Probable reserves.* Probable reserves are those additional reserves that are less certain to be recovered than proved reserves but which, together with proved reserves, are as likely as not to be recovered.

(i) When deterministic methods are used, it is as likely as not that actual remaining quantities recovered will exceed the sum of estimated proved plus probable reserves. When probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the proved plus probable reserves estimates.

(ii) Probable reserves may be assigned to areas of a reservoir adjacent to proved reserves where data control or interpretations of available data are less certain, even if the interpreted reservoir continuity of structure or productivity does not meet the reasonable certainty criterion. Probable reserves may be assigned to areas that are structurally higher than the proved area if these areas are in communication with the proved reservoir.

(iii) Probable reserves estimates also include potential incremental quantities associated with a greater percentage recovery of the hydrocarbons in place than assumed for proved reserves.

(iv) See also guidelines in paragraphs (a)(17)(iv) and (a)(17)(vi) of this section.

(19) *Probabilistic estimate.* The method of estimation of reserves or resources is called probabilistic when the full range of values that could reasonably occur for each unknown parameter (from the geoscience and engineering data) is used to generate a full range of possible outcomes and their associated probabilities of occurrence.

* * * * *

(22) *Proved oil and gas reserves.* Proved oil and gas reserves are those quantities of oil and gas, which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be economically producible—from a given date forward, from known reservoirs, and under existing economic conditions, operating methods, and government regulations—prior to the time at which contracts providing the right to operate expire, unless evidence indicates that renewal is reasonably certain, regardless of whether deterministic or probabilistic methods are used for the estimation. The project to extract the hydrocarbons must have commenced or the operator must be reasonably certain that it will commence the project within a reasonable time.

(i) The area of the reservoir considered as proved includes:

(A) The area identified by drilling and limited by fluid contacts, if any, and

(B) Adjacent undrilled portions of the reservoir that can, with reasonable certainty, be judged to be continuous

with it and to contain economically producible oil or gas on the basis of available geoscience and engineering data.

(ii) In the absence of data on fluid contacts, proved quantities in a reservoir are limited by the lowest known hydrocarbons (LKH) as seen in a well penetration unless geoscience, engineering, or performance data and reliable technology establishes a lower contact with reasonable certainty.

(iii) Where direct observation from well penetrations has defined a highest known oil (HKO) elevation and the potential exists for an associated gas cap, proved oil reserves may be assigned in the structurally higher portions of the reservoir only if geoscience, engineering, or performance data and reliable technology establish the higher contact with reasonable certainty.

(iv) Reserves which can be produced economically through application of improved recovery techniques (including, but not limited to, fluid injection) are included in the proved classification when:

(A) Successful testing by a pilot project in an area of the reservoir with properties no more favorable than in the reservoir as a whole, the operation of an installed program in the reservoir or an analogous reservoir, or other evidence using reliable technology establishes the reasonable certainty of the engineering analysis on which the project or program was based; and

(B) The project has been approved for development by all necessary parties and entities, including governmental entities.

(v) Existing economic conditions include prices and costs at which economic producibility from a reservoir is to be determined. The price shall be the average price during the 12-month period prior to the ending date of the period covered by the report, determined as an unweighted arithmetic average of the first-day-of-the-month price for each month within such period, unless prices are defined by contractual arrangements, excluding escalations based upon future conditions.

* * * * *

(24) *Reasonable certainty.* If deterministic methods are used, reasonable certainty means a high degree of confidence that the quantities will be recovered. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate. A high degree of confidence exists if the quantity is much more likely to be achieved than not, and, as changes due to increased availability of geoscience (geological, geophysical, and geochemical), engineering, and economic data are made to estimated ultimate recovery (EUR) with time, reasonably certain EUR is much more likely to increase or remain constant than to decrease.

(25) *Reliable technology.* Reliable technology is a grouping of one or more technologies (including computational methods) that has been field tested and has been demonstrated to provide reasonably certain results with consistency and repeatability in the formation being evaluated or in an analogous formation.

(26) *Reserves.* Reserves are estimated remaining quantities of oil and gas and related substances anticipated to be economically producible, as of a given date, by application of development projects to known accumulations. In addition, there must exist, or there must be a reasonable expectation that there will exist, the legal right to produce or a revenue interest in the production, installed means of delivering oil and gas or related substances to market, and all permits and financing required to implement the project.

Note to paragraph (a)(26): Reserves should not be assigned to adjacent reservoirs isolated by major, potentially sealing, faults until those reservoirs are penetrated and evaluated as economically producible. Reserves should not be assigned to areas that are clearly separated from a known accumulation by a non-productive reservoir (*i.e.*, absence of reservoir, structurally low reservoir, or negative test results). Such areas may contain prospective resources (*i.e.*, potentially recoverable resources from undiscovered accumulations).

* * * * *

(28) *Resources.* Resources are quantities of oil and gas estimated to exist in naturally occurring accumulations. A portion of the resources may be estimated to be recoverable, and another portion may be considered to be unrecoverable. Resources include both discovered and undiscovered accumulations.

* * * * *

(30) *Stratigraphic test well.* A stratigraphic test well is a drilling effort, geologically directed, to obtain information pertaining to a specific geologic condition. Such wells customarily are drilled without the intent of being completed for hydrocarbon production. The classification also includes tests identified as core tests and all types of expendable holes related to hydrocarbon exploration. Stratigraphic tests are classified as ''exploratory type'' if not drilled in a known area or ''development type'' if drilled in a known area.

(31) *Undeveloped oil and gas reserves.* Undeveloped oil and gas reserves are reserves of any category that are expected to be recovered from new wells on undrilled acreage, or from existing wells where a relatively major expenditure is required for recompletion.

(i) Reserves on undrilled acreage shall be limited to those directly offsetting development spacing areas that are reasonably certain of production when drilled, unless evidence using reliable technology exists that establishes reasonable certainty of economic producibility at greater distances.

(ii) Undrilled locations can be classified as having undeveloped reserves only if a development plan has been adopted indicating that they are scheduled to be drilled within five years, unless the specific circumstances, justify a longer time.

(iii) Under no circumstances shall estimates for undeveloped reserves be attributable to any acreage for which an application of fluid injection or other improved recovery technique is contemplated, unless such techniques have been proved effective by actual projects in the same reservoir or an analogous reservoir, as defined in paragraph (a)(2) of this section, or by other evidence using reliable technology establishing reasonable certainty.

* * * * *

(c) * * *

(8) For purposes of this paragraph (c), the term ''current price'' shall mean the average price during the 12-month period prior to the ending date of the period covered by the report, determined as an unweighted arithmetic average of the first-day-of-the-month price for each month within such period, unless prices are defined by contractual arrangements, excluding escalations based upon future conditions.

* * * * *

PART 211—INTERPRETATIONS RELATING TO FINANCIAL REPORTING MATTERS

■ 3. Amend Part 211, subpart A, by adding ''Modernization of Oil and Gas Reporting,'' Release No. FR–78 and the release date of December 31, 2008, to the list of interpretive releases.

PART 229—STANDARD INSTRUCTIONS FOR FILING FORMS UNDER SECURITIES ACT OF 1933, SECURITIES EXCHANGE ACT OF 1934 AND ENERGY POLICY AND CONSERVATION ACT OF 1975—REGULATION S–K

■ 4. The authority citation for part 229 continues to read in part as follows:

Authority: 15 U.S.C. 77e, 77f, 77g, 77h, 77j, 77k, 77s, 77z–2, 77z–3, 77aa(25), 77aa(26), 77ddd, 77eee, 77ggg, 77hhh, 77iii, 77jjj, 77nnn, 77sss, 78c, 78i, 78j, 78*l*, 78m, 78n, 78o, 78u–5, 78w, 78*ll*, 78mm, 80a–8, 80a–9, 80a–20, 80a–29, 80a–30, 80a–31(c), 80a–37, 80a–38(a), 80a–39, 80b–11, and 7201 *et seq.*; and 18 U.S.C. 1350, unless otherwise noted.

* * * * *

■ 5. Amend § 229.102 by revising the introductory text of Instruction 3 and Instructions 4, 5 and 8 to read as follows.

§ 229.102 (Item 102) Description of property.

* * * * *

Instructions to Item 102: * * *

3. In the case of an extractive enterprise, not involved in oil and gas producing activities, material information shall be given as to production, reserves, locations, development, and the nature of the registrant's interest. If individual properties are of major significance to an industry segment:

* * * * *

4. A registrant engaged in oil and gas producing activities shall provide the information required by Subpart 1200 of Regulation S–K.

5. In the case of extractive reserves other than oil and gas reserves, estimates other than proven or probable reserves (and any estimated values of such reserves) shall not be disclosed in any document publicly filed with the Commission, unless such information is required to be disclosed in the document by foreign or state law; provided, however, that where such estimates previously have been provided to a person (or any of its affiliates) that is offering to acquire, merge, or consolidate with the registrant, or otherwise to acquire the registrant's securities, such estimates may be included in documents relating to such acquisition.

* * * * *

8. The attention of certain issuers engaged in oil and gas producing activities is directed to the information called for in Securities Act Industry Guide 4 (referred to in § 229.801(d)).

* * * * *

■ 6. Amend § 229.801 by removing and reserving paragraph (b) and removing the authority citation following the section.

■ 7. Amend § 229.802 by removing and reserving paragraph (b) and removing the authority citation following the section.

■ 8. Add Subpart 229.1200 to read as follows:

Subpart 229.1200—Disclosure by Registrants Engaged in Oil and Gas Producing Activities

Sec.

Subpart 229.1200—Disclosure by Registrants Engaged in Oil and Gas Producing Activities

§ 229.1201 (Item 1201) General instructions to oil and gas industry-specific disclosures.

(a) If oil and gas producing activities are material to the registrant's or its subsidiaries' business operations or financial position, the disclosure specified in this Subpart 229.1200 should be included under appropriate captions (with cross references, where applicable, to related information disclosed in financial statements). However, limited partnerships and joint ventures that conduct, operate, manage, or report upon oil and gas drilling or income programs, that acquire properties either for drilling and production, or for production of oil, gas, or geothermal steam or water, need not include such disclosure.

(b) To the extent that Items 1202 through 1208 (§§ 229.1202–229.1208) call for disclosures in tabular format, as specified in the particular Item, a registrant may modify such format for ease of presentation, to add information or to combine two or more required tables.

(c) The definitions in Rule 4–10(a) of Regulation S–X (17 CFR 210.4–10(a)) shall apply for purposes of this Subpart 229.1200.

(d) For purposes of this Subpart 229.1200, the term *by geographic area* means, as appropriate for meaningful disclosure in the circumstances:

(1) By individual country;

(2) By groups of countries within a continent; or

(3) By continent.

§ 229.1202 (Item 1202) Disclosure of reserves.

(a) *Summary of oil and gas reserves at fiscal year end.* (1) Provide the information specified in paragraph (a)(2) of this Item in tabular format as provided below:

SUMMARY OF OIL AND GAS RESERVES AS OF FISCAL-YEAR END BASED ON AVERAGE FISCAL-YEAR PRICES

Reserves category	Reserves				
	Oil (mbbls)	Natural gas (mmcf)	Synthetic oil (mbbls)	Synthetic gas (mmcf)	Product A (measure)
PROVED					
Developed:					
Continent A					
Continent B					
Country A					
Country B					
Other Countries in Continent B					
Undeveloped:					
Continent A					
Continent B					

SUMMARY OF OIL AND GAS RESERVES AS OF FISCAL-YEAR END BASED ON AVERAGE FISCAL-YEAR PRICES—Continued

Reserves category	Reserves				
	Oil (mbbls)	Natural gas (mmcf)	Synthetic oil (mbbls)	Synthetic gas (mmcf)	Product A (measure)
Country A					
Country B					
Other Countries in Continent B					
TOTAL PROVED					
PROBABLE					
Developed					
Undeveloped					
POSSIBLE					
Developed					
Undeveloped					

(2) Disclose, in the aggregate and by geographic area and for each country containing 15% or more of the registrant's proved reserves, expressed on an oil-equivalent-barrels basis, reserves estimated using prices and costs under existing economic conditions, for the product types listed in paragraph (a)(4) of this Item, in the following categories:

(i) Proved developed reserves;

(ii) Proved undeveloped reserves;

(iii) Total proved reserves;

(iv) Probable developed reserves (optional);

(v) Probable undeveloped reserves (optional);

(vi) Possible developed reserves (optional); and

(vii) Possible undeveloped reserves (optional).

Instruction 1 to paragraph (a)(2): Disclose updated reserves tables as of the close of each fiscal year.

Instruction 2 to paragraph (a)(2): The registrant is permitted, but not required, to disclose probable or possible reserves pursuant to paragraphs (a)(2)(iv) through (a)(2)(vii) of this Item.

Instruction 3 to paragraph (a)(2): If the registrant discloses amounts of a product in barrels of oil equivalent, disclose the basis for such equivalency.

Instruction 4 to paragraph (a)(2): A registrant need not provide disclosure of the reserves in a country containing 15% or more of the registrant's proved reserves if that country's government prohibits disclosure of reserves in that country. In addition, a registrant need not provide disclosure of the reserves in a country containing 15% or more of the registrant's proved reserves if that country's government prohibits disclosure in a particular field and disclosure of reserves in that country would have the effect of disclosing reserves in particular fields.

(3) Reported total reserves shall be simple arithmetic sums of all estimates for individual properties or fields within each reserves category. When probabilistic methods are used, reserves should not be aggregated probabilistically beyond the field or property level; instead, they should be aggregated by simple arithmetic summation.

(4) Disclose separately material reserves of the following product types:

(i) Oil;

(ii) Natural gas;

(iii) Synthetic oil;

(iv) Synthetic gas; and

(v) Sales products of other non-renewable natural resources that are intended to be upgraded into synthetic oil and gas.

(5) If the registrant discloses probable or possible reserves, discuss the uncertainty related to such reserves estimates.

(6) If the registrant has not previously disclosed reserves estimates in a filing with the Commission or is disclosing material additions to its reserves estimates, the registrant shall provide a general discussion of the technologies used to establish the appropriate level of certainty for reserves estimates from material properties included in the total reserves disclosed. The particular properties do not need to be identified.

(7) *Preparation of reserves estimates or reserves audit.* Disclose and describe the internal controls the registrant uses in its reserves estimation effort. In addition, disclose the qualifications of the technical person primarily responsible for overseeing the preparation of the reserves estimates and, if the registrant represents that a third party conducted a reserves audit, disclose the qualifications of the technical person primarily responsible for overseeing such reserves audit.

(8) *Third party reports.* If the registrant represents that a third party prepared, or conducted a reserves audit of, the registrant's reserves estimates, or any estimated valuation thereof, or conducted a process review, the registrant shall file a report of the third party as an exhibit to the relevant registration statement or other Commission filing. If the report relates to the preparation of, or a reserves audit of, the registrant's reserves estimates, it must include the following disclosure, if applicable to the type of filing:

(i) The purpose for which the report was prepared and for whom it was prepared;

(ii) The effective date of the report and the date on which the report was completed;

(iii) The proportion of the registrant's total reserves covered by the report and the geographic area in which the covered reserves are located;

(iv) The assumptions, data, methods, and procedures used, including the percentage of the registrant's total reserves reviewed in connection with the preparation of the report, and a statement that such assumptions, data, methods, and procedures are appropriate for the purpose served by the report;

(v) A discussion of primary economic assumptions;

(vi) A discussion of the possible effects of regulation on the ability of the registrant to recover the estimated reserves;

(vii) A discussion regarding the inherent uncertainties of reserves estimates;

(viii) A statement that the third party has used all methods and procedures as it considered necessary under the circumstances to prepare the report;

(ix) A brief summary of the third party's conclusions with respect to the reserves estimates; and

(x) The signature of the third party.

(9) For purposes of this Item 1202, the term *reserves audit* means the process of reviewing certain of the pertinent facts interpreted and assumptions underlying a reserves estimate prepared by another party and the rendering of an opinion about the appropriateness of the methodologies employed, the adequacy and quality of the data relied upon, the depth and thoroughness of the reserves estimation process, the classification of reserves appropriate to the relevant definitions used, and the reasonableness of the estimated reserves quantities.

(b) *Reserves sensitivity analysis (optional).* (1) The registrant may, but is not required to, provide the information specified in paragraph (b)(2) of this Item in tabular format as provided below:

SENSITIVITY OF RESERVES TO PRICES BY PRINCIPAL PRODUCT TYPE AND PRICE SCENARIO

Price case	Proved reserves					Probable reserves					Possible reserves				
	Oil	Gas	Syn. oil	Syn. gas	Product A	Oil	Gas	Syn. oil	Syn. gas	Product A	Oil	Gas	Syn. oil	Syn. gas	Product A
	mbbls	mmcf	mbbls	mmcf	measure	mbbls	mmcf	mbbls	mmcf	measure	mbbls	mmcf	mbbls	mmcf	measure
Scenario 1.															
Scenario 2.															

(2) The registrant may, but is not required to, disclose, in the aggregate, an estimate of reserves estimated for each product type based on different price and cost criteria, such as a range of prices and costs that may reasonably be achieved, including standardized futures prices or management's own forecasts.

(3) If the registrant provides disclosure under this paragraph (b), disclose the price and cost schedules and assumptions on which the disclosed values are based.

Instruction to Item 1202: Estimates of oil or gas resources other than reserves, and any estimated values of such resources, shall not be disclosed in any document publicly filed with the Commission, unless such information is required to be disclosed in the document by foreign or state law; provided, however, that where such estimates previously have been provided to a person (or any of its affiliates) that is offering to acquire, merge, or consolidate with the registrant or otherwise to acquire the registrant's securities, such estimate may be included in documents related to such acquisition.

§ 229.1203 (Item 1203) Proved undeveloped reserves.

(a) Disclose the total quantity of proved undeveloped reserves at year end.

(b) Disclose material changes in proved undeveloped reserves that occurred during the year, including proved undeveloped reserves converted into proved developed reserves.

(c) Discuss investments and progress made during the year to convert proved undeveloped reserves to proved developed reserves, including, but not limited to, capital expenditures.

(d) Explain the reasons why material amounts of proved undeveloped reserves in individual fields or countries remain undeveloped for five years or more after disclosure as proved undeveloped reserves.

§ 229.1204 (Item 1204) Oil and gas production, production prices and production costs.

(a) For each of the last three fiscal years disclose production, by final product sold, of oil, gas, and other products. Disclosure shall be made by geographical area and for each country and field that contains 15% or more of the registrant's total proved reserves expressed on an oil-equivalent-barrels basis unless prohibited by the country in which the reserves are located.

(b) For each of the last three fiscal years disclose, by geographical area:

(1) The average sales price (including transfers) per unit of oil, gas and other products produced; and

(2) The average production cost, not including ad valorem and severance taxes, per unit of production.

Instruction 1 to Item 1204: Generally, net production should include only production that is owned by the registrant and produced to its interest, less royalties and production due others. However, in special situations (*e.g.*, foreign production) net production before any royalties may be provided, if more appropriate. If ''net before royalty'' production figures are furnished, the change from the usage of ''net production'' should be noted.

Instruction 2 to Item 1204: Production of natural gas should include only marketable production of natural gas on an ''as sold'' basis. Production will include dry, residue, and wet gas, depending on whether liquids have been extracted before the registrant transfers title. Flared gas, injected gas, and gas consumed in operations should be omitted. Recovered gas-lift gas and reproduced gas should not be included until sold. Synthetic gas, when marketed as such, should be included in natural gas sales.

Instruction 3 to Item 1204: If any product, such as bitumen, is sold or custody is transferred prior to conversion to synthetic oil or gas, the product's production, transfer prices, and production costs should be disclosed separately from all other products.

Instruction 4 to Item 1204: The transfer price of oil and gas (natural and synthetic) produced should be determined in accordance with SFAS 69.

Instruction 5 to Item 1204: The average production cost, not including ad valorem and severance taxes, per unit of production should be computed using production costs disclosed pursuant to SFAS 69. Units of production should be expressed in common units of production with oil, gas, and other products converted to a common unit of measure on the basis used in computing amortization.

§ 229.1205 (Item 1205) Drilling and other exploratory and development activities.

(a) For each of the last three fiscal years, by geographical area, disclose:

(1) The number of net productive and dry exploratory wells drilled; and

(2) The number of net productive and dry development wells drilled.

(b) *Definitions.* For purposes of this Item 1205, the following terms shall be defined as follows:

(1) A *dry well* is an exploratory, development, or extension well that proves to be incapable of producing either oil or gas in sufficient quantities to justify completion as an oil or gas well.

(2) A *productive well* is an exploratory, development, or extension well that is not a dry well.

(3) *Completion* refers to installation of permanent equipment for production of oil or gas, or, in the case of a dry well, to reporting to the appropriate authority that the well has been abandoned.

(4) The *number of wells drilled* refers to the number of wells completed at any time during the fiscal year, regardless of when drilling was initiated.

(c) Disclose, by geographic area, for each of the last three years, any other exploratory or development activities conducted, including implementation of mining methods for purposes of oil and gas producing activities.

§ 229.1206 (Item 1206) Present activities.

(a) Disclose, by geographical area, the registrant's present activities, such as the number of wells in the process of being drilled (including wells temporarily suspended), waterfloods in process of being installed, pressure maintenance operations, and any other related activities of material importance.

(b) Provide the description of present activities as of a date at the end of the most recent fiscal year or as close to the date that the registrant files the document as reasonably possible.

(c) Include only those wells in the process of being drilled at the ''as of'' date and express them in terms of both gross and net wells.

(d) Do not include wells that the registrant plans to drill, but has not commenced drilling unless there are factors that make such information material.

§ 229.1207 (Item 1207) Delivery commitments.

(a) If the registrant is committed to provide a fixed and determinable quantity of oil or gas in the near future under existing contracts or agreements, disclose material information concerning the estimated availability of oil and gas from any principal sources, including the following:

(1) The principal sources of oil and gas that the registrant will rely upon and the total amounts that the registrant expects to receive from each principal source and from all sources combined;

(2) The total quantities of oil and gas that are subject to delivery commitments; and

(3) The steps that the registrant has taken to ensure that available reserves and supplies are sufficient to meet such commitments for the next one to three years.

(b) Disclose the information required by this Item:

(1) In a form understandable to investors; and

(2) Based upon the facts and circumstances of the particular situation, including, but not limited to:

(i) Disclosure by geographic area;

(ii) Significant supplies dedicated or contracted to the registrant;

(iii) Any significant reserves or supplies subject to priorities or curtailments which may affect quantities delivered to certain classes of customers, such as customers receiving services under low priority and interruptible contracts;

(iv) Any priority allocations or price limitations imposed by Federal or State regulatory agencies, as well as other factors beyond the registrant's control that may affect the registrant's ability to meet its contractual obligations (the registrant need not provide detailed discussions of price regulation);

(v) Any other factors beyond the registrant's control, such as other parties having control over drilling new wells, competition for the acquisition of reserves and supplies, and the availability of foreign reserves and supplies, which may affect the registrant's ability to acquire additional reserves and supplies or to maintain or increase the availability of reserves and supplies; and

(vi) Any impact on the registrant's earnings and financing needs resulting from its inability to meet short-term or long-term contractual obligations. (See Items 303 and 1209 of Regulation S–K (§§ 229.303 and 229.1209).)

(c) If the registrant has been unable to meet any significant delivery commitments in the last three years, describe the circumstances concerning such events and their impact on the registrant.

(d) For purposes of this Item, *available reserves* are estimates of the amounts of oil and gas which the registrant can produce from current proved developed reserves using presently installed equipment under existing economic and operating conditions and an estimate of amounts that others can deliver to the registrant under long-term contracts or agreements on a per-day, per-month, or per-year basis.

§ 229.1208 (Item 1208) Oil and gas properties, wells, operations, and acreage.

(a) Disclose, as of a reasonably current date or as of the end of the fiscal year, the total gross and net productive wells, expressed separately for oil and gas (including synthetic oil and gas produced through wells) and the total gross and net developed acreage (*i.e.*, acreage assignable to productive wells) by geographic area.

(b) Disclose, as of a reasonably current date or as of the end of the fiscal year, the amount of undeveloped acreage, both leases and concessions, if any, expressed in both gross and net acres by geographic area, together with an indication of acreage concentrations, and, if material, the minimum remaining terms of leases and concessions.

(c) *Definitions.* For purposes of this Item 1208, the following terms shall be defined as indicated:

(1) A *gross well or acre* is a well or acre in which the registrant owns a working interest. The number of gross wells is the total number of wells in which the registrant owns a working interest. Count one or more completions in the same bore hole as one well. In a footnote, disclose the number of wells with multiple completions. If one of the multiple completions in a well is an oil completion, classify the well as an oil well.

(2) A *net well or acre* is deemed to exist when the sum of fractional ownership working interests in gross wells or acres equals one. The number of net wells or acres is the sum of the fractional working interests owned in gross wells or acres expressed as whole numbers and fractions of whole numbers.

(3) *Productive wells* include producing wells and wells mechanically capable of production.

(4) *Undeveloped acreage* encompasses those leased acres on which wells have not been drilled or completed to a point that would permit the production of economic quantities of oil or gas regardless of whether such acreage contains proved reserves. Do not confuse undeveloped acreage with undrilled acreage held by production under the terms of the lease.

PART 249—FORMS, SECURITIES EXCHANGE ACT OF 1934

■ 9. The authority citation for part 249 continues to read in part as follows:

Authority: 15 U.S.C. 78a *et seq.* and 7201; and 18 U.S.C. 1350, unless otherwise noted.

* * * * *

■ 10. Amend Form 20–F (referenced in § 249.220f) by:

■ a. Revising ''Instruction to Item 4'' and the introductory text and paragraph (b) of ''Instructions to Item 4.D''; and

■ b. Removing paragraph (c) of ''Instructions to Item 4.D'' and ''Appendix A to Item 4.D—Oil and Gas.''

The revisions read as follows:

[**Note:** The text of Form 20–F does not, and this amendment will not, appear in the Code of Federal Regulations.]

Form 20–F

* * * * *

Item 4. Information on the Company

* * * * *

Instructions to Item 4

1. Furnish the information specified in any industry guide listed in Subpart 229.800 of Regulation S–K (§ 229.801 *et seq.* of this chapter) that applies to you.

2. If oil and gas operations are material to you or your subsidiaries' business operations or financial position, provide the information specified in Subpart 1200 of Regulation S–K (§ 229.1200 *et seq.* of this chapter).

* * * * *

Instruction to Item 4.D: In the case of an extractive enterprise, other than an oil and gas producing activity:

* * * * *

(b) In documents that you file publicly with the Commission, do not disclose estimates of reserves unless the reserves are proven or probable and do not give estimated values of those reserves, unless foreign law requires you to disclose the information. If these types of estimates have already been provided to any person that is offering to acquire you, however, you may include the estimates in documents relating to the acquisition.

* * * * *

Dated: December 31, 2008.

By the Commission.

Florence E. Harmon,

Acting Secretary.

[FR Doc. E9–409 Filed 1–13–09; 8:45 am]

BILLING CODE 8011–01–P

Subject: Cabot #2 Well
From: David Kovach <David.Kovach@drbc.state.nj.us>
Date: Tue, 04 Aug 2009 17:05:30 -0400
To: jimmy@arbor-resources.com

Dear Mr. Eichstadt,
I am writing concerning the application for the Cabot #2 well submitted to the Commission by Arbor Operating, LLC (Arbor) on April 16, 2009. As you are aware, on May 19, 2009, the Executive Director of the DRBC issued a determination concerning proposed and existing natural gas wells and associated appurtenances completed in the Marcellus Shale and other shale formations in the drainage area of Special Protection Waters in the Delaware River Basin. As the Cabot #2 natural gas well that Arbor has proposed lies within the drainage area to the special protection waters known as the Lower Delaware and is proposed to be drilled into a shale formation, it is covered under the Executive Director determination. As Arbor has stated that they propose to develop the well if a viable quantity of natural gas is discovered, the well is not therefore being drilled solely for exploratory purposes and is again covered under the Executive Directors Determination. The well may not be covered under the determination if a cap and plug plan is submitted to the Commission and it is affirmed that the well will be properly abandoned upon completion and collection of necessary exploratory data. The groundwater withdrawal rate of significantly less than 100,000 gpd during any consecutive 30-day period detailed in the application is not specifically covered by DRBC regulations, but all water supplies, no matter what the withdrawal volume, will be considered from a potential impact/interference standpoint when an application for a natural gas well in Marcellus or other shale proposed in special protection waters is being reviewed.

The application for the Cabot #2 well as submitted requires additional information if natural gas development at the well is to be considered for DRBC approval. These include, but are not necessarily limited to the following:

1) A revised applicant statement and appropriate fee, related to the actual total project costs that would include the drilling and construction of the Cabot #2 well.

2) The necessary information included in the attached draft natural gas project submission requirements word document.

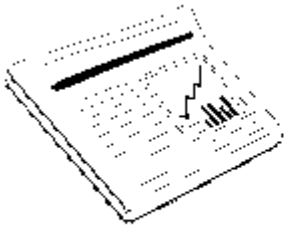
If the well will be used solely for exploratory purposes, then an appropriate cap and plug plan must be submitted to the Commission affirming that the well will be properly abandoned upon completion and collection of necessary scientific data.

Please contact me if you have any further questions,
Dave

--
David Kovach, P.G.
Geologist, Project Review Section
Delaware River Basin Commission
(p) 609-883-9500 ext 264
(f) 609-883-9522
(e) david.kovach@drbc.state.nj.us

Shale gas drilling project submission requirements.doc	**Content-Type:** application/msword **Content-Encoding:** base64

Delaware River Basin Commission



News Release

For Immediate Release

May 19, 2009

DRBC ELIMINATES REVIEW THRESHOLDS FOR GAS EXTRACTION PROJECTS IN SHALE FORMATIONS IN DELAWARE BASIN'S SPECIAL PROTECTION WATERS

(WEST TRENTON, N.J.) -- Delaware River Basin Commission (DRBC) Executive Director Carol R. Collier today announced that she has issued a determination notifying natural gas extraction project sponsors that they may not commence any natural gas extraction project located in shale formations within the drainage area of the basin's Special Protection Waters without first applying for and obtaining commission approval.

"This determination explains DRBC regulatory requirements on an interim basis and asserts commission review over all aspects of natural gas extraction projects in shale formations within the drainage area of the basin's Special Protection Waters, regardless of the amount of water withdrawn or the capacity of domestic sewage treatment facilities accepting fracking wastewater," Collier said. "The commissioners intend to adopt regulations pertaining to the subject matter contained in this determination after public notice and a full opportunity for public comment, but this rulemaking process can be lengthy. In the meantime, DRBC will apply this determination in combination with its existing regulations."

In taking this action, Collier considered and determined that as a result of water withdrawals, wastewater disposal, and other activities, natural gas extraction projects in shale formations may individually or cumulatively affect the water quality of Special Protection Waters by altering their physical, biological, chemical or hydrological characteristics. This finding is in accordance with Section 2.3.5 B.18 of the commission's Rules of Practice and Procedure, which provide that any project "that the Executive Director may specially direct by notice to the project sponsor or land owner as

having a potential substantial water quality impact on waters classified as Special Protection Waters" may be required to undergo review.

"The intent behind this executive director determination is to provide directional signals, not put up roadblocks," Collier said. "Each of these activities, if not properly performed, may cause adverse environmental effects on water resources. The bottom line for the DRBC is to ensure that proper environmental controls are provided to safeguard our basin's water resources that are used by nearly 15 million people."

Most of the shale formations that may be subject to new horizontal drilling and hydraulic fracturing techniques requiring large volumes of water in the basin are located within the drainage area to DRBC's designated Special Protection Waters (SPW). The commission's SPW program is designed to prevent degradation in streams and rivers considered to have exceptionally high scenic, recreational, ecological, and/or water supply values through stricter control of wastewater discharges, non-point pollution control, and reporting requirements. Coverage of the DRBC's SPW anti-degradation regulations includes the 197-mile non-tidal Delaware River from Hancock, N.Y. south to Trenton, N.J. and the land draining to this stretch.

Under this determination, a natural gas extraction project encompasses the drilling pad upon which a well intended for eventual production is located, all accompanying facilities and related activities, and all locations of water withdrawals used or to be used to supply water to the project. Wells intended solely for exploratory purposes are not covered by this determination. An exploratory well is one that the project sponsor intends to plug and cap at the conclusion of exploratory activities without use for production or fracking. Exploratory wells are subject to state regulation.

"To determine whether the Rules of Practice and Procedure require DRBC review of any projects falling outside this determination, we continue to recommend that any company proposing natural gas extraction activities anywhere in the basin contact DRBC staff to schedule a pre-application meeting," Collier said.

The DRBC recognizes that each natural gas extraction project also will be subject to the review of the environmental agency of the state in which the project is located and, in some cases, subject to federal agency review. The commission intends to coordinate with and, where feasible, to utilize the review process and approvals of the applicable state or federal agency to minimize duplication of effort and redundant requirements imposed on project sponsors.

Any person adversely affected by this determination may request a hearing by submitting a request in writing to the commission secretary within 30 days of the date of this determination in accordance with the DRBC's Rules of Practice and Procedure.

The DRBC was formed by compact in 1961 through legislation signed into law by President John F. Kennedy and the governors of the four basin states with land draining to the Delaware River (Delaware, New Jersey, New York, and Pennsylvania). The

passage of this compact marked the first time in our nation's history that the federal government and a group of states joined together as equal partners in a river basin planning, development, and regulatory agency.

Additional information, including the complete determination, can be found by clicking here.

COMMONWEALTH OF PENNSYLVANIA
Department of Environmental Protection

Guidelines for the Development and Implementation of Environmental Emergency Response Plans

400-2200-001

PA Department of Environmental Protection
PO Box 2063
Harrisburg, PA 17105-2063

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

DOCUMENT ID:	400-2200-001
TITLE:	Guidelines for the Development and Implementation of Environmental Emergency Response Plans
EFFECTIVE DATE:	April 2001 Minor changes were made throughout the document on September 7, 2004 Minor changes were made throughout the document on August 6, 2005
AUTHORITY	The Federal Clean Water Act, the Pennsylvania Clean Streams Law (35 P.S. §§691.1-691.1001), the Pennsylvania Solid Waste Management Act, the Pennsylvania Storage Tank Act, the Oil Pollution Act and regulations promulgated thereunder.
POLICY:	To plan and provide effective and efficient response to emergencies and accidents for any situation dealing with the public health, safety and the environment.
PURPOSE:	To improve and preserve the purity of the Waters of the Commonwealth by prompt adequate response to all emergencies and accidental spills of polluting substances for the protection of public health, animal and aquatic life and for recreation.
BACKGROUND:	This document is being revised to add regulatory references in Table 1 and Procedures, Item A. Revisions were made to Procedures, Items A, C, D and F. Some telephone contact names, telephone contact numbers and bureau names have been updated in Appendices IV and V. Bureau and division names have been changed on the cover page of the Addendum.
APPLICABILITY:	This document provides a one stop requirement to comply with the state and federal laws and regulations dealing with emergency planning and response and pollution prevention and contingency planning requirements (plans such as PIP, SPCC, SWPPP, etc.) for all activities to be carried out in the Commonwealth.
DISCLAIMER:	The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.
PAGE LENGTH:	48 Pages
LOCATION:	Vol. 33, Tab 56

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Guidelines for the Development and Implementation of Environmental Emergency Response Plans

This document (400-2200-001) provides a one stop requirement to comply with the state and federal laws and regulations dealing with emergency planning and response and pollution prevention and contingency planning requirements (i.e., PIP, SPCC, SWPPP, etc) for all activities to be carried out in the Commonwealth.

The use of the document and compliance with it are required as part of applying for any permit or requesting approval of any action that has a potential to cause pollution of the Commonwealth's air, water and land resources. The manual is also available to download from the DEP website at: www.dep.state.pa.us.

The document may be revised from time to time or as the need arises due to changes in state/federal laws and regulations. If you have suggestions for improvement to this document or desire that future revisions be sent to you, please provide the following information to the Department.

Date this request made: _____

Name _____

Street or Route _____

City _____

State _____ Zip Code _____

Telephone _____ E-mail _____

This manual could be improved by _____

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☐ Yes, send me future revisions to the manual

☐ Yes, please notify me of any revisions for downloading from DEP web site.

Send to: Director, Environmental Emergency Response
Pennsylvania Department of Environmental Protection
Field Operations Deputate, RCSOB 16th Floor
P.O. Box 2063
Harrisburg, PA 17105-2063

Guidelines for the Development and Implementation of Environmental Emergency Response Plans

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Guidelines for the Development and Implementation of Environmental Emergency Response Plans

INTRODUCTION

A wide variety of industrial activities, both manufacturing and commercial, exist in Pennsylvania. Many of these activities have the potential for causing environmental degradation or endangerment of public health and safety through accidental releases of toxic, hazardous, or other pollutional materials.

In recognition of this fact, several State and Federal regulatory programs have been developed to encourage the use of preventive approaches to deal with unwarranted releases of toxic, hazardous, or other pollutants to the environment.

Table 1 lists these programs and defines the statutory and regulatory basis for each. A more detailed summary of each program is shown in Table 2 which illustrates the similarities among them. A review of the regulations and guidelines pertaining to each program more clearly illustrates these similarities. The main differences between the programs are the types of industrial activities and the nature of the polluting materials addressed.

The Department's objective is to consolidate the similarities of the State and Federal pollution incident prevention and emergency response programs into one overall program. Industrial and commercial installations which have the potential for causing accidental pollution of air, land or water, or the endangerment of public health and safety are required to develop and implement **Preparedness, Prevention and Contingency (PPC) Plans** which encompass the other Departmental program requirements.

A PPC Plan is required for any NPDES Application for Storm Water Discharge General Permits or Water Management Permits. A special addendum has been added to the document for NPDES Stormwater discharge applicants.

In the case of regulated storage tank facilities, with an aggregate aboveground storage capacity > 21,000 gallons, a **Spill Prevention Response (SPR)** plan is required. This SPR plan, in **addition to the contents** of a PPC plan, requires a specific downstream notification requirement. Those storage tank facilities that already have a PPC plan need only update the PPC plan and include the downstream notification requirement.

The Department strongly recommends that regulated facilities consolidate all required plans into one single document. For those facilities required to develop plans under SARA Title III, the Department will support deviation from the format suggested in this guidance document to ensure consistency with the SARA Title III plans provided that all required information is included in the one plan.

TABLE 1
STATE AND FEDERAL POLLUTION INCIDENT
PREVENTION AND EMERGENCY RESPONSE PROGRAMS

Plan	Implemented By	State and Federal Laws Which Apply	State and Implementing Regulations	Effective Date of Regulations
Spill Prevention Control and Countermeasure (SPCC)	U.S. EPA*	Federal Clean Water Act	40 CFR 112	1973
Preparedness, Prevention, and Contingency (PPC), or Contingency Planning	Pa. DEP as part of the Hazardous Waste Program	Pa. Solid Waste Management Act	25 Pa. Code Ch. 262a, 264a, 265a, 266a	5/01/99
	Pa. DEP as part of the Residual Waste Program	Pa. Solid Waste Management Act	25 Pa. Code Ch. 287, 288, 289, 293, 295 and 297	7/4/92
	Pa. DEP as part of the Municipal Waste Program	Pa. Solid Waste Management Act	25 Pa. Code Ch. 273, 277, 279, 281, 283 and 284	4/9/88
	Pa. DEP as part of the Oil and Gas Program[1]	Pa. Clean Streams Law, Pa Solid Waste Management Act	25 Pa. Code Ch. 91.34, 25 Pa. Code Ch. 78	1971
	Pa. DEP as part of the Water Quality Program.	PA Clean Streams Law	25 PA Code Chapter 91.34	1971
	Pa. DEP and US EPA as part of the NPDES Program	Federal Clean Water Act.	40 CFR 125 Subpart K	5/19/80
Spill Prevention Response (SPR) Plan	Pa. DEP as part of the Storage Tank Program	Pa. Storage Tank and Spill Prevention Act	Act 32-1989	8/89
Facility Response Plan (FRP)	US EPA* US Coast Guard	Oil Pollution Act	40 CFR 112	1990

(1) Complete information on PPC Plans required under the Oil and Gas Program can be found in the ***Oil & Gas Operators Manual*** available from the Bureau of Oil and Gas Management.

* Additional information is available from US EPA Region III, Philadelphia, PA, (215) 814-3292.

TABLE 2
COMPARISON OF STATE AND FEDERAL POLLUTION
INCIDENT PREVENTION AND EMERGENCY RESPONSE PROGRAMS

Aspect	Preparedness, Prevention, and Contingency (PPC) (Water)	Preparedness, Prevention, and Contingency (PPC) (Waste)	Spill Prevention Response (SPR) Plan	Spill Prevention Control, and Countermeasures (SPCC)
Purpose	Prevention/Control of accidental discharge of polluting materials to surface waste or groundwater	To minimize and abate hazards to human health and the environment from fires, explosions, or release of solid wastes to air, soil, or surface water	Prevention/Control of accidental discharge of regulated substances and downstream notification requirements	Prevention of accidental discharges of oils and hazardous substances into the waters of the United States
Types of Industrial Activities Affected	All industrial activities having potential for accidental pollution	Activities which generate, store, recycle, treat, transport, or dispose of solid wastes, activities associated with drilling and operating oil and gas wells	Activities pertaining to above ground storage facilities with >21,000 gallons of regulated substances	Non-transportation related activities with potential for discharge of oil and hazardous substances
Activities Covered?	Transportation, storage, processing of raw materials, intermediates, products, fuels, wastes	Generation, storage, transport, recycle, treatment, disposal of hazardous wastes; processing and disposal of residual or municipal wastes; road spreading operations, brine disposal	Storage and handling of regulated substances	Production, storage, processing, refining, handling, transferring, distributing
What Pollution Materials are Addressed?	All polluting materials	Any hazardous, residual, municipal, or medical wastes	Hazardous Substances and Petroleum	Oil and hazardous substances defined pursuant to Sec. 311 of the Clean Water Act

TABLE 2 (Cont.)
COMPARISON OF STATE AND FEDERAL POLLUTION
INCIDENT PREVENTION AND EMERGENCY RESPONSE PROGRAMS

Aspect	Preparedness, Prevention, and Contingency (PPC) (Water)	Preparedness, Prevention, and Contingency (PPC) (Waste)	Spill Prevention Response (SPR) Plan	Spill Prevention Control, and Countermeasures (SPCC)
Hazards Addressed	Container leaks, ruptures, spills, floods, power failures, mechanical failure, human error, strikes, vandalism	Same plus fires and explosions	Same	Same
Plan Includes	Study of past incidents, training, preventive maintenance, housekeeping, security, backup equipment, internal, external communicator, spill containment, drainage controls, inspections	Same plus additional local notification, emergency coordination, and evacuation requirements	Same, plus downstream notification requirement	Same
Amendments to Plan Required for Significant Facility or Operational Changes?	Yes	Yes	Yes	Yes
Emergency Incident Report Required?	Yes	Yes	Yes	Yes
Annual Notification/Updated	No	No	Yes	No

I. PROCEDURES FOR DEVELOPMENT AND REVIEW OF ENVIRONMENTAL EMERGENCY RESPONSE PLANS

A. Who Must Develop These Plans?

PPC

In general, any manufacturing or commercial installation which has the potential for causing accidental pollution of air, land, or water or for causing endangerment of public health and safety through accidental release of toxic, hazardous, or other polluting materials must develop, maintain, and implement a PPC Plan.*

Manufacturing or commercial waste water dischargers, which are required to obtain NPDES permits, must develop PPC plans in order to satisfy the requirements of Chapter 101 of the Department's Rules and Regulations. In addition to NPDES discharges there are a variety of other non-NPDES manufacturing or commercial installations which may be directed by the Department to develop PPC plans on a case-by-case basis.

Manufacturing or commercial installations which generate hazardous waste, or which involve treatment, recycling, storage, or disposal of hazardous waste must develop PPC plans in conformance with Chapter 262a, 264a, and 265a of the Department's regulations. Generators, of between 100 and 1,000 kilograms of hazardous waste per month, may not be required to have a PPC plan if they comply with the Preparedness and Prevention requirements in the regulations. (Note: hazardous waste transporters must also develop PPC plans under Chapter 263a. A separate PPC guidance document has been developed for transporters.)

A person who owns or operates a residual waste disposal or processing facility must develop a PPC plan under Chapters 287, 288, 289, 293, 295, and 297 of the residual waste regulations.

A person who owns or operates a municipal waste disposal or processing facility must develop a PPC plan under Chapters 273, 277, 279, 281, 283, and 284 of the municipal waste regulations.

In regards to the Oil and Gas Program, PPC Plans are required under the Clean Streams Law for approval of road spreading operations, drilling and operating oil and gas wells, and brine disposal wells. These plans are required under 25 Pa. Code Chapters 91.34 and 78.55. In addition, PPC Plans are required for NPDES and Part II Water Quality Management Permits. The Plan requirements are contained in the Oil and Gas Operators Manual

SPR

Facility owners with aboveground storage tank aggregate capacity > 21,000 gallons of a regulated substance.

*Note: PPC plans developed by hazardous waste generators and/or treatment, recycling, storage or disposal facilities, which would not otherwise be required to obtain NPDES or Water Quality Protection Part II permits, generally need only to address the PPC planning requirements as they pertain to their hazardous waste activity (unless otherwise directed by the Department).

B. How Do Existing Emergency Response Plans Fit in With Newer Program Requirements?

It should be noted that oil-related Spill Prevention, Control, and Countermeasure (SPCC) plans, which are or have been developed pursuant to EPA's oil-related SPCC regulations, should also be considered as part of an installation's overall PPC plan. Some installations may elect to integrate their oil-related SPCC plan with the PPC or SPR plan elements, or may elect to keep it as a separate chapter, or appendix, to the PPC or SPR plan.

Likewise, the additional downstream notification requirement of an SPR plan can be added to an existing plan to satisfy the "Storage Tank and Spill Prevention Act," providing all required elements of a SPR plan are completed for the existing plan.

Other types of existing emergency response plans should be handled in a similar manner.

C. Development and Submission of Plans for Review and Approval.

The plan must be developed in accordance with good engineering practice by someone who is familiar with the day-to-day operations at the site. If an outside consultant is employed for this purpose, he must be authorized to conduct a thorough study of the material storage, handling, usage, disposal, and waste management practices conducted at the installation.

Section II outlines the general content and format of PPC and SPR plans.

In general, plans should be submitted for review and approval by the Department in conjunction with applications for NPDES Water Quality Management, Storage Tank, Residual Waste Management, Municipal Water Management, or Hazardous Waste Management permits, as follows:

1. NPDES dischargers should submit (2) copies of the PPC plan for review, along with the NPDES application materials. All Stormwater General Permit applicants must complete and implement the Plans before or at the same time as application submission.

   Facilities which are not required to obtain NPDES permits, but which must obtain Water Quality Protection Part II permits, should submit (2) copies of the PPC plan for review, along with the Part II permit application.

2. Residual waste disposal/processing/transfer/composting facilities are required to develop and submit a PPC Plan as part of the residual waste permit application. Facilities permitted under permit-by-rule are required to develop PPC Plans and maintain them on site.

3. Municipal waste disposal/processing, transfer/composting facilities are required to develop and submit a PPC plan as part of the municipal waste permit application. Facilities permitted under permit-by-rule are required to develop PPC plans and maintain them on site.

   Other facilities which are not normally required to obtain NPDES or WQM Part II permits may also be required to develop and submit a PPC Plan, should conditions warrant, pursuant to Chapter 92 of the Department's regulations.

4. Hazardous waste generators are required to develop PPC plans and to maintain them on site. They are required to submit PPC plans to the Department for review upon request by the Department.

5. Hazardous waste treatment, recycling, storage, or disposal facilities should submit one copy of the PPC plan for each copy of the Hazardous Waste Part B permit application being submitted. In these situations the PPC plan is considered as part of the overall Hazardous Waste Part B permit application. Final PPC plan approval will accompany the issuance of a Hazardous Waste Management permit.

6. Aboveground storage tank facilities (with aggregate capacity >21,000 gallons) are required to submit one copy of the SPR plan to the appropriate regional DEP office for review. This plan must be developed in consultation with county and municipal emergency management agencies. Facilities that already have a PPC plan can update the PPC plan with the downstream notification requirement to satisfy this obligation.

7. Oil and gas well operators must prepare and implement a plan describing the measures to prevent pollution of the surface water and groundwater and for the control and disposal of pollutional substances and waste. A copy of the plan must be provided to the Department upon request.

D. Distribution of the Plan

A copy of the plan and any subsequent revisions must be maintained on-site. All members of the installation's organization for developing, implementing, and maintaining the plan and all emergency coordinators must review the plan and be thoroughly familiar with provisions.

In addition to the site copy and the copy submitted to the Department, other facility plans should be made available to the following agencies, to the extent which they may become involved in an actual emergency (see Description of PPC Plan Elements, Part E.1.):

Submission of copies to all of these entities is a legal requirement for hazardous waste facilities. Bulk aboveground storage tank facilities are required to submit copies to emergency management agencies, as noted below.

1. County and local Emergency Management Agencies. (This is a legal requirement for storage tank facilities with >21,000 gallons of above ground storage.)

2. Local Fire Service Agencies and/or Hazmat Team

3. Local Emergency Medical Service Agencies

4. Local Police

E. Implementation of the Plan

The provisions of the plan must be carried out whenever emergency situations arise which endanger public health and safety, or the environment.

F. Revisions of the Plan

The PPC Plan must be periodically reviewed and updated, if necessary. At minimum, this must occur when:

1. Applicable Department regulations are revised;

2. The plan fails in an emergency;

3. The installation changes in its design, construction, operation, maintenance, or other circumstances, in a manner that materially increases the potential for fires, explosions or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency;

4. The list of emergency coordinators changes;

5. The list of emergency equipment changes; or

6. As otherwise required by the Department.

In addition to the above, the SPR or PPC plans must also be revised upon the removal or addition of a storage tank(s).

II. PLAN CONTENT AND FORMAT

General Instructions

A. Table 3 outlines the basic elements of a PPC and SPR Plan. Each of these elements is further described in this guidance document. Certain plan elements may not be entirely applicable or appropriate for a specific manufacturing or commercial installation. In these cases the person preparing the plan should act accordingly and should provide a brief explanation as to why the plan element(s) in question is not applicable or appropriate.

B. The most important thing to remember in developing your plan is that the actual effectiveness of the plan will depend upon its simplicity and readability.

Plans which are composed of several volumes of overly detailed narrative discussions and specifications tend to discourage the reader or user. Diagrams, charts, tables, maps, and plans must be easily readable and understandable, particularly in times of an actual emergency.

The plan should additionally be indexed or tabbed in such a way that the key portions which pertain to emergency response can be quickly referred to.

TABLE 3

ELEMENTS AND FORMAT OF A PPC AND SPR PLAN

A. Description of Facility

1. Description of the Industrial or Commercial Activity
2. Description of Existing Emergency Response Plans
3. Material and Waste Inventory
4. Pollution Incident History
5. Implementation Schedule for Plan Elements Not Currently in Place

B. Description of How Plan is Implemented by Organization

1. Organizational Structure of Facility for Implementation
2. List of Emergency Coordinators
3. Duties and Responsibilities of the Coordinator
4. Chain of Command

C. Spill Leak Prevention and Response

1. Pre release Planning
2. Material Compatibility
3. Inspection and Monitoring Program
4. Preventive Maintenance
5. Housekeeping Program
6. Security
7. External Factor Planning
8. Employe Training Program

D. Countermeasures

1. Countermeasures to be Undertaken by Facility
2. Countermeasures to be Undertaken by Contractors
3. Internal and External Communications and Alarm Systems
4. Evacuation Plan for Installation Personnel
5. Emergency Equipment Available for Response

E. Emergency Spill Control Network

1. Arrangements with Local Emergency Response Agencies
2. Notification Lists
3. Downstream Notification Requirement for Storage Tanks

DESCRIPTION OF PLAN ELEMENTS

A. Description of Facility

1. Description of the Industrial or Commercial Activity

- Briefly describe the nature of the industrial or commercial activity which occurs at the site. Include a general discussion of products manufactured, manufacturing processes used, wastes generated, etc.
- On a copy of a 7 1/2 minute USES map show the following:
  - Facility location
  - Facility name
  - Facility ID #
  - Name of 7 1/2 minute USES quadrangle
  - County
  - Location of facility site and site boundaries
  - Location of each storage tank
  - Location of surface drainage courses leading away from the site, and major surface streams and tributaries near the site
  - Location of any known public and private surface water intakes downstream from the site
- Include a drawing which shows the following:
  - General layout of the site
  - Property boundaries
  - Areas occupied by manufacturing or commercial activities
  - Raw materials and product storage
  - Loading and unloading operations
  - High risk areas where spills and leaks most likely would occur
  - Waste handling, storage, and treatment facilities
  - Drains, pipes, and channels which lead away from potential leak or spill areas
  - Outfall pipes which discharge to surface streams or drainage channels
  - Secure and open-access areas
  - Entrance and exit routes to the site

2. Description of Existing Emergency Response Plans

- Briefly describe any existing plan, which has been previously developed by the installation, for the purpose of pollution incident prevention or emergency response preparedness. If the plan has previously been

approved by the Department, this should also be noted, along with the date of approval.

- Provide a brief discussion as to how the existing plan relates to the overall PPC or SPR Plan being developed. The degree to which the existing plan encompasses some, or all, of the PPC/SPR Plan elements should also be noted. When the PPC has been developed and an SPR plan is needed, the downstream notification requirement information can be added as an addendum.

  Similar plans which have been prepared for agencies other than DEP should also be described and cross-referenced to the maximum extent possible to the PPC Plan elements so as to minimize rewriting. For example, an oil related Spill Prevention Control and Countermeasure (SPCC) Plan which has been developed to comply with EPA's regulations 40 CFR 112, may be treated as an appendix, or as a separate chapter, to the overall PPC/SPR Plan for an installation.

3. Material and Waste Inventory

- Identify and list by common chemical name and trade name, the locations, sources and quantities of raw chemical materials, commercial chemical products, manufacturing chemical intermediates, and process wastes managed at the installation which have the potential for causing environmental degradation or endangerment of public health and safety through accidental releases. Requests for confidentiality of this information will be handled in accordance with Department regulations.

  Detailed descriptions must be available for materials that have a high potential for spills, discharges, explosions, or fires (such as those stored in bulk storage). Materials that have a low potential for spills, discharges, explosions, or fires (such as those used and stored in small quantities in a laboratory) should be minimally detailed.

  This information should be used to evaluate the prevention, containment, mitigation, cleanup, and disposal measures which would be used in the event of a spill, discharge, explosion, or fire. As new materials are added to the list, their pollution potential should be evaluated.

- Attach to this plan the Material Safety Data Sheet (MSDS) for each material in storage (the MSDS must be completed to the extent it meets the requirements of 29 CFR 1910.1200(9) Hazardous Communications Standard Requirements).

4. Pollution Incident History

- List the previous pollution incidents, the date, the material or waste spilled, approximate amount spilled, environmental damage, and action taken to prevent a recurrence.

  An important criteria in determining the effectiveness of the plan and its implementation is the history of incidents at the installation. A history of no incidents suggest that the practices and procedures at the site are effective. For a site with a history of incidents, it is important to

investigate the reasons for the spills and the response of the company in minimizing the potential for their recurrence.

5. Implementation Schedule for Plan Elements Not Currently in Place

- Provide a list of any missing or incomplete aspects of the plan and a time schedule when they will be implemented.

  An implementation schedule, or any elements of the plan not currently in place, must be developed. Each missing or incomplete aspect of the plan should be addressed and discussed within the applicable elements of the plan. Missing or incomplete aspects must be implemented as soon as possible and in conformance with all Department regulations and requirements.

B. Description of How Plan is Implemented by Organization

1. Organizational Structure of Facility for Implementation

- Describe the organizational structure for implementation of the plan.
- Describe the duties and responsibilities of the individuals within the organization that will implement the plan.

  Each installation must develop a permanent organizational structure for developing, implementing, and maintaining the plan. The exact nature and make-up of this structure will vary considerably, depending upon the size and complexity of the installation.

  For example, a large manufacturing company may either establish a formal preparedness-response committee, or it may assign this responsibility to an existing organization within the company, such as a safety committee or a preventive maintenance group. A small manufacturing or commercial facility may only have one or two individuals responsible for developing and implementing the plan. However, the preparedness-response organization, regardless of its size, must be given both the responsibility and authority by management for developing, implementing, and maintaining the plan.

  The main duties and responsibilities of the preparedness-response organizational structure should include identification of materials and wastes handled (materials inventory), identification of potential spill sources (risk assessment), establishment of spill-reporting procedures, visual inspection programs review of past incidents and spills, and countermeasures utilized. In addition, the preparedness-response organizational structure should be responsible for coordination needed to implement the goals of the plan, coordination of the activities for spill cleanup, notification of authorities and establishment of training and educational programs for installation personnel.

  The preparedness response organizational structure should have the overall responsibility for periodically reviewing and evaluating the plan and instituting appropriate changes at regular intervals. The organizational structure should also be responsible for the review of new construction and process changes at an installation relative to the plan.

The organizational structure should also evaluate the effectiveness of the overall plan and make recommendations to management on related matters.

2. List of Emergency Coordinators

- Provide an up-to-date list of names, addresses, and phone numbers (office and home) of all persons qualified to act as emergency coordinator. Where more than one is listed, one must be named as the primary coordinator, and others shall be listed in the order in which they will assume responsibility as alternates.

  At all times there must be at least one employee either on the installation's premises or on-call with the responsibility for coordinating all emergency response measures. The emergency coordinator must be thoroughly familiar with all aspects of the plan, all operations and activities, the location and characteristics of all materials handled, the location of all records and the lay out of the installation. In addition, this individual should have the authority to commit the resources necessary to carry out the plan.

3. Duties and Responsibilities of the Coordinator

- Describe the duties and responsibilities of the emergency coordinator specific to your installation or activity in the event of an imminent or actual emergency.

  During an emergency, the emergency coordinator should activate alarm systems, notify emergency response agencies, identify the problem, assess the health or environmental hazards, and take all reasonable measures to stabilize the situation. The emergency coordinator should also be responsible for follow-up activities after the incident such as treating, storing, or disposing of residues and contaminated soil, decontamination and maintenance of emergency equipment, and submission of any reports. Appendix I describes some example duties and responsibilities of the emergency coordinator.

4. Chain of Command

- Provide an internal list, by position, of key employees that must be contacted in the event of an emergency or spill.

  List the positions, office telephone extensions, and home phone numbers (if applicable) of key employees, in the order of responsibility that would be contacted in the event of an emergency or spill.

  This list, along with the notification procedure, should be posted on bulletin boards or other conspicuous locations around the installation.

C. Spill Leak Prevention and Response

1. Pre-release Planning

- Describe the sources and areas where potential spills and leaks may occur, the direction of flow of spilled materials, and the pollution incident prevention practices (see Appendix II) specific to the source or area.

- Provide separate drawings, plot plans (or include in the general layout drawings), showing sources and quantities of materials and wastes. Sources and areas where potential spills may occur, and pollution incident prevention practices (see Appendix II).

  The plan should include a prediction of the direction of the flow of materials spilled as a result of equipment failure, accident, or human error. Particular care and attention should be paid to evaluating the following: raw materials storage, in plant transfer, process and materials handling, intermediary and product storage (if applicable), truck and rail car loading and unloading, and waste handling and storage. Describe and identify valving for the storage tank and system to be used to partition off each storage tank in case of a release.

  Liquid storage areas must have containment capacity sufficient to hold the volume of the largest single container or tank, plus a reasonable allowance for precipitation based on local weather conditions and plant operations. Containment systems must be sufficiently impervious to contain spilled material or waste until it can be removed or treated. Tank or container materials must be compatible with the material or waste stored.

  Pollution incident prevention practices to eliminate contaminated runoff, leaching, or windblowing must be implemented in non liquid storage areas. Provisions must be made to contain or manage contaminated run-off or leachate from these areas.

  Piping, processing, and materials handling equipment at in-plant transfer, process, and materials handling areas must be designed and operated so as to prevent spills. Containment practices should be instituted at processing and handling areas including floor drains, storm sewers, or drainage swales to prevent an accidental discharge. Protection such as covers or shields to prevent windblowing, spraying, and releases from pressure relief values from causing a discharge should be provided as appropriate.

  Truck and rail car loading and unloading areas must have sufficient containment capacity to hold the volume of the largest tank truck or rail car loaded or unloaded at the installation, plus a reasonable allowance for precipitation. Any overhead piping must have adequate clearance over roadways. Containment systems must be sufficiently impervious to contain spilled material or waste until it can be removed or treated.

2. Material Compatibility

- Summarize the engineering practices followed with regard to material compatibility such as materials of construction, corrosion, etc.

  Engineering practices with regard to material compatibility normally consist of an appraisement of the compatibility of construction materials of tanks, pipelines, etc., with their contents; the reaction of materials or wastes when intentionally or inadvertently mixed or combined; and, the compatibility of a container such as a storage tank or pipeline with its environment.

Specific consideration should be given to the procedures and practices delineating the mixing of materials and prohibiting mixing of incompatible materials which may result in fire, explosion, or unusual corrosion. Thorough cleaning of storage vessels and equipment before reuse should be standard practice to ensure that there is no residual incompatible with the next or later materials used. Coatings or cathodic protection should be considered for protecting buried pipelines or storage tanks from corrosion.

3. Inspection and Monitoring Program

- Describe the type and frequency of inspections and monitoring for leaks or other conditions that could lead to spills or emergency situations.

  Typical inspections include the following: pipes, pumps, values, and fittings for leaks; tanks for corrosion; tanks supports and foundations for deterioration; chemical material piles for windblowing; evidence of spilled materials along drainage ditches; effectiveness of housekeeping practices; damage to shipping containers; leaks, seeps, or overflows at waste treatment, storage, or disposal sites; etc. Areas that should be inspected include the following: storage, loading and unloading, transfer pipelines, waste treatment facilities, and disposal sites. The use of an inspection checklist may be useful in an inspection and monitoring program.

  Routine monitoring should be performed to determine the physical conditions and liquid levels in tanks, the quality of plant site runoff in diked areas, etc., either by manual testing or in-situ instrumentation. Monitoring should be used to initiate a warning of the need for immediate corrective action to prevent a spill or other emergency condition. Monitoring systems should be used in conjunction with a communications or alarm system to immediately notify personnel of abnormal conditions.

  An inventory system should also be considered for keeping track of those materials having the greatest potential for causing problems due to leaks, spills, or mishandling.

  As a minimum, the frequency of inspection and monitoring must be in accordance with the applicable Department regulations and permits. Appendix II includes some additional inspection and monitoring examples.

4. Preventive Maintenance

- Describe the aspects of the preventive maintenance program for equipment and systems relating to conditions that could cause environmental degradation or endangerment of public health and safety.

  Describe the procedures for the correction of those conditions by adjustment, repair, or replacement before the equipment or system fails.

  A good preventive maintenance program includes the following: (1) identification of equipment and systems to which the program should apply; (2) periodic inspections of identified equipment and systems; (3) periodic testing of equipment and systems, (such as routine calibration

of environmental monitoring equipment); (4) appropriate adjustment, repair, or replacement of parts; and (5) complete recordkeeping of the preventive maintenance activities, inspection and test results, calibration dates, repairs, replacement, and adjustments to the applicable equipment and systems.

5. Housekeeping Program

- Identify the areas and the type of housekeeping practices that should apply to reduce the possibility of accidental spills and safety hazards to plant personnel.

  Examples of good housekeeping include the following: neat and orderly storage of chemicals; prompt removal of small spillage; regular refuse pickup and disposal; maintenance of dry, clean floors by use of brooms, vacuum cleaners, or cleaning machines; and, provisions for the storage of containers or drums to keep them from protruding into open walkways, pathways, or roads.

  Dry chemicals should be swept or cleaned up to prevent possible washdown to drains and drainage ditches or windblowing of the material to other areas of the plant. Small liquid accumulations on the ground or on a floor in a building should be cleaned up to prevent discharge or transport to other areas. See Appendix I for additional examples.

6. Security

- Describe the security procedures employed at the installation to prevent accidental or intentional entry that could result in a violation of Departmental regulations, or injury to persons or livestock.

  Security systems described in the plan should address, as necessary: fencing; lighting; vehicular traffic control; access control; visitors passes; locked entrances; vandalism; locks on drain valves and television monitoring. Security procedures must be in accordance with applicable Department regulations.

7. External Factor Planning

- Describe the possible effects of power outages, strikes, floods, snowstorms, etc., and the action to be taken to alleviate any resulting effects to public health and safety or the environment.

8. Employe Training Program

- Summarize the training program given to employees which will enable them to understand the processes and-materials with which they are working, the safety and health hazards, the practices for preventing, and the procedures for responding properly and rapidly to spills.

  At a minimum, the training program must be designed to ensure that personnel are able to respond effectively to emergencies by familiarizing them with emergency procedures, emergency equipment systems including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for

automatic cut-off systems; communications and alarm systems; response to fires and explosions; site evacuation procedures; and shut down of operations.

In addition the employee training program should address other aspects of the preparedness-response program such as preventive maintenance, inspection and monitoring, housekeeping practices, etc. The training program must be designed and conducted in accordance with applicable Department regulations. Records of the employes' attendance in the training program should be included in personnel files.

D. Countermeasures

1. Countermeasures to be Undertaken by Facility

- Provide specific countermeasures which will be undertaken by facility personnel in the event of a release. Include valve activations, equipment isolations, flow diversions, boom deployment, and any other activities which will be undertaken to halt the migration of the contaminant off site and to mitigate the consequence of the release.

2. Countermeasures to be Undertaken by Contractors

- Provide a list of emergency response contractors, phone numbers, and the services they will provide.

  The services of nearby contractors should be investigated and arrangements made for the prompt performance of contractual services on short notice. Equipment suppliers should be contacted to determine the availability and means of delivery of equipment needed for removing pollution or hazards to the public health and safety. Describe arrangements with these contractors and the time frame in which they can respond with required equipment.

3. Internal and External Communications and Alarm Systems

- Describe the internal communications or alarm used to provide immediate emergency instruction (voice or signal) to installation personnel.
- Describe the external communications or alarm system used to summon emergency assistance from local police or fire departments.

  Examples of communications or alarm systems are: hand held two way radios; CB radios; telephones; fire or police alarms; PA systems; beeper or voice pagers, etc.

4. Evacuation Plan for Installation Personnel

- Describe the evacuation plan for facility personnel where there is a possibility that evacuation could be necessary.

  The plan must describe signals to be used to begin evacuation, primary evacuation route, and alternate evacuation routes (in cases where primary routes could be blocked by releases of hazardous materials, wastes, gases, or fires). Periodic drills should be conducted to evaluate the effectiveness of the plan.

5. Emergency Equipment Available for Response

- Provide an up-to-date list of available emergency equipment. The list must include the location, a physical description, and a brief description of the intended use and capabilities of each item on the list.
- Describe the procedures for maintenance and decontamination of emergency equipment.

  All installations should have equipment available to allow personnel to respond safely and quickly to emergency situations. Some examples of emergency equipment are portable fire extinguishers, fire control equipment (including special extinguishing equipment such as that using foam, inert gas, or dry chemicals), spill control equipment, decontamination equipment, self contained breathing apparatus, gas masks, and emergency tool and patching kits. See Appendix III for more examples.

  All equipment must be tested and maintained as necessary to assure its proper operation in time of emergency. After an emergency, all equipment must be decontaminated, cleaned, and fit for its intended use before normal operations resume.

E. Emergency Spill Control Network

1. Arrangements with Local Emergency Response Agencies and Hospitals

- Provide a list of local emergency response agencies and hospitals. Include the phone numbers and describe arrangements concerning the emergency services they will provide.

  Arrangements must be made, as appropriate, to inform local emergency response agencies, and hospitals concerning the type of materials or wastes handled at the installation and the potential need for services. Arrangements should be made which will designate who will be the primary emergency response agency and who will provide support services during emergencies.

  Efforts should be made to familiarize police, fire departments, emergency response teams, and the County Emergency Management Coordinator with the layout of the installation, the properties and dangers associated with the hazardous materials handled, places where personnel would normally be working, entrances to roads inside the facility, and the possible evacuation routes. At a minimum, this requirement must be in accordance with applicable Department regulations.

2. Notification Lists

- Provide a list of agencies and phone numbers that must be contacted in the event of an emergency or spill.

  A list must be developed for notifying State, local, and Federal regulatory agencies of all spills. Such a list should include, as applicable: PA DEP (see Appendix IV); PA Emergency Management Agency; County Health Department; County EMA; PA Fish Commission; the National Response

Center (U.S. EPA and U.S. Coast Guard); local police and fire departments; the local sewage treatment plant (for discharges to sewer system); and downstream public water supplies, industrial water users, and recreation areas.

3. Downstream Notification Requirement for Storage Tanks

- This is an additional requirement of storage tank facilities with aggregate aboveground storage >21,000 gallons of regulated substances. It can be addended to an updated PPC plan so as to meet the SPR plan requirement.

  The requirement includes a 20-mile downstream Notification List, an annual notification requirement, and an annual Notification List update. Lists of downstream users may be developed from information provided by your county Emergency Management Agency.

  Downstream Notification List shall include all municipalities and surface water users within 20 downstream miles of the tank facility. Surface water users include drinking water companies, and industries that utilize surface water intakes; and municipalities include each county, township, city and borough located within this downstream corridor. This list is to be developed via assistance from the local emergency management agency. (Refer to Appendix V for an example.)

  Annual Written Notification must be given to downstream water users and municipalities on the Notification List. This written notification at a minimum must include a detailed inventory of the type and quantity of material in storage at the facility.

  Annual Update must be developed each year in cooperation with the local Emergency Management Agency. This Notification List update will show any changes in contacts, users, telephone #'s needed for emergency downstream notification and the annual written notification. Also, any changes in the emergency response organization (such as telephone numbers) should be updated.

APPENDIX I

EXAMPLES OF AN EMERGENCY COORDINATOR'S DUTIES AND RESPONSIBILITIES

Whenever there is an imminent or actual emergency situation, the emergency coordinator must immediately:

1. Activate facility alarms or communications systems, where applicable, to notify facility personnel; and

2. Notify local emergency response agencies including the Department.

   Whenever there is an emission or discharge, fire, or explosion, the emergency coordinator must immediately identify the character, exact source, amount, and areal extent of emitted or discharged materials. He may do this by observation or review of records and, if necessary, by chemical analysis.

   Concurrently, the emergency coordinator must assess possible hazards to human health or the environment that may result from the emission or discharge, fire, or explosion. This assessment must consider both direct and indirect effects of the emission, discharge, fire, or explosion.

   If the emergency coordinator determines that the installation has had an emission, discharge, fire, or explosion which would threaten human health or the environment, he must immediately notify the applicable local authorities including the county emergency management agency and indicate if evacuation of local areas may be advisable; and immediately notify the Department in accordance with Appendix IV; the National Response Center; and the Pennsylvania Emergency Management Agency; and report the following:

   a. Name of the person reporting the incident

   b. Name and location of the installation

   c. Phone number where the person reporting the spill can be reached

   d. Date, time, and location of the incident

   e. A brief description of the incident, nature of the materials or wastes involved, extent of any injuries, and possible hazards to human health or the environment

   f. The estimated quantity of the materials or wastes spilled, and

   g. The extent of contamination of land, water, or air, if known.

   When there is a release from an aboveground storage tank which threatens the water supply of downstream users, these downstream users (on the Downstream Notification List) must be notified within 2 hours of the release. Priority for notification is by closest proximity to the release site.

   During an emergency, the emergency coordinator must take all reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, reoccur, or spread to other materials or wastes at the installation. These measures shall include where applicable, stopping manufacturing processes and operations, collecting and containing released materials or wastes, and removing or isolating containers.

   If the installation stops operations in response to a fire, explosion, emission, or discharge, the emergency coordinator must ensure that adequate monitoring is conducted for leaks, pressure

buildup, gas generation, or ruptures in valves, pipes, or other equipment, wherever this is appropriate.

Immediately after an emergency, the emergency coordinator, with Departmental approval, must provide for treating, storing, or disposing of residues, contaminated soil, etc., from an emission, discharge, fire, or explosion at the installation.

The emergency coordinator must insure that in the affected areas of the installation, no material or waste incompatible with the emitted or discharged residues is processed, stored, treated, or disposed of until cleanup procedures are completed; and, all emergency equipment listed in the plan is cleaned and fit for its intended use before operations are resumed.

Within 15 days after the incident, the installation must submit a written report on the incident to the Department. The report must include the following:

a. Name, address, and telephone number of the individual filing the report

b. Name, address, and telephone number of the installation

c. Date, time, and location of the incident

d. A brief description of the circumstances causing the incident

e. Description and estimated quantity by weight or volume of materials or wastes involved

f. An assessment of any contamination of land, water, or air that has occurred due to the incident

g. Estimated quantity and disposition of recovered materials or wastes that resulted from the incident, and

h. A description of what actions the installation intends to take to prevent a similar occurrence in the future.

APPENDIX II
POLLUTION INCIDENT PREVENTION PRACTICES

Pollution incident prevention practices can be divided into the following four categories: prevention, containment, mitigation and ultimate disposition. The listings below provide specific examples of each category.

1. PREVENTION

Visual Observations of:

Storage facilities
Transfer pipelines
Loading and unloading areas
Waste handling and storage areas

Detailed Inspections of:

Pipes, pumps, valves, and fittings for leaks
Tanks for corrosion (internal and external)
Dry material or waste stockpiles for windblowing
Tanks supports or foundations for deterioration
Walls for stains
Drainage ditches and areas around old tanks for evidence of spilled materials
Primary or secondary containment for deterioration
Housekeeping practices
Shipping containers for damage
Material or waste conveyance systems for leaks, spills, or overflows
Integrity of stormwater collection systems
Waste storage, treatment, or disposal sites for leaks, seeps, and overflows

Monitoring

Liquid-level detectors
Alarm systems
Pressure and temperature gauges
Analytical testing instrumentation
Pressure drop shut-off devices
Flow meters
Valve positioning indicators
Equipment operational lights
Excess-flow valves
Automatic runoff diversion devices
Routine sample collection (including groundwater and monitoring wells)
Redundant instrumentation
Records (all monitoring results/findings)

Nondestructive Testing

Hydrostatic pressure tests
Acoustical emission tests
Radiographic tests
Magnetic particle tests
Liquid Penetration
Records of tank wall thicknesses and results of all testing

2. CONTAINMENT

Secondary Containment

- Dikes
- Curbs
- Depressed areas
- Storage basins
- Sumps
- Drip pans
- Liners
- Double piping
- Sewer collection systems

Flow Diversion

- Trenches
- Drains
- Graded pavement
- Grating
- Overflow structures
- Sewers
- Culverts

Vapor Control

- Water spray
- Vapor space
- Vacuum exhaust

Dust Control

- Hoods
- Cyclone collectors
- Bag-type collectors
- Filters
- Negative-pressure systems
- Water spraying

Sealing

- Foamed plastic compounds used for plugging leaks in tanks

3. MITIGATION

Physical Clean-up

- Brooms
- Shovels
- Plows

Labeling

- U.S. DOT or National Fire Protection Association's (NFPA) designation on tanks and pipelines
- Color coding of tanks and pipelines
- Warning signs

Vehicle Positioning

Physical barriers (e.g., wheel chocks)
Underlying drains
Designated loading and unloading areas

Covering

Tarpaulins over outdoor dry waste or material stockpiles
Buildings or roofs over outside processes or stockpiles
Vegetation, rock, or synthetic covering on surface impoundments

Pneumatic and Vacuum Conveying

Loading and unloading by air pressure or vacuum
Safety relief valves
Dust collectors
Air slide trucks and rail cars

Preventive Maintenance

Periodic inspections
Periodic testing to determine soundness of system
Identification of equipment and systems that need to be upgraded, repaired, or replaced
Appropriate adjustment, repair, or replacement of parts
Complete recordkeeping of all repairs, upgrading, replacements, and adjustments; and all testing findings/results after system modifications were made

Good Housekeeping

Neat and orderly storage of chemicals
Prompt removal of small spillage
Regular garbage pickup and disposal
Maintenance of dry, clean floors by use of brooms, vacuum cleaners, etc.
Maintenance of proper spacing for pathways and walkways between containers and drums
Stimulation of employee interest in good housekeeping

Employee Training Programs

Materials Inventory Systems
Material Safety Data Sheets

Mechanical Clean up

Vacuum systems
Pumps
Pump/bag system

Chemical Clean up

Sorbents

activated carbon
polyurethane and polyolefin spheres, beads, and foam belts
amorphous silicate glass foam
clay
sawdust

Gelling agents

polyelectrolytes
polyacrylamide
butylstyrene copolmyers
polyacrylonitrile
polyethylene oxide

Foams

rockwood alcohol
protein
fluoroprotein
aqueous film-forming foam
polar liquid foam
surfactant-based foam

Volatilization

distillation
stripping
evaporation

Carbon absorption
Coagulation/precipitation
Neutralization
Ion exchange
Chemical oxidation
Biological treatment

4. ULTIMATE DISPOSITION

Thermal oxidation
Land disposal
Recycle
Recover
Reuse
Detoxification

APPENDIX III
EXAMPLES OF EMERGENCY EQUIPMENT

Special equipment is often required and may be needed quickly in an emergency. Examples include the following:

Aerial ladder

Absorbant materials

Accident investigation kit

Air compressor

Air supply, for breathing equipment

Backhoe

Basket stretchers

Bulldozer

Bullhorn

Camera/photo equipment

Cellar pump

Chain hoist

Chain saw

Chemical neutralizers

Crane

Cutters (power)

Decontamination equipment with a clean Resuscitator water supply (70-80%F)

Ejector - smoke

Elevated platform truck

Explosimeters

Fans

Firefighting equipment

First aid supplies

Foam concentrate supply

Foam generators

Forklift

Fuel Supply

Geiger counter

Generator trailer

Heaters, portable

Helicopter

Hydraulic spreader jacks

Inhalator

Jack hammer

Jacks

Ladder Truck

Lighting equipment, portable

Medical supplies

Metal saw (power)

Public address system

Radio

Resuscitator

Sand supply

Self-contained breathing apparatus (SCBA)

Self-contained underwater breathing apparatus (SCUBA)

Submersible pump

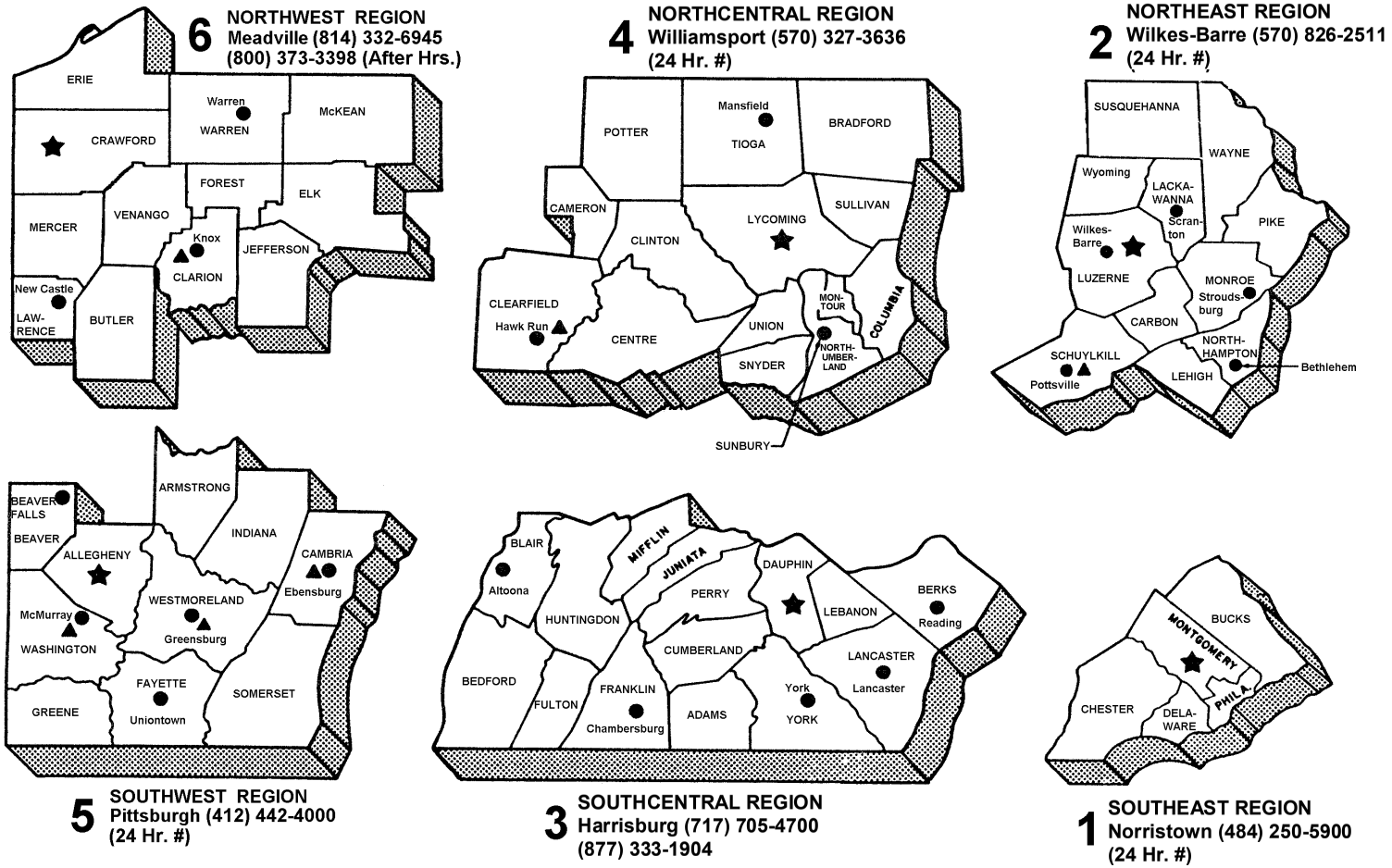
Tank truck

Tool box

Welding/cutting equipment

Water pump

APPENDIX IV
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
EMERGENCY NOTIFICATION NUMBERS
STATEWIDE EMERGENCY NOTIFICATION NUMBER (800) 541-2050 (PA ONLY)
OR (717) 787-4343
(To Be Used If There Is A Problem In Contacting The Region)



APPENDIX V
PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Field Operations--Environmental Cleanup Program
Regional Storage Tank List

Region	Contact
Southeast Regional Office 2 East Main Street Norristown, PA 19401-4915 Telephone: (484) 250-5900	Kathy Nagle
Northeast Regional Office 2 Public Square Wilkes-Barre, PA 18711-0790 Telephone: (570) 826-2511	Ron Brezinski
Southcentral Regional Office 909 Elmerton Avenue Harrisburg, PA 17110-8200 Telephone: (717) 705-4700	Gregory Bowman
Northcentral Regional Office 208 W. Third Street Williamsport, PA 17701 Telephone: (570) 327-3636	Steve Webster
Southwest Regional Office 400 Waterfront Drive Pittsburgh, PA 15222 Telephone: (412) 442-4000	Gale Campbell
Northwest Regional Office 230 Chestnut Street Meadville, PA 16335 Telephone: (814) 332-6945	Daniel F. Peterson

In the event no contact with the Regional Office is made, the Department Emergency number (717) 787-4343 shall receive calls during and after business hours, 24 hours daily and holidays and weekends.

Oil and Gas Management Program

South Regional Office 400 Waterfront Drive Pittsburgh, Pa 15222-4745 (412) 442-4000	David F. Janco
Northwest Regional Office 230 Chestnut Street Meadville, PA 16335 (814) 332-6945	Craig Lobins

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Field Operations--Water Management

Region	Contact
Southeast Regional Office 2 East Main Street Norristown, PA 19401-4915 Telephone: (484) 250-5900	James Newbold
Northeast Regional Office 2 Public Square Wilkes-Barre, PA 18711-0790 Telephone: (570) 826-2511	Kate Crowley
Southcentral Regional Office 909 Elmerton Avenue Harrisburg, PA 17110-8200 Telephone: (717) 705-4700	Jim Spontak
Northcentral Regional Office 208 W. Third Street Williamsport, PA 17701 Telephone: (570) 327-3636	Daniel Alters
Southwest Regional Office 400 Waterfront Drive Pittsburgh, PA 15222 Telephone: (412) 442-4000	Steve Balta
Northwest Regional Office 230 Chestnut Street Meadville, PA 16335 Telephone: (814) 332-6945	Dave Milhous

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Field Operations--Waste Management
Regional Contact

Region	Contact
Southeast Regional Office 2 East Main Street Norristown, PA 19401-4915 Telephone: (484) 250-5900	Facilities Manager
Northeast Regional Office 2 Public Square Wilkes-Barre, PA 18711-0790 Telephone: (570) 826-2511	Facilities Manager
Southcentral Regional Office 909 Elmerton Avenue Harrisburg, PA 17110-8200 Telephone: (717) 705-4700	Facilities Manager
Northcentral Regional Office 208 W. Third Street Williamsport, PA 17701 Telephone: (570) 327-3636	Facilities Manager
Southwest Regional Office 400 Waterfront Drive Pittsburgh, PA 15222 Telephone: (412) 442-4000	Facilities Manager
Northwest Regional Office 230 Chestnut Street Meadville, PA 16335 Telephone: (814) 332-6945	Facilities Manager

APPENDIX VI
IGMARS STORAGE FACILITY
Harrisonberg, PA
Example
DOWNSTREAM NOTIFICATION LIST FOR YEAR 1992

Facility	Address	Mile Mark	Contact	Telephone
Harrison County	PO Box 15 Harrison Co. Courthouse Harrisonberg, PA	-	Ronald Swoyer Co. Emergency Mgt. Coordinator	Office: (717) 674-1212 Emergency: (717) 674-3434
Greenly Township	PO Box 498, RD 1 Harrisonberg, PA 19865	0	Donald Trump	Office: (717) 765-3468 Emergency: (717) 765-4579
Harrisonberg City	PO Box 21, City Hall Harrisonberg, PA 19869	3	Jay Miller	Office: (717) 674-2185 Emergency: (717) 674-2194
Harrisonberg Water	Harrisonberg, PA	6	Richard Miles	Office: (717) 254-8904 Emergency: (717) 254-8910
Harrison Township	Harrison Township Building Krissville, PA 19872	10	Charles Davis Township Manager	Office: (717) 760-3120 Emergency: (717) 760-3123
Harrison Township Auth.	PO Box 234 Krissville, PA 19870	12	Kemp Olsen Auth. Manager	Office: (717) 760-2334 Emergency: (717) 760-2333
Villa Assoc.	Box 29 Krissville, PA 19880	14	George Kay	Office: (717) 675-8960 Emergency: (717) 675-8961
Harrison Water Auth.	Box 28 Krissville, PA 19879	16	Justine Keener	Office: (717) 675-9004 Emergency: (717) 675-9005

_____ _____
Igmars Emergency Coor. Date

NOTE: This Downstream Notification List when annually updated should be dated for the year updated and signed by the storage tank facility's emergency coordinator.

ADDENDUM

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

SUPPLEMENTAL GUIDANCE FOR THE DEVELOPMENT AND IMPLEMENTATION OF PREPAREDNESS, PREVENTION AND CONTINGENCY (PPC) PLANS UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) STORM WATER PERMITTING PROGRAM

September 2001

BUREAU OF WATER STANDARDS AND FACILITY REGULATION
DIVISION OF PLANNING AND PERMITS

FORWARD

The "Supplemental Guidance for the Development and Implementation of Preparedness, Prevention and Contingency (PPC) Plans under the National Pollutant Discharge Elimination System (NPDES) Storm Water Permitting Program" has been prepared to provide those owners, operators, and municipalities who must prepare Preparedness, Prevention and Contingency (PPC) Plans (in accordance with the General Permit for Discharges of Storm Water from Industrial Activities and the Department's Chapter 91 regulations) with guidance on what storm water issues must be addressed. This supplemental guidance, when used with the existing guidance entitled "Guidelines for the Development and Implementation of Environmental Emergency Response Plans", hereafter called the PPC guidance or guidelines, will provide complete information on incorporating the new storm water requirements into existing or new PPC Plans for facilities seeking coverage under the general permit to discharge storm water associated with industrial activity.

Section 1 provides an introduction to the regulatory requirements for storm water discharges, the General Permit for Discharges of Storm Water From Industrial Activities and the special condition within the permit to develop and implement a Preparedness, Prevention and Contingency Plan.

Section 2 follows the format of the original guidelines. Where changes must be incorporated to address the new storm water requirements, the necessary modifications or addendums are explicitly presented.

It is emphasized that the original guidance pertains to emergency response plans that include potential releases, their controls, and management practices that are applicable to facilities regardless of whether they discharge storm water associated with industrial activity. The supplemental guidance's requirements, on the other hand, have specific requirements that focus exclusively on managing storm water discharges associated with industrial activity.

SECTION 1

INTRODUCTION

The Department of Environmental Protection is authorized by law to protect the quality of both surface and underground waters of the Commonwealth through the prevention and abatement of water pollution. Specifically, the federal Clean Water Act and the Pennsylvania Clean Streams Law require that all point source discharges of pollutants be authorized and regulated under a National Pollutant Discharge Elimination System (NPDES) permit. Point source discharges that are not regulated under a NPDES permit are in violation of the federal Clean Water Act and the Pennsylvania Clean Streams Law, and may be subject to applicable penalties and fines.

Recent revisions to the federal NPDES regulations (55 FR 47990; November 16, 1990) require that permit applications be submitted and NPDES permits be issued for storm water discharges associated with industrial activity (see the Bureau of Water Quality Management's "Notice of Intent Requirements for Coverage Under the General Permit for Discharges of Storm Water From Industrial Activities" for definition of industries covered). In accordance with the Department's regulations at 25 Pa. §§92.81 - 92.83, the Department of Environmental Protection has developed and issued a general NPDES permit that sets forth the requirements and conditions to control storm water discharges from industrial activities.

Special Permit Condition for the Development and Implementation of a PPC Plan

The General Permit for Discharges of Storm Water from Industrial Activities requires operators of facilities covered under the permit to develop and implement a Preparedness, Prevention and Contingency (PPC) Plan in accordance with 25 Pa. Code §91.34 and the PPC guidelines contained in this document prior to authorization to discharge under this general permit.[1] The PPC Plan, once implemented, will provide best management practices (BMPs) to control the discharges of pollutants to receiving waters. In general, the PPC Plan is required to identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges associated with industrial activity from the facility. In addition, the PPC Plan is required to describe the implementation of practices that are to be used to reduce the pollutants in storm water discharges associated with industrial activity at the facility.

This supplemental guidance provides the additional elements and requirements needed to address storm water issues in the PPC Plan required under the general permit. When used in conjunction with this document, the terms and conditions of the permit should be satisfied and the appropriate "spill prevention control" and "storm water control" - requirements should be addressed.

[1] See Part C.3.a. of the General permit.

SECTION 2

MODIFICATIONS TO EXISTING ELEMENTS AND FORMAT OF THE PPC PLAN

Modify or add to Section II of the PPC guidance, the elements beginning with A (Description of Facility). Each modification or addendum is identified explicitly in the following pages using the format contained in this document. In cases where no modifications to the original guidelines are necessary, the element heading is presented and the user is referred to the requirements in the PPC guidance. Again, users or developers of PPC Plans that meet the requirements of a general permit to discharge storm water associated with industrial activity must fulfill all of the requirements of the PPC guidance and the additional requirements and addendums of this supplemental guidance.

A. Description of Facility

1. Description of the Industrial or Commercial Activity

Add the following to the requirements in the original guidance for this section.

- Provide a narrative description of significant materials[2] that have been treated, stored or disposed in a manner to allow exposure to storm water within the three years prior to the issuance of the general permit and the present; the method of on-site storage or disposal; materials management practices that were employed to minimize contact of these materials with storm water runoff between the time of three years prior to the date of the issuance of this permit and the present; materials loading and access areas; the location and a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of any treatment the storm water receives.
- On the 7 1/2-minute USGS map show the following:
  - -- Provide an outline of the drainage area for each storm water outfall.
- On the drawings required in the original guidance show the following:
  - -- Indicate existing structural control measures to reduce pollutants in storm water runoff.
  - -- Identify commercial and industrial activities that are exposed to precipitation to include fueling stations, vehicle and equipment maintenance and/or cleaning areas, loading/unloading areas, locations used for treatment, storage or disposal of wastes, liquid storage tanks, and processing areas.

2. Description of Existing Emergency Response Plans

Refer to the requirements in the original guidance.

3. Material and Waste Inventory

Refer to the requirements in the original guidance.

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[2] Significant materials includes, but is not limited to: raw materials; fuels, materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to EPCRA Section 313; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

4. Pollution Incident History

Add the following to the requirements in the original guidance for this section.

- Provide a list of significant leaks and spills[3] of toxic and hazardous pollutants that occurred in areas that are exposed to precipitation or that otherwise drain to a storm water conveyance at the facility after the date of three years prior to the effective date of the permit. This list shall be updated as appropriate during the permit.

5. Implementation for Plan Elements Not Currently in Place

Refer to the requirements in the original guidance.

B. Description of How Plan is Implemented by Organization

1. Organizational Structure of Facility for Implementation

Refer to the requirements in the original guidance.

2. List of Emergency Coordinators

Refer to the requirements in the original guidance.

3. Duties and Responsibilities of the Coordinator

Refer to the requirements in the original guidance.

4. Chain of Command

Refer to the requirements in the original guidance.

C. Spill Leak Prevention and Response

1. Pre-release Planning

Add the following to the requirements in the PPC guidance for this section.

- Assess the potential of various sources at the plant to contribute pollutants to storm water discharges. Each of the following shall be evaluated for the reasonable potential for contributing pollutants to runoff: loading and unloading operations; outdoor storage activities; outdoor manufacturing or processing activities; significant dust or particulate generating processes; and on-site waste disposal practices. Consider the toxicity of chemicals; quantity of chemicals used, produced, or discharged; the likelihood of contact with storm water; and history of significant leaks or spills of toxic or hazardous pollutants. The description shall specifically list any significant potential source of pollutants at the site and for each potential source, any pollutant or pollutant parameter of concern (e.g., biochemical oxygen demand).
- Describe pollution incident prevention practices in storage areas used for the storage of salts for deicing or other commercial or industrial purposes. Storage piles of salt used for deicing or other commercial or industrial purposes and which generate a storm water discharge associated with industrial activity which is discharged to a waters of the United States

[3] Significant spills includes, but is not limited to: releases of oil and hazardous substances in excess of reportable quantities under Section 311 of the Clean Water Act (see 40 CFR 110.10 and CFR 117.21) or section 102 of CERCLA (see 40 CFR 302.4).

shall be enclosed or covered to prevent exposure to precipitation, except for exposure resulting from adding or removing materials from the pile. Dischargers shall demonstrate compliance with this provision as expeditiously as practicable, but in no event later than October 1, 1995. Piles do not need to be enclosed or covered where storm water from the pile is not discharged to waters of the United States.

2. Material Compatibility

Refer to the requirements in the PPC guidance.

3. Inspection and Monitoring Program

Add the following to the requirements in the PPC guidance for this section.

- Identify qualified personnel to conduct site compliance evaluations for storm water discharges associated with industrial activities, but in no case, less than once per year. Such evaluations will provide the following:

  Visually inspect areas contributing to storm water discharges associated with industrial activity for evidence of, or the potential for, pollutants entering the drainage system. Measures to reduce pollutant loadings should be evaluated to determine whether additional control measures are needed. Structural storm water management measures, sediment and erosion control measures, and other structural pollution prevention measures identified in the plan should be observed to ensure that they are operating correctly. A visual inspection of equipment needed to implement the plan, such as spill response equipment, should be made.

  Based on the results of these inspections, potential pollutant sources identified (Section C) and control measures (i.e., good housekeeping, preventive maintenance, spill prevention and response), should be revised as necessary within 15 days of the inspection. The revision will provide for the implementation of any changes to the PPC plan in a timely manner, but in no case later than 90 days after the inspection.

  A report summarizing the scope of the inspection, personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the PPC plan, and any actions taken as a result, should be retained for a period of at least one year after coverage under this permit terminates. This report will identify any incidents of non-compliance. Where a report does not identify any incidents of non-compliance, the report should contain a certification that the facility is in compliance with the PPC plan and the permit. This report shall be signed in accordance to the signatory requirements stipulated in the general permit.

  Where annual site inspections are shown in the plan to be impractical for inactive mining sites due to the remote location and inaccessibility of the site, site inspections required under this part should be conducted at appropriate intervals specified in the plan, but, in no case less than once in three years.

4. Preventive Maintenance

Add the following to the requirements in the PPC guidance for this section.

- Describe the aspects of the preventive maintenance program. This program should involve the timely inspection and maintenance of storm water management devices (e.g., cleaning oil/water separators, catch basins, etc.) as well as inspecting and testing plant equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants to surface waters. Records of these maintenance procedures should be maintained.

5. Housekeeping Program

Add the following to the requirements in the PPC guidance for this section.

- Establish housekeeping protocols to ensure the proper handling of materials and the maintenance of a clean, orderly facility to prevent pollutants from entering separate storm water sewers and/or to prevent contact with storm water runoff.

6. Security

Refer to the requirements in the PPC guidance.

7. External Factor Planning

Refer to the requirements in the PPC guidance.

8. Employee Training Program

Add the following to the requirements in the PPC guidance for this section.

- Employee training should inform personnel responsible for implementing activities identified in the storm water pollution prevention plan or otherwise responsible for storm water management at all levels of responsibility of the components and goals of the storm water pollution prevention plan. Training should address topics such as spill response, good housekeeping and material management practices. A pollution prevention plan shall identify periodic dates for such training.

D. Countermeasures

1. Countermeasures to be Undertaken by Facility

Refer to the requirements in the PPC guidance.

2. Countermeasures to be Undertaken by Contractors

Refer to the requirements in the PPC guidance.

3. Internal and External Communications and Alarm Systems

Refer to the requirements in the PPC guidance.

4. Evacuation Plan for Installation Personnel

Refer to the requirements in the PPC guidance.

5. Emergency Equipment Available for Response

Refer to the requirements in the PPC guidance.

E. Emergency Spill Control Network

1. Arrangements with Local Emergency Response Agencies and Hospitals

Refer to the requirements in the PPC guidance.

2. Notification Lists

Refer to the requirements in the PPC guidance.

3. Downstream Notification Requirements for Storage Tanks

Refer to the requirements in the PPC guidance.

THE ELEMENTS F THROUGH J ARE <u>ADDENDUMS</u> TO THE ORIGINAL GUIDANCE.

The PPC plan should also meet the requirements stipulated in these addendums to the PPC guidance. All of the management practices required for facilities (including EPCRA Section 313 facilities) are to be implemented and described in the plan.

F. Storm Water Management Practices

- Provide a narrative considering the appropriateness of traditional storm water management practices (practices other than source control) and the use of BMPs to control storm water runoff and prevent storm water pollution. Based on an assessment of the potential of various sources at the plant to contribute pollutants to storm water, provide that measures determined to be reasonable and appropriate, be implemented and maintained.

  Traditional storm water management practices are measures which reduce pollutant discharges by reducing the volume of storm water discharges, such as swales, or preventing storm water to run-on to areas of the site which conduct industrial activities. Low cost measures may include diverting rooftop or other drainage across grass swales, cleaning catch basins, and installing and maintaining oil and grit separators. Other measures may include infiltration devices and unlined retention and detention basins. Traditional storm water management practices can also include water reuse activities and snow removal activities.

- The PPC plan shall include a certification that the discharge has been tested or evaluated for the presence of non-storm water discharges. The certification shall include the identification of potential significant source of non-storm water at the site. A description of the results of any test and/or evaluation for the presence of non-storm water discharges, the evaluation criteria or testing method used, the date of any testing and/or evaluation, and the on-site drainage points that were directly observed during the test.

G. Sediment and Erosion Prevention

- In the PPC plan, identify areas which, due to topography, activities, or other factors, have a high potential for significant soil erosion, and identify measures to limit erosion.

  Sediment and erosion prevention and control measures should be developed and implemented in accordance with Chapter 102 of the Department's rules and regulations and the Bureau of Soil and Water Conservation's "Erosion and Sediment Pollution Control Program Manual."

H. Additional Requirements for EPCRA, Section 313 Facilities[4]

- Describe the types of storm water controls (containment, drainage control and/or diversionary structures) that will be used in areas where Section 313 water priority chemicals are stored,[5] processed or otherwise handled.

  Storm water controls should provide for the following preventive systems or its equivalent: Curbing, culverting, gutters, sewers or other forms or drainage control to prevent or minimize the potential for storm water run-on to come into contact with significant sources of pollutants; or roofs, covers or other forms of appropriate protection to prevent storage piles from exposure to storm water and wind blowing.

- In addition to the minimum standards for EPCRA Section 313 facilities, the storm water pollution prevention plan will meet the following requirements for liquid storage areas, material storage areas other than liquids, truck and rail car loading and unloading areas for liquid Section 313 water priority chemicals:

  -- Liquid storage areas where storm water comes into contact with any equipment, tank container, or other vessel used for Section 313 water priority chemicals.

- No tank or container shall be used for the storage of a Section 313 water priority chemical unless its material and construction are compatible with the material stored and conditions of storage such as pressure and temperature, etc.

- Secondary containment must be provided to contain the entire capacity of largest single container or tank plus sufficient freeboard to allow for precipitation, a strong spill contingency and integrity testing plan, and/or other equivalent measures. If the secondary containment and its upstream drainage system are subject to precipitation, an allowance for drainage for a 25-year, 24-hour storm event shall be provided over and above. Secondary containment shall be sufficiently impervious. Plant's treatment system may be substituted for secondary containment if it has sufficient excess holding capacity always available.

  -- Material storage areas for Section 313 water priority chemicals other than liquids.

- Material storage areas for Section 313 water priority chemicals other than liquids which are subject to runoff, leaching, or wind shall incorporate drainage or other control features which will minimize the discharge of Section 313 water priority chemicals.

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[4] An "EPCRA, Section 313 Facility" means a facility that manufactures, imports, processes, or otherwise uses listed toxic chemicals and who, pursuant to Section 313 of Title III of SARA, are required to report annually their releases of those chemicals to any environmental media.

[5] Section 313 water priority chemical means a chemical or chemical categories which: 1) Are listed at 40 CFR 372.65 pursuant to Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) (also known as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986; 2) are present at or above threshold levels at a facility subject to EPCRA Section 313 reporting requirements; and 3) that meet at least one of the following criteria: (i) Are listed in Appendix D of 40 CFR 122 on either Table II (organic priority pollutants), Table III (certain metals, cyanides, and phenols) or Table V (certain toxic pollutants and hazardous substances); (ii) are listed as a hazardous substance pursuant to Section 311(b)(2)(A) of the CWA at 40 CFR 116.4; or (iii) are pollutants for which EPA has published acute or chronic water quality criteria.

-- Truck and rail car loading and unloading areas for liquid Section 313 water priority chemicals.

- These areas shall be operated to minimize discharges of Section 313 water priority chemicals. Protection such as overhangs or door skirts to enclose trailer ends at truck loading/unloading docks shall be provided as appropriate. Appropriate measures to minimize discharges of Section 313 chemicals may include: placement and maintenance of drip pans (including the proper disposal of materials collected in the drip pans where spillage may occur such as hose connections); a strong spill contingency and integrity testing plan; and/or other equivalent measures.

  -- Areas where Section 313 water priority chemicals are transferred, processed or otherwise handled.

- Processing equipment and materials handling equipment shall be operated so as to minimize the discharges of Section 313 water priority chemicals. Materials used in piping and equipment shall be compatible with the substances handled. Drainage from process and materials handling areas shall minimize storm water contact with Section 313 water priority chemicals. Additional protection such as covers or guards to prevent exposure to wind, spraying, or releases from pressure relief vents from causing a discharge of Section 313 water priority chemicals to the drainage system shall be provided as appropriate. Visual inspections or leak tests shall be provided for overhead piping conveying Section 313 water priority chemicals without secondary containment.

  -- For drainage originating from the above described areas, valves or other positive means should be used to prevent discharges or excessive leaks of Section 313 water priority chemicals. Where containment units are employed, such units may be emptied by pumps or ejectors; however, these shall be manually activated.

  Flapper-type drain valves must not be used to drain containment areas. Valves used for the drainage of containment areas should not be used to drain non-containment areas. Valves used should be of the open-and-closed design.

  If plant drainage is not engineered as above, the final discharge of all in-plant storm sewers should be equipped to be equivalent with a diversion system that could, in the event of an uncontrolled spill of a Section 313 water priority chemical, return the spilled material to the facility. Records shall be kept of the frequency and estimated volume (in gallons) of discharges from the containment areas.

  -- Records shall be kept of the frequency and estimated volume (in gallons) of discharges from containment areas.

  -- Other areas (other than those described above) of the facility from which runoff which may contain a Section 313 water priority chemical, or spills of Section 313 water priority chemicals could cause a discharge, shall incorporate the necessary drainage or other control features to prevent discharge of spilled or improperly disposed material and ensure the mitigation of pollutants in runoff or leachate.

-- All areas of the facility shall be inspected at specific intervals for leaks or conditions that could lead to discharges of Section 313 water priority chemicals or direct contact of storm water with raw materials, intermediate materials, waste materials or products. In particular, plant piping, pumps storage tanks and bins, pressure vessels, process and materials handling equipment, and material bulk storage area shall be examined for any conditions or failures which could cause a discharge. Inspection shall include examination for leaks, wind blowing, corrosion, support or foundation failure, or other forms of deterioration or noncontainment. Inspection intervals shall be specified in the plan and shall be based on design and operational experience. Different areas may require different inspection intervals. Where a leak or other condition is discovered which may result in significant releases of Section 313 water priority chemicals to the drainage system, corrective action shall be taken. When a leak or noncontainment of a Section 313 water priority chemical has occurred, contaminated soil, debris, or other material must be promptly removed and disposed in accordance with this PPC Plan.

-- Facility employees and contractor personnel using the facility shall be trained in and informed of preventive measures at the facility. Employee training shall be conducted at intervals specified in the plan, but not less than once per year, in matters of pollution control laws, and regulations and in the PPC Plan, and the particular features of the facility and its operation which are designed to minimize discharges of Section 313 water priority chemicals. The plan should designate a person who is accountable for spill prevention at the facility and who will set up the necessary spill emergency procedures and reporting requirements so that spills and emergency releases of Section 313 water priority chemicals can be isolated and contained before a discharge of a Section 313 water priority chemical can occur. Contractor or temporary personnel shall be informed of plant operation and design features in order to prevent discharges or spills from occurring.

If the installment of secondary containment structures or equipment listed above are not economically achievable at a facility, the PPC Plan should provide a spill contingency and integrity testing plan which provides a description of measures that ensure spills or other releases of toxic amounts of Section 313 water priority chemicals do not occur. The testing plan should contain the following:

-- Detailed descriptions which demonstrate that secondary containment is not economically achievable;

-- Description of response plans, personnel needs, and methods of mechanical containment such as the use or sorbents, booms collection devices, etc.); steps to be taken for removal of spilled Section 313 water priority chemicals; and access and availability of sorbents and other equipment;

-- The testing component of the alternative plan must provide for conducting integrity testing of storage tanks at least once every five years, and

conducting integrity and leak testing of valves and piping a minimum every year; and

-- A written and actual commitment of manpower, equipment and materials required to comply with this permit and to expeditiously control and remove quantity of Section 313 water priority chemicals that may result in a toxic discharge.

- Provide a certification by a Registered Professional Engineer. The Professional Engineer shall certify that he or she has examined the facility and is familiar with the provisions in the PPC Plan and can attest that the PPC Plan has been prepared in accordance with good engineering practices. The Professional Engineer must recertify the PPC Plan once a year.

I. Certification Requirements for Non-Storm Water Discharges

- Provide a certification meeting the requirements of Part C, Section 3(a) of the industrial activities stormwater general permit (PAG #3) relating to the presence of non-stormwater discharges in the system.

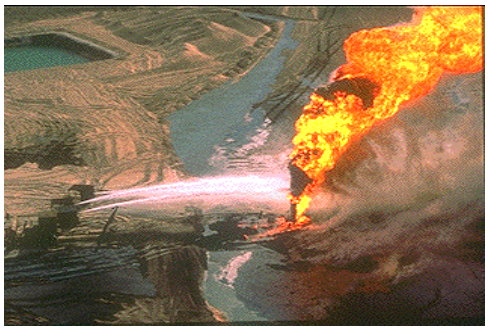
  If a facility does not have access to an outfall, manhole, or other point of access to the ultimate conduit which receives the discharge, this section of the plan shall indicate why the certification was not feasible. A discharge that is unable to provide the certification required by this paragraph must also then notify the Department within 180 days of the effective date of the general permit in accordance with Section A.3. of the permit.

J. Signatory Requirements

The PPC plan must be signed in accordance with the signatory requirements stipulated in the general permit.

John Wright Co.

Part 9-Firefighting. The mechanics of oil/gas fires, meltdown and secondary damage, water/chemical/explosive extinguishing methods and considerations for voluntary ignition



Coots Matthews, Consultant, Boots & Coots L.P.,
L. Flak, former Wright, Boots & Coots, employee.

This article deals with the highly visible and potentially dangerous operations of extinguishing and capping burning blowouts. To understand the nature of oil and gas fires in blowout conditions, basic mechanics and terms are explained, and important features of meltdown and radiant heat exposure limits are discussed. Methods of extinguishing fire with water, chemicals and explosives are described, and examples of cap ping a well while it is burning are given. Finally, reasons for voluntarily igniting a blowout in high risk wells are presented.

INTRODUCTION

Surprisingly few surface blowouts ever ignite. Except in Kuwait, in 1991, less than 10 blow outs per year ever catch on fire, world wide. Typically, large formation water flows lifted by the hydrocarbon flow make ignition difficult if not impossible. Water cones into the blowout zone, drawn in by low flowing bottomhole pressure; or adjacent wet zones are exposed to the flow path.

Highly flammable blowouts may never ignite if no ignition source is present and flow is quickly dispersed. Thus, knowledgeable and experienced blowout specialists always restrict blowout access and carefully inspect the area around blowouts for ignition sources, particularly areas within an explosive vapor cloud. Failure to do this on a recent inland barge blowout in South Louisiana resulted in two deaths and other severe injuries.(1) "Victory awaits those who have everything in order-people call that luck. Defeat awaits those who don't- this they call bad luck." Roald Amundsen (leader of the first expedition to reach the South Pole)(2)

OIL AND GAS FIRE MECHANICS

Knowledge that hydrocarbons are highly flammable is common to our industry. Less well known are the explosive characteristics of hydrocarbon vapor-air mixtures and the dramatic impact of ignition of these mixtures on surrounding structures and personnel. To understand this risk, some ignition terms must be understood.

Flashpoint is the lowest temperature at which a material gives off enough flammable vapor to produce a momentary flash when exposed to a small flame. The flash point of gasoline is -43 deg. C (-45 deg. F), which is the reason it is considered highly flammable.

Spontaneous ignition temperature is the minimum temperature at which a material spontaneously ignites. Methane has a relatively high spontaneous ignition temperature of 537 deg. C (999 deg. F). This makes re-ignition of a methane fuel fire after extinguishment difficult. In practice, low-flash-point, low-spontaneous-ignition-temperature gas condensate blowouts present the greatest blowout ignition hazard.

Explosive limit of differing blowout flows varies with chemical composition. There is a minimum ratio of hydrocarbon vapor to air, below which ignition will not occur. Alternately, there is also a maximum ratio of hydrocarbon vapor to air, at which ignition will not occur. These limits are termed the lower and upper explosive limits. For gasoline vapor, the explosive range is from 1.3 to 6.0% vapor to air. For methane, this range is 5 to 15%. "Crude oil is a highly volatile, explosive cocktail which is lighter than water and burns twice as hot as coal. " (3) Vapor cloud explosion is possible through the following sequence:

- Hydrocarbons are released near wellhead
- Some gas liquids flash evaporate, forming an aerosol of liquid droplets and vapor
- Heavier hydrocarbon liquids that do not flash evaporate pool around well and release vapors
- Vapors mix with air and form a combustible vapor cloud
- An ignition source is exposed within this explosive mixture
- Combustion starts and a flame front propagates through the flammable zone.

Research has shown that speed of the flame front movement is directly proportional to the amount of blast over-pressure. High flame front speeds and resulting high blast over pressures are seen in situations where there is a significant amount of confinement and congestion that limits flame front expansion and increases flame turbulence.

Most vapor cloud explosions are deflagrations, not detonations. Flame speed of a deflagration is subsonic, with flame speed increasing in restricted areas and decreasing in open areas. Significantly, a detonation is supersonic, and will proceed through almost all of the available flammable vapor at the detonation reaction rate. This creates far more severe peak over-pressures and much higher amounts of blast energy (4).

Offshore rigs, production platforms and inland barges are at greatest risk. Hard-welded quarters and other enclosed areas are at particular risk as it is possible to get detonation in these confined areas.

MELTDOWN

The pressure-feed fire of a blowout will totally destroy the surrounding steel structure in minutes. Derricks have fallen-in less than 30 minutes after blowout ignition. The core temperature of a low-GOR 28 deg. F API crude oil blowout in Kuwait was measured at 1,677 deg. C (3,051 deg. F). And a radiant heat temperature of 510 deg. C (950 deg. F) was measured at ground level, 15 m (49 ft) from the base of this large vertical fire, which was estimated at 30,000 bopd. Oil well firefighters commonly see surrounding sand and stones melted and fused on large fires. Steel loses most of its strength at 500 deg. C (932 deg. F) and melts at 1,500 deg. C (2,732 deg. F).

Radiant heat. Common radiant heat exposure limits are:

- 0.5 KW/m2: Maximum working level for unprotected personnel
- 10.0 KW/m2: Maximum working level with protective equipment
- 15.0 KW/m2: Maximum working level for equipment.

On a very large Kuwait fire (about 30,000 bopd) the following heat radiations were recorded (upwind): 1.5 KW/m2 at 200 m (656 ft); 10.0 KW/m2 at 75 m (246 ft); and 15 KW/m2 at 35 m (115 ft). To understand the significance of these radiation levels, aluminized reflective fire entry suits are generally rated to only about the 15 KW/m2 radiation level. Oil well fire fighters commonly work inside the 15 KW/m2 level using Nomex long johns and hoods, heavy socks, insulated boots and heavy cotton outer wear, under a continuous water spray.

In Kuwait, maximum recording heat strips measured temperatures as high as 230¡C (446¡F) on the hard hats of firefighters. The one reason that they continue to use heavy aluminum hard hats is that common plastic oil field hard hats melt.

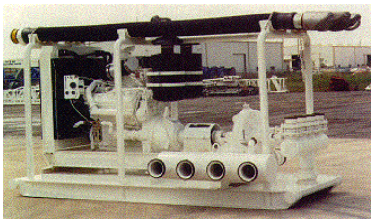


Fig. 23. Air-transportable fire pumps stocked by oil well firefighters.

Sufficient water application to a blowout greatly reduces heat impact on surrounding structures, Fig. 22. Radiant heat is effectively eliminated as a problem when sufficient water is pumped into the fire. Work in high heat radiation areas is obviously dangerous and should only be attempted by experienced oil well firefighters.

Secondary damage. Flammable fluid storage and gas handling systems can start a fire that leads to well blowouts, e.g., Piper Alpha. At Piper Alpha, it was established that the night shift had attempted to restart a pump, unaware that a key pressure safety valve had been removed during maintenance. The low-lying cloud of condensate resulting from the leak ignited and caused an initial explosion followed by a large crude oil fire.5 In the resulting disaster, 167 men lost their lives, but the relatively small blowouts from fire-damaged well heads had nothing to do with their deaths. Fires from improperly handled production streams and stored flammable liquid can be a greater fire risk and cause more damage than a blowout.

Emergency response plans must address how stored flammable fluids on an offshore platform are displaced with water and de-pressurized if a fire or well blowout occurs.

Fig. 25. Large land rig immediately after operator voluntarily ignited the gas well blowout due to H2S safety concerns.

EXTINGUISHMENT METHODS

Several methods are available to extinguish a blowout fire. Summarized here are the use of water, chemicals, explosives and an example of capping a well while it is burning.

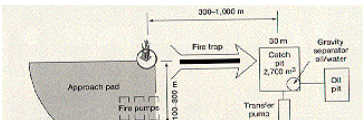


Fig. 24. Major rig fire water system designed for Kuwait Oil Co.

Water. The most important method to limit fire damage to structures from a blowout fire is application of water. The common use of sprinkler heads and deluge nozzles in modern offshore production platforms has greatly reduced the risk of a Piper Alpha type tragedy. Yet, in land rig operations and older offshore moveable rigs and platforms, there is little or no water protection integral to the operation. Without modern fire water systems, blowout ignition is more likely, with probable total loss of rig or platform.

Water alone has extinguished some of the largest blowout fires experienced by our industry, once flow was directed vertically by firefighters. Water works to extinguish blowout fires by various means:

- It cools fire below spontaneous ignition temperature by absorbing heat as it is flashed to steam
- Water flashed to steam displaces oxygen and smothers fire
- Powerful water streams displace fuel from fire.

Main water use in blowout fire fighting is not to extinguish the fire, but to allow men and equipment to work near the fire. Early firefighters' efforts on burning blowouts involve removal of debris and working to get the fire burning vertically. Wells capped while burning may require more water than conventional extinguish-and-cap efforts.

Offshore marine vessels commonly have substantial firefighting capabilities, i.e., 10,000 gpm, with monitors mounted high on the vessel to allow water to reach even large plat forms. Fire pumps in inventory with oil well firefighters are smaller, air transportable systems, Fig. 23. These pumps provide 4,000 gpm at 250-psi head. Two of these pumps are used on a typical large fire on a land or inland barge rig. Oil well firefighters also inventory piping systems for these pumps that contain 4-in. aluminum water delivery pipe, fire monitors and associated equipment. One U pipe rack" is used typically with two pumps on a large onshore fire.

Modern derrick barges, MSVs, pipeline lay barges and large hydraulic dredge barges have been used offshore to support firefighting efforts. On land, common mobile fire pumps in use with civilian fire departments have been used on small fires. These truck-mounted pumps can provide 1,500 to 3,000 gpm, but require greater care and may present associated problems in coordinating with civilian firefighters.

Onshore water requirements depend greatly on the nature of the fire, but most blowouts would be adequately handled with the system out lined in Fig. 24. This system is similar to that used for all firefighters in Kuwait in 1991, and was designed by the authors for Kuwait Oil Co. in December 1990, prior to any Kuwaiti blowout. Note use of the fire trap between run-off and re-circulation pits to allow safe recovery of produced oil, and fire water recycling.

Produced water can be added to Fire water systems to reduce external water supply needs. Multiple water wells can be used with trucked-in water if no near-surface water supply is available.

Firefighters inventory high volume, low-head transfer pumps if water must be moved some distance from the f'ire. A water supply of about 9 bpm is adequate for most fires, given sufficient surface storage, 24-hr delivery and recycling.

On critical wells near populated areas or other facilities, or in remote areas, emergency response plans should consider sourcing the water supply and whether a deluge system should he incorporated in drilling plans.

Chemicals. Foam and dry chemicals have been used in limited roles in oil well firefighting. Foam consists of water, foam concentrate and air. It is used on liquid hydrocarbon fires to smother the fuel surface (excludes oxygen), suppress vapor emissions (explosive vapor release is restricted), generate steam (removes heat and displaces oxygen), cool surface (heat absorption) and reflect radiant heat. Use on blowouts is restricted to gas condensate fires and oil wells where lateral flow has led to a large fire-surface area.

Foam can help contain fire near the source and allow work near the flow source. Generally, water alone is adequate for this, but with large, low velocity, lateral oil flow, foam may be required. Modern firefighting foam such as 3M Lightwater ATC is commonly used with the William's Hydro Foam nozzle. This self-proportioning nozzle, when used with the ATC foam, allows foam to be thrown farther. Nozzles are available to handle up to 6,000 gpm, but the 2,000-bpm nozzle is most used on oil well fires.

Dry chemical extinguishers work like water, but principally act as a smothering agent. Common compounds used are sodium bicarbonate, Purple K (potassium bicarbonate base) and Monnex (highest efficiency rating). Use is generally on methane well fires where explosives cannot be used and water supply is inadequate. The main problem is that these systems are "one shot" devices that can not be topped up or refilled during application. The largest systems commonly available have 68 kg of powder in storage.

In Kuwait, extremely large (1,350 kg) dry chemical extinguishers from Ansul were used with Purple K powder as part of a mobile firefighting system used on smaller fires. Also used for the first time in Kuwait was the new William's Hydro-Chem nozzle that allows one nozzle to be used for water, foam and dry chemical. This would allow 1) using one nozzle to start water cool down, 2) adding foam to knock out the liquid fire, and finally 3) injecting dry chemical to knock down the remaining gas fire. Use in blowout fire fighting will be limited, but this new nozzle has good potential in industrial applications.

Explosives. Commonly available explosives such as 80% nitroglycerin grade dynamite are still used in oil well firefighting. It is believed that M. M. Kinley invented the presently used method, which was employed by experienced firefighters in the 1920s. For the mechanism, slow-speed photography indicates that the explosion acts to temporarily drive fuel away from the point where the flame develops and deprive that immediate area of oxygen to support instant reignition. Depending on fire size and prior experience, up to 500 lb of explosive may be used.

Explosives are used today in con junction with water to cool the shot and prevent reignition, when water supply or pump capability is insufficient to extinguish fire alone. As in any firefighting effort, all ignition sources must be removed from the well area prior to making the shot.

Typically, a smaller lube oil drum is used and packed with explosive. This drum is detonated using detonating cord run through the athey wagon boom. The cord is electrically detonated at the front of the athey wagon, some 60 to 70 ft away from the explosive drum. Heat insulating, silicon based cloth and water spray are used to protect the explosives from the fire. There is little risk of premature explosion as hot spots would only lead to non-detonation, and the explosives would burn up in the fire.

This is, interestingly, the lowest cost fire fighting technique, as the cost of a shot may be less than $2,000. This is exceeded by one recharge of the large Ansul dry chemical extinguisher and just a few drums of ATC foam concentrate. Less-experienced firefighters tend to discount the use of explosive shots only because of their lack of knowledge in the method, not because of any legitimate safety or economic reason.

Killing flow with well on fire. Recently, a blowout in inland waters was capped while burning by Boots & Coots to limit environmental dam age and for added safety. This technique has also been used on an H2S blowout in Canada after Boots & Coots replaced a company that lost two men during conventional capping attempts.6 The basic method involves using conventional capping stacks, as will be described next month, but equipping the capping BOPs with heat shielding and water deluge to limit high temperature exposure. Once the BOPs are over the flow and burning is underway above the riser tube, flow within the capping stack helps protect the BOPs. Wells have been stung, as will be discussed next month, while on fire to kill both flow and fire.

VOLUNTARY IGNITION

H2S hazard has led operators to voluntarily ignite a blowout for safety. Fig. 25 is a spectacular picture of a 30% H2S blowout (>50 MMcfd) taken immediately after ignition by a flare gun. Interestingly, no more than 2 ppm SO2 could ever be detected at ground level in the plume from this fire. Most operators that are planning these types of high-risk wells have plans that leave blowout ignition choice up to the field personnel. Two reasons for considering voluntary ignition are discussed here.

Pollution. This potential problem has not yet-to the authors' knowledge-led an operator to voluntarily ignite a blowout. However, after natural ignition, major efforts have been taken to keep the fire burning to lessen pollution. There is little question that a burning blowout presents less long-term environmental dam age than a well spewing oil unchecked into a marine estuary. And recent experiences have indicated that voluntary ignition of a rig, or particularly an inland barge, may be the less-expensive option, considering the cost of environmental dam age and clean-up.

Operators have spent more money on clean-up than was spent on blowout control. Yet, ignition of an oil well blowout on a major offshore plat form would tremendously complicate control efforts and likely result in total platform loss. A small land rig or inland barge rig represents less capital investment and easier removal of fire damaged debris. Difficult legal and insurance questions must be answered before an operator can determine its policy.

Safety. This consideration is a major concern in the blowout control business. Unexpected vapor cloud ignition resulted in the only deaths (two) and lost time injuries (six) seen by firefighters in Kuwait-all by inexperienced firefighting teams. With the recent deaths of two men in Louisiana and near misses seen over the years, consideration should be given to igniting some blowouts for safety. This is an easier choice if there is H2S present, significant pollution potential, or close proximity to civilian population. Blowout work is safer on burning wells. In many cases, operators and firefighters in hindsight wished that they had opted for voluntary ignition from the start, rather than suffer the consequences of an unexpected ignition.

On critical wells of higher risk, operators should consider whether voluntary ignition should be part of the emergency response plan and, if so, instructions and flare guns should be made available to wellsite personnel. *"We judge ourselves by our policies. Others judge us by our actions" Anon.*

Coming Next

Blowout surface intervention methods. Equipment and methods used to control blowout flow at surface will be reviewed. These include conventional capping with wellhead and BOPs, use of slip rams in capping stacks, tree and BOP replacement, stinging, junk shots, hot tapping, freezing and induced well bridging. Use of snubbing units on diverted blowouts will be discussed.

 Next Article

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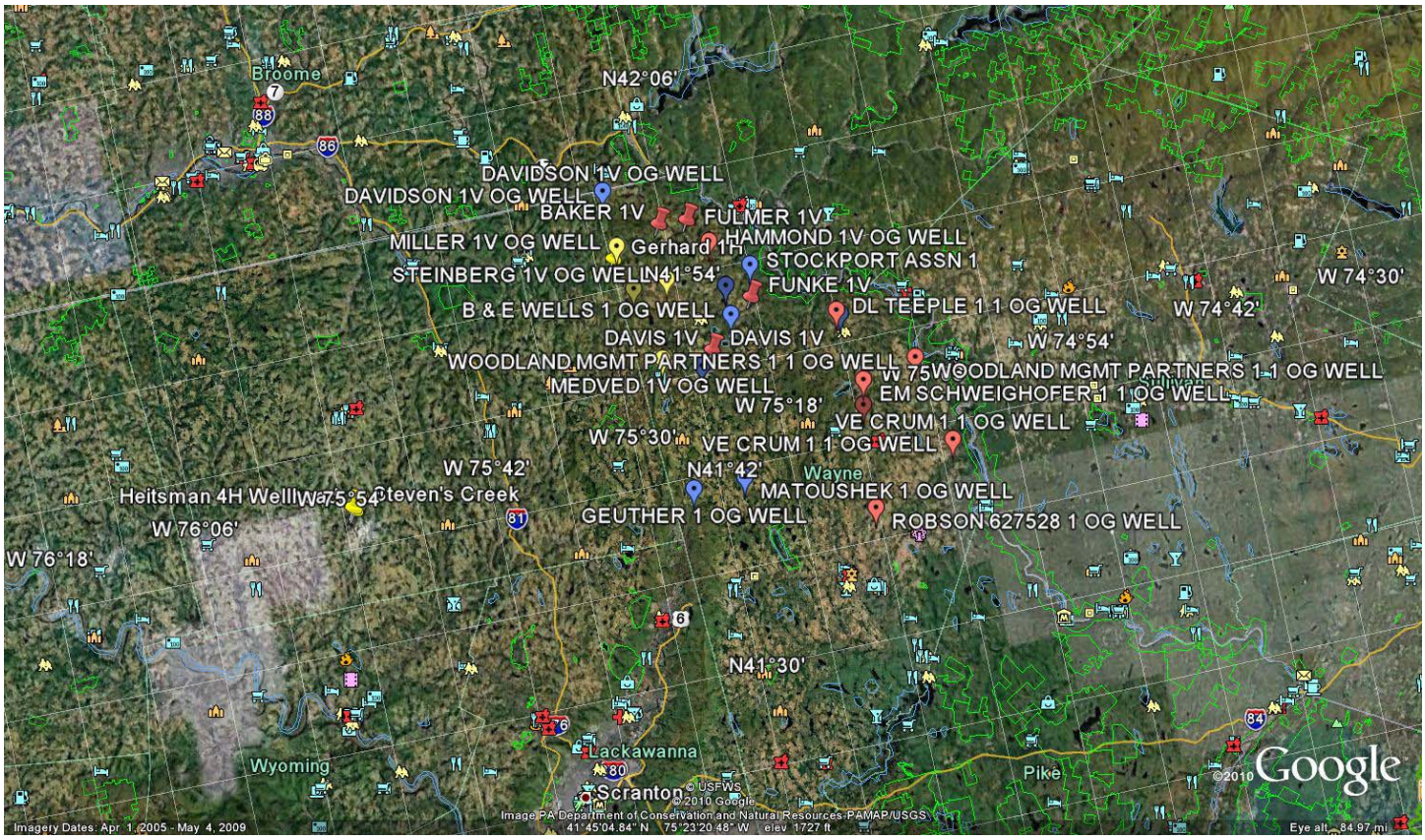
Literature Cited

1. Simoneaux, A, "Authorities monitor exploded well," The Advocate, Lafayette, La. July 12 1994, pp. lB-2B.
2. Amundsen, R., quoted by Griffiths, T., Judgement over the dead, Verso, London, 1986, p. 129.
3. Paterson, T, Offshore f re safety Pennwell. 1993. p. 31.
4. Baker, Q. A., "Use of gas dispersion model results in vapor cloud explosion predictions," presented at the American Institute of Chemical Engineers' 1994 Process Plant Safety Symposium, Feb. 28-Mar. 1994.
5. Lord Cullen, The Hon., 'The public inquiry into the PiperAlpha disaster, 2 Vols., controller of Her Britannic Majesty's Stationery Office, 1990.
6. Gregory, V, "Boots put to Joe-Bob," Dec. 2, 1982, pp. 1-2 and "Killer well under control," Dec. 24, 1982, p. 4, Calgary Sun.

The authors

Coots Matthews is a consultant for Boots & Coots L.P. He began his oil field career with Halliburton in 1947, and later, in 1947, he joined the M. M. Kinley Co., where he worked with Boots Hansen and Red Adair to pioneer the methods used in firefighting and blowout control today. In 1959, he began working at the Red Adair Co.; and in 1978, he co-founded Boots & Coots. He has worked on more than 1,000 blowout control projects in his career which spans five decades.

L. Flak is a former John Wright Company employee.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ANNEX A

Title 25. Environmental Protection

Part I. Department of Environmental Protection

Subpart C. Protection of Natural Resources

Article I. Land Resources

CHAPTER 78. OIL AND GAS WELLS

Subchapter A. GENERAL PROVISIONS

§ 78.1. Definitions.

(a) The words and terms defined in section 103 of the act (58 P. S. § 601.103), section 2 of the Coal and Gas Resource Coordination Act (58 P. S. § 502), section 2 of the Oil and Gas Conservation Law (58 P. S. § 402), section 103 of the Solid Waste Management Act (35 P. S. § 6018.103) and section 1 of The Clean Stream Law (35 P. S. § 691.1), have the meanings set forth in those statutes when the terms are used in this chapter.

(b) The following words and terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise:

* * * * *

Casing seat—The depth to which [**~~the surface casing or coal protection~~**] casing **[is run] [~~or intermediate casing~~] is set.** [~~In wells without surface casing, the~~ **~~surface~~** ~~casing seat shall be~~ **~~considered to be~~** ~~equal to~~ **~~50 feet below the deepest fresh groundwater~~ ~~[the depth of casing which is normal for wells in the area]~~**.

* * * * *

Cement—A mixture of materials for bonding or sealing that attains a 7-day maximum permeability of 0.01 millidarcies and a 24-hour compressive strength of at least 500 psi in accordance with applicable **[API]** standards and specifications.

***Cement job log* – a written record that documents the actual procedures and specifications of the cementing operation. [~~The record must include the type of cement with additives, the volume, yield and density in pounds per gallon of the cement and the amount of cement returned to the surface, if any. Cementing procedural information must include a description of the pumping rates in bbls per minute, pressures in psi, time in minutes and sequence of events during the cementing operation.~~]**

* * * * *

Conductor pipe **– a short string of large-diameter casing used to stabilize the top of the wellbore in shallow unconsolidated formations.**

* * * * *

Intermediate casing **– a string of casing SET AFTER THE SURFACE CASING AND BEFORE [~~other than~~] production casing, NOT TO INCLUDE COAL PROTECTION CASING, that is used in the wellbore to isolate, stabilize or provide well control. [~~to a greater depth than that provided by the surface casing or coal protection casing.~~]**

* * * * *

L.E.L.— LOWER EXPLOSIVE LIMIT

* * * * *

[*Retrievable*—When used in conjunction with surface casing, coal protective casing or production casing, the casing that can be removed after exerting a prudent effort to pull the casing while applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% of the casing weight, whichever is greater.]

* * * * *

Surface Casing—**[A string of pipe which extends from the surface and that segregates and protects fresh groundwater and stabilizes the hole.][~~ Casing~~] A STRING OR STRINGS OF CASING used to isolate the wellbore from fresh groundwater and to prevent the escape or migration of gas, oil [~~and~~] OR other fluids from the wellbore into fresh groundwater. The surface casing is also commonly referred to as the water string or water casing.**

* * * * *

UNCONVENTIONAL FORMATIONS – FORMATIONS THAT TYPICALLY PRODUCE GAS THROUGH THE USE OF ENHANCED DRILLING OR COMPLETION TECHNOLOGIES SUCH AS THE RHINESTREET, BURKET, MARCELLUS, MANDATA AND UTICA SHALE FORMATIONS, OR OTHER FORMATIONS IDENTIFIED BY THE DEPARTMENT.

Subchapter C. ENVIRONMENTAL PROTECTION

PERFORMANCE STANDARDS

§ 78.51. Protection of water supplies.

(a) A well operator who affects a public or private water supply by pollution or diminution shall restore or replace the affected supply with an alternate source of water adequate in quantity and quality for the purposes served by the supply **as determined by the Department**.

* * * * *

(d) **[The operator shall affirmatively demonstrate to the Department's satisfaction that the quality of the restored or replaced water supply to be used for human consumption is at least equal to the quality of the water supply before it was affected by the operator. If the quality of the water supply before it was affected by the operator cannot be affirmatively established, the operator shall demonstrate that the concentrations of substances in the restored or replaced water supply do not exceed the primary and secondary maximum contaminant levels established under § 109.202 (relating to State MCLs and treatment technique requirements).] A restored or replaced water supply shall include any well, spring, public water system or other WATER supply approved by the Department, which meets the criteria for adequacy as follows:**

(1) *Reliability, cost, maintenance and control.* A restored or replaced water supply, at a minimum, must:

(i) Be as reliable as the previous water supply.

(ii) Be as permanent as the previous water supply.

(iii) Not require excessive maintenance.

(iv) Provide the [~~owner and the~~] WATER user with as much control and accessibility as exercised over the previous water supply.

(v) Not result in increased costs to operate and maintain. If the operating and maintenance costs of the restored or replaced water supply are increased, the operator shall provide for permanent payment of the increased operating and maintenance costs of the restored or replaced water supply.

(2) *Quality.* The quality of a restored or replaced water supply will be deemed adequate if it meets the standards established pursuant to the Pennsylvania Safe Drinking Water Act (35 P. S. § § 721.1—721.17), or is comparable to the [~~unaffected~~] THE QUALITY OF THE water supply BEFORE IT WAS AFFECTED BY THE OPERATOR if that water supply did not meet these standards.

(3) A*dequate quantity.* A restored or replaced water supply will be deemed adequate in quantity if it meets one of the following as determined by the Department:

(i) It delivers the amount of water necessary to satisfy the water user's needs and the demands of any reasonably foreseeable uses.

(ii) It is established through a connection to a public water supply system [~~which~~] THAT is capable of delivering the amount of water necessary to satisfy the water user's needs and the demands of any reasonably foreseeable uses.

(iii) For purposes of this paragraph and with respect to agricultural water supplies, the term reasonably foreseeable uses includes the reasonable expansion of use where the water supply available prior to drilling exceeded the actual use.

(4) *Water source serviceability.* Replacement of a water supply includes providing plumbing, conveyance, pumping or auxiliary equipment and facilities necessary for the [~~surface landowner or water purveyor~~] WATER USER to utilize the water supply.

(e) If the water supply is for uses other than human consumption, the operator shall demonstrate to the Department's satisfaction that the restored or replaced water supply is adequate for the purposes served by the supply.

(f) **[The oil or gas well operator's duty to replace or restore a water supply includes providing plumbing, conveyance, pumping or auxiliary equipment and facilities necessary for the surface landowner or water purveyor to utilize the water supply.]**

[(g)] Tank trucks or bottled water are acceptable only as temporary water replacement for a period approved by the Department and do not relieve the operator of the obligation to provide a restored or replaced water supply.

[(h)] (g) If the well operator and the [**~~landowner, water purveyor or affected person~~**] **WATER USER** are unable to reach agreement on the means for restoring or replacing the water supply, the Department or either party may request a conference under section 501 of the act (58 P. S. § 601.501).

(h) A well operator who receives notice from a landowner, water purveyor or affected person that a water supply has been affected by pollution or diminution, shall report receipt of [~~such~~] notice FROM AN AFFECTED PERSON to the Department within [~~10 calendar days~~] 24 HOURS of receiving the notice.

§ 78.52**.** Predrilling or prealteration survey**.**

(a) A well operator who wishes to preserve its defense under section 208(d)(1) of the act (58 P. S. § 601.208(d)(1)) that the pollution of a water supply existed prior to the drilling or alteration of the well shall **[cause]** **conduct** a predrilling or prealteration survey **[to be conducted]** in accordance with this section.

* * * * *

(d) An operator electing to preserve its defenses under section 208(d)(1) of the act shall provide a copy of the results of the survey to the Department and the landowner or water purveyor within 10-[~~calendar~~] **BUSINESS** days of **receipt** **[being notified by the Department to submit a copy]** of the results. **TEST RESULTS NOT RECEIVED BY THE DEPARTMENT WITHIN 10 BUSINESS DAYS MAY NOT BE USED TO PRESERVE THE OPERATOR'S DEFENSES UNDER SECTION 208(D)(1) OF THE ACT.**

* * * * *

§ 78.55. Control and disposal plan.

(a) Prior to generation of waste, the well operator shall prepare and implement a plan under § 91.34 (relating to activities utilizing pollutants) for the control and disposal of fluids, residual waste and drill cuttings, including tophole water, brines, drilling fluids, additives, drilling muds, stimulation fluids, well servicing fluids, oil, production fluids and drill cuttings from the drilling, alteration, production, plugging or other activity associated with oil and gas wells.

(b) The plan shall identify the control and disposal methods and practices utilized by the well operator and be consistent with the act, The Clean Streams Law (35 P. S. § § 691.1—691.1001), the Solid Waste Management Act (35 P. S. § § 6018.101—6018.1003) and § § 78.54, 78.56—78.58 and 78.60—78.63. **THE PLAN SHALL ALSO INCLUDE A PRESSURE BARRIER POLICY THAT IDENTIFIES BARRIERS TO BE USED DURING IDENTIFIED OPERATIONS.**

(c) The operator shall revise the plan prior to implementing a change to the practices identified in the plan.

(d) A copy of the plan shall be provided to the Department upon request **AND SHALL BE AVAILABLE AT THE WELL SITE DURING DRILLING AND COMPLETION ACTIVITIES FOR REVIEW**.

(E) A LIST OF EMERGENCY CONTACT PHONE NUMBERS FOR THE AREA IN WHICH THE WELL SITE IS LOCATED MUST BE INCLUDED IN THE PLAN AND BE PROMINENTLY DISPLAYED AT THE WELL SITE DURING DRILLING, COMPLETION OR ALTERATION ACTIVITIES.

Subchapter D. WELL DRILLING, OPERATION AND PLUGGING

GENERAL

Sec.

CASING AND CEMENTING

OPERATING WELLS

* * * * *

Subchapter D. WELL DRILLING, OPERATION AND PLUGGING

GENERAL

§ 78.71. Use of safety devices—well casing.

(a) The operator shall equip the well with one or more strings of casing of sufficient **cemented** length and strength to **attach [~~blow-out prevention~~] PROPER WELL CONTROL equipment and** prevent blowouts, explosions, fires and casing failures during installation, completion and operation.

* * * * *

§ 78.72. Use of safety devices—blow-out prevention equipment.

(a) The operator shall use blow-out prevention equipment **AFTER SETTING CASING WITH A COMPETENT CASING SEAT[when well head pressures or natural open flows are anticipated at the well site that may result in a blow-out or when the operator is drilling in an area where there is no prior knowledge of the pressures or natural open flows to be encountered.] in the following circumstances:**

(1) When drilling a well that is intended to produce natural gas from [the Marcellus Shale] AN UNCONVENTIONAL formation;

(2) WHEN DRILLING OUT SOLID CORE HYDRAULIC FRACTURING PLUGS TO COMPLETE A WELL;

(2) When well head pressures or natural open flows are anticipated at the well site that may result in a loss of well control;

(3) When the operator is drilling in an area where there is no prior knowledge of the pressures or natural open flows to be encountered;

(4) On wells regulated by the Oil and Gas Conservation Law (58 P.S. §§ 401 – [~~409~~] 419);

(5) When drilling within 200 feet of a building.

(b) Blow-out prevention equipment used shall be in good working condition at all times.

(c) Controls for the blow-out preventer shall be accessible to allow actuation of the equipment. Additional controls for a blow-out preventer with a pressure rating of

greater than 3,000 psi, not associated with the rig hydraulic system, shall be located AT LEAST 50 FEET away from the drilling rig such that the blow-out preventer can be actuated if control of the well is lost.

[(c)] (d) * * * * *

[(d)] (e) The operator shall conduct a complete test of the ram type blow-out preventer and related equipment for both pressure and ram operation before placing it in service on the well. The operator shall test the annular type blow-out preventer in accordance with the manufacturer's published instructions, or the instructions of a professional engineer, prior to the device being placed in service. **Blow-out prevention equipment that fails the test shall not be used until it is repaired and passes the test.**

[(e)] (f) When the equipment is in service, the operator shall visually inspect blow-out prevention equipment during each tour of drilling operation and during actual drilling operations test the pipe rams for closure daily and the blind rams for closure on each round trip. When more than one round trip is made in a day, one daily closure test for blind rams is sufficient. Testing shall be conducted in accordance with American Petroleum Institute publication API RP53, ''API Recommended Practice for Blowout Prevention Equipment Systems for Drilling Wells.''**, OR OTHER PROCEDURE APPROVED BY THE DEPARTMENT**. The operator shall record the results of the inspection and closure test in the drillers log before the end of the tour. **IF blow-out prevention equipment [~~that~~] is not in good working order, DRILLING SHALL CEASE WHEN CESSATION OF DRILLING CAN BE ACCOMPLISHED SAFELY AND NOT RESUME UNTIL THE BLOW-OUT PREVENTION EQUIPMENT IS [~~shall be~~] repaired or replaced [~~immediately~~] and re-tested. [~~prior to the resumption of drilling.~~]**

(g) All lines, valves and fittings between the closing unit and the blow-out preventer stack shall be flame resistant and have a rated working pressure that meets or exceeds the requirements of the blow-out preventer system.

[(f)] (h) [~~**During drilling when conditions are such that the use of a blowout preventer can be anticipated**~~] **WHEN A BLOWOUT PREVENTER IS INSTALLED OR REQUIRED PURSUANT TO SUBSECTION (A)**, there shall be present on the **[rig floor a certified] well site an** individual **[responsible to] [~~who the operator has determined is trained and competent in the use of the blow-out prevention equipment.~~** ~~Satisfactory completion of~~ **[a United States Geologic Survey (U.S.G.S.)]** ~~a~~**[n approved] WITH A CURRENT CERTIFICATION FROM A** well control course **ACCREDITED by the [American Petroleum Institute,]** [~~**Independent**~~**] INTERNATIONAL Association of Drilling Contractors OR OTHER ORGANIZATION APPROVED BY THE DEPARTMENT. THE CERTIFICATION SHALL BE AVAILABLE FOR REVIEW AT THE WELL SITE. THE DEPARTMENT SHALL MAINTAIN A LIST OF APPROVED**

ACCREDITING ORGANIZATIONS ON ITS WEBSITE. **[**~~or equivalent study shall be deemed adequate **[certification]** for purposes of this subsection.~~]

(I) WELL DRILLING AND COMPLETION OPERATIONS REQUIRING PRESSURE BARRIERS, AS IDENTIFIED BY THE OPERATOR PURSUANT TO 25 PA. CODE § 78. 55(B), SHALL EMPLOY AT LEAST TWO MECHANICAL PRESSURE BARRIERS BETWEEN THE OPEN PRODUCING FORMATION AND THE ATMOSPHERE THAT ARE CAPABLE OF BEING TESTED. THE MECHANICAL PRESSURE BARRIERS SHALL BE TESTED ACCORDING TO MANUFACTURER SPECIFICATIONS PRIOR TO OPERATION. IF DURING THE COURSE OF OPERATIONS THE OPERATOR ONLY HAS ONE FUNCTIONING BARRIER, OPERATIONS MUST CEASE UNTIL ADDITIONAL BARRIERS ARE ADDED AND TESTED OR THE REDUNDANT BARRIER IS REPAIRED AND TESTED. STRIPPER RUBBER OR A STRIPPER HEAD SHALL NOT BE CONSIDERED A BARRIER.

(J) A COILED TUBING RIG OR A HYDRAULIC WORKOVER UNIT WITH APPROPRIATE BLOWOUT PREVENTION EQUIPMENT MUST BE EMPLOYED DURING POST COMPLETION CLEANOUT OPERATIONS IN HORIZONTAL UNCONVENTIONAL FORMATIONS.

[(g)] (k) The minimum amount of **INTERMEDIATE** [~~cemented~~] casing **THAT IS CEMENTED TO THE SURFACE** to which blow-out prevention equipment may be attached, shall be in accordance with the following:

*Proposed Total **VERTICAL** Depth (in feet)*	*Minimum Cemented Casing Required (in feet of casing cemented)*
Up to 5,000	400
5,001 to 5,500	500
5,501 to 6,000	600
6,001 to 6,500	700
6,501 to 7,000	800
7,001 to 8,000	1,000
8,001 to 9,000	1,200
9,001 to 10,000	1,400
Deeper than 10,000	1,800

[(h)] (l) * * * * *

§ 78.73. General provision for well construction and operation.

(a) The operator shall construct and operate the well in accordance with this chapter and ensure that the integrity of the well is maintained and health, safety, environment and property are protected.

[(a)] (b) The operator shall prevent gas **[and other fluids from lower formations from entering fresh groundwater.], oil, brine, completion and servicing fluids, and any other fluids OR MATERIALS from below the casing seat from entering fresh groundwater, and SHALL OTHERWISE prevent pollution or diminution of fresh groundwater.**

[(b)] (c) After a well has been completed, recompleted, reconditioned or altered the operator shall prevent **SURFACE** shut-in pressure **[or] and SURFACE** producing back pressure [at] **INSIDE** the surface casing [**seat,**]**[or]** coal protective casing [**seat or intermediate casing seat when the intermediate casing is used in conjunction with the surface casing to isolate fresh groundwater]** from exceeding **THE FOLLOWING PRESSURE: 80 percent (80%) [**of the hydrostatic pressure of the surrounding fresh groundwater system in accordance with the following formula. The maximum allowable shut-in pressure [or] and producing back pressure to be exerted at the [surface casing seat, or coal protective] casing seat may not exceed the [hydrostatic] pressure calculated as follows: Maximum pressure = (0.8 x 0.433 psi/foot) multiplied by (casing length in feet).] **MULTIPLIED BY 0.433 PSI PER FOOT MULTIPLIED BY THE CASING LENGTH (IN FEET) OF THE APPLICABLE CASING.**

[**(c)] (d)** After a well has been completed, recompleted, reconditioned or altered, if the **SURFACE** shut-in pressure or **SURFACE** producing back pressure exceeds the **[hydrostatic]** pressure [**at the surface casing seat, coal protective casing**] as calculated in subsection **[(b)] (c)**, the operator shall take action to prevent the migration of gas and other fluids from lower formations into fresh groundwater. To meet this standard the operator may cement or install on a packer sufficient intermediate or production casing or take other actions approved by the Department. This section does not apply during testing for mechanical integrity in accordance with State or Federal requirements.

(e) Excess gas encountered during drilling, completion or stimulation shall be flared, captured or diverted away from the drilling rig in a manner that does not create a hazard to the public health or safety.

(f) Except for gas storage wells, the well must be equipped with a check valve to prevent backflow from the pipelines into the well.

* * * * *

§ 78.75a. Area of alternative methods.

(a) The Department may designate an area of alternative methods if the Department determines that well drilling requirements beyond those provided in this chapter

are necessary to drill, operate or plug a well in a safe and environmentally protective manner.

(b) To establish an area of alternative methods, the Department shall publish a notice in the *Pennsylvania Bulletin* of the proposed area of alternative methods and provide the public with an opportunity to comment on the proposal. After reviewing any comments received on the proposal, the Department shall publish a final designation of the area and required alternative methods in the P*ennsylvania Bulletin.*

(c) Wells drilled within an area of alternative methods established pursuant to subsection (b) must meet the requirements specified by the Department unless the operator obtains approval from the Department to drill, operate or plug the well in a different manner that is at least as safe and protective of the environment as the requirements of the area of alternative methods.

§ 78.76. Drilling within a gas storage reservoir area.

(a) An operator proposing to drill a well within a gas storage reservoir area or a reservoir protective area to produce gas or oil shall forward by certified mail a copy of the well location plat, the drilling, casing and cementing plan and the anticipated date drilling will commence to the gas storage reservoir operator **and to the Department for approval by the Department** and shall submit proof of notification **TO THE GAS STORAGE RESERVOIR OPERATOR** to the Department with the well permit application.

* * * * *

CASING AND CEMENTING

* * * * *

[(c) Casing and cementing standards in § § 78.83—78.85 (relating to surface and coal protective casing and cementing procedures; casing standards; and cement standards) apply to surface casing and coal protective casing but do not apply to production casing.]

§ 78.82 Use of conductor pipe**.**

If the operator installs conductor pipe in the well, the **[operator may not remove the pipe] following provisions shall apply:**

(i) The operator may not remove the pipe;

(ii) Conductor pipe shall be installed in a manner that prevents THE SUBSURFACE infiltration of surface water or fluids [~~from the operation into~~] [~~groundwater~~] BY EITHER DRIVING THE PIPE

INTO PLACE OR CEMENTING THE PIPE FROM THE SEAT TO THE SURFACE;

(iii) Conductor pipe must be made of steel unless a different material is approved for use by the Department.

§ 78.83. Surface and coal protective casing and cementing procedures.

(a) For wells drilled, altered, reconditioned or recompleted after [effective date], surface casing or any casing functioning as a water protection casing must not be utilized as production casing unless one of the following applies:

(1) In oil wells where the operator does not produce any gas generated by the well and the annulus between the surface casing and the production pipe is left open;

(2) The operator demonstrates that the pressure in the well [~~bore at the casing seat~~] is no greater than the pressure permitted by § 78.73(c), [~~and~~] demonstrates through a pressure test or other method approved by the Department that all gas and fluids will be contained within the well, AND INSTALLS A WORKING PRESSURE GAUGE THAT CAN BE INSPECTED BY THE DEPARTMENT.

[(a)] (b) If the well is to be equipped with threaded and coupled casing, the operator shall drill a hole so that the diameter is at least 1 inch greater than the outside diameter of the casing collar to be installed. If the well is to be equipped with plain-end welded casing, the operator shall drill a hole so that the diameter is at least 1 inch greater than the outside diameter of the **[casing tube]** [**~~centralizer band~~] CASING COUPLING**.

[(b)] (c) [Except as provided in subsection (c)*,* t]The operator shall drill to approximately 50 feet below the deepest fresh groundwater or at least 50 feet into consolidated rock, whichever is deeper, and immediately set and permanently cement a string of surface casing to that depth. **EXCEPT AS PROVIDED IN SUBSECTION (F), THE SURFACE CASING SHALL NOT BE SET MORE THAN 200 FEET BELOW THE DEEPEST FRESH GROUNDWATER EXCEPT IF NECESSARY TO SET THE CASING IN CONSOLIDATED ROCK. The surface hole shall be drilled using air, freshwater, or freshwater-based drilling fluid. PRIOR TO CEMENTING, THE WELLBORE SHALL BE CONDITIONED TO ENSURE AN ADEQUATE CEMENT BOND BETWEEN THE CASING AND THE FORMATION. The surface casing seat shall be set in consolidated rock. When drilling a new well or redrilling an existing well, the operator shall install at least one centralizer within 50 feet of the casing seat and then install a centralizer in intervals no greater than every 150 feet above the first centralizer.**

[(c) If no fresh groundwater is being utilized as a source of drinking water within a 1,000-foot radius of the well, the operator may set and permanently cement a single string of surface casing through all water zones, including fresh, brackish and salt

water zones. Prior to penetrating zones known to contain, or likely containing, oil or gas, the operator shall install and permanently cement the string of casing in a manner that segregates the various waters.]

* * * * *

(f) If additional fresh groundwater is encountered in drilling below the permanently cemented surface casing, the operator shall **DOCUMENT THE DEPTH OF THE FRESH GROUND WATER ZONE IN THE WELL RECORD AND** protect the additional fresh groundwater by installing and cementing a subsequent string of casing or other procedures approved by the Department to completely isolate and protect fresh groundwater. The string of casing may also penetrate zones bearing salty or brackish water with cement in the annular space being used to segregate the various zones. Sufficient cement shall be used to cement the casing **~~[at least 20 feet into the permanently cemented surface casing~~] TO THE SURFACE**. **THE OPERATOR SHALL INSTALL AT LEAST ONE CENTRALIZER WITHIN 50 FEET OF THE CASING SEAT AND THEN INSTALL A CENTRALIZER IN INTERVALS NO GREATER THAN, IF POSSIBLE, EVERY 150 FEET ABOVE THE FIRST CENTRALIZER.**

(g) The operator shall set and cement a coal protective string of casing through workable coal seams. The base of the coal protective casing shall be at least 30 feet below the lowest workable coal seam. **The operator shall install at least two centralizers. One centralizer shall be within 50 feet of the casing seat and the second centralizer shall be within 100 feet of the surface.**

(h) **Unless an alternative method has been approved by the Department in accordance with § 78.75 (relating to Alternative methods), [W]w**hen a well is drilled through a coal seam at a location where the coal has been removed **or when a well is drilled through a coal pillar**, the operator shall drill to a depth of at least 30 feet but no more than 50 feet deeper than the bottom of the coal seam. The operator shall set and cement a coal protection string of casing to this depth. The operator shall equip the casing with a cement basket or other similar device above and as close to the top of the coal seam as practical. The bottom of the casing shall be equipped with an appropriate device designed to prevent deformation of the bottom of the casing. The interval from the bottom of the casing to the bottom of the coal seam shall be filled with cement either by the balance method or by the displacement method. Cement shall be placed on top of the basket between the wall of the hole and the outside of the casing by pumping from the surface. If the operator penetrates more than one coal seam from which the coal has been removed, the operator shall protect each seam with a separate string of casing that is set and cemented or with a single string of casing which is stage cemented so that each coal seam is protected as described in this subsection. The operator shall cement the well to isolate workable coal seams from each other.

(i) If the operator sets and cements casing under subsection (g) or (h) and subsequently encounters additional fresh groundwater zones below the deepest cemented casing string

installed, the operator shall protect the fresh groundwater by installing and cementing another string of casing or other method approved by the Department. Sufficient cement shall be used to cement the casing **[~~at least 20 feet into the surface or coal protective casing~~] TO THE SURFACE**. The additional casing string may also penetrate zones bearing brackish or salt water, but shall be run and cemented prior to penetrating a zone known to or likely to contain oil or gas**. THE OPERATOR SHALL INSTALL AT LEAST ONE CENTRALIZER WITHIN 50 FEET OF THE CASING SEAT AND THEN, IF POSSIBLE, INSTALL A CENTRALIZER IN INTERVALS NO GREATER THAN EVERY 150 FEET ABOVE THE FIRST CENTRALIZER.**

(j) If it is anticipated that cement used to permanently cement the surface casing can not be circulated to the surface a cement basket may be installed immediately above the depth of the **anticipated [last] lost** circulation zone. The casing shall be permanently cemented by the displacement method. Additional cement may be added above the cement basket, if necessary, by pumping through a pour string from the surface to fill the annular space. **FILLING THE ANNULAR SPACE BY THIS METHOD DOES NOT CONSTITUTE PERMANENTLY CEMENTING THE SURFACE OR COAL PROTECTIVE CASING PURSUANT TO 25 PA. CODE § 78.83B.**

§ 78.83a. Casing and cementing plan.

(a) The operator shall prepare and maintain a casing and cementing plan showing how the well will be drilled and completed. The plan must demonstrate compliance with this subchapter and include the following information:

(1) The anticipated depth and thickness of any producing formation, expected pressures, [~~and~~] anticipated fresh groundwater zones AND THE METHOD OR INFORMATION BY WHICH THE DEPTH OF THE DEEPEST FRESH GROUNDWATER WAS DETERMINED;

(2) Diameter of the [~~well bore~~] BOREHOLE;

(3) Casing type, whether the casing is new or used, depth, diameter, wall thickness and burst pressure rating;

(4) Cement type, yield, additives, and estimated amount;

(5) Estimated location of centralizers;

(6) PROPOSED BOREHOLE CONDITIONING PROCEDURES.

[~~(6)~~](7) Alternative methods or materials as required by the Department as a condition of the well permit.

(b) The plan must be available at the well site for review by the Department.

(c) Upon request, the operator shall provide a copy of the well-specific casing and cementing plan to the Department for review and approval.

(d) Any revisions to the plan made as a result of on-site modification shall be documented in the plan [~~by the operator~~] and be available for review by the Department. THE PERSON MAKING THE REVISIONS TO THE PLAN SHALL INITIAL AND DATE THE REVISIONS.

§ 78.83b. Casing and cementing – lost circulation.

(a) If cement used to permanently cement the surface or coal protective casing is not circulated to the surface despite pumping a volume of cement equal to or greater than 120% of the calculated annular space, the operator shall DETERMINE THE TOP OF THE CEMENT, notify the Department, and meet one of the following requirements AS APPROVED BY THE DEPARTMENT:

(1) Run an additional string of casing at least 50 feet deeper than the STRING WHERE CIRCULATION WAS LOST [~~surface casing~~] and cement the [~~second~~] ADDITIONAL string of casing back to the seat of the [~~surface or coal protective casing~~] STRING WHERE CIRCULATION WAS LOST and vent the annulus of the additional casing string to the atmosphere at all times unless closed for well testing or maintenance. Shut-in pressure on the casing seat of the [~~second~~] ADDITIONAL string of casing must not exceed the requirements of section 78.73(c).

(2) [~~If the additional string of casing is the~~] RUN production casing[~~, the operator shall~~] AND set the production casing on a packer in a competent formation below the [~~surface casing seat,~~] STRING WHERE CIRCULATION WAS LOST and vent the annulus of the production casing to the atmosphere at all times unless closed for well testing or maintenance.

(3) Run production casing at least to the top of the formation that is being produced and cement the production casing to the surface.

(4) RUN INTERMEDIATE AND PRODUCTION CASING AND CEMENT BOTH STRINGS OF CASING TO THE SURFACE.

[~~(4)~~] (5) Produce oil but not gas and leave the annulus between the surface casing and the production pipe open.

(B) IN ADDITION TO MEETING THE REQUIREMENTS OF SUBSECTION (A), THE OPERATOR MAY ALSO PUMP ADDITIONAL CEMENT THROUGH A POUR STRING FROM THE SURFACE TO FILL THE ANNULAR SPACE.

~~[(b) If cement used to permanently cement the surface or coal protective casing is not circulated to the surface, the Department may require the operator to determine the amount of casing that was cemented by logging or other suitable method.]~~

§ 78.83c. Intermediate and production casing.

~~[(a) Except as provided in § 78.72 (relating to Use of safety devices – blow-out prevention equipment), intermediate and production casing must be cemented according to this section.]~~

(A) PRIOR TO CEMENTING THE INTERMEDIATE AND PRODUCTION CASING, THE BOREHOLE, MUD AND CEMENT SHALL BE CONDITIONED TO ENSURE AN ADEQUATE CEMENT BOND BETWEEN THE CASING AND THE FORMATION.

[(b)] If the well is to be equipped with an intermediate casing, CENTRALIZERS SHALL BE USED AND the casing must be cemented TO THE SURFACE BY THE DISPLACEMENT METHOD. [~~from the casing seat to a point at least 500 feet above the seat. If any producing horizon is open to the wellbore above the casing seat, the casing must be cemented from the casing seat up to a point at least 500 feet above the top of the shallowest productive horizon, or to a point at least 200 feet above the shoe of the next shallower casing string that was set and cemented in the well.]~~ GAS MAY BE PRODUCED OFF [~~The~~] THE intermediate casing [~~may be perforated to produce gas or oil~~ if a shoe test demonstrates THAT ALL GAS WILL BE CONTAINED WITHIN THE WELL [~~a pressure gradient greater than 0.465 psi/ft multiplied by casing length in feet~~] AND A RELIEF VALVE IS INSTALLED AT THE SURFACE THAT IS SET LESS THAN THE SHOE TEST PRESSURE. THE SHOE TEST PRESSURE SHALL BE RECORDED IN THE COMPLETION REPORT.

[(c)] Except as provided for in § 78.83 (relating to surface and coal protective casing and cementing procedures), each well must be equipped with production casing. The production string may be set on a packer or cemented in place. If the production casing is cemented in place, CENTRALIZERS SHALL BE USED AND cement must be placed by the displacement method with sufficient cement to fill the annular space [~~to the surface or~~] to a point at least 500 feet above [~~the production casing seat~~] TRUE VERTICAL DEPTH OR AT LEAST 200 FEET ABOVE THE UPPERMOST PERFORATIONS, WHICHEVER IS GREATER.

§ 78.84. Casing standards.

(a) The operator shall install casing that can withstand the effects of tension, and prevent **leaks,** burst and collapse during its installation, cementing and subsequent drilling and producing operations.

(b) [~~Surface~~] EXCEPT AS PROVIDED IN SUBSECTION (C), ALL casing must be a string of new pipe with [~~a~~] AN INTERNAL pressure rating that is at least 20 percent greater than the anticipated maximum pressure to which the [~~surface~~] casing will be exposed.

(c) Used casing may be approved for use as surface, intermediate or production casing but must be pressure tested after cementing and before continuation of drilling. A passing pressure test is holding the anticipated maximum pressure to which it will be exposed for 30 minutes with not more than a 10 percent decrease in pressure.

(d) New or used plain end casing, except when being used as [~~drive pipe,~~] conductor PIPE, [~~or as a casing string prior to setting and cementing surface casing,~~] that is welded together for use must meet the following requirements:

(1) It must pass a pressure test by holding the anticipated maximum pressure to which the casing will be exposed for 30 minutes with not more than a 10 percent decrease in pressure. The operator shall notify the Department at least 24 hours before conducting the test. The test results shall be entered on the drilling log.

(2) It shall be welded using at least three passes with the joint cleaned between each pass.

(3) It shall be welded by a person trained and certified in the applicable American Petroleum Institute[’s], AMERICAN SOCIETY OF MECHANICAL ENGINEERS, AMERICAN WELDING SOCIETY OR EQUIVALENT standard for welding casing and pipe or an equivalent training and certification program as approved by the Department. THE CERTIFICATION REQUIREMENTS OF THIS PARAGRAPH SHALL TAKE EFFECT [INSERT DATE – 6 MONTHS AFTER THE EFFECTIVE DATE]. A person with 10 or more years of experience welding casing as of [effective date] who registers with the Department within nine months of the effective date of this subsection is deemed to be certified.

[(b) The operator shall equip the casing string with appropriate equipment to center the casing through the hole in fresh groundwater zones. This equipment is

not required when existing hole conditions such as caving or crookedness might cause loss of the well or result in a defective cement job.]

[(c)] **(e)** When casing through a workable coal seam, the operator shall install coal protective casing that has a minimum wall thickness of 0.23 inches.

(f) Casing which is attached to a blow-out preventer with a pressure rating of greater than 3,000 psi shall be pressure tested AFTER CEMENTING. A passing pressure test must be holding [~~120 percent of the highest expected working pressure of the casing string being tested,~~] THE ANTICIPATED MAXIMUM PRESSURE TO WHICH THE CASING WILL BE EXPOSED for 30 minutes with not more than a 10 percent decrease. Certification of the pressure test shall be confirmed by entry and signature of the person performing the test on the driller's log.

§ 78.85. Cement standards.

(a) **When cementing surface casing[~~,~~] OR coal protective casing [~~and intermediate casing when the intermediate casing is used in conjunction with the surface casing to isolate fresh groundwater~~].** [T]**t**he operator shall use cement that **[will resist degradation by chemical and physical conditions in the well.] meets or exceeds the ASTM International C 150, Type I, II or III Standard or API Specification 10. The cement must also:**

(1) Secure the casing in the wellbore;

(2) Isolate the wellbore from fresh groundwater;

(3) Contain any pressure from drilling, completion and production;

(4) [~~Protect the casing from corrosion;~~

~~(5) Resist degradation by the chemical and physical conditions in the well;~~]

PROTECT THE CASING FROM CORROSION FROM, AND DEGRADATION BY, THE GEOCHEMICAL, LITHOLOGIC AND PHYSICAL CONDITIONS OF THE SURROUNDING WELLBORE. FOR WELLS EMPLOYING COAL PROTECTIVE CASING, THIS INCLUDES, BUT IS NOT LIMITED TO, FORMULATING CEMENT TO WITHSTAND ELEVATED SULFATE CONCENTRATIONS AND OTHER GEOCHEMICAL CONSTITUENTS OF COAL AND ASSOCIATED STRATA WHICH HAVE THE POTENTIAL TO ADVERSELY AFFECT THE INTEGRITY OF THE CEMENT.

[~~(6)~~] (5) Prevent gas flow in the annulus. IN AREAS OF KNOWN SHALLOW GAS PRODUCING ZONES, GAS BLOCK ADDITIVES AND LOW FLUID LOSS SLURRIES SHALL BE USED.

(b) **[The operator shall permit the cement to set to a minimum compressive strength of 350 pounds per square inch (psi) in accordance with the American Petroleum Institute's API Specification 10. The operator shall permit the cement to set for a minimum period of 8 hours prior to the resumption of actual drilling.]** **After the casing cement is placed behind surface casing [~~and intermediate casing when the intermediate casing is used in conjunction with the surface casing to isolate fresh groundwater~~], the operator shall permit the cement to set to a minimum designed compressive strength of 350 pounds per square inch (psi) at the casing seat. THE CEMENT PLACED AT THE BOTTOM 300 FEET OF THE SURFACE CASING SHALL CONSTITUTE A ZONE OF CRITCAL CEMENT AND SHALL ACHIEVE A 72 HOUR COMPRESSIVE STRENGTH OF 1,200 PSI AND THE FREE WATER SEPARATION SHALL BE NO MORE THAN SIX MILLILITERS PER 250 MILLILITERS OF CEMENT. IF THE SURFACE CASING IS LESS THAN 300 FEET, THE ENTIRE CEMENTED STRING SHALL CONSTITUTE A ZONE OF CRITICAL CEMENT.**

(c) After [~~the~~] ANY casing cement is placed and cementing operations are complete, the casing may not be disturbed for a minimum of eight (8) hours by:

(1) Releasing pressure on the cement head WITHIN FOUR HOURS OF CEMENTING if [~~float~~] CASING equipment check valves did not hold or [~~float~~] CASING equipment was not equipped with check valves. AFTER FOUR HOURS, THE PRESSURE MAY BE RELEASED AT A CONTINUOUS, GRADUAL RATE OVER THE NEXT FOUR HOURS PROVIDED THE FLOATS ARE SECURE;

(2) Nippling up on or in conjunction to the casing;

(3) Slacking off by the rig supporting the casing in the cement sheath; or

(4) Running drill pipe[~~, wireline,~~] or other mechanical devices into or out of the wellbore WITH THE EXCEPTION OF A WIRELINE USED TO DETERMINE THE TOP OF CEMENT.

[(c)] (d) Where special cement or additives are used, the operator may request approval from the Department to reduce the cement setting time specified in subsection **[(b)] (d)**.

(e) The operator shall notify the Department a minimum of one day before cementing of the surface casing begins, unless the cementing operation begins within 72 hours of commencement of drilling.

(f) A copy of the cement job log must be available at the well site for inspection by the Department during drilling operations. THE CEMENT JOB LOG MUST

INCLUDE THE MIX WATER TEMPERATURE AND PH, TYPE OF CEMENT WITH LISTING AND QUANTITY OF ADDITIVE TYPES, THE VOLUME, YIELD AND DENSITY IN POUNDS PER GALLON OF THE CEMENT AND THE AMOUNT OF CEMENT RETURNED TO THE SURFACE, IF ANY. CEMENTING PROCEDURAL INFORMATION MUST INCLUDE A DESCRIPTION OF THE PUMPING RATES IN BARRELS PER MINUTE, PRESSURES IN POUNDS PER SQUARE INCH, TIME IN MINUTES AND SEQUENCE OF EVENTS DURING THE CEMENTING OPERATION.

(G) The cement job log shall be maintained by the operator after drilling operations for at least five years and be made available to the Department upon request.

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OPERATING WELLS

§ 78.88. Mechanical integrity of operating wells.

(a) Except for wells regulated under Subchapter H (relating to Underground gas storage) AND WELLS THAT HAVE BEEN GRANTED INACTIVE STATUS, the operator shall inspect each operating well at least quarterly to ensure it is in compliance with the well construction and operating requirements of this chapter and the Act. The results of the inspections shall be recorded and retained by the operator for at least five years and shall be available for review by the Department and the coal owner or operator.

(b) At a minimum, inspections must determine:

(1) The well-head pressure or water level measurement;

(2) The open flow on the annulus of the production casing or the annulus pressure if the annulus is shut in;

(3) If there is evidence of gas escaping from the well and the amount escaping, using measurement or best estimate of quantity;

(4) If there is evidence of progressive corrosion, rusting or other signs of equipment deterioration.

(c) For structurally sound wells in compliance with §78.73(c), the operator shall follow the reporting schedule outlined in subsection (e).

(d) For wells exhibiting progressive corrosion, rusting or other signs of equipment deterioration that compromise the integrity of the well, or the well is not in compliance with §78.73(c), the operator shall immediately notify the Department and take corrective actions to repair or replace defective equipment or casing or

mitigate the excess pressure on the surface casing seat[,] OR coal protective casing seat [~~or intermediate casing seat when the intermediate casing is used in conjunction with the surface casing to isolate fresh groundwater~~] according to the following hierarchy:

(1) The operator shall reduce the shut-in or producing back pressure on the casing seat to achieve compliance with § 78.73(c).

(2) The operator shall retrofit the well by installing production casing to reduce the pressure on the casing seat to achieve compliance with § 78.73(c). The annular space surrounding the production casing must be open to the atmosphere. The production casing shall be either cemented to the surface or installed on a permanent packer. The operator shall notify the Department at least seven days prior to initiating the corrective measure.

(3) Additional mechanical integrity tests, including but not limited to pressure tests, may be required by the Department to demonstrate the integrity of the well.

(e) The operator shall submit an annual report to the Department identifying the compliance status of each well with the mechanical integrity requirements of this section. The report shall be submitted on forms prescribed by, and available from, the Department or in a similar manner approved by the Department.

§ 78.89. Gas migration response.

(a) When an operator or owner is notified of or otherwise made aware of a POTENTIAL natural gas migration incident, the operator shall immediately [~~notify the Department and, if so directed by the Department,~~] conduct an investigation of the incident. The purpose of the investigation is to determine the nature of the incident, assess the potential for hazards to public health and safety, and mitigate any hazard posed by [~~the levels of natural gas~~] THE CONCENTRATIONS OF STRAY NATURAL GAS. [~~The operator, in conjunction with the Department and local emergency response agencies, shall take measures necessary to ensure public health and safety.~~]

(b) The investigation undertaken by the operator pursuant to subsection (a) shall include, but not be limited to:

(1) [~~An~~] A SITE VISIT AND interview with the complainant to obtain information about the complaint and to assess the reported [~~problem~~] NATURAL GAS MIGRATION INCIDENT;

(2) A field survey to assess the presence and concentrations of natural gas and aerial extent of the stray natural gas; and

(3) If necessary, [~~Establishment of~~] establish monitoring locations at potential sources, in potentially impacted structures, and the subsurface [~~if necessary~~].

~~(c) If the level of natural gas is greater than 10 percent of the lower explosive limit of natural gas, the operator shall:~~

~~(1) Immediately notify the local emergency response agency, police and fire departments and the Department;~~

~~(2) Conduct an immediate field survey of the operator's adjacent oil or gas wells to assess the wells for mechanical integrity, defective casing or cementing, and excess pressures within any part of the well. The initial area of assessment shall include wells within 2,500 feet and expanded to a greater distance if necessary as determined by the Department;~~

~~(3) Initiate mitigation controls, which may include remedial measures, access control, advisories, evacuation, signs and other actions;~~

~~(d) The operator shall take action to correct any defect in the oil and gas wells to mitigate the stray gas incident.~~

~~(e) The operator and owner shall report to the Department by phone within 12 hours after the interview with the complainant and field survey of the natural gas levels. A follow-up report shall be filed in writing with the Department within three days of the complaint. This follow-up report must include the results of the investigation, monitoring results and measures taken by the operator to repair any defects at any of the adjacent oil and gas wells.]~~

(C) IF COMBUSTIBLE GAS IS DETECTED INSIDE A BUILDING OR STRUCTURE AT CONCENTRATIONS EQUAL TO OR GREATER THAN 10% OF THE LOWER EXPLOSIVE LIMIT (L.E.L.), THE OPERATOR SHALL:

(1) IMMEDIATELY NOTIFY THE DEPARTMENT, LOCAL EMERGENCY RESPONSE AGENCY, GAS AND ELECTRIC UTILITY COMPANIES, POLICE AND FIRE DEPARTMENTS AND, IN CONJUNCTION WITH THE DEPARTMENT AND LOCAL EMERGENCY RESPONSE AGENCIES, TAKE MEASURES NECESSARY TO ENSURE PUBLIC HEALTH AND SAFETY;

(2) INITIATE MITIGATION MEASURES NECESSARY TO CONTROL AND PREVENT FURTHER MIGRATION;

(3) IMPLEMENT THE ADDITIONAL INVESTIGATION AND MITIGATION MEASURES AS PROVIDED IN SUBSECTION (E)(1) – (5) .

(D) THE OPERATOR SHALL NOTIFY THE DEPARTMENT AND, IN CONJUNCTION WITH THE DEPARTMENT, TAKE MEASURES NECESSARY TO ENSURE PUBLIC HEALTH AND SAFETY, IF SUSTAINED DETECTABLE CONCENTRATIONS OF COMBUSTIBLE GAS SATISFY ANY OF THE FOLLOWING:

(1) GREATER THAN 1% AND LESS THAN 10% OF THE L.E.L., IN A BUILDING OR STRUCTURE;

(2) EQUAL TO OR GREATER THAN 25% OF THE L.E.L. IN A WATER WELL HEAD SPACE;

(3) DETECTABLE IN THE SOILS; OR

(4) EQUAL TO OR GREATER THAN 7 MG/L DISSOLVED METHANE IN WATER.

(E) THE DEPARTMENT MAY REQUIRE THE OPERATOR TO TAKE THE FOLLOWING ADDITIONAL ACTIONS:

(1) CONDUCT A FIELD SURVEY TO ASSESS THE PRESENCE AND CONCENTRATIONS OF COMBUSTIBLE GAS AND THE AREAL EXTENT OF THE COMBUSTIBLE GAS IN THE SOILS, SURFACE WATER BODIES, WATER WELLS, AND OTHER POTENTIAL MIGRATION PATHWAYS;

(2) COLLECT GAS AND/OR WATER SAMPLES AT A MINIMUM FOR MOLECULAR AND STABLE CARBON AND HYDROGEN ISOTOPE ANALYSES FROM THE IMPACTED LOCATIONS SUCH AS WATER WELLS, AND FROM POTENTIAL SOURCES OF THE MIGRATION SUCH AS GAS WELLS;

(3) CONDUCT AN IMMEDIATE EVALUATION OF THE OPERATOR'S ADJACENT OIL OR GAS WELLS TO DETERMINE WELL CEMENT AND CASING INTEGRITY AND TO EVALUATE THE POTENTIAL MECHANISM OF MIGRATION. THIS EVALUATION MAY INCLUDE ASSESSING PRESSURES FOR ALL CASING INTERVALS, REVIEWING RECORDS FOR INDICATIONS OF DEFECTIVE CASING OR CEMENT, APPLICATION OF CEMENT BOND LOGS, ULTRASONIC IMAGING TOOLS, GEOPHYSICAL LOGS, AND OTHER MECHANICAL INTEGRITY TESTS AS REQUIRED. THE INITIAL AREA OF ASSESSMENT SHALL INCLUDE WELLS WITHIN A RADIUS OF 2,500 FEET AND MAY BE EXPANDED IF REQUIRED BY THE DEPARTMENT;

(4) TAKE ACTION TO CORRECT ANY DEFECT IN THE OIL AND GAS WELLS TO MITIGATE THE STRAY GAS INCIDENT.

(5) ESTABLISH MONITORING LOCATIONS AND MONITORING FREQUENCY IN CONSULTATION WITH THE DEPARTMENT AT POTENTIAL SOURCES, IN POTENTIALLY IMPACTED STRUCTURES, AND THE SUBSURFACE.

(F) IF CONCENTRATIONS OF STRAY NATURAL GAS AS DEFINED IN SUBSECTIONS (C) OR (D) ARE NOT DETECTED, THE OPERATOR SHALL NOTIFY THE DEPARTMENT, AND DO THE FOLLOWING IF REQUESTED BY THE DEPARTMENT:

(1) CONDUCT ADDITIONAL MONITORING,
(2) DOCUMENT FINDINGS
(3) SUBMIT A CLOSURE REPORT.

(G) *REPORTING REQUIREMENTS* - IF CONCENTRATIONS OF STRAY NATURAL GAS ARE DETECTED INSIDE A BUILDING OR STRUCTURE AT CONCENTRATIONS EQUAL TO OR GREATER THAN 10% OF THE L.E.L., THE OPERATOR AND OWNER SHALL FILE A REPORT WITH THE DEPARTMENT BY PHONE AND EMAIL WITHIN 24 HOURS AFTER THE INTERVIEW WITH THE COMPLAINANT AND FIELD SURVEY OF THE EXTENT OF STRAY NATURAL GAS. ADDITIONAL DAILY OR WEEKLY REPORTS SHALL BE SUBMITTED IF REQUESTED BY THE DEPARTMENT.

(D) FOR ALL STRAY NATURAL GAS MIGRATION INCIDENTS, A FINAL WRITTEN REPORT DOCUMENTING THE RESULTS OF THE INVESTIGATION SHALL BE SUBMITTED TO THE DEPARTMENT FOR APPROVAL WITHIN 30 DAYS OF THE CLOSE OF THE INCIDENT, OR IN A TIMEFRAME OTHERWISE APPROVED BY THE DEPARTMENT. THE FINAL REPORT SHALL INCLUDE THE FOLLOWING

(1) DOCUMENTATION OF ALL RESULTS OF THE INVESTIGATION, INCLUDING ANALYTICAL DATA, MONITORING RESULTS
(2) OPERATIONAL CHANGES ESTABLSIHED AT THE OPERATOR'S OIL AND GAS WELLS IN PENNSYLVANIA
(3) MEASURES TAKEN BY THE OPERATOR TO REPAIR ANY DEFECTS AT ANY OF THE INVESTIGATED OIL AND GAS WELLS.

(E) ALL REPORTS SUBMITTED IN ACCORDANCE WITH THIS SECTION THAT CONTAIN AN ANALYSIS OF GEOLOGICAL OR ENGINEERING DATA SHALL BE PREPARED AND SEALED BY A PENNSYLVANIA LICENSED GEOLOGIST OR ENGINEER.

PLUGGING

§ 78.92. Wells in coal areas—surface or coal protective casing is cemented.

(a) In a well underlain by a workable coal seam, where the surface casing or coal protective casing is cemented and the production casing is not cemented or the production casing is not present, the owner or operator shall plug the well as follows:

(1) The retrievable production casing shall be removed **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater. [and the] The** well shall be filled with nonporous material from the total depth or attainable bottom of the well, to a point **50 feet** below **[20 feet above the top of]** the lowest stratum bearing or having borne oil, gas or water. At this point there shall be placed a plug of cement, which shall extend for at least 50 feet above **this stratum [that point]. Each overlying formation bearing or having borne oil, gas or water shall be plugged with cement a minimum of 50 feet below this formation to a point 50 feet above this formation. The zone between cement plugs shall be filled with nonporous material. [Between this sealing plug and a point 20 feet above the next higher stratum bearing or having borne oil, gas or water, the hole shall be filled with nonporous material and at that point there shall be placed another 50-foot plug of cement which] The cement plugs shall be placed in a manner that** will completely seal the hole. **[In like manner, the hole shall be filled and plugged, with reference to each of the strata bearing or having borne oil, gas or water.]** The operator may treat multiple strata as one stratum and plug as described in this subsection with a single column of cement or other materials approved by the Department. Where the production casing is not retrievable, the operator shall plug that portion of the well under § 78.91(d) (relating to general provisions).

* * * * *

(b) The owner or operator shall plug a well, where the surface casing, coal protective casing and production casing are cemented, as follows:

* * * * *

(3) Following the plugging of the cemented portion of the production casing, the uncemented portion of the production casing shall be separated from the cemented portion and retrieved **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater** . The maximum distance the stub of the uncemented portion of the production casing may extend is 100 feet below the surface or coal protective casing whichever is lower. In no case may the uncemented portion of the

casing left in the well extend through a formation bearing or having borne oil, gas or water. Other stratum above the cemented portion of the production casing bearing or having borne oil, gas or water shall be plugged by filling the hole with nonporous material to 20 feet above the stratum and setting a 50-foot plug of cement. The operator may treat multiple strata as one stratum and plug as described in this subsection with a single column of cement or other material as approved by the Department. When the uncemented portion of the production casing is not retrievable, the operator shall plug that portion of the well under § 78.91(d).

§ 78.93. Wells in coal areas—surface or coal protective casing anchored with a packer or cement.

(a) In a well where the surface casing or coal protective casing and production casing are anchored with a packer or cement, the owner or operator shall plug the well as follows:

(1) The retrievable production casing shall be removed **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater.**

[and the] **The** well shall be filled with nonporous material from the total depth or attainable bottom of the well, to a point **50 feet below** **[20 feet above the top of]** the lowest stratum bearing or having borne oil, gas or water. At this point there shall be placed a plug of cement, which shall extend for at least 50 feet above **this stratum** **[that point]. Each overlying formation bearing or having borne oil, gas or water shall be plugged with cement a minimum of 50 feet below this formation to a point 50 feet above this formation. The zone between cement plugs shall be filled with nonporous material. [Between this sealing plug and a point 20 feet above the next higher stratum bearing or having borne oil, gas or water, the hole shall be filled with nonporous material and at that point there shall be placed another 50-foot plug of cement which]** **The cement plugs shall be placed in a manner that** will completely seal the hole. **[In this manner, the hole shall be filled and plugged, with reference to each of the strata bearing or having borne oil, gas or water.]** The operator may treat multiple strata as one stratum and plug as described in this subsection with a single column of cement or other material as approved by the Department. When the production casing is not retrievable, the operator shall plug this portion of the well under § 78.91(d) (relating to general provisions).

(2) The well shall then be filled with nonporous material to a point approximately 200 feet below the lowest workable coal seam, or surface or coal protective casing seat, whichever is deeper. Beginning at this point a 100-foot plug of cement shall be installed.

(3) After it has been established that the surface casing or coal protective casing is free and can be retrieved, the surface or coal protective casing shall be retrieved **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120%**

whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater. **[and a]** **A** string of casing with an outside diameter of not less than 4 1/2 inches for gas wells, or not less than 2 inches for oil wells, shall be run to the top of the 100-foot plug described in paragraph (2) and cemented to the surface.

* * * * *

§ 78.94. Wells in noncoal areas—surface casing is not cemented or not present.

(a) The owner or operator shall plug a noncoal well, where the surface casing and production casing are not cemented, or is not present as follows:

(1) The retrievable production casing shall be removed **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater.** The well shall be filled with nonporous material from the total depth or attainable bottom of the well, to a point **50 feet below [20 feet above the top of]** the lowest stratum bearing or having borne oil, gas or water. At this point there shall be placed a plug of cement, which shall extend for at least 50 feet above **this stratum [that point]. Each overlying formation bearing or having borne oil, gas or water shall be plugged with cement a minimum of 50 feet below this formation to a point 50 feet above this formation. The zone between cement plugs shall be filled with nonporous material. [Between this sealing plug and a point 20 feet above the next higher stratum bearing or having borne oil, gas or water, the hole shall be filled with nonporous material and at that point there shall be placed another 50-foot plug of cement which] The cement plugs shall be placed in a manner that** will completely seal the hole. **[The hole shall be filled and plugged, with reference to each of the strata bearing or having borne oil, gas or water.]** The operator may treat multiple strata as one stratum and plug as described in this paragraph with a single column of cement or other materials as approved by the Department. When the production casing is not retrievable, the operator shall plug this portion of the well under § 78.91(d) (relating to general provisions).

(2) After plugging strata bearing or having borne oil, gas or water, the well shall be filled with nonporous material to approximately 100 feet below the surface casing seat and there shall be placed another plug of cement or other equally nonporous material approved by the Department extending at least 50 feet above that point.

(3) After setting the uppermost 50-foot plug, the retrievable surface casing shall be removed **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to**

separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater. [and the] The hole shall be filled from the top of the 50-foot plug to the surface with nonporous material other than gel. If the surface casing is not retrievable, the hole shall be filled from the top of the 50-foot plug to the surface with a noncementing material.

* * * * *

§ 78.95. Wells in noncoal areas—surface casing is cemented.

(a) The owner or operator shall plug a well, where the surface casing is cemented and the production casing is not cemented or not present, as follows:

(1) The retrievable production casing shall be removed **by applying a pulling force at least equal to the casing weight plus 5000 pounds or 120% whichever is greater. If this fails, an attempt shall be made to separate the casing by cutting, ripping, shooting or other method approved by the Department, and making a second attempt to remove the casing by exerting a pulling force equal to the casing weight plus 5,000 pounds or 120 percent of the casing weight, whichever is greater. [and] T[t]**he well shall be filled with nonporous material from the total depth or attainable bottom of the well, to a point **50 feet below [20 feet above the top of]** the lowest stratum bearing or having borne oil, gas or water. At this point there shall be placed a plug of cement, which shall extend for at least 50 feet above **this stratum [that point]. Each overlying formation bearing or having borne oil, gas or water shall be plugged with cement a minimum of 50 feet below this formation to a point 50 feet above this formation. The zone between cement plugs shall be filled with nonporous material. [Between this sealing plug and a point 20 feet above the next higher stratum bearing or having borne oil, gas or water, the hole shall be filled with nonporous material and at that point there shall be placed another 50-foot plug of cement] The cement plugs shall be placed in a manner that will completely seal the hole. [The hole shall be filled and plugged, with reference to each of the strata bearing or having borne oil, gas or water.]** The operator may treat multiple strata as one stratum and plug as described in this subsection with a single column of cement or other materials as approved by the Department. When the production casing is not retrievable, the operator shall plug this portion of the well under § 78.91(d) (relating to general provisions).

* * * * *

§ 78.96. Marking the location of a plugged well**.**

(a) Upon the completion of plugging or replugging a well, the operator shall erect over the plugged well a permanent marker of concrete, metal**, plastic or equally durable material [or metal and concrete].** The marker shall extend at least 4 feet above the ground surface and enough below the surface to make the marker permanent. **Cement**

may be used to hold the marker in place provided the cement does not prevent inspection of the adequacy of the well plugging. The permit or registration number shall be stamped or cast or otherwise permanently affixed to the marker. In lieu of placing the marker above the ground surface, the marker may be buried below plow depth and shall contain enough metal to be detected at the surface by conventional metal detectors

* * * **

SUBCHAPTER E. WELL REPORTING

§ 78.121. **[Annual] P[p]**roduction report**ing.**

(a) The well operator shall submit an annual production and status report for each **PERMITTED OR REGISTERED** well on an individual basis, on or before **[March 31] February 15** of each year. **The operator of a well [~~which produces gas~~] PERMITTED TO PRODUCE GAS from the Marcellus shale formation shall submit a production and status report for each well on an individual basis, on or before February 15 and August 15 of each year.** Production shall be reported for the preceding calendar year **or in the case of a Marcellus shale well, for the preceding six months**. When the production data is not available to the operator on a well basis, the operator shall report production on the most well-specific basis available. The annual production report [~~**shall**~~] **MUST** include information on the amount and type of waste produced and the method of waste disposal or reuse. Waste information submitted to the Department in accordance with this subsection [~~**shall**~~] **IS DEEMED TO** satisfy the residual waste biennial reporting requirements of § 287.52 (relating to biennial report).

(b) The **[~~annual~~]** production report shall be submitted **ELECTRONICALLY TO THE DEPARMENT THROUGH ITS WEBSITE.[on forms prescribed by, and available from, the Department or in a similar manner approved by the Department.]**

§ 78.122. Well record and completion report**.**

(a) For each well that is drilled or altered, the operator shall keep a detailed drillers log at the well site available for inspection until drilling is completed. Within 30 calendar days of cessation of drilling or altering a well, the well operator shall submit a well record to the Department on a form provided by the Department that includes the following information:

* * * * *

(6) Size and depth of conductor pipe, surface casing, coal protective casing, **INTERMEDIATE CASING,** production casing and borehole.

* * * * *

[~~(9)~~] (10) A certification by the operator that the well has been constructed in accordance with this chapter and any permit conditions imposed by the Department.

[(10)] 11 Other information required by the Department.

(b) Within 30 calendar days after completion of the well, the well operator shall submit a completion report to the Department on a form provided by the Department that includes the following information:

(1) Name, address and telephone number of the permittee.

(2) Name, address and telephone number of the service companies.

(3) Permit number and farm name and number.

(4) Township and county.

(5) Perforation record.

(6) Stimulation record **WHICH INCLUDES THE FOLLOWING:** [~~**including pump rates, pressure, total volume and list of hydraulic fracturing chemicals used, the volume of water used, and identification of water sources used pursuant to an approved water management plan.**~~]

(I) A DESCRIPTIVE LIST OF THE CHEMICAL ADDITIVES IN THE STIMULATION FLUID, INCLUDING ANY ACID, BIOCIDE, BREAKER, BRINE, CORROSION INHIBITOR, CROSSLINKER, DEMULSIFIER, FRICTION REDUCER, GEL, IRON CONTROL, OXYGEN SCAVENGER, PH ADJUSTING AGENT, PROPPANT, SCALE INHIBITOR, AND SURFACTANT;

(II) THE PERCENT BY VOLUME OF EACH CHEMICAL ADDITIVE IN THE STIMULATION FLUID;

(III) A LIST OF THE CHEMICALS IN THE MATERIAL SAFETY DATA SHEETS, BY NAME AND CHEMICAL ABSTRACT SERVICE NUMBER, CORRESPONDING TO THE APPROPRIATE CHEMICAL ADDITIVE;

(IV) THE PERCENT BY VOLUME OF EACH CHEMICAL LISTED IN THE MATERIAL SAFETY DATA SHEETS;

(V) THE TOTAL VOLUME OF THE BASE FLUID;

(VI) A LIST OF WATER SOURCES USED PURSUANT TO AN APPROVED WATER MANAGEMENT PLAN AND THE VOLUME OF WATER USED FROM EACH SOURCE;

(VII) THE TOTAL VOLUME OF RECYCLED WATER USED; AND

(VIII) THE PUMP RATE AND PRESSURE USED IN THE WELL.

(7) Actual open flow production and **[rock]** [~~**reservoir**~~**]** **SHUT IN SURFACE** pressure.

(8) Open flow production and **[rock]** [~~**reservoir**~~**]** **SHUT IN SURFACE** pressure, measured 24 hours after **[treatment]** **completion**.

(c) [~~No information described in subsection (b)(5)—(8) will be required as part of the report unless the operator has had the information compiled in the ordinary course of business. No interpretation of the data is to be filed.~~] **WHEN THE WELL OPERATOR SUBMITS A STIMULATION RECORD, IT MAY DESIGNATE SPECIFIC PORTIONS OF THE STIMULATION RECORD AS CONTAINING A TRADE SECRET OR CONFIDENTIAL PROPRIETARY INFORMATION. THE DEPARTMENT SHALL PREVENT DISCLOSURE OF SUCH DESIGNATED CONFIDENTIAL INFORMATION TO THE EXTENT PERMITTED BY THE RIGHT TO KNOW LAW, 65 P.S. 67.101 ET SEQ.**

(D) IN ADDITION TO SUBMITTING A STIMULATION RECORD TO THE DEPARTMENT PURSUANT TO SUBSECTION (B), AND SUBJECT TO THE PROTECTIONS AFFORDED FOR TRADE SECRETS AND CONFIDENTIAL PROPRIETARY INFORMATION UNDER THE RIGHT TO KNOW LAW, 65 P.S. 67.101 ET SEQ., THE OPERATOR SHALL ARRANGE TO PROVIDE A LIST OF THE CHEMICAL CONSTITUENTS OF THE CHEMICAL ADDITIVES USED TO HYDRAULICALLY FRACTURE A WELL, BY CHEMICAL NAME AND ABSTRACT SERVICE NUMBER, UNLESS THE ADDITIVE DOES NOT

HAVE SUCH A NUMBER, TO THE DEPARTMENT UPON WRITTEN REQUEST BY THE DEPARTMENT.

* * * * *

Notice of Final Rulemaking
Department of Environmental Protection
Environmental Quality Board
25 *Pa. Code,* Chapter 78
Oil and Gas Well Cementing and Casing

Order

The Environmental Quality Board (Board) by this order amends 25 *Pa. Code*, Chapter 78 (relating to oil and gas well requirements) as set forth in Annex A.

Properly constructed and operated oil and gas wells are critical to protecting water supplies and public safety. If a well is not properly cased and cemented, natural gas in subsurface formations may potentially migrate from the wellbore through bedrock and soil. This stray gas may adversely affect water supplies, as well as accumulate in or adjacent to structures such as residences and water wells. Under certain conditions, stray gas has the potential to cause a fire or explosion. These situations present a serious threat to public health and safety as well as the environment. The purpose of this final rulemaking is to improve drilling, casing, cement, testing, monitoring and plugging requirements for oil and gas wells to minimize gas migration and protect water supplies.

The final form rulemaking differs from the proposed rulemaking in several important respects. The differences reflect the concerns raised by the regulated community and the public, resulting in an improved rule. The changes to the final form rulemaking strengthen well design requirements to prevent gas migration incidents.

The significant revisions to the final form rulemaking include: the addition of a provision that requires operators to have a pressure barriers plan to minimize well control events; the addition of a provision that requires operators to keep a list of emergency contact phone numbers at the well site; amended provisions that clarify how and when blow-out prevention equipment is to be installed and operated; the addition of a provision that requires operators to condition the wellbore to ensure an adequate bond between the cement, casing and the formation; the addition of provisions that require the use of centralizers to ensure that casings are properly positioned in the wellbore; the addition of a provision that improves the quality of the cement placed in the casing that protects fresh groundwater; the addition of provisions that specify the actions an operator must take in the event of a gas migration incident; and revisions to the reporting requirements for chemicals used to hydraulically fracture a well.

This order was adopted by the Board at its meeting of _____(blank)_____.

A. Effective Date

These amendments will go into effect upon publication in the *Pennsylvania Bulletin* as final rulemaking.

B. Contact Persons

For further information contact Scott R. Perry, Director, Bureau of Oil and Gas Management, Rachel Carson State Office Building, 5th Floor, P.O. Box 8765, Harrisburg, PA 17105-8461, (717) 772-2199; or Elizabeth A. Nolan, Assistant Counsel, Bureau of Regulatory Counsel, Rachel Carson State Office Building, 9th Floor, P.O. Box 8464, Harrisburg, PA 17105-8464, (717) 787-7060. Persons with a disability may use the AT&T Relay Service by calling (800) 654-5984 (TDD users) or (800) 654-5988 (voice users). This final form rulemaking is available on the Department of Environmental Protection's website at http://www.dep.state.pa.us

C. Statutory Authority

The final form rulemaking is being made under the authority of Section 604 of the Oil and Gas Act (58 P.S. § 601.604), which directs the Board to adopt regulations necessary to implement the Act, and Section 1917-A and 1920-A of the Administrative Code (71 P.S. §§ 510-17 and 510-20). Section 1917-A authorizes and requires the Department to protect the people of this Commonwealth from unsanitary conditions and other nuisances, including any condition that is declared to be a nuisance by any law administered by the Department. Section 1920-A authorizes the Board to promulgate regulations of the Department.

D. Background of the Amendments

Many of the regulations governing well construction and water supply replacement were promulgated in July 1989 and remained largely unchanged until this rulemaking. Since that time, recent advances in drilling technology have attracted interest in producing natural gas from the Marcellus Shale, a rock formation that underlies approximately two-thirds of Pennsylvania. New well drilling and completion practices now employed to extract natural gas from the Marcellus Shale and other similar shale formations in Pennsylvania, as well as several recent incidents of contaminated drinking water caused by traditional and Marcellus Shale wells resulted in the Department's decision to re-evaluate the existing well construction requirements.

It was determined that the existing regulations were not specific enough in detailing the Department's expectations of a properly cased and cemented well, especially in light of the new techniques used by Marcellus Shale operators. The Department also determined that the existing regulations did not address the need for an immediate response by operators to a gas migration complaint and did not require routine inspection of existing wells by the operator.

The final rulemaking contains revised design, construction, operational, monitoring, plugging, water supply replacement, and hydraulic fracturing reporting requirements. The final rulemaking also provides material specifications and performance testing to ensure the proper casing, cementing and operation of a well. Additionally, the final rulemaking contains new provisions that require routine inspection of wells and outline the actions an operator and the Department must take in the event of a gas migration incident.

The proposed rulemaking was published in the *Pennsylvania Bulletin* on July 10, 2010. See 40 *Pa.B.* 3845 (July 10, 2010). The public comment period closed on August 9, 2010. In addition,

five public hearings were held: July 19, 2010, in Tunkhannock, PA; July 21, 2010, in Williamsport, PA; July 22, 2010, in Meadville, PA; July 22, 2010, in Pittsburgh, PA; and July 26, 2010, in Pittsburgh, PA.

Prior to recommending that the proposed regulations be offered to the Environmental Quality board, the Oil and Gas Technical Advisory board (TAB) formed a technical subcommittee with representatives from various companies, trade groups and consultants to review and provide comments on the proposed rulemaking. The Department met with TAB and this subcommittee on October 28, 2009, January 14, 2010, January 21, 2010 and March 25, 2010.

The Department presented the draft final form rulemaking to TAB on September 16, 2010. During this discussion, TAB members made several recommendations regarding the definition of unconventional formations, use of blow-out preventers, cementing the intermediate casing, producing gas off the intermediate casing, and the actions the operator must take when it loses circulation of cement. At the conclusion of the meeting, TAB members were not able to endorse nor disapprove the rulemaking and instead expressed an interest in having the TAB subcommittee review the amendments to the final form rulemaking.

E. Summary of Comments and Responses

The Board received approximately 2,000 comments regarding the proposed Oil and Gas Well Casing and Cementing regulations during the public hearings and public comment period. Many of the comments received sought clarification or additional protective measures. The majority of comments were supportive of the proposal.

Several commentators made suggestions seeking to clarify the definition of "deepest fresh groundwater, including suggesting that the term be defined with reference to certain levels of total dissolved solids (TDS) ranging from 500 to 10,000 mg/l TDS. The Board appreciated these comments, but decided that numerical criteria should not be used to define deepest fresh groundwater because many water supplies provide water that exceed the 500 mg/l drinking water standard, but 10,000 mg/l is far too saline for Pennsylvania drinking water supplies. It is critical that the casing be set deep enough to isolate usable water supplies but not so deep that brine be permitted to co-mingle with fresh groundwater. It is also important to recognize that testing water produced during drilling will not yield accurate test results. For these reasons, the final form rulemaking has been amended to require operators to identify how the deepest fresh groundwater was determined and record the information in the casing and cementing plan.

Many commentators sought clarification regarding the provisions that require an operator who affects a water supply to restore or replace the affected water supply with an alternate supply adequate in quantity and quality for the purposes served by the supply. The amendments to § 78.51 reflect the Department's interpretation of an adequate alternate water supply according to recent caselaw.

Several commentators suggest that all replaced or restored water should meet safe drinking water standards. The Board deems a supply adequate if it meets safe drinking water standards or is comparable to the unaffected water supply if that water supply didn't meet those standards.

A commentator was uncertain about who would determine reasonable foreseeable uses. The regulation states that it is the duty of the Department to determine if the operator is in compliance with this subsection.

Additionally, several commentators were concerned that § 78.51(h) did not provide a timely response for affected water supplies. The Board agrees and amends § 78.51(h) to require operators to notify the Department within 24 hours of receiving a report that a water supply has been affected by pollution of diminution caused by drilling activities.

Several commentators objected to the provisions that would allow the use of used pipe. The Board considers used casing to be acceptable in certain applications, notably in low pressured shallow oil wells that do not produce gas. In these instances, used casing has been utilized successfully and has been shown to be suitable for long-term use in these applications. All used casing, however, is subject to the casing integrity requirement of § 78.84(b), as well as new requirements for pressure testing in § 78.84(c).

Many commentators suggested amendments to § 78.85(b) that would require a 72-hour compressive strength standard of at least 1,200 psi across critical zones of cement at the bottom of the casing seat where the highest pressures and stresses are likely to be encountered and in places where the well bore passes through aquifers and drinking water. The Board agrees and has amended §78.85(b) to require a zone of critical cement at the surface casing seat which must achieve a 72-hour compressive strength of 1200 psi and have a free-water separation of no more than six milliliters per 250 milliliters of cement.

Several commentators suggest that the cement ticket include testing of pH, temperature, and a record of the wait on cement time. The Board agrees and the regulation has been revised accordingly.

Some commentators objected to the quarterly mechanical integrity inspections required by §78.88(a), arguing that the requirement is excessive. While several commentators believed that quarterly inspections were not enough, other commentators supported § 78.88(a) quarterly inspection requirements. The Board has decided that quarterly inspections are sufficient to ensure that well pressures are within allowable limits and the casing is structurally sound. The Board does not consider quarterly mechanical integrity testing to be excessive. Rather, the inspections provide the operator an opportunity to correct problems at the well before such problems create a condition that will require significant time and expense to address. The Board has also determined that required evaluation of the well does not include invasive procedures.

Several commentators made suggestions to § 78.89 regarding the gas migration response requirements, including a provision requiring immediate notification to the Department. The Board agrees and has amended the final form rulemaking to require the operator to immediately conduct an investigation and contact the Department.

Commentators suggested that operators conduct an initial response action to determine the nature of the incident, assess the potential for hazards to public health and safety, and mitigate any hazard posed by the concentration of stray natural gas in the environment. Commentators

suggested what the investigation include a site visit and an interview of the complainant. Commentators suggested that the actions that an operator must take in the event of a reported gas migration incident be delineated by the concentration of combustible gas detected in the investigation. Commentators also suggested other additional investigation and mitigation measures that operators should be required to take, including a field survey, the collection of gas and/or water samples, the establishment of monitoring locations, and an evaluation of the operator's adjacent wells. Commentators also suggested certain reporting requirements following a reported gas migration incident. The Board agrees with many of the commentators suggestions and has revised § 78.89. These changes largely follow the commentators' suggestions. The revisions also require continued monitoring of gas migration complaints where the levels of dissolved methane in the water supply exceed 7 milligrams per liter. This level is based on 25% of the capacity of water to contain dissolved methane under one atmosphere of pressure. This number is much more certain and scientifically based than the unknown "background" level proposed by the commentator.

Commentators suggested that the information required in the completion report's stimulation record be expanded to require more specific information, including information regarding the chemical additives used and a the chemicals listed in the operator's Material Safety Data Sheets by Chemical Abstract Number. Other commentators object to requirements that require operators to submit confidential information and suggest that the issue of confidentiality be addressed in § 78.122. The Board has expanded the stimulation record requirements in subsection §78.122(b)(6) to include the Chemical Abstract Number for each Material Safety Data Sheet-listed hydraulic fracturing chemical used, as well as the percent (by volume) of each listed chemical used. The Board has also amended this subsection allowing the designation of confidential or trade secret information. The Department shall prevent disclosure of such designated confidential information to the extent permitted by the Right To Know Law, 65 P.S. 67.101 et seq.

F. Summary of Final Form Regulation and Changes from Proposed to Final Form Rulemaking

§ 78.1. Definitions.

Section 78.1 amends the definitions of the following terms to improve clarity or to explain new or existing provisions: "casing seat," "cement" and "surface casing." Section 78.1 also adds definitions for the following terms to explain new or existing provisions within Chapter 78: "cement job log," "conductor pipe" and "intermediate casing."

The final form rulemaking amends the following definitions listed above in response to public comment to improve clarity: "casing seat," "cement job log," "intermediate casing" and "surface casing."

Section 78.1 removes the definition of "retrievable" and inserts the substantive portion of the definition into the appropriate plugging regulations.

The final form rulemaking § 78.1 adds definitions for “L.E.L” and “unconventional formation.”

§ 78.51. Protection of water supplies.

The Oil and Gas Act requires an operator who affects a water supply by pollution or diminution as a result of gas or oil well drilling to restore or replace the affected water supply. Section 78.51 reflects current caselaw regarding an operator’s duty to replace or restore a water supply.

Section 78.51(d)(2) provides that a restored or replaced water supply must meet safe drinking water standards. If the pre-contamination water supply did not meet safe drinking water standards, the operator must restore or replace the contaminated water supply with a supply that is comparable to the water supply that existed prior to contamination.

Section 78.51(d)(1)(v) requires the operator to provide permanent payment for any increased cost to operate or maintain the restored or replaced water supply. Sections 78.51(d)(3)(i) and 78.51(d)(3)(ii) clarify that the replaced or restored water supply must be able to satisfy the water user’s needs.

The final form rulemaking modifies proposed § 78.51 (d) to provide uniform terms and add clarity and amends § 78.51(h), in response to public comment, providing that an operator who receives notice that a water supply has been affected by pollution or diminution must notify the Department within twenty-four hours of receiving that notice.

§ 78.52 Predrilling or prealteration survey.

Section 78.52(d) provides that an operator must provide the Department and the landowner or water purveyor with the results of their predrilling survey within ten business days of receiving the survey results. The final form rulemaking establishes that survey results not received within ten days may not be used to preserve the operator’s defenses under § 601.208(d)(1) of the Oil and Gas Act.

§ 78.55. Control and disposal plan.

Section 78.55(b) of the final form rulemaking establishes that an operator’s control and disposal plan must include a pressure barrier policy identifying the pressure barriers to be used during identified well drilling and completion operations. The final form rulemaking section 78.55(e) provides that an operator’s control and disposal plan must also contain a list of emergency contact phone numbers and that this list must also be displayed at the well site.

Section 78.55(d) of the final form rulemaking establishes that an operator’s control and disposal plan must be available at the well site during well drilling and completion operations.

§ 78.71. Use of safety devices—well casing.

Section 78.71(a) clarifies that the well control equipment must be attached to casing that is cemented in place.

§ 78.72. Use of safety devices—blow-out prevention equipment.

Section 78.72(a) of the final form rulemaking clarifies when blow-out equipment must be used. The final form rulemaking specifies that blow-out equipment must be must be used when drilling a well intending to produce from an unconventional formation and when drilling out solid core hydraulic fracturing plugs to complete a well.

Section 78.72(c) establishes that controls for the blow-out preventer must be accessible in case of an emergency. The final form rulemaking §78.72(c) specifies that controls for a blow-out preventer with a high pressure rating must be located at least 50 feet away from the drilling rig to assure accessibility in the event of loss of well control.

Section 78.72 (f) was amended to clarify when drilling must cease when blow-out prevention equipment is discovered to be in poor working order.

Section 78.72(h) of the final form rulemaking establishes that an individual with specified certifications must be at the well site when blow-out prevention equipment is being used and that those certifications must be available at the well site.

The final form rulemaking adds § 78.72(i), establishing that pressure barriers must be comprised of at least two mechanical pressure barriers between the open producing formation and the atmosphere. Additionally, these mechanical pressure barriers must be capable of being tested according to the manufacturers' specifications prior to operation. Moreover, if the operator has only one pressure barrier, operations must cease until additional pressure barriers are added or repaired and tested.

The final form rulemaking § 78.72(j) establishes that a hydraulic workover unit must be used during post-completion cleanout operations in unconventional formations.

The final form rulemaking specifies that intermediate casing must be cemented to surface, and now allows blow-out preventers to be attached to surface casing without regard to its length.

§ 78.73. General provision for well construction and operation.

Sections 78.73(a) and 78.73(b) further clarify that the well must be constructed and operated in a manner that protects public health and safety and the environment.

§ 78.73(c) reduces the allowable pressure that may be exerted on the surface and coal protective casing seats. The final form rulemaking clarifies how to calculate the pressure that must not be exceeded on the surface and coal protective casings. The final form rulemaking specifies that the pressure on the surface or coal protective casing seats is determined by

measuring the surface shut-in pressure and the surface producing back pressure exerted on the surface or coal protective casing.

Section 78.73(e) was added in the proposed rulemaking, requiring excess gas encountered during drilling to be flared, captured or diverted away from the drilling rig. Section 78.73(f) was also added in the proposed rulemaking, requiring check flow valves that prevent backflow from the pipelines into the well.

§ 78.75a. Area of alternative methods.

The Oil and Gas Act provides that the Department may approve alternative methods for the casing, plugging or equipping of a well. Section 78.75a, added in the proposed rulemaking, establishes procedures by which the Department may on its own initiative designate an area of alternative methods – an area that requires alternative drilling, casing, equipping, or plugging methods to operate the well in a safe and environmentally protective manner. Establishing such an area requires notice in the Pennsylvania Bulletin and an opportunity for the public to comment.

§ 78.81. General provisions.

Section 78.81(c), which stated that certain sections of the regulation do not apply to production or intermediate casings, is deleted to reflect new casing requirements.

§ 78.82. Use of conductor pipe.

The final form rulemaking § 78.82 clarifies that conductor pipe is used to stabilize the top hole of a well and must be driven into place or cemented from the seat to the surface to prevent the infiltration of water or other fluids into the subsurface.

§ 78.83 Surface and coal protective casing and cementing procedures.

Section 78.83(a) prohibits the use of surface casing as production casing and requires an additional string of casing to be installed in a well unless the well is only used to produce oil that does not present a threat to groundwater or if the operator of a gas well demonstrates that all gas and fluids will be contained in the well and installs a working pressure gauge that can be inspected by the Department.

The final form rulemaking deletes § 78.83(c), which gave operators the ability to drill to producing zones prior to isolating the fresh groundwater under certain circumstances, and adds a new § 78.83(c), requiring the use of air or freshwater based fluids when drilling through the fresh groundwater zone. Additionally, final form rulemaking § 78.83(c) specifies that the surface casing must be set fifty feet below the deepest fresh groundwater or at least fifty feet into consolidated rock, but not more than 200 feet below the deepest fresh groundwater unless necessary to set the casing in consolidating rock. The final form rulemaking also establishes that the wellbore must be conditioned prior to cementing.

The final form rulemaking amends §§ 78.83(c), (f), (g) and (i), mandating the use of centralizers to position the surface casing, coal protective casing, and any additional fresh groundwater casings in the wellbore. Subsections (f) and (i) have been further amended to require the additional water string to be cemented to the surface as opposed to 20 feet into the surface or coal protective casing.

§ 78.83a. Casing and cementing plan.

Section 78.83a establishes that operators must develop a casing and cementing plan that is available for the Department to review at the well site. The plan must describe the casing to be used and the cementing practices to be employed. The Department may request a copy of the plan for review and approval prior to drilling.

The final form rulemaking amends § 78.83a(a)(1) and (a)(6), specifying that the operator must include in its casing and cementing plan the method or information by which the depth of the deepest fresh groundwater was determined and the proposed wellbore conditioning procedures.

§ 78.83b. Casing and cementing—lost circulation.

Section 78.83b(a), added on proposed rulemaking, requires operators to notify the Department when cement used to protect fresh groundwater is not returned to the surface despite pumping more than 120% of the estimated required volume. If cement is not returned to the surface, the operator must determine the top of the cement and additional casing must be run and cemented, unless the well only produces oil off a vented production pipe if approved by the Department. Final form rulemaking § 78.83b(a)(1) clarifies what the operator must do when this happens and what additional measures must be taken.

The final form rulemaking adds § 78.83b(b) which provides that, in the event of lost circulation, the operator may, in addition to § 78.83a(a)'s requirements, pump additional cement through a pour string from the surface to fill the annular space.

§ 78.83c. Intermediate and production casing.

Section 78.83c, added on proposed rulemaking, specifies the cementing requirements for intermediate and production casing and establishes the pressure limitation for wells that produce gas off the annulus of the intermediate casing string.

The final form rulemaking adds a new § 78.83c(a) to require the intermediate and production borehole to be prepared prior to cementing.

The final form rulemaking amends § 78.83c(b) to mandate the use of centralizers when cementing the intermediate casing and requires the intermediate casing to be cemented to the surface.

The final form rulemaking amends § 78.83c(c) to mandate the use of centralizers when cementing the production casing and further specifies how much cement must be used to cement production casing.

§ 78.84. Casing standards.

The substantial amendments to § 78.84 require specified pressure ratings or pressure testing for different types of casings. Final form rulemaking § 78.84(d)(3) clarifies the certification requirements for a person welding casing.

The final form rulemaking § 78.84(f) clarifies that if the casing attached to the blow-out preventer has a pressure rating of greater then 3,000 psi, it must be pressure tested after it is cemented. To pass this pressure test, the casing must able to hold the anticipated maximum pressure to which the casing will be exposed for thirty minutes with not more than a ten percent decrease.

§ 78.85. Cement standards.

Section 78.85 provides additional standards for well casing cement, as well as references to ASTM International and American Petroleum Institute standards.

The final form rulemaking amends § 78.85(a)(4) and deletes proposed § 78.85(a)(5), clarifying that cement must protect the casing from corrosion and degradation, including that the cement used for coal protective casing must be formulated to withstand elevated sulfate concentrations in the surrounding wellbore. The final form rulemaking new § 78.85(a)(5) specifies that gas block additives and low fluid loss slurries must be used in areas of known shallow gas producing zones.

The final form rulemaking amends § 78.85(b) by adding requirements regarding surface casing cement. This subsection specifies that the cement at the bottom 300 feet of the surface casing constitutes a zone of critical cement, meaning that the cement in this zone must achieve a seventy-two hour compressive strength of 1,200 psi and the free water separation must not be more than six milliliters per 250 milliliters of cement.

The final form rulemaking amends § 78.85(c) by clarifying the actions that are prohibited during the mandatory eight-hour wait time on the cement for all casings.

The final form rulemaking § 78.85(f) specifies the information that must be included in the operator's cement job log.

§ 78.88. Mechanical integrity of operating well.

Section 78.88, added on proposed rulemaking, requires operators to inspect their wells at least quarterly for signs of physical degradation in addition to determining whether the pressure in the well is within allowable limits. Wells that fail inspection must be attended to immediately and the Department must be notified.

§ 78.89. Gas migration response.

Section 78.89 is substantially amended in the final form rulemaking to specify the actions an operator must take in the event of a gas migration incident. Section 78.89(a) of the final form rulemaking requires an operator to conduct an investigation immediately after it is notified or otherwise made aware of a potential gas migration incident to assess the nature of the incident, assess any potential hazards, and mitigate any hazards. Section 78.89(b) of the final form rulemaking specifies that the investigation must consist of a site visit, an interview of the complainant, a field survey, and if necessary, monitoring locations must be established. If the operator detects a high concentration of combustible gas inside a building or structure, the final-form rulemaking § 78.89(c) establishes that the operator must immediately notify the Department and local emergency response agencies, initiate mitigation measures and conduct further investigation and monitoring of the surrounding area.

Section 78.89(d) of the final form rulemaking specifies that if sustained detectable concentrations of combustible gas are detected at certain specified levels, the operator must notify the Department and take measures to ensure public health and safety. If the operator conducts an investigation and is not required to take the measures outlined in §§78.89(c) or (d), § 78.89(f) requires the operator to conduct additional monitoring, document its findings, and submit a report.

The final form rulemaking adds § 78.89(e) which establishes that the Department may require the operator to take additional investigative and monitoring measures in the event of a reported natural gas migration incident. The final form rulemaking §§ 78.89(g)-(i) provide additional notification and reporting requirements.

§§ 78.92–78.95. Plugging.

Sections 78.92–78.95 incorporate the substantive requirements of the eliminated definition of "retrievable" along with requiring an additional attempt to remove uncemented casing prior to plugging a well. The revised sections also require cement to be placed across the formerly producing formation as opposed to placing the cement plug on top of the formation as is the current requirement.

§ 78.96. Marking the location of a plugged well.

Section 78.96(a) permits the use of materials other than cement and metal to mark and hold a marker for a plugged well.

§ 78.121. Well record and completion report.

Section 78.121 incorporates the requirements of Act 15 of 2010 which mandate semi-annual production reporting of Marcellus Shale wells. In § 78.121(a), the dates are amended to reflect Act 15's requirements. Because Act 15 also requires the Department to post the production of Marcellus Shale wells on the Department's website, § 78.121(b) is amended to require that the production reports be submitted electronically.

§ 78.122. Well record and completion report.

Section 78.122(a)(10) requires the operator to certify that the well has been properly constructed. The final form rulemaking amends § 78.122(b)(6), requiring the operator to submit additional information in its completion report's stimulation record, including a descriptive list of the chemical additives used in the stimulation fluid, the percent by volume of those chemical additives, a list of the hazardous chemicals used in the stimulation fluid, the percent by volume of those hazardous chemicals, the total volume or water used and a list of the water sources used pursuant to an approved water management plan. The final form rulemaking § 78.122(c) provides that a well operator may designate any trade secrets or confidential proprietary information in the completion report and the Department will prevent disclosure of confidential information to the extent permitted by the Right to Know Law, 65 P.S. 67.101 *et seq.* Additionally, § 78.122(d) specifies that the operator must maintain records of every chemical used to hydraulically fracture the well and provide those records to the Department upon request.

G. Benefits, Costs and Compliance

Benefits

Both the residents of this Commonwealth and the regulated community will benefit from this regulation

The public will benefit in several ways. The updated casing and cementing requirements will provide an increased degree of protection for homeowners and both public and private water supplies. The construction standards will align Pennsylvania's regulations with other states' rules as well as current industry standards. Pressure testing the casing and testing surface casing seats will detect construction deficiencies before a well could create a potential safety or environmental problem. Minimizing annular pressure will reduce the potential for gas migration. The new quarterly inspections and annual reporting will be a vital tool for operators to use in detecting potential safety or environmental impacts before they may become an issue. The proposed regulations also outline the procedures the operator and the Department will utilize if there is a reported gas migration incident.

The new construction standards and the well remediation measures will far outweigh the liability to the operator from the potential impacts to public safety and harm to the environment from gas migration or from polluting water resources that may result without these additional precautions. As new areas of the Commonwealth are developed for natural gas, these proposed regulations will avoid many potential health, safety and environmental issues.

Compliance Costs

This rulemaking will impose minimal additional cost on the Department. This proposal will help the Department offset potential health, safety and environmental issues.

The Department finds that most gas migration issues stem from inadequate cementing procedures, cement returns, or combinations of inadequate casing and cementing or over-pressured casing seats. Because many of the Marcellus Shall well operators meet or exceed the current well casing and cementing regulations, any increased cost associated with drilling and operating oil and gas wells will be minimal. All of the potential increases in cost to an operator will be associated with assuring a well is properly completed, operated and plugged.

The potential increase in cost is minor when compared to the overall cost of well construction. Where cement is not returned to the surface or when excessive pressure is placed on the surface casing seat, the revised regulations require the operator to install an additional string of casing. The construction cost for the additional string of casing is about $10,000 per well.

Some commentators questioned the Department's estimate for the additional string of casing, stating that the cost of an additional casing string is much more than $10,000 per well, and is more likely on the order of $300,000 to $500,000 per well, depending on depth and area. The commentators stated that if the additional string of casing is justified from a technical standpoint, then it is the correct course of action. But nowhere do the proposed regulations provide a technical justification for an additional casing string.

The added expense described by the commentators does not apply to situations where cement is not returned to the surface. Where production casing is run and set on a packer or casing is set 50 feet deeper than the surface casing, the Department's estimate is sound. Instead, the scenario described more directly relates to the Board's decision to prohibit operators from comingling fresh groundwater with brine by setting very deep surface casing. By setting deep surface casing, operators avoid using deeper intermediate casing and costly cement and cementing practices.

The proposed casing design advocated by the commentators has resulted in several recent gas migration cases in Pennsylvania. These gas migration cases threaten the lives and safety of the citizens of the Commonwealth. The Board did not consider the expense of an intermediate string of casing when it crafted the regulations because the casing design advocated by the commentator results in an unlawful condition. Prohibiting gas migration is the cornerstone of these regulations and compromising on the issue to save money on a necessary string of casing is not acceptable.

Used casing, welded casing and casing attached to a blow-out preventer must be pressure tested to demonstrate its ability to withstand the highest anticipated working pressures to which the casing will be exposed. If the casing fails this test, the operator must repair of replace the casing and ultimately pass the pressure test. The cost to repair or replace the defective casing is completely outweighed by the environmental damage that would result from a failed string of casing and the fact that the casing would still need to be repaired or replaced.

The typical cost to develop a Marcellus Shale well is around $5,000,000. The additional cost of compliance would only be approximately 0.2% of the overall cost to develop a Marcellus Shale well.

The typical cost to develop a shallow gas well is $250,000 and the typical cost to develop an oil well is $200,000. In either situation, the additional cost of compliance would only be approximately 4% to 5% of the overall cost of the well.

All of the additional measures are proposed to reduce the potential for gas migration. If an operator fails to prevent a pollution event of a water supply, the anticipated cost to permanently replace one private water supply would be approximately $4,000 to drill a new water well or $30,000 to provide and permanently pay for a treatment system.

Compliance Assistance Plan

The Department has worked extensively with representatives from the regulated community and leaders the several trade organizations. The requirements of this regulation are, therefore, well known.

The Department, however, several scheduled training sessions for the regulated community to address the Department's regulatory requirements. The Department will use these training sessions as an opportunity to further education the industry about the new requirements.

Paperwork Requirements

The annual well inspection report, the semi-annual production report mandated by Act 15 for operators of Marcellus Shale wells and the additional information required in the completion report will require submittal of two additional forms and additional information on an existing form. The results of gas migration investigations will also require additional reporting obligations.

H. Pollution Prevention

The Federal Pollution Prevention Act of 1990 established a national policy that promotes pollution prevention as the preferred means for achieving state environmental protection goals. The Department encourages pollution prevention, which is the reduction or elimination of pollution at its source, through the substitution of environmentally friendly materials, more efficient use of raw materials, or the incorporation of energy efficiency strategies. Pollution prevention practices can provide greater environmental protection with greater efficiency because they can result in significant cost savings to facilities that permanently achieve or move beyond compliance. This regulation has incorporated the following pollution prevention provisions and incentives:

This regulation will minimize gas migration and will provide an increased degree of protection for both public and private water supplies by updating material specifications and performance testing as well as adding more specific design, construction, operational an monitoring requirements. The plugging, water supply replacement, and gas migrations reporting regulations have been amended to ensure that public safety and groundwater are protected.

I. Sunset Review

This regulation will be reviewed in accordance with the sunset review schedule published by the Department to determine whether the regulation effectively fulfills the goals for which it was intended.

J. Regulatory Review

Under section 5(a) of the Regulatory Review Act (71 P.S. § 745.5(a)), on June 25, 2010, the Department submitted a copy of the notice of proposed rulemaking, published at 40 *Pa.B.* 3845, to the Independent Regulatory Review Commission (IRRC) and the Chairpersons of the House and Senate Environmental Resources and Energy Committees for review and comment.

Under section 5(c) of the Regulatory Review Act, IRRC and the Committees were provided with copies of the comments received during the public comment period, as well as other documents when requested. In preparing these final form regulations, the Department has considered all comments from IRRC, the Committees and the public.

Under section 5.1(j.2) of the Regulatory Review Act, on ___(blank)___, these final form regulations were deemed approved by the House and Senate Committees. Under section 5.1(e) of the Regulatory Review Act, IRRC met on ____(blank)____ and approved the final form regulations.

K. Findings of the Board

The Board finds that:

(1) Public notice of proposed rulemaking was given under sections 201 and 202 of the act of July 31, 1968 (P.L. 769, No. 240) (45 P.S. §§ 1201 and 1202) and regulations promulgated thereunder at *1 Pennsylvania Code* §§ 7.1 and 7.2.

(2) A public comment period was provided as required by law, and all comments were considered.

(3) These regulations do not enlarge the purpose of the proposal published at 40 *Pa.B.* 3845.

(4) These regulations are necessary and appropriate for administration and enforcement of the authorizing acts identified in Section C of this order.

L. Order of the Board

The Board, acting under the authorizing statutes, orders that:

(1) The regulations of the Department of Environmental Protection, *25 Pennsylvania Code,* Chapter 78 are amended to read as set forth in Annex A.

(2) The Chairperson of the Board shall submit this order and Annex A to the Office of General Counsel and the Office of Attorney General for review and approval as to legality and form, as required by law.

(3) The Chairperson of the Board shall submit this order and Annex A to the Independent Regulatory Review Commission and the Senate and House Environmental Resources and Energy Committees as required by the Regulatory Review Act.

(4) The Chairperson of the Board shall certify this order and Annex A and deposit them with the Legislative Reference Bureau, as required by law.

(5) This order shall take effect immediately upon publication in the *Pennsylvania Bulletin*.

BY:

JOHN HANGER
Chairperson
Environmental Quality Board

Notice of Final Rulemaking
Department of Environmental Protection
Environmental Quality Board
25 *Pa. Code,* Chapter 78
Oil and Gas Well Cementing and Casing

Order

The Environmental Quality Board (Board) by this order amends 25 *Pa. Code*, Chapter 78 (relating to oil and gas well requirements) as set forth in Annex A.

Properly constructed and operated oil and gas wells are critical to protecting water supplies and public safety. If a well is not properly cased and cemented, natural gas in subsurface formations may potentially migrate from the wellbore through bedrock and soil. This stray gas may adversely affect water supplies, as well as accumulate in or adjacent to structures such as residences and water wells. Under certain conditions, stray gas has the potential to cause a fire or explosion. These situations present a serious threat to public health and safety as well as the environment. The purpose of this final rulemaking is to improve drilling, casing, cement, testing, monitoring and plugging requirements for oil and gas wells to minimize gas migration and protect water supplies.

The final form rulemaking differs from the proposed rulemaking in several important respects. The differences reflect the concerns raised by the regulated community and the public, resulting in an improved rule. The changes to the final form rulemaking strengthen well design requirements to prevent gas migration incidents.

The significant revisions to the final form rulemaking include: the addition of a provision that requires operators to have a pressure barriers plan to minimize well control events; the addition of a provision that requires operators to keep a list of emergency contact phone numbers at the well site; amended provisions that clarify how and when blow-out prevention equipment is to be installed and operated; the addition of a provision that requires operators to condition the wellbore to ensure an adequate bond between the cement, casing and the formation; the addition of provisions that require the use of centralizers to ensure that casings are properly positioned in the wellbore; the addition of a provision that improves the quality of the cement placed in the casing that protects fresh groundwater; the addition of provisions that specify the actions an operator must take in the event of a gas migration incident; and revisions to the reporting requirements for chemicals used to hydraulically fracture a well.

This order was adopted by the Board at its meeting of _____(blank)_____.

A. Effective Date

These amendments will go into effect upon publication in the *Pennsylvania Bulletin* as final rulemaking.

B. Contact Persons

For further information contact Scott R. Perry, Director, Bureau of Oil and Gas Management, Rachel Carson State Office Building, 5th Floor, P.O. Box 8765, Harrisburg, PA 17105-8461, (717) 772-2199; or Elizabeth A. Nolan, Assistant Counsel, Bureau of Regulatory Counsel, Rachel Carson State Office Building, 9th Floor, P.O. Box 8464, Harrisburg, PA 17105-8464, (717) 787-7060. Persons with a disability may use the AT&T Relay Service by calling (800) 654-5984 (TDD users) or (800) 654-5988 (voice users). This final form rulemaking is available on the Department of Environmental Protection's website at http://www.dep.state.pa.us

C. Statutory Authority

The final form rulemaking is being made under the authority of Section 604 of the Oil and Gas Act (58 P.S. § 601.604), which directs the Board to adopt regulations necessary to implement the Act, and Section 1917-A and 1920-A of the Administrative Code (71 P.S. §§ 510-17 and 510-20). Section 1917-A authorizes and requires the Department to protect the people of this Commonwealth from unsanitary conditions and other nuisances, including any condition that is declared to be a nuisance by any law administered by the Department. Section 1920-A authorizes the Board to promulgate regulations of the Department.

D. Background of the Amendments

Many of the regulations governing well construction and water supply replacement were promulgated in July 1989 and remained largely unchanged until this rulemaking. Since that time, recent advances in drilling technology have attracted interest in producing natural gas from the Marcellus Shale, a rock formation that underlies approximately two-thirds of Pennsylvania. New well drilling and completion practices now employed to extract natural gas from the Marcellus Shale and other similar shale formations in Pennsylvania, as well as several recent incidents of contaminated drinking water caused by traditional and Marcellus Shale wells resulted in the Department's decision to re-evaluate the existing well construction requirements.

It was determined that the existing regulations were not specific enough in detailing the Department's expectations of a properly cased and cemented well, especially in light of the new techniques used by Marcellus Shale operators. The Department also determined that the existing regulations did not address the need for an immediate response by operators to a gas migration complaint and did not require routine inspection of existing wells by the operator.

The final rulemaking contains revised design, construction, operational, monitoring, plugging, water supply replacement, and hydraulic fracturing reporting requirements. The final rulemaking also provides material specifications and performance testing to ensure the proper casing, cementing and operation of a well. Additionally, the final rulemaking contains new provisions that require routine inspection of wells and outline the actions an operator and the Department must take in the event of a gas migration incident.

The proposed rulemaking was published in the *Pennsylvania Bulletin* on July 10, 2010. See 40 *Pa.B.* 3845 (July 10, 2010). The public comment period closed on August 9, 2010. In addition,

five public hearings were held: July 19, 2010, in Tunkhannock, PA; July 21, 2010, in Williamsport, PA; July 22, 2010, in Meadville, PA; July 22, 2010, in Pittsburgh, PA; and July 26, 2010, in Pittsburgh, PA.

Prior to recommending that the proposed regulations be offered to the Environmental Quality board, the Oil and Gas Technical Advisory board (TAB) formed a technical subcommittee with representatives from various companies, trade groups and consultants to review and provide comments on the proposed rulemaking. The Department met with TAB and this subcommittee on October 28, 2009, January 14, 2010, January 21, 2010 and March 25, 2010.

The Department presented the draft final form rulemaking to TAB on September 16, 2010. During this discussion, TAB members made several recommendations regarding the definition of unconventional formations, use of blow-out preventers, cementing the intermediate casing, producing gas off the intermediate casing, and the actions the operator must take when it loses circulation of cement. At the conclusion of the meeting, TAB members were not able to endorse nor disapprove the rulemaking and instead expressed an interest in having the TAB subcommittee review the amendments to the final form rulemaking.

E. Summary of Comments and Responses

The Board received approximately 2,000 comments regarding the proposed Oil and Gas Well Casing and Cementing regulations during the public hearings and public comment period. Many of the comments received sought clarification or additional protective measures. The majority of comments were supportive of the proposal.

Several commentators made suggestions seeking to clarify the definition of "deepest fresh groundwater, including suggesting that the term be defined with reference to certain levels of total dissolved solids (TDS) ranging from 500 to 10,000 mg/l TDS. The Board appreciated these comments, but decided that numerical criteria should not be used to define deepest fresh groundwater because many water supplies provide water that exceed the 500 mg/l drinking water standard, but 10,000 mg/l is far too saline for Pennsylvania drinking water supplies. It is critical that the casing be set deep enough to isolate usable water supplies but not so deep that brine be permitted to co-mingle with fresh groundwater. It is also important to recognize that testing water produced during drilling will not yield accurate test results. For these reasons, the final form rulemaking has been amended to require operators to identify how the deepest fresh groundwater was determined and record the information in the casing and cementing plan.

Many commentators sought clarification regarding the provisions that require an operator who affects a water supply to restore or replace the affected water supply with an alternate supply adequate in quantity and quality for the purposes served by the supply. The amendments to § 78.51 reflect the Department's interpretation of an adequate alternate water supply according to recent caselaw.

Several commentators suggest that all replaced or restored water should meet safe drinking water standards. The Board deems a supply adequate if it meets safe drinking water standards or is comparable to the unaffected water supply if that water supply didn't meet those standards.

A commentator was uncertain about who would determine reasonable foreseeable uses. The regulation states that it is the duty of the Department to determine if the operator is in compliance with this subsection.

Additionally, several commentators were concerned that § 78.51(h) did not provide a timely response for affected water supplies. The Board agrees and amends § 78.51(h) to require operators to notify the Department within 24 hours of receiving a report that a water supply has been affected by pollution of diminution caused by drilling activities.

Several commentators objected to the provisions that would allow the use of used pipe. The Board considers used casing to be acceptable in certain applications, notably in low pressured shallow oil wells that do not produce gas. In these instances, used casing has been utilized successfully and has been shown to be suitable for long-term use in these applications. All used casing, however, is subject to the casing integrity requirement of § 78.84(b), as well as new requirements for pressure testing in § 78.84(c).

Many commentators suggested amendments to § 78.85(b) that would require a 72-hour compressive strength standard of at least 1,200 psi across critical zones of cement at the bottom of the casing seat where the highest pressures and stresses are likely to be encountered and in places where the well bore passes through aquifers and drinking water. The Board agrees and has amended §78.85(b) to require a zone of critical cement at the surface casing seat which must achieve a 72-hour compressive strength of 1200 psi and have a free-water separation of no more than six milliliters per 250 milliliters of cement.

Several commentators suggest that the cement ticket include testing of pH, temperature, and a record of the wait on cement time. The Board agrees and the regulation has been revised accordingly.

Some commentators objected to the quarterly mechanical integrity inspections required by §78.88(a), arguing that the requirement is excessive. While several commentators believed that quarterly inspections were not enough, other commentators supported § 78.88(a) quarterly inspection requirements. The Board has decided that quarterly inspections are sufficient to ensure that well pressures are within allowable limits and the casing is structurally sound. The Board does not consider quarterly mechanical integrity testing to be excessive. Rather, the inspections provide the operator an opportunity to correct problems at the well before such problems create a condition that will require significant time and expense to address. The Board has also determined that required evaluation of the well does not include invasive procedures.

Several commentators made suggestions to § 78.89 regarding the gas migration response requirements, including a provision requiring immediate notification to the Department. The Board agrees and has amended the final form rulemaking to require the operator to immediately conduct an investigation and contact the Department.

Commentators suggested that operators conduct an initial response action to determine the nature of the incident, assess the potential for hazards to public health and safety, and mitigate any hazard posed by the concentration of stray natural gas in the environment. Commentators

suggested what the investigation include a site visit and an interview of the complainant. Commentators suggested that the actions that an operator must take in the event of a reported gas migration incident be delineated by the concentration of combustible gas detected in the investigation. Commentators also suggested other additional investigation and mitigation measures that operators should be required to take, including a field survey, the collection of gas and/or water samples, the establishment of monitoring locations, and an evaluation of the operator's adjacent wells. Commentators also suggested certain reporting requirements following a reported gas migration incident. The Board agrees with many of the commentators suggestions and has revised § 78.89. These changes largely follow the commentators' suggestions. The revisions also require continued monitoring of gas migration complaints where the levels of dissolved methane in the water supply exceed 7 milligrams per liter. This level is based on 25% of the capacity of water to contain dissolved methane under one atmosphere of pressure. This number is much more certain and scientifically based than the unknown "background" level proposed by the commentator.

Commentators suggested that the information required in the completion report's stimulation record be expanded to require more specific information, including information regarding the chemical additives used and a the chemicals listed in the operator's Material Safety Data Sheets by Chemical Abstract Number. Other commentators object to requirements that require operators to submit confidential information and suggest that the issue of confidentiality be addressed in § 78.122. The Board has expanded the stimulation record requirements in subsection §78.122(b)(6) to include the Chemical Abstract Number for each Material Safety Data Sheet-listed hydraulic fracturing chemical used, as well as the percent (by volume) of each listed chemical used. The Board has also amended this subsection allowing the designation of confidential or trade secret information. The Department shall prevent disclosure of such designated confidential information to the extent permitted by the Right To Know Law, 65 P.S. 67.101 et seq.

F. Summary of Final Form Regulation and Changes from Proposed to Final Form Rulemaking

§ 78.1. Definitions.

Section 78.1 amends the definitions of the following terms to improve clarity or to explain new or existing provisions: "casing seat," "cement" and "surface casing." Section 78.1 also adds definitions for the following terms to explain new or existing provisions within Chapter 78: "cement job log," "conductor pipe" and "intermediate casing."

The final form rulemaking amends the following definitions listed above in response to public comment to improve clarity: "casing seat," "cement job log," "intermediate casing" and "surface casing."

Section 78.1 removes the definition of "retrievable" and inserts the substantive portion of the definition into the appropriate plugging regulations.

The final form rulemaking § 78.1 adds definitions for “L.E.L” and “unconventional formation.”

§ 78.51. Protection of water supplies.

The Oil and Gas Act requires an operator who affects a water supply by pollution or diminution as a result of gas or oil well drilling to restore or replace the affected water supply. Section 78.51 reflects current caselaw regarding an operator’s duty to replace or restore a water supply.

Section 78.51(d)(2) provides that a restored or replaced water supply must meet safe drinking water standards. If the pre-contamination water supply did not meet safe drinking water standards, the operator must restore or replace the contaminated water supply with a supply that is comparable to the water supply that existed prior to contamination.

Section 78.51(d)(1)(v) requires the operator to provide permanent payment for any increased cost to operate or maintain the restored or replaced water supply. Sections 78.51(d)(3)(i) and 78.51(d)(3)(ii) clarify that the replaced or restored water supply must be able to satisfy the water user’s needs.

The final form rulemaking modifies proposed § 78.51 (d) to provide uniform terms and add clarity and amends § 78.51(h), in response to public comment, providing that an operator who receives notice that a water supply has been affected by pollution or diminution must notify the Department within twenty-four hours of receiving that notice.

§ 78.52 Predrilling or prealteration survey.

Section 78.52(d) provides that an operator must provide the Department and the landowner or water purveyor with the results of their predrilling survey within ten business days of receiving the survey results. The final form rulemaking establishes that survey results not received within ten days may not be used to preserve the operator’s defenses under § 601.208(d)(1) of the Oil and Gas Act.

§ 78.55. Control and disposal plan.

Section 78.55(b) of the final form rulemaking establishes that an operator’s control and disposal plan must include a pressure barrier policy identifying the pressure barriers to be used during identified well drilling and completion operations. The final form rulemaking section 78.55(e) provides that an operator’s control and disposal plan must also contain a list of emergency contact phone numbers and that this list must also be displayed at the well site.

Section 78.55(d) of the final form rulemaking establishes that an operator’s control and disposal plan must be available at the well site during well drilling and completion operations.

§ 78.71. Use of safety devices—well casing.

Section 78.71(a) clarifies that the well control equipment must be attached to casing that is cemented in place.

§ 78.72. Use of safety devices—blow-out prevention equipment.

Section 78.72(a) of the final form rulemaking clarifies when blow-out equipment must be used. The final form rulemaking specifies that blow-out equipment must be must be used when drilling a well intending to produce from an unconventional formation and when drilling out solid core hydraulic fracturing plugs to complete a well.

Section 78.72(c) establishes that controls for the blow-out preventer must be accessible in case of an emergency. The final form rulemaking §78.72(c) specifies that controls for a blow-out preventer with a high pressure rating must be located at least 50 feet away from the drilling rig to assure accessibility in the event of loss of well control.

Section 78.72 (f) was amended to clarify when drilling must cease when blow-out prevention equipment is discovered to be in poor working order.

Section 78.72(h) of the final form rulemaking establishes that an individual with specified certifications must be at the well site when blow-out prevention equipment is being used and that those certifications must be available at the well site.

The final form rulemaking adds § 78.72(i), establishing that pressure barriers must be comprised of at least two mechanical pressure barriers between the open producing formation and the atmosphere. Additionally, these mechanical pressure barriers must be capable of being tested according to the manufacturers' specifications prior to operation. Moreover, if the operator has only one pressure barrier, operations must cease until additional pressure barriers are added or repaired and tested.

The final form rulemaking § 78.72(j) establishes that a hydraulic workover unit must be used during post-completion cleanout operations in unconventional formations.

The final form rulemaking specifies that intermediate casing must be cemented to surface, and now allows blow-out preventers to be attached to surface casing without regard to its length.

§ 78.73. General provision for well construction and operation.

Sections 78.73(a) and 78.73(b) further clarify that the well must be constructed and operated in a manner that protects public health and safety and the environment.

§ 78.73(c) reduces the allowable pressure that may be exerted on the surface and coal protective casing seats. The final form rulemaking clarifies how to calculate the pressure that must not be exceeded on the surface and coal protective casings. The final form rulemaking specifies that the pressure on the surface or coal protective casing seats is determined by

measuring the surface shut-in pressure and the surface producing back pressure exerted on the surface or coal protective casing.

Section 78.73(e) was added in the proposed rulemaking, requiring excess gas encountered during drilling to be flared, captured or diverted away from the drilling rig. Section 78.73(f) was also added in the proposed rulemaking, requiring check flow valves that prevent backflow from the pipelines into the well.

§ 78.75a. Area of alternative methods.

The Oil and Gas Act provides that the Department may approve alternative methods for the casing, plugging or equipping of a well. Section 78.75a, added in the proposed rulemaking, establishes procedures by which the Department may on its own initiative designate an area of alternative methods – an area that requires alternative drilling, casing, equipping, or plugging methods to operate the well in a safe and environmentally protective manner. Establishing such an area requires notice in the Pennsylvania Bulletin and an opportunity for the public to comment.

§ 78.81. General provisions.

Section 78.81(c), which stated that certain sections of the regulation do not apply to production or intermediate casings, is deleted to reflect new casing requirements.

§ 78.82. Use of conductor pipe.

The final form rulemaking § 78.82 clarifies that conductor pipe is used to stabilize the top hole of a well and must be driven into place or cemented from the seat to the surface to prevent the infiltration of water or other fluids into the subsurface.

§ 78.83 Surface and coal protective casing and cementing procedures.

Section 78.83(a) prohibits the use of surface casing as production casing and requires an additional string of casing to be installed in a well unless the well is only used to produce oil that does not present a threat to groundwater or if the operator of a gas well demonstrates that all gas and fluids will be contained in the well and installs a working pressure gauge that can be inspected by the Department.

The final form rulemaking deletes § 78.83(c), which gave operators the ability to drill to producing zones prior to isolating the fresh groundwater under certain circumstances, and adds a new § 78.83(c), requiring the use of air or freshwater based fluids when drilling through the fresh groundwater zone. Additionally, final form rulemaking § 78.83(c) specifies that the surface casing must be set fifty feet below the deepest fresh groundwater or at least fifty feet into consolidated rock, but not more than 200 feet below the deepest fresh groundwater unless necessary to set the casing in consolidating rock. The final form rulemaking also establishes that the wellbore must be conditioned prior to cementing.

The final form rulemaking amends §§ 78.83(c), (f), (g) and (i), mandating the use of centralizers to position the surface casing, coal protective casing, and any additional fresh groundwater casings in the wellbore. Subsections (f) and (i) have been further amended to require the additional water string to be cemented to the surface as opposed to 20 feet into the surface or coal protective casing.

§ 78.83a. Casing and cementing plan.

Section 78.83a establishes that operators must develop a casing and cementing plan that is available for the Department to review at the well site. The plan must describe the casing to be used and the cementing practices to be employed. The Department may request a copy of the plan for review and approval prior to drilling.

The final form rulemaking amends § 78.83a(a)(1) and (a)(6), specifying that the operator must include in its casing and cementing plan the method or information by which the depth of the deepest fresh groundwater was determined and the proposed wellbore conditioning procedures.

§ 78.83b. Casing and cementing—lost circulation.

Section 78.83b(a), added on proposed rulemaking, requires operators to notify the Department when cement used to protect fresh groundwater is not returned to the surface despite pumping more than 120% of the estimated required volume. If cement is not returned to the surface, the operator must determine the top of the cement and additional casing must be run and cemented, unless the well only produces oil off a vented production pipe if approved by the Department. Final form rulemaking § 78.83b(a)(1) clarifies what the operator must do when this happens and what additional measures must be taken.

The final form rulemaking adds § 78.83b(b) which provides that, in the event of lost circulation, the operator may, in addition to § 78.83a(a)'s requirements, pump additional cement through a pour string from the surface to fill the annular space.

§ 78.83c. Intermediate and production casing.

Section 78.83c, added on proposed rulemaking, specifies the cementing requirements for intermediate and production casing and establishes the pressure limitation for wells that produce gas off the annulus of the intermediate casing string.

The final form rulemaking adds a new § 78.83c(a) to require the intermediate and production borehole to be prepared prior to cementing.

The final form rulemaking amends § 78.83c(b) to mandate the use of centralizers when cementing the intermediate casing and requires the intermediate casing to be cemented to the surface.

The final form rulemaking amends § 78.83c(c) to mandate the use of centralizers when cementing the production casing and further specifies how much cement must be used to cement production casing.

§ 78.84. Casing standards.

The substantial amendments to § 78.84 require specified pressure ratings or pressure testing for different types of casings. Final form rulemaking § 78.84(d)(3) clarifies the certification requirements for a person welding casing.

The final form rulemaking § 78.84(f) clarifies that if the casing attached to the blow-out preventer has a pressure rating of greater then 3,000 psi, it must be pressure tested after it is cemented. To pass this pressure test, the casing must able to hold the anticipated maximum pressure to which the casing will be exposed for thirty minutes with not more than a ten percent decrease.

§ 78.85. Cement standards.

Section 78.85 provides additional standards for well casing cement, as well as references to ASTM International and American Petroleum Institute standards.

The final form rulemaking amends § 78.85(a)(4) and deletes proposed § 78.85(a)(5), clarifying that cement must protect the casing from corrosion and degradation, including that the cement used for coal protective casing must be formulated to withstand elevated sulfate concentrations in the surrounding wellbore. The final form rulemaking new § 78.85(a)(5) specifies that gas block additives and low fluid loss slurries must be used in areas of known shallow gas producing zones.

The final form rulemaking amends § 78.85(b) by adding requirements regarding surface casing cement. This subsection specifies that the cement at the bottom 300 feet of the surface casing constitutes a zone of critical cement, meaning that the cement in this zone must achieve a seventy-two hour compressive strength of 1,200 psi and the free water separation must not be more than six milliliters per 250 milliliters of cement.

The final form rulemaking amends § 78.85(c) by clarifying the actions that are prohibited during the mandatory eight-hour wait time on the cement for all casings.

The final form rulemaking § 78.85(f) specifies the information that must be included in the operator's cement job log.

§ 78.88. Mechanical integrity of operating well.

Section 78.88, added on proposed rulemaking, requires operators to inspect their wells at least quarterly for signs of physical degradation in addition to determining whether the pressure in the well is within allowable limits. Wells that fail inspection must be attended to immediately and the Department must be notified.

§ 78.89. Gas migration response.

Section 78.89 is substantially amended in the final form rulemaking to specify the actions an operator must take in the event of a gas migration incident. Section 78.89(a) of the final form rulemaking requires an operator to conduct an investigation immediately after it is notified or otherwise made aware of a potential gas migration incident to assess the nature of the incident, assess any potential hazards, and mitigate any hazards. Section 78.89(b) of the final form rulemaking specifies that the investigation must consist of a site visit, an interview of the complainant, a field survey, and if necessary, monitoring locations must be established. If the operator detects a high concentration of combustible gas inside a building or structure, the final-form rulemaking § 78.89(c) establishes that the operator must immediately notify the Department and local emergency response agencies, initiate mitigation measures and conduct further investigation and monitoring of the surrounding area.

Section 78.89(d) of the final form rulemaking specifies that if sustained detectable concentrations of combustible gas are detected at certain specified levels, the operator must notify the Department and take measures to ensure public health and safety. If the operator conducts an investigation and is not required to take the measures outlined in §§78.89(c) or (d), § 78.89(f) requires the operator to conduct additional monitoring, document its findings, and submit a report.

The final form rulemaking adds § 78.89(e) which establishes that the Department may require the operator to take additional investigative and monitoring measures in the event of a reported natural gas migration incident. The final form rulemaking §§ 78.89(g)-(i) provide additional notification and reporting requirements.

§§ 78.92–78.95. Plugging.

Sections 78.92–78.95 incorporate the substantive requirements of the eliminated definition of "retrievable" along with requiring an additional attempt to remove uncemented casing prior to plugging a well. The revised sections also require cement to be placed across the formerly producing formation as opposed to placing the cement plug on top of the formation as is the current requirement.

§ 78.96. Marking the location of a plugged well.

Section 78.96(a) permits the use of materials other than cement and metal to mark and hold a marker for a plugged well.

§ 78.121. Well record and completion report.

Section 78.121 incorporates the requirements of Act 15 of 2010 which mandate semi-annual production reporting of Marcellus Shale wells. In § 78.121(a), the dates are amended to reflect Act 15's requirements. Because Act 15 also requires the Department to post the production of Marcellus Shale wells on the Department's website, § 78.121(b) is amended to require that the production reports be submitted electronically.

§ 78.122. Well record and completion report.

Section 78.122(a)(10) requires the operator to certify that the well has been properly constructed. The final form rulemaking amends § 78.122(b)(6), requiring the operator to submit additional information in its completion report's stimulation record, including a descriptive list of the chemical additives used in the stimulation fluid, the percent by volume of those chemical additives, a list of the hazardous chemicals used in the stimulation fluid, the percent by volume of those hazardous chemicals, the total volume or water used and a list of the water sources used pursuant to an approved water management plan. The final form rulemaking § 78.122(c) provides that a well operator may designate any trade secrets or confidential proprietary information in the completion report and the Department will prevent disclosure of confidential information to the extent permitted by the Right to Know Law, 65 P.S. 67.101 *et seq.* Additionally, § 78.122(d) specifies that the operator must maintain records of every chemical used to hydraulically fracture the well and provide those records to the Department upon request.

G. Benefits, Costs and Compliance

Benefits

Both the residents of this Commonwealth and the regulated community will benefit from this regulation

The public will benefit in several ways. The updated casing and cementing requirements will provide an increased degree of protection for homeowners and both public and private water supplies. The construction standards will align Pennsylvania's regulations with other states' rules as well as current industry standards. Pressure testing the casing and testing surface casing seats will detect construction deficiencies before a well could create a potential safety or environmental problem. Minimizing annular pressure will reduce the potential for gas migration. The new quarterly inspections and annual reporting will be a vital tool for operators to use in detecting potential safety or environmental impacts before they may become an issue. The proposed regulations also outline the procedures the operator and the Department will utilize if there is a reported gas migration incident.

The new construction standards and the well remediation measures will far outweigh the liability to the operator from the potential impacts to public safety and harm to the environment from gas migration or from polluting water resources that may result without these additional precautions. As new areas of the Commonwealth are developed for natural gas, these proposed regulations will avoid many potential health, safety and environmental issues.

Compliance Costs

This rulemaking will impose minimal additional cost on the Department. This proposal will help the Department offset potential health, safety and environmental issues.

The Department finds that most gas migration issues stem from inadequate cementing procedures, cement returns, or combinations of inadequate casing and cementing or over-pressured casing seats. Because many of the Marcellus Shall well operators meet or exceed the current well casing and cementing regulations, any increased cost associated with drilling and operating oil and gas wells will be minimal. All of the potential increases in cost to an operator will be associated with assuring a well is properly completed, operated and plugged.

The potential increase in cost is minor when compared to the overall cost of well construction. Where cement is not returned to the surface or when excessive pressure is placed on the surface casing seat, the revised regulations require the operator to install an additional string of casing. The construction cost for the additional string of casing is about $10,000 per well.

Some commentators questioned the Department's estimate for the additional string of casing, stating that the cost of an additional casing string is much more than $10,000 per well, and is more likely on the order of $300,000 to $500,000 per well, depending on depth and area. The commentators stated that if the additional string of casing is justified from a technical standpoint, then it is the correct course of action. But nowhere do the proposed regulations provide a technical justification for an additional casing string.

The added expense described by the commentators does not apply to situations where cement is not returned to the surface. Where production casing is run and set on a packer or casing is set 50 feet deeper than the surface casing, the Department's estimate is sound. Instead, the scenario described more directly relates to the Board's decision to prohibit operators from comingling fresh groundwater with brine by setting very deep surface casing. By setting deep surface casing, operators avoid using deeper intermediate casing and costly cement and cementing practices.

The proposed casing design advocated by the commentators has resulted in several recent gas migration cases in Pennsylvania. These gas migration cases threaten the lives and safety of the citizens of the Commonwealth. The Board did not consider the expense of an intermediate string of casing when it crafted the regulations because the casing design advocated by the commentator results in an unlawful condition. Prohibiting gas migration is the cornerstone of these regulations and compromising on the issue to save money on a necessary string of casing is not acceptable.

Used casing, welded casing and casing attached to a blow-out preventer must be pressure tested to demonstrate its ability to withstand the highest anticipated working pressures to which the casing will be exposed. If the casing fails this test, the operator must repair of replace the casing and ultimately pass the pressure test. The cost to repair or replace the defective casing is completely outweighed by the environmental damage that would result from a failed string of casing and the fact that the casing would still need to be repaired or replaced.

The typical cost to develop a Marcellus Shale well is around $5,000,000. The additional cost of compliance would only be approximately 0.2% of the overall cost to develop a Marcellus Shale well.

The typical cost to develop a shallow gas well is $250,000 and the typical cost to develop an oil well is $200,000. In either situation, the additional cost of compliance would only be approximately 4% to 5% of the overall cost of the well.

All of the additional measures are proposed to reduce the potential for gas migration. If an operator fails to prevent a pollution event of a water supply, the anticipated cost to permanently replace one private water supply would be approximately $4,000 to drill a new water well or $30,000 to provide and permanently pay for a treatment system.

Compliance Assistance Plan

The Department has worked extensively with representatives from the regulated community and leaders the several trade organizations. The requirements of this regulation are, therefore, well known.

The Department, however, several scheduled training sessions for the regulated community to address the Department's regulatory requirements. The Department will use these training sessions as an opportunity to further education the industry about the new requirements.

Paperwork Requirements

The annual well inspection report, the semi-annual production report mandated by Act 15 for operators of Marcellus Shale wells and the additional information required in the completion report will require submittal of two additional forms and additional information on an existing form. The results of gas migration investigations will also require additional reporting obligations.

H. Pollution Prevention

The Federal Pollution Prevention Act of 1990 established a national policy that promotes pollution prevention as the preferred means for achieving state environmental protection goals. The Department encourages pollution prevention, which is the reduction or elimination of pollution at its source, through the substitution of environmentally friendly materials, more efficient use of raw materials, or the incorporation of energy efficiency strategies. Pollution prevention practices can provide greater environmental protection with greater efficiency because they can result in significant cost savings to facilities that permanently achieve or move beyond compliance. This regulation has incorporated the following pollution prevention provisions and incentives:

This regulation will minimize gas migration and will provide an increased degree of protection for both public and private water supplies by updating material specifications and performance testing as well as adding more specific design, construction, operational an monitoring requirements. The plugging, water supply replacement, and gas migrations reporting regulations have been amended to ensure that public safety and groundwater are protected.

I. Sunset Review

This regulation will be reviewed in accordance with the sunset review schedule published by the Department to determine whether the regulation effectively fulfills the goals for which it was intended.

J. Regulatory Review

Under section 5(a) of the Regulatory Review Act (71 P.S. § 745.5(a)), on June 25, 2010, the Department submitted a copy of the notice of proposed rulemaking, published at 40 *Pa.B.* 3845, to the Independent Regulatory Review Commission (IRRC) and the Chairpersons of the House and Senate Environmental Resources and Energy Committees for review and comment.

Under section 5(c) of the Regulatory Review Act, IRRC and the Committees were provided with copies of the comments received during the public comment period, as well as other documents when requested. In preparing these final form regulations, the Department has considered all comments from IRRC, the Committees and the public.

Under section 5.1(j.2) of the Regulatory Review Act, on ___(blank)___, these final form regulations were deemed approved by the House and Senate Committees. Under section 5.1(e) of the Regulatory Review Act, IRRC met on ____(blank)____ and approved the final form regulations.

K. Findings of the Board

The Board finds that:

(1) Public notice of proposed rulemaking was given under sections 201 and 202 of the act of July 31, 1968 (P.L. 769, No. 240) (45 P.S. §§ 1201 and 1202) and regulations promulgated thereunder at *1 Pennsylvania Code* §§ 7.1 and 7.2.

(2) A public comment period was provided as required by law, and all comments were considered.

(3) These regulations do not enlarge the purpose of the proposal published at 40 *Pa.B.* 3845.

(4) These regulations are necessary and appropriate for administration and enforcement of the authorizing acts identified in Section C of this order.

L. Order of the Board

The Board, acting under the authorizing statutes, orders that:

(1) The regulations of the Department of Environmental Protection, *25 Pennsylvania Code,* Chapter 78 are amended to read as set forth in Annex A.

(2) The Chairperson of the Board shall submit this order and Annex A to the Office of General Counsel and the Office of Attorney General for review and approval as to legality and form, as required by law.

(3) The Chairperson of the Board shall submit this order and Annex A to the Independent Regulatory Review Commission and the Senate and House Environmental Resources and Energy Committees as required by the Regulatory Review Act.

(4) The Chairperson of the Board shall certify this order and Annex A and deposit them with the Legislative Reference Bureau, as required by law.

(5) This order shall take effect immediately upon publication in the *Pennsylvania Bulletin*.

BY:

JOHN HANGER
Chairperson
Environmental Quality Board

WATER USE IN MARCELLUS DEEP SHALE GAS EXPLORATION

FACT SHEET

MARCH 2010

How much water is used in Marcellus deep shale gas development?

Water is an essential component of Chesapeake Energy's (Chesapeake) deep shale gas development. Chesapeake uses water for drilling, where a mixture of clay and water is used to carry rock cuttings to the surface, as well as to cool and lubricate the drillbit. Drilling a typical Chesapeake Marcellus deep shale gas well requires approximately 100,000 gallons of water.

Water is also used in hydraulic fracturing, where a mixture of water and sand is injected into the deep shale at a high pressure to create small cracks in the rock and allow gas to freely flow to the surface. Hydraulically fracturing a typical Chesapeake Marcellus horizontal deep shale gas well requires an average of five and a half million gallons per well.

How does Marcellus deep shale gas water use compare to regional uses?

The volume of water necessary to drill and fracture Marcellus deep shale gas wells represents a very small percentage of the total water resources used in the Marcellus geographic region. This region generally includes central and western Pennsylvania, southern New York and northern West Virginia. The total water use in the Marcellus Shale area in 2000 was approximately 3.6 trillion gallons. The natural gas industry is expected to increase the amount used by less than 0.1%, and is well within available resources in the region. Again, this volume is very small in terms of the overall water budget for this region. The largest water users in the Marcellus Shale geographic area are power generation (approximately 72%), industry and mining (approximately 16%), and municipal/public water supply (approximately 12%). Agricultural water use accounts for only one-tenth of one percent in this area (0.10%). Water used in Chesapeake Marcellus deep shale gas differs most notably from all other uses because it is temporary, occurring only once during the drilling and completion phases of each well. Use of this water does not represent a long-term commitment of the resource in the Marcellus Shale geographic area.

How much is 5.6 million gallons?

The 5.6 million gallons of water needed to drill and fracture a Marcellus deep shale gas well is equivalent to the amount of water consumed by:

- **New York City** in **eight minutes**
- A 1,000 megawatt coal-fired **power plant** in **13 hours**
- A **golf course** in **28 days**
- **Nine acres of corn** in a season

While these represent continuing consumption, the water used for a shale gas well is a one-time use.

KEY POINTS

- Water resources are protected through stringent state, regional and local permitting processes.
- Natural gas production uses significantly less water per BTU of energy produced than other fuel sources such as coal, oil or ethanol.
- Water is essential for Marcellus deep shale gas development.
- Marcellus deep shale gas drilling and hydraulic fracturing uses a small amount of water compared to other uses within the geographic area.

How much water is used in Marcellus deep shale gas development compared with other energy sources?

Water and energy are interdependent. Water is essential to energy resource development. Conversely, energy resources are needed for producing, processing, distributing and using water resources. A typical Marcellus deep shale gas well will produce approximately 4.2 Bcf (billion cubic feet) of gas over its lifetime, the amount of water used to produce the gas equates to about 1.3 gallons for every million British thermal unit (MMBTU - one MMBTU equals about a thousand cubic feet of gas). To put this in perspective, this is approximately 15% of the water needed to produce one MMBTU of coal that is ready to burn in a power plant or 0.05% of the water needed to produce the same energy equivalent of ethanol for fuel. The table on the following page compares water use per unit of energy for several energy sources.

Water requirements for various energy resources

Energy Resource	Range of Gallons of Water Used per MMBTU of Energy Produced
Marcellus Shale Natural Gas[1]	1.30 [2]
Coal (no slurry transport) Coal (with slurry transport)	2 – 8 13 – 32
Nuclear (uranium ready to use in a power plant)	8 – 14
Conventional Oil	8 – 20
Synfuel - Coal Gasification	11 – 26
Oil Shale	22 – 56
Tar Sands	27 – 68
Synfuel - Fisher Tropsch (from coal)	41 – 60
Enhanced Oil Recovery (EOR)	21 – 2,500
Biofuels (Irrigated Corn Ethanol, Irrigated Soy Biodiesel)	> 2,500

[1]Source: GWPC Report
[2]The transport of natural gas can add between zero and two gallons per MMBTU.
Other Sources: DOE

Where does the water come from?

Chesapeake utilizes a variety of sources of water in Marcellus deep shale gas exploration. The sources include rivers, creeks and lakes. Chesapeake is also reviewing the use of a variety of other water resources such as discharge water from industrial or city wastewater treatment plants, groundwater and reuse of fracturing water. Chesapeake often works directly with local officials to arrange water purchases from a municipality when drilling inside city limits. Water is typically transported by truck to drilling locations for storage prior to use in tanks or impoundments. Chesapeake also uses temporary pipelines to transport water supplies. Due to the extensive and diverse geographic area overlying the Marcellus Shale, the overall mix of water sources used depends on the region and the availability of sources near drilling sites.

Are water resources protected and regulated?

Regardless of the source, water used in the drilling and fracturing process by Chesapeake is purchased and, if necessary, properly permitted. This permitting ensures that water used for drilling and hydraulic fracturing does not interfere with the available supply for other users. In addition, both Pennsylvania and New York require an impact analysis to ensure that the surface water withdrawals will not harm the watershed or other users. The assessments ensure that our use will not adversely affect stream flow, aquatic life, recreational resources or sensitive environments.

Chesapeake works collaboratively with regional, state and local agencies to ensure that water use for deep shale gas development is consistent with water use plans and does not adversely affect other users.

In the Marcellus Shale area, regional river authorities have jurisdiction in multiple states. The federally established watershed authorities have been created to protect the water quality of the entire river basin and to regulate uses of the water. Additional approvals and permits are required for operations in these river basins. Chesapeake actively works with the Delaware River Basin Commission (DRBC) and the Susquehanna River Basin Commission (SRBC) to obtain water for use in Pennsylvania and New York.

Chesapeake's deep shale gas development, with its comparatively small water use per unit of energy, is consistent with the nation's energy/water strategy by making a positive energy and economic contribution at a relatively low cost to the overall water supply. Chesapeake's deep shale gas has the potential to supply decades of natural gas for the U.S., while using less water than other currently available viable energy sources.

Information Sources

- Argonne National Laboratory
- Delaware River Basin Commission
- Ground Water Protection Council (GWPC)
- Sandia National Laboratory
- Susquehanna River Basin Commission
- U.S. Department of Energy (DOE)
- U.S. Geological Survey

About Chesapeake

Chesapeake Energy Corporation is the second-largest producer of natural gas in the U.S. Headquartered in Oklahoma City, the company's operations are focused on the development of onshore unconventional and conventional natural gas in the U.S. in the Barnett Shale, Haynesville Shale, Fayetteville Shale, Marcellus Shale, Anadarko Basin, Arkoma Basin, Appalachian Basin, Permian Basin, Delaware Basin, South Texas, Texas Gulf Coast and East Texas regions of the United States. If you have questions about water use in deep shale gas exploration or other facets of our operations, visit www.chk.com or email us at marcellusshale@askchesapeake.com.

Department of Environmental Protection
Bureau of Oil and Gas Management
Stray Natural Gas Migration Associated with Oil and Gas Wells

Commercial oil production started in Pennsylvania in 1859 when Colonel Drake drilled the famous Drake well in Titusville. From there, petroleum production expanded further into the Venango, Southern and Bradford oil fields of Venango, Warren, McKean, Clarion, Butler and Armstrong Counties. Eventually, the oil belt extended to the southwest corner of the state in the Washington County area. During this 150-year span, hundreds of thousands of gas and oil wells have been drilled in Pennsylvania.

With the number of gas wells drilled in the Commonwealth since the inception of the industry, the potential exists for natural gas to migrate from the wellbore (via either improperly constructed or old, deteriorated wells) and adversely affect water supplies, as well as accumulate within or adjacent to structures such as residences and businesses. Collectively, this may represent a threat to public health, safety and welfare, and is a potential threat of a fire or explosion. The Department has documented such occurrences and these cases are provided in this document.

It should be noted that the Department also receives complaints of stray gas from other sources such as methane gas due to microbial processes or caused by burial of organic matter, landfills, mining activity, transmission or distribution pipeline, or natural causes. These cases are not included in this paper. The discussion in this paper is limited to gas migration cases associated with oil and natural gas wells (i.e. thermogenic in origin).

The gas migration cases are organized into several categories: new wells, operating or active wells, legacy or abandoned wells, and wells associated with underground storage of natural gas.

New wells involve that initial phase of an oil or gas well when the well is being drilled or re-drilled, completed and put into production. For most wells, well completion involves hydraulic fracturing either immediately after the well is drilled or at a later date.

Operating or production wells include wells that are actively producing. It also includes wells that the operator is not actively producing and that are not plugged.

Legacy or abandoned well incidents are associated with natural gas and oil wells drilled from 1859, when Colonel Drake drilled his first commercial well in Titusville, until the present and there is no responsibility operator for the well. The well may have been abandoned by the operator and not properly plugged or plugged according to the standards or practices that were in place at the time. Some of the wells were constructed under the Oil and Gas Act, which was passed in 1984 when new standards for casing, cementing and plugging wells were established. Many were not.

These cases typically involved gas migration from old wells that were abandoned without proper plugging procedures. Often, these wells are associated with the old oil and gas fields surrounding the greater Pittsburgh area or the Bradford or Venango oil fields.

Underground Storage of Natural Gas includes gas migration problems associated with operating gas storage fields.

INVENTORY OF OIL AND GAS WELL STRAY GAS CASES

NEW WELLS – STRAY GAS MIGRATION CASES

McNett Township, Lycoming County - East Resources – NCRO – July 2009: A natural gas leak from an East Resources Oriskany well was confirmed on July 27, 2009. Methane gas from the well impacted multiple private drinking water wells and two tributaries to Lycoming Creek, forced one resident to evacuate her home, and required the closure of access roads near the well. Company personnel took necessary measures to stop the gas leak at the well and stream and drinking water well conditions improved. The suspected cause of the leak is a casing failure of some sort. East Resources continues to monitor homes and wells in the effected area (approximately 6000 foot + radius) where methane has been documented and reports to the Department weekly. Methane was evident in some wells and the subsurface. One gas extraction system was installed at a residence. The investigation is on-going. The Northcentral Regional office expects to receive a report regarding the incident from East Resources in approximately 30 days.

Dimock Migration, Dimock Twp., Susquehanna County - Cabot Oil and Gas – NCRO - 2009: The Department is actively monitoring domestic water supplies and investigating potential cause(s) of a significant gas migration that has been documented in several homes along Carter Road. Free gas has been encountered in six domestic water supplies and dissolved has been found in several of the wells. The operator has placed pilot water treatment systems on three water supplies. Of particular note is that this area has not experienced previous drilling and recent gas drilling in the vicinity has targeted the Marcellus Shale.

Hedgehog Lane, Foster Twp., McKean County – Schriener Oil and Gas – NWRO – April 2009: The Department is actively investigating the report of fugitive gas in domestic water well. Prior to Departmental involvement, the company drilling gas wells in the area provided a new water well to an affected residence. After stray gas was evident in the water well, apparently the concerned resident approached the company directly, a new water well was provided and the impacted well was plugged with bentonite. Some time later, neighboring water well became impacted with stray gas and the resident contacted the Department. During the investigation**,** four gas wells were discovered over-pressured. Packers were placed in those over-pressured wells and the wells were brought into regulatory compliance. At this time, a response in the affected water well has not been observed. Complaints of water quality degradation and water diminutions are also under investigation in the area.

Little Sandy Creek Migration, McCalmont Twp., Jefferson County – NWRO – April 2008: In April, 2008 the Department was informed of a large fugitive expression in Little Sandy Creek. Subsequent investigation indicated the presence of combustible gas in the basement of a nearby residence. It was determined that the gas was entering the structure through an un-sealed sump opening in the concrete floor of the basement. The sump was vented through the wall and the threat to the home was minimized. During the investigation the Department discovered that two recently drilled gas wells were over-pressured and were producing from different geologic strata. Isotopic analysis indicated that a specific gas well was the probable source of the fugitive gas and measures were undertaken to reduce pressure on the casing seat. After continued monitoring at the residence, it was determined that the amount of gas in the sump was decreasing. The basement sump remains vented and the problem is dissipating.

Kushequa Migration, **Hamlin Twp., McKean County – NWRO – September 2007:** A stray gas migration caused a change in water quality and a minor explosion in a community water well. Combustible gas was also encountered in a few private water wells within the village. The Department investigated the stray gas occurrence in September of 2007 and through an investigation determined that a specific over-pressured gas well was the cause of the migration. Pressure was released from the potentially responsible gas well and a positive change in the impacted water well was rapidly noted. Additional production casing was placed in the suspect well to permanently resolve the problem. The responsible party was recently issued a Consent Order and Civil Assessment which they plan to comply. The Department issued a well plugging contract to plug 15 orphan wells adjacent to the water wells.

Alexander Migration, Hickory, Washington County – SWRO: It appears the operator affected an old abandoned well when completing a new well in the area. Stray gas occurs in the soils and contamination exists in private water supplies. DEP is evaluating several wells in the area. The investigation is ongoing.

Five Mile Run A, Knox Twp., Jefferson County – NWRO – April 2009: The Department was made aware that on April 18, 2009 fugitive gas began escaping from a domestic water well. During the investigation, the Department also encountered combustible gas in neighboring water well. At this time evidence is being gathered and it is likely that the cause of the fugitive gas migration may be linked to a recently drilled neighboring gas well. The Department is also investigating three reports of water quality problems that may be associated with the recent gas well drilling in the area. The fugitive gas in the water well is a recent problem and at this time is not linked to the gas in Five Mile Run that is approximately 2,500 feet away.

Five Mile Run, Knox Twp., Jefferson County – NWRO – 2008: Consistent gas streams have been identified at two locations within Five Mile Run. Isotopic samples

were obtained in early 2008 and the analysis indicates that the gas is of thermogenic origin. It is unknown when the gas first appeared in the stream. At the time of sampling, only older historic wells (pre-1920's) were in the vicinity. Presently the area is experiencing an increase in drilling activity. The permitted boundary for the Galbraith Gas Storage Field (operated by National Fuel Gas) is located approximately 4000 feet to the closest stream expression of fugitive gas. The source of the gas at this time is unknown.

Mix Run Migration, Gibson Twp., Cameron County – NWRO – Fall 2007: In the fall of 2007, the Department continued the investigation of fugitive gas reported in the water well of a seasonal residence. The presence of gas in the water well is sporadic with no apparent trends in its occurrence noted. The area has experienced no recent drilling although historic records indicate Oriskany gas was produced in the vicinity. All wells that could be identified and field verified within one mile of the stray gas location are in regulatory compliance. The closest gas well was plugged and a gas well with potentially compromised casing (approximately 3000' away) was repaired. Gas was not present in the water well at the time of the last inspection in May, 2009.

Ohl Complaint, Hebron Twp., Potter County – NWRO – June 2007: The Department responded to a complaint of fugitive gas in a water well that serves a seasonal structure in June, 2007. Isotopic analysis indicated a possible similar thermogenic origin of the gas in the water well to a neighboring gas well. Initial efforts to vent the suspected gas well to atmosphere for an extended time failed to reduce the amount of gas in the neighboring water well. The new well owner placed a down-hole packer and additional production casing in the well. This action did not produce a reduction in the fugitive gas in the water well. The Department continues to investigate the complaint.

Miller Gas Migration, **Liberty Twp, McKean County – NWRO – January 2008:** Departmental personnel responded to a report of fugitive gas in a domestic water well that serves a seasonal residence in January, 2008. Investigation by Departmental field representatives discovered that two recently drilled gas well was over-pressured (exceeding the amount of allowable pressure on the casing seat). The operator Placed packers and additional production casing in the gas well, thereby eliminating pressure on the casing seat. The water well was aggressively pumped and over time the amount of combustible gas in the well bore decreased significantly. The gas well was brought back into production when the amount of gas was below the allowable amount.

Head Drive Migration, Millcreek Twp., Erie County – NWRO – fall 2007. In the fall of 2007, the Department initiated an investigation into the report of fugitive gas in the vicinity of several homes along Walnut Creek. The discovery of fugitive gas in the soil near the residences, forced the Erie County Health Dept. to evacuate the neighborhood. The residents were displaced for at least two months. Through the use of isotopic analysis and with a through investigation performed by the Department's field staff, it

was determined that the recently drilled neighboring gas wells were the cause of the migration. Through a Consent Order with the Department, the responsible party plugged two defective gas wells and placed packers in the remaining gas wells. The case is presently in private litigation.

Hughes Migration, **Hamlin Twp., McKean County – NWRO – June 2006:** In June, 2006 the Department responded to two water quality/diminution complaints and determined that a change in water quality was evident. Over-pressured conditions were noted at a recently drilled nearby gas well. The gas well operator drilled new water wells for the impacted residences and gas was encountered during the drilling process. Subsequently, when the operator placed additional production casing in the gas well, the Department noted a marked decrease in the amount of gas in the recently drilled water wells. Over time the problem has diminished.

Foote Rest Camp Ground Migration. Hamlin Twp., McKean County – NWRO – Late 1990s: In the late 1990's, the Department responded to a complaint of gas escaping from an abandoned gas well located in a wooded area near a private campground. During the investigation, it was discovered that an extremely large amount of gas (estimated at more than 100 Mcf/day) was venting from the abandoned gas well. The old well became activated when fracing was completed on a new gas well approximately 4000'away. Installation of production casing placed in the new well prevented additional gas from migrating to the abandoned well and the problem was resolved.

OPERATING WELLS STRAY GAS MIGRATION CASES

Harper Migration, Jefferson County – SWRO and NWRO – March 2004: An operating gas well. House explosion resulted in three fatalities. Origin/mechanism of migration: Operating gas well. Pressurization of the annulus on one or more operating gas well(s) was the mechanism of stray gas migration that caused the explosion. Status: Final agreement pending. . Elements of DEP Compliance Order still outstanding.

Dayton Investigation, Armstrong County – SWRO - March, 2008: Area-wide stray gas migration. Evacuation of one residence. Newly drilled gas well was over-pressured and communicated with an abandoned gas well and other operating gas wells. Corrective action at the well resolved the problem.

Origin/mechanism of migration: Newly drilled gas well. Pressurization of surface casing resulted in migration. Frac communicated with abandoned gas well and other operating gas wells. Status: Resolved.

Tin Town Road Migration, Monroe Twp., Clarion County – NWRO – July 2008: The Department became aware of fugitive gas migration that resulted in the fatality in July of 2008. Apparently, fugitive gas migrated from a very old gas well (drilled early 1900's) through the septic system and entered the bathroom of the residence. It is reported that the explosion resulted when the resident attempted to light a candle in the room. It is possible that gas migrated from the gas well through casing that over time had become compromised. The suspect gas well was vented to atmosphere and the problem dissipated. Presently, the well has been plugged by the operator and the case is in private litigation.

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Toy Migration, Armstrong County – SWRO – October 2007: Explosion at a water well enclosure. Well pump was destroyed and damage to enclosure. No injuries. The source was a nearby operating gas well. The water well has been properly vented and is now back in service. The water well quality was affected during drilling and previously restored by the operator of the gas well. The investigation is ongoing.

Origin/mechanism of migration is a newly drilled gas well. Pressurization of the annulus on a recently drilled well was the mechanism of stray gas migration. Status: Investigation is ongoing.

Wilson Investigation, Armstrong County – SWRO - October, 2007: Explosion inside residence. No injuries or significant damage. Stray gas impacted private water supply well and entered home through conduit for waterline. Origin/mechanism of migration was a newly drilled gas well. Pressurization of the surface casing in newly drilled gas well. Status: Resolved

Montgomery Migration, Hamlin Twp., McKean County – NWRO – July 2007: A domestic water well became impacted by fugitive gas in July, 2007. With Departmental involvement, the operator of nearby gas wells initiated a program of pressure testing suspect wells and it was determined that the casing failed on a specific well. Apparently, without a check valve in the production pipeline, the suspect well was feeding pipeline gas into the gas well. The gas migrated through the compromised well casing and into the local aquifer. The operator plugged the suspect well and problem was resolved.

Alexander Investigation, Washington County – SWRO - September, 2006: Stray gas migration impacting several private water supplies, and surface soils. Frac in recently drilled well communicated with abandoned gas well and migrated to shallow groundwater and surface soils.

Origin/mechanism of migration: Operating gas well. Frac communicated with abandoned gas well. Abandoned gas well is constructed with wooden surface casing. Investigation reveals frac at recently drilled well created pathway to abandoned well and further migration into the shallow groundwater system. Status: Investigation is ongoing.

703 Liberty Street Migration, Warren County – NWRO – January 2005: Gas migrating from an operating gas well resulted in an explosion in the boiler room of the house. There were no injuries. Two nearby wells provided house gas to the residence. The problem well was identified and repaired. The investigation lasted several months.

Chestnut Street migration, Washington County – SWRO - May, 2003: An operating gas well resulted in fire and caused house explosions, with two injuries and an evacuation. Origin/mechanism of migration is an operating gas well had leak in casing. Status: Resolved. Gas well was repaired; outcome of the civil court case is unknown.

Unknown name, Armstrong County – SWRO - ~1999: House explosion, resulting in destruction of residence and one fatality. Investigation is not well documented. Origin/mechanism of migration is an operating gas well. Pressurization of casing. Status: Resolved

Vtodian Investigation, Allegheny County – SWRO - January, 1992: House explosion, resulting in destruction of residence, one injury and an area-wide evacuation. Origin/mechanism of migration is an operating gas well. Pressurization of the casing was the mechanism of migration of stray gas that caused the explosion. The well has been repaired. Status: Resolved

LEGACY OR ABANDONED WELL CASES

Hulton Road Migration, Westmoreland County – SWRO - October 2009: This incident was first investigated in August of 2004**.** The stray gas occurs in the soils on private property and in the right of way of Hulton Road. Origin/mechanism of migration is an abandoned gas well. In 2009 the Department issued a contract to plug the suspected well and install venting.. Plugging the well did not alleviate the stray gas. The Department let another contract for an additional $10,500 to vent the stay gas..

128 Lilac Court Migration, Allegheny County – SWRO - June, 2009: The stray gas occurs in the soils in a suburban housing development. Currently, the gas is localized in an area in front of a single residence. Origin/mechanism of migration is an abandoned gas well, location and mechanism of migration unknown. Status: Investigation ongoing.

226 Thompson Run Road Migration, Allegheny County – SWRO - May, 2009: The stray gas occurs in the soils in the vicinity of a residence. The area has had historical stray gas incidents. Venting systems have been installed at several locations in the area. Origin/mechanism of migration: source of gas is an abandoned gas well. Its location is unknown. DEP investigation is ongoing.

Independent Valley News Migration, Allegheny County – SWRO - April, 2009: The stray gas occurs in the soils in front of a business. The gas is being vented with a temporary vent system. Origin/mechanism of migration: source of stray gas is an abandoned gas well. Its location is known. The well has been placed on the list for plugging/venting. Status: DEP contractor to properly vent or plug suspect abandoned gas well.

112 Buss Road Migration, Beaver County – SWRO - March, 2009: The stray gas occurs in the soils on private property. Origin/mechanism of migration: source of gas is an abandoned gas well; its location is known. Status: The leaking gas well is being evaluated for proper venting/plugging.

2526 Wexford Bayne Road Migration, Allegheny County – SWRO - March, 2009: Stray gas in soils and inside home. Origin/mechanism of migration: abandoned gas well; its location is unknown. Natural gas service was terminated at a residence. Status: Resolved. The owner installed a venting/alarm system at his own expense.

Wendt Drive Migration, Allegheny County – SWRO - June, 2009: The stray gas occurs in the soils on private property. Origin/mechanism of migration: source of gas is an abandoned gas well. Its location is unknown. DEP investigation is ongoing.

Charleroi Migration, Washington County – SWRO - March, 2009: Stray gas encountered in soils in close proximity to business. Origin/mechanism of migration is an abandoned gas well. The operator of the well refused to accept responsibility for the problem and take corrective actions. Gas was leaking from the well in the parking lot and was adjacent to the buildings slab foundation. DEP issued a contract to plug the well and initially vented the well until work on plugging the well could begin. Plugging was recently completed. DEP will pursuing cost recovery from the operator.

Tarentum Migration, Allegheny County – SWRO - March, 2005 to October 2009: This incident was initially investigated in March, 2005. Thermogenic source from an unknown location resulted in natural gas service to be terminated by the gas utility 3 years ago at 220 W. 7th Avenue. The DEP plugged one abandoned well. This well plugging did not alleviate the stray gas in the 7th avenue area. There was another plugged well nearby, but did not show any signs of a problem. DEP is conducting follow-up work to the plugging contract to vent the area adjacent to the structure. Origin/mechanism of migration: abandoned gas well, location unknown (contracting is awarded and work is about to begin).

Versailles Migration, Versailles, Allegheny County – SWRO – 2007 through 2008: The natural gas migration problem in Versailles has been ongoing for many years. During the boom period from 1919 through 1921, over 175 wells were drilled in the Borough of Versailles which was part of the McKeesport Gas Field. Some wells produced little or no gas and were abandoned without casing or plugging the boreholes. Other wells produced for a few years and were also abandoned with out plugging the wells. During World War II, the call for scrap steel resulted in the removal of steel casings and wellheads. The abandoned wells were cover over or otherwise abandoned. Over the years many venting systems have been installed by the property owners, borough or by DEP. In 2007 and 2008, the Department let an emergency contract to rehabilitate a well on the Saraka property for to relieve the natural gas pressure in the area. The DOE's National Energy Technology Laboratory (NETL) conducted an extensive study of the area. The original budget for the study was about $1 million dollars. This case is ongoing.

Buckner Migration, Washington County – SWRO - December, 2008: The stray gas occurs in a private water supply well. Origin/mechanism of migration source of gas is an abandoned gas well. Its location is unknown. DEP is conducting an ongoing investigation. The water well has been properly vented. Stray gas was migrating into a residence. DEP discovered pathway into home. Gas appears to be migrating through an abandoned coal mine. Status Immediate danger resolved. Investigation as to specific source is ongoing.

2228 Private Drive Migration, Fayette County – SWRO - October, 2008: Stray gas in soils. Origin/mechanism of migration is an abandoned gas well. Its location is unknown. Status: Resolved. This case was resolved by venting gas away from the structure.

630 Tara Court Migration, Ross Township, Allegheny County – SWRO - September 2008: The source of gas is an abandoned gas well, probably located under the parking lot of the Ross Park Mall. Gas service was terminated at the house at 630 Tara Court in the adjacent subdivision. The Mall was contacted and they are to provide maps of the parking lot to help locate the abandoned wells. The stray gas problem at Tara Court was

resolved by installing a venting system until the abandoned wells under the parking lot can be located. The case is ongoing.

Pottle Migration, Allegheny County – SWRO - October, 2007: Stray gas discovered in soils at location for new commercial building. Origin/mechanism of migration is an abandoned gas well. Its location is unknown. Status: Resolved. The owners of a commercial building installed a mitigation/alarm system at their expense to resolve the problem.

1100 McCartney Avenue Migration, Allegheny County – SWRO - February, 2007: Stray gas along front of commercial business. The source of gas is an abandoned gas well; its location is unknown. The owner of the commercial building installed a mitigation/alarm system at his expense. Natural Gas service restored. .

Sturgeon Migration, Allegheny County – SWRO - September, 2005: Stray gas in close proximity to several residences. Natural gas service terminated. Origin/mechanism of migration is an abandoned gas well. Its location is unknown. DEP installed a venting system to mitigate the gas migration problem at two residences. Status: Resolved. Gas service restored and the occupants returned to their residence. DEP investigated a well between the two properties; however, it was determined during preparations to plug the well that it was an old water well and not the source of gas.

Childers Migration, Washington County – SWRO - June, 2005: Stray gas has impacted soils area wide on private property. The source of gas is an abandoned gas well; its location is known. A gas well was leaking at the surface. There is a dispute of ownership with the well. The Department suspects the integrity of the well may have been affected by deep mining as the stray gas occurrence coincides with documented mine subsidence in the area.

Origin/mechanism of migration: abandoned gas well. Suspected casing/cement failure possible caused by mine subsidence. Status: Investigation Ongoing

Mediate Migration, Westmoreland County – SWRO - November, 2003: The stray gas was impacting private residence. Origin/mechanism of migration: source of gas is an abandoned gas well; its location is unknown. Natural gas service to a structure was terminated. Status: DEP funded mitigation system installed. Structure is protected. Natural gas service restored.

Tanoma Migration, Indiana County – SWRO - July, 2001: The stray gas occurs throughout the soils on private property. Origin/mechanism of migration: The origin of

the stray gas is likely coalbed/gas well mixture. The situation was resolved through venting. The specific sources have not identified. Status: Resolved

McDonald Sr. Care Home Migration, Washington County – SWRO - November 2002: Stray gas found inside a Senior Care home, resulted in temporary evacuation. Origin/mechanism of migration is an abandoned gas well. Its location is unknown. The home was evacuated. The problem was resolved by installation of a mitigation system.

Paiano Migration, Armstrong County, -SWRO - September, 2002: Stray gas inside private water supply well resulted explosion in well enclosure. No injuries. Well was properly vented. Origin/mechanism of migration is an abandoned gas well, location unknown. Status: Resolved. Water well properly vented. Well not found.

Bagdad Road Migration, Waterford Twp., Erie County – NWRO – July 2008:
The Department is in the process of investigating a complaint of fugitive gas in a domestic water well received in July of 2008. All area gas wells are in regulatory compliance and isotopic analysis does not indicate a specific source of the stray thermogenic gas.

Clarington Migration, Barnett Twp., Clarion County - NWRO
The Department has been aware of a soil gas seep in a remote area since at least 1987. The source of the gas is unknown, no active gas wells are in the vicinity and a search of historical records failed to indicate any record of oil and gas drilling. The site near Cherry Run has become a seasonal camping spot and the surface expression of the stray gas migration has been improved with stone fire-ring to serve as a campfire location.

Groshek Migration, Keating Twp., McKean County – NWRO – 2008. In 2008 the Department responded to a complaint of stray gas in a domestic water supply. The area of the complaint is in an old oil and gas field that was drilled near the turn of the 20th century. Historic maps were used to attempt to locate nearby abandoned wells. Without any new drilling activity vicinity, the Department plugged four abandoned wells. These efforts of find and fix the cause of the migration have been unsuccessful. A recently discovered gas well has been identified in the field and the well was placed on the department's plugging list.

Leichtenberger Migration, Howe Twp., Forest County - NWRO
In June 2005 stray gas was reported to have entered two springs that serve as domestic water supplies. Located in an area that experienced a long history of oil and gas drilling activity, it was discovered that the migration began near the same time that two gas wells, located more that 3000' away, were fraced. The new gas wells are in regulatory

compliance and additional measures were taken to prevent a gas migration. The department has plugged three abandoned gas wells in the vicinity. All efforts to identify the cause of the migration have been unsuccessful.

Nicholls Migration, Rome Twp., Bradford County – NCRO – June 2007: Complaint received by the Department in June, 2007 of stray gas in a domestic water supply. Isotopic analysis of the gas indicates that it is of thermogenic origin although it apparently does not match any production gas in nearby gas wells.

Skinner Migration, Columbus Twp., Warren County - NWRO
The Department responded to a complaint of stray gas in a domestic water well in June, 2005. All wells within 6000' were inspected and found to be in regulatory compliance except two gas wells. Those two wells were brought into compliance with the addition of production casing. The water supply improved however small amounts of fugitive gas remain in the water well. An abandoned well discovered by the department during the investigation remains on the State's plugging list.

Wayland Road Gas Migration, East Mead Twp., Crawford County – NWRO – October 2008: The Department continues to investigate a fugitive gas migration expressed in a domestic water well first reported in October, 2008. No difficulties were reported by the drilling company during construction of nearby gas wells, all gas wells are in regulatory compliance and it is difficult to determine when the problem became apparent. Isotopic analysis indicates that the fugitive gas is thermogenic in origin although a match to a nearby gas well is not apparent.

Hetrick Gas Migration, Redbank Twp., Clarion County – NWRO – Spring 2007: In the spring of 2007 the Department initiated an investigation into the conditions surrounding the report of fugitive gas in a domestic water well. Isotopic analysis of the stray gas indicates a thermogenic origin potentially similar to neighboring gas wells. A legally defensible case against a potentially responsible party could not be demonstrated and the Department eventually provided the resident with an alternative source of water.

Julie Anne Lane, Summit Twp., Erie County – August 2008: In August of 2008 the Department responded to a report of fugitive gas near a private residence. During the investigation a nearby "plugged" National Fuel Gas well was leaking a very small amount of gas. Isotopic analysis of soil gas samples obtained by the DEP indicated that the gas was probably of microbial origin and fuel gas was restored to the residence.

Mainesburg Migration, Sullivan Twp., Tioga County – NWRO – 2004: The Department became involved with this larger scale stray gas migration in 2004. Elevated

levels of fugitive gas were identified in approximately 15 residences. Through a joint action between the department and Township officials, and with funding through a Growing Greener Grant, treatment systems were placed on those affected water wells. Three abandoned gas wells were plugged by the Department.

McCommons Migration, Leidy Twp., Clinton County – NWRO – November 1998: In November 1998 the Department responded to a complaint of stray gas in three water supply wells. Through the course of the investigation it was discovered that because one of the affected water wells was located in the basement of a church, combustible gas migrated from the well and into the indoor air of the structure, causing a significant risk of explosion. Also discovered was that during a recent resurfacing project on Rt. 144, Penndot paved over an abandoned gas well. The Department proceeded to remove the recent pavement and plug the abandoned well. Two of the three impacted water wells returned to normal and a marked improvement in conditions were noted in the third water well.

Mt. Jewett Municipal Well-field Migration, Hamlin Township, McKean County: Three water wells for the municipality of Mt. Jewett were temporarily affected by a stray gas occurrence in 2008. The migration lasted approximately one week and went away for no apparent reason. After the event, the department plugged a nearby abandoned gas well.

Sara Coyne, City of Erie, Erie County – NWRO – April 2008: In April of 2008, the department responded to a complaint of gas bubbling in a large body of standing water in a campground near the entrance to Presque Isle State Park. Soil gas samples obtained for isotopic analysis indicated that the composition of the gas is consistent with shallow shale gas of the area. Excavation done by the property owner encountered an abandoned gas well approximately 6 feet below ground surface. The gas well was subsequently plugged.

Environmental Air Migration, Pittsburgh, Allegheny County
The source of gas is an abandoned gas well; its location is unknown. Natural gas service was restored following installation of a mitigation system.

Owens Migration, Allegheny County
The source of gas is an abandoned gas well; its location is known. A site developer disturbed the well and was required to properly abandon the well.

Marshall Avenue Migration, Chartiers, Washington County

The source of gas is a possible coalbed/gas well mixture. The area has been properly vented. DEP suspects a gas well was leaking into a mine void.

Elliot Migration, Armstrong County
The source of gas is an abandoned gas well; its location is unknown. The case was resolved by properly venting a water well.

UNDERGROUND STORAGE OF NATURAL GAS CASES

Tioga Junction Migration, Tioga Twp., Tioga County – NWRO - 2008: In January 2001, the Department responded to a report of gas in the soil near two buildings. Further investigation indicated the presence of a potentially widespread stray gas migration problem. In 2008, Dominion Transmission and PPL Gas Utilities Corp. initiate a voluntary program to ensure safe source of drinking water for residences near Tioga Storage Field. 288 letters were sent of area homeowners requesting the opportunity to sample individual water supplies. A large number of residents responded and the extent of the potential stray gas by sampling was delineated. Water treatment systems were provided, at no cost to the homeowner, to those water supplies that were shown to have been impacted. The companies and the Department remain in the investigation process.

Sabinsville Migration, Borough of Sabinsville, Tioga County – NWRO – 2005 ongoing: The Department is aware of a fugitive gas migration in the water supplies for several residences in Sabinsville. Initial sampling occurred in 2005 and elevated levels of methane/ethane were encountered. The homes are located within the footprint for the Sabinsville Gas Storage Field that is operated by Dominion Transmission Inc. Isotopic samples have been obtained from the affected water wells and gas wells within the storage field. The cause of the migration has not been determined.

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DEP Issues Report on Short-Term Air Quality Impacts from Marcellus Shale Operations in Southwest PA
Agency Continues to Monitor Air Quality in Other PA Regions

HARRISBURG -- Department of Environmental Protection today released a report on a five-week air quality study conducted near Marcellus Shale natural gas operations in southwestern Pennsylvania's Greene and Washington counties.

"This short-term study only provides a snapshot of the air contaminants we found at surveyed sites, but the data shows no emission levels that would constitute a concern to the health of residents living near these operations," DEP Secretary John Hanger said, noting that the report does not assess the potential cumulative effects from natural gas operations.

"These results only provide preliminary information about the type of pollutants released to the atmosphere. Drilling activity continues to increase at a rapid pace across the state, so this study provides us with good information as part of our ongoing effort to gauge the impact these operations have on our air quality, public health and the environment. Needless to say, we plan to conduct more of these types of air-sampling exercises moving forward," Hanger added.

DEP's assessment focused on concentrations of volatile organic compounds, including benzene, toluene and xylene, which are typically found in petroleum products. The department also sampled for other pollutants including carbon monoxide and nitrogen dioxide near natural gas extraction and processing sites.

The agency gathered samples to provide background data at its monitoring station in Florence, a section of Hanover Township, Washington County.

The air monitoring surveys near natural gas operations were conducted at a wastewater impoundment, tank farm and two compressor stations. Those surveys detected the main constituents of natural gas—including methane, ethane, propane and butane—as well as low levels of associated compounds, including benzene and n-hexane, which were detected infrequently at the tank farm and at a compressor station. Higher concentrations of the main constituents of natural gas were detected mainly near the compressor stations.

Methyl mercaptan, a gas which has a penetrating and unpleasant odor similar to rotten cabbage or rotten eggs, was also detected at concentrations that generally produce odors at each location where samples were taken. That threshold is about one part per billion.

The air sampling surveys conducted for carbon monoxide, nitrogen dioxide and ozone precursor emissions did not detect levels above national ambient air quality standards at any of the surveyed sites. However, DEP has not yet determined if the potential cumulative emissions of these air contaminants will cause or contribute to violations of the national ambient air quality standards.

DEP is conducting similar air monitoring studies near Marcellus gas facilities in the Dimock area of Susquehanna County, as well as in the north-central region of the state, to determine if there is a consistent statewide emissions profile for air contaminants near natural gas operations. All studies are expected to be complete in January 2011.

Since 2005, 2,300 Marcellus Shale wells have been drilled in Pennsylvania.

To view the report, visit **www.depweb.state.pa.us** and click on "Regional Resources," then on "Southwest Region" and choose the "Community Information" link on the right side of the page.

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Report for the Delaware River Basin Commission Consolidated Administrative Hearing on Grandfathered Exploration Wells

To
Delaware Riverkeeper Network
and
Damascus Citizens for Sustainability

Prepared by
Paul A. Rubin
HydroQuest
November 15, 2010

1) On behalf of the Delaware Riverkeeper, the Delaware Riverkeeper Network, and Damascus Citizens for Sustainability, I have reviewed numerous reports and much material that relates to the practice of developing gas wells in shales. Much of my focus relates to the Appalachian Basin that encompasses portions of New York State, Pennsylvania, New Jersey, and Delaware. While this testimony is oriented to exploration wells in Wayne County, PA and the broader Delaware River Basin, the concepts forwarded are applicable throughout the Appalachian Basin to areas overlying the Marcellus and Utica shales. In my professional opinion, vertical exploratory gas wells, as well as horizontal hydraulically fractured wells, create a high risk of contamination of the water resources of the Delaware River Basin. This risk exists not only at the time of drilling but also increases over time, because of a) the likelihood of failure of the well over time, b) the likelihood of eventual migration of toxic natural and drilling-related substances through extensive natural fractures that exist throughout the region, and c) the exacerbation of a) and b) above by natural or drilling-induced seismic activity. This report also documents significant natural seismic activity in and adjacent to the Delaware River Basin over time. Ground motions from even one significant earthquake, among many that occur over time, may catastrophically shear numerous gas well casings or, at the very least, may result in fracturing and loss of integrity of well casing cement designed to isolate freshwater aquifers from deep saline waters. As such, earthquakes may instantly destroy the integrity of hundreds of gas wells, thereby forever and irreparably compromising the hydrologic integrity of geologic formations that formerly protected freshwater aquifers. Restoration of contaminated freshwater aquifers is probably not possible, thus well failures from any single or combination of mechanisms is likely an irrevocable commitment of natural resources. These points will be discussed in greater detail below.

2) I offer this opinion based on my training as a geologist, hydrogeologist, and hydrologist with more than twenty-nine years of professional environmental experience, which includes work conducted for the New York State Attorney General's Office (Environmental Protection Bureau), Oak Ridge National Laboratory (Environmental Sciences Division), the New York City

Department of Environmental Protection, and as an independent environmental consultant as President of HydroQuest. My educational background and professional experience are more fully set forth in my Curriculum Vitae, attached as Addendum A, attached to my report. I have conducted detailed assessments of streams, wetlands, watersheds, and aquifers for professional characterizations, for clients, and as part of my own personal research. I have authored numerous reports and affidavits related to this work and have made presentations to judges and juries. In addition, I have published papers and led all-day field trips relating to this work at professional conferences.

Location and Bedrock Geology

3) The Delaware River Basin encompasses portions of New York State, Pennsylvania, New Jersey, and Delaware. Figure 1 portrays this large watershed area. The exploratory wells that are the subject of this testimony lie in Wayne County, the furthest northeastern county of Pennsylvania. Immediately north, northeast, and east of Wayne County are three New York State counties: Broome, Delaware, and Sullivan respectively.

4) Geologically, Wayne County, PA is virtually indistinguishable from portions of Broome, Delaware, and Sullivan Counties. Figure 2 depicts similar geologic formations present in Broome, Delaware, Sullivan and other counties throughout New York State that lie in close proximity to Wayne County. Geologically, these units are composed of a series of sedimentary shales, siltstones, sandstones, and some conglomerates layered from the Honesdale Formation downward through and below the Marcellus Formation. These rock units were deposited under the same hydrologic conditions through the widespread area now recognized by geologists as the Catskill Delta. Before the sediments of these rock units were lithified into bedrock, they were shed northwesterly from the ancestral Acadian Mountains.

5) The subcrop of the Marcellus shale underlies portions of these New York State counties and all of Wayne County, PA. Portions of these counties, as well as portions of Schoharie, Greene, and Ulster counties in New York State, lie within the headwater region of the Delaware River Basin. In Figure 2, Wayne County, PA lies in a white area directly southwest of the boxed label titled: Cannonsville Reservoir Delaware R. headwaters.

6) As reflected in Figure 2, it is apparent that erosion has, in places, removed some of the uppermost bedrock units through glaciation and erosion. In places, Wayne County and nearby watershed areas have the same bedrock units exposed at the ground surface. Significantly, geologically and hydrologically, ground and surface water flow in Wayne County and surrounding counties behaves similarly – all potentially being vulnerable to gas field related contaminants from below and above.

7) The Marcellus and Utica shales extend under a large, multi-state, land area. The environmental risks associated with the installation of vertical exploratory wells and hydraulic fracturing are interstate in nature and must be fully evaluated in this manner - not solely state by state or watershed by watershed. The need to comprehensively evaluate and regulate hydrologic and hydrogeologic risks on a gas field basis is paramount.

Joints, Faults, Methane Presence, and Blowouts

8) Jacobi (2002) documented numerous joints and faults (collectively termed fractures) present throughout the headwaters of the Delaware River Basin, as well as elsewhere throughout portions of New York State overlying the Marcellus and Utica shales (Figure 3). While much of Jacobi's work did not extend into Pennsylvania, the density of these fractures clearly argues that similar joint sets and faults are present in neighboring Wayne County, PA and beyond. Reference to Figure 3 reveals the dominant NW, N-NW, NE, and E-NE fracture orientations. As seen below, these trends coincide with those throughout the broader Appalachian Basin.

9) Exploratory wells may target or have a high likelihood of penetrating vertical bedrock joints that have the potential of hydrologically connecting saline and freshwater horizons. Prominent joint orientations throughout the Appalachian Basin, inclusive of Wayne County Pennsylvania, are well documented by Evans (1994), Engelder et al. (2009), and Lash and Engelder (2009). Figure 4 depicts four figures from Engelder et al. (2009) and Lash and Engelder (2009) that illustrate dominant joint orientations throughout the Appalachian Basin. These geologists determined that most pervasive systematic joints hosted by Devonian black shale strike east-northeast (J_1 joint set) with younger cross-fold joints striking northwest (J_2 joint set). They concluded that "*[B]oth sets were driven exclusively by fluid pressure generated as a consequence of hydrocarbon-related maturation supplemented by subsequent tectonic compaction during the Alleghanian tectonic cycle. In the more deeply buried, proximal region of the Catskill Delta, joints of both sets cross-cut.*" (Lash and Engelder, 2009). Figure 3 confirms this cross-cutting relationship in New York State counties immediately north, northeast, and east of Wayne County. Engelder et al. (2009) confirm that the more permeable J_1 joint sets are found at depth in the Marcellus based on the presence of systematic J_1 joints in Marcellus outcrops on either side of the deep central region of the Appalachian Basin, as well joint appearance in Formation MicroImager images of recent wells. Thus, two regional, well-integrated, perpendicular joint sets exist throughout Wayne County, PA. Exploratory and other wells have a high likelihood of intersecting these interconnected joint sets.

10) Vertical exploration wells, even in the absence of stimulation via hydraulic fracturing, pose similar environmental risks as do horizontal well completions. Natural fractures function as high-permeability gas pathways (Engelder et al., 2009). The greater the fracture interconnectivity, the greater the potential gas production. Recent drilling technology in the Marcellus Shale uses hydraulic fracturing to take advantage (i.e., maximize production) of the more densely spaced and more permeable E-NE oriented J_1 joint sets by interconnecting them via horizontal drilling methods oriented perpendicular to J_1 joints (i.e., N-NW and S-SE). Hydraulic fracture interconnection results in J2 joints draining to J1 joints and gas production wells. In the absence of hydraulic fracturing, vertical exploratory wells have been known to intersect high permeability gas-bearing fractures, sometimes with disastrous results. Engelder et al. (2009) document the presence of unhealed (i.e., methane-filled) joints at depth in the Marcellus shale and major blowouts that occurred when these unhealed joints were encountered (as cited from Bradley and Pepper, 1938 and Taylor, 2009). For example, Taylor (2009) discusses the 1940 Crandell Farm blowout near Independence, New York where massive uncontrolled gas flow occurred from joints intersected by an unstimulated vertical Marcellus well that lacked any evidence of faulting. Engelder et al. (2009) further discuss blowouts in the

Marcellus Shale after the Crandell Farm blowout:

> *"Over the following half century, blowouts were a common consequence of drilling vertical wells penetrating the Marcellus. The low permeability of the Marcellus suggests that many, if not all, blowouts must have tapped a reservoir of interconnected natural fractures. In fact, blowouts were one of the major attractions drawing Range resources to Washington County, Pennsylvania, where Range started targeting the Marcellus gas shale during 2004 (W.A. Zagorski, personal communication)."*

11) Engelder et al. (2009) document that, even in the absence of stimulation, some gas wells that tap unhealed and well-interconnected joint sets at depth are excellent producers. Clearly, preserved unhealed joints are important to gas production because healed fractures and veins would otherwise serve as barriers to gas flow (Engelder et al., 2009). Thus, vertical exploration wells that intersect permeable, gas-rich, interconnected joint sets pose a potential hydraulic pathway (i.e., with a decreasing pressure gradient) for upward migration and release of methane, especially in the event of casing or grout failure or stemming from seismic activity – whether natural or induced at some point later in time by hydraulic fracturing. In the latter case, earthquake or micro-seismicity stemming from future hydraulic fracturing in the area may result in shearing of exploration well casing and the opening of inter-formational pathways. Beyond this, blowouts themselves may pose a means of catastrophically interconnecting brine-rich and freshwater geologic horizons. Therefore, vertical exploration wells bear many of the same potential adverse environmental impacts as hydraulically fractured horizontal wells.

12) Numerous joints in the Appalachian Basin, even in the absence of gas well installations, provide open, functioning, avenues for upward migration of methane. Gas-rich joints encountered by exploration well boreholes may interconnect and enhance preexisting joint pathways for methane, deep-seated saline water, radioactivity and, following development of horizontal gas wells, for contaminated LNAPL (Light Non-Aqueous Phase Liquids; e.g., chemicals with a density less than freshwater, such as benzene) fracture fluids to migrate to aquifers, reservoirs, lakes, rivers, streams, wells, and even homes.

13) Importantly, Figure 3 of New York State counties north, northeast, and east of Wayne County, PA provides a <u>conservative</u> approximation of the actual number of joints and faults present throughout the area. In establishing a relationship between seismicity and faults, Jacobi (2002) examined Fracture Intensification Domains (FIDs: closely spaced fractures commonly with a frequency greater than 2/m and with a fracture frequency an order of magnitude greater than in the region surrounding the FID), E97 lineaments (Fig. 3), topographic lineaments, gradients in gravity and magnetic data, seismic reflections profiles, and well logs. Jacobi states:

> *"In interbedded shales and thin sandstones in NYS, fractures within the FID that parallel the FID characteristically have a fracture frequency greater than 2/m, and commonly the frequency is an order of magnitude greater than in the region surrounding the FID."*

14) Jacobi makes a case for repeated reactivation along faults in the Appalachian Basin. Furthermore, and importantly, Jacobi addresses his and Fountain's identification of FIDs based on soil gas anomalies over open fractures:

"Certain sets of FIDs are marked by soil gas anomalies commonly less than 50 m wide (Jacobi and Fountain, 1993, 1996; Fountain and Jacobi, 2000). In NYS, the background methane gas content in soil is on the order of 4 ppm, but over open fractures in NYS, the soil gas content increases to 40-1000+ ppm."

The fact that Jacobi and Fountain have successfully identified and measured methane seepage from fractures that most likely extend downward to gas producing shales shows that open vertical pathways already exist, confirming the risk of increasing gas excursions as a result of exploratory boreholes penetrating joints or, later in time, as horizontal wells are hydraulically fractured. Clearly, Jacobi and Fountain's work suggests that opening and expanding fractures that now naturally release methane from gas-rich shales will provide even greater gas and contaminant migration pathways if later interconnected and widened via hydraulic fracturing. As with environmental concerns attendant to completing hydrofracked horizontal gas wells, installing vertical exploratory boreholes into gas-rich joint sets should not occur until after full environmental review.

Earthquakes, Seismicity, and Risk of Casing Shearing

15) The installation of exploratory wells that open borehole or nearby joint pathways between formerly separated geologic horizons pose an environmental risk, particularly because the area is seismically active. Ground motion associated with seismic activity has the real potential of instantly shearing multiple well casings, degrading cement grout designed to isolate geologic horizons, and thereby opening vertical joint and borehole vectors between formerly separated geologic horizons. Numerous earthquakes have occurred in Pennsylvania, New York, and adjacent states (see Addendum B and Addendum C), pointing out that the region of the exploratory wells is seismically active. Figure 5 depicts historical earthquake epicenters, documenting that significant portions of the Appalachian Basin are seismically active. Figure 6 portrays USGS seismic hazard maps for Pennsylvania, New York, Delaware, and New Jersey. The Wayne County, PA area shows a peak horizontal ground acceleration of some 6-8% g with a 2% probability of exceedance in 50 years (i.e., earthquake ground motions that have a common given probability of being exceeded in 50 years). The %g relates to the acceleration due to gravity. It is a measure of ground motion that decreases the farther one is from an earthquake epicenter. A 6-8%g roughly correlates with a Modified Mercalli Intensity of VI. This intensity of an earthquake is likely to be felt by everyone, may result in movement of heavy furniture, and may damage house plaster and chimneys (DCNR, 2006). While damage on the ground surface is slight, it is likely that damage to casing grout and possibly well casings may occur – potentially compromising the integrity and physical isolation of different bedrock horizons.

16) Seismic activity in Pennsylvania and nearby states may result in significant ground motions that may compromise the integrity of well grout and casing. This, in turn, may result in interformational mixing of groundwater along exploratory well boreholes or adjacent joints. Earthquakes have occurred in Pennsylvania and elsewhere (DCNR, 2006). One of the largest earthquakes, of unknown magnitude, had an epicenter near Attica, NY and is reported to have cracked walls in Sayre, PA in 1929. Sayre is located in Bradford County, only some 50 miles

from Wayne County. Another nearby New York State earthquake, with a magnitude of 5.5, occurred in New York City in 1884 (only about eighty miles from Wayne County, PA), again documenting that the region is seismically active.

17) Numerous earthquakes have occurred in Pennsylvania, many in recent time, with the largest recorded in 1998 with a magnitude of 5.2. Some of those reasonably close to Wayne County include Berks County (to magnitude 4.0 and 4.6 in 1994), Bucks County (to 2.5), Lancaster County (to 4.4), Lehigh County (to 3.3), Monroe County (immediately south of Wayne County; 3.4, epicenter may have been in NJ), and Montgomery County (3.5). While these earthquakes did not produce substantial damage, there is a reasonable probability that higher magnitude earthquakes, with related damage, may occur. DCNR (2006) details this real possibility:

> *"Earthquakes having magnitudes greater than 5 can occur in Pennsylvania, as demonstrated by the earthquake of September 25, 1998 (Armbruster and others, 1998) (Table 2, Crawford County). Southeastern Pennsylvania, the state's most seismically active region, is not known to have experienced an earthquake with magnitude greater than 4.7, but the historical record goes back only about 200 years. No obvious reason exists to conclude that an earthquake of magnitude between 5 and 6 could not occur there also. An earthquake with magnitude greater than 6 is much less likely, but the fact that such large earthquakes have occurred elsewhere in the East means that this possibility cannot be ruled out entirely for Pennsylvania. … The possibility that a magnitude 7 earthquake could occur having an epicenter near New York City cannot be completely discounted, and such an earthquake could produce significant damage (intensity VIII) in eastern Pennsylvania. … A large local earthquake, one with magnitude greater than 6, though unlikely, is not impossible."*

18) Earthquakes of these magnitudes in Pennsylvania have the real potential of resulting in sufficient ground motion to shear well casings and degrade the integrity of grout designed to physically separate different geologic and hydrologic horizons. For example, earthquakes of magnitude 5.0 to 5.9 on the Richter or moment magnitude scales can cause major damage to poorly constructed buildings. Wikipedia provides an approximate energy equivalent in terms of TNT explosive force for a 5.0 Richter magnitude earthquake as being equivalent to the seismic yield of the Nagasaki atomic bomb. Clearly, the decision to permit installation of exploratory wells, or horizontal wells, should be based on a comprehensive analysis of all environmental risks. It should be noted that the risk to grout and casing integrity exists both from natural earthquake activity and, in the case of hydraulically fractured horizontal wells, from microearthquakes stemming from fluid-induced seismicity (Bame and Fehler, 1986; LI, 1996; Feng and Lees, 1998; Horálek et al., 2009; Shapiro and Dinske, 2009). Therefore, the potential impacts of seismicity, whether from natural or man-induced activities, should be extensively analyzed prior to any deep drilling efforts. Because portions of Pennsylvania are seismically active, a real risk exists that earthquakes might instantly and catastrophically degrade casing grout integrity and shear multiple well casings, resulting in the commingling of formation fluids and release of methane. Unlike the recent British Petroleum disaster in the Gulf of Mexico, once the integrity of bedrock formations is breached, it will not be possible to restore degraded freshwater aquifers.

19) As an example of active seismicity in the Appalachian Basin, Jacobi and Smith (2002) document the epicenters of three seismic events in eastern Otsego County, New York. These seismic events indicate that earth movement occurs from great depth along faults upward to aquifers and near the ground surface. The great lateral extent of these faults, and their visually observable connectivity with other faults, confirms that the process of gas drilling activities, which may interconnect naturally occurring faults and fractures, has a great and very real potential of causing contaminants to migrate to aquifers and surface water from localized zones across and beyond county and watershed boundaries.

Grout and Casing Failure

20) The high risk of compromising the integrity of the physical separation of freshwater aquifers from deeper saline water-bearing bedrock formations may be compounded as a result of well grout and casing failures that occur A) as a result of poor well construction (e.g., as in the BP well failure), B) due to mechanisms including cement shrinkage, or C) due to differences in downhole bedrock conditions (e.g., pressure differentials). Zhou et al. (2010) point out that casing pipes in well construction may suddenly buckle inward as their inside and outside hydrostatic pressure difference increases. Dusseault et al. (2000) document the many reasons why oil and gas wells leak, thus providing important supportive scientific rationale as to why both vertical exploratory wells and horizontal gas wells should not be permitted in advance of extensive environmental risk characterization:

> *"Oil and gas wells can develop gas leaks along the casing years after production has ceased and the well has been plugged and abandoned (P&A). Explanatory mechanisms include channeling, poor cake removal, shrinkage, and high cement permeability. The reason is probably cement shrinkage that leads to circumferential fractures that are propagated upward by the slow accumulation of gas under pressure behind the casing.*
>
> *The consequences of cement shrinkage are non-trivial: in North America, there are literally tens of thousands of abandoned, inactive, or active oil and gas wells, including gas storage wells, that currently leak gas to surface. Much of this enters the atmosphere directly, contributing slightly to greenhouse effects. Some of the gas enters shallow aquifers, where traces of sulfurous compounds can render the water non-potable, or where the methane itself can generate unpleasant effects such as gas locking of household wells, or gas entering household systems to come out when taps are turned on."*

21) Dusseault et al. (2000) detail the underlying causes behind tens of thousands of grout failures in North America that likely compromise environmental security and zonal isolation while leading to contamination of freshwater aquifers. They conclude that:

- Surface casings have little effect on gas migration;
- Water-cement slurries generally placed at low densities will shrink and will be influenced by elevated pressures and temperatures encountered at depth;

- While cement is in an almost liquid, early-set state, massive shrinkage can occur by water expulsion, resulting in shrinkage of the annular cement sheath;
- Portland cements continue to shrink after setting and during hardening;
- Other processes can lead to cement shrinkage. High salt content formation brines and salt beds lead to osmotic dewatering of typical cement slurries during setting and hardening, resulting in substantial shrinkage;
- Dissolved gas, high curing temperatures, and early (flash) set may also lead to shrinkage;
- Initiation and growth of a circumferential fracture ("micro-annulus") at the casing-rock interface will not be substantially impeded because cement shrinks;
- Circumferential fractures develop and gas leakage typically increase over time;
- Wells that experience several pressure cycles are more likely to develop circumferential fractures;
- Circumferential fractures propagate vertically upward because of the imbalance between the pressure gradient in the fracture and the stress gradient in the rock;
- Free gas will serve to further degrade the casing-grout-rock interface, increase gas flow into circumferential fractures, and may lead to continuous gas leakage;
- In turn, differences in pressure favor driving gas, and pressurized fluids present at depth, upward and outward from circumferential fractures back into bedrock formations (including those present in freshwater aquifers) where the pore pressure is less. Over time, the excess pressure is large enough to fracture even excellent cement bonds and force flow outward into surrounding strata;
- Methane from leaking wells into freshwater aquifers is unlikely to attenuate, and the concentration of the gases in shallow aquifers will increase with time;
- Loss of this zonal seal can have negative effects, such as pressurizing higher strata, or leakage of brines and formation fluids into shallower strata causing contamination; and
- Despite our best efforts, the vagaries of nature and human factors will always contribute to grout failures.

22) As detailed above by Dusseault et al. (2000), gas leakage up circumferential fractures at the cement-bedrock interface may also enter and degrade freshwater aquifers. In fact, the greatest risk of this occurring is in vertical wells, not in deep horizontal wells that have not been hydraulically fractured (Dusseault et al., 2000). Thus, unfracked vertical exploratory wells pose a greater environmental risk than do deep, unfracked, horizontal boreholes. When the above issues are considered within the broader context of documented regional seismicity, the real threat to the long-term integrity of our freshwater aquifers and quality of our surface waters is obvious.

Contamination of Freshwater Aquifers and Loss of Aquifer Integrity

23) Contamination of freshwater aquifers via the mechanisms detailed above by Dusseault et al. (2000) (i.e., methane entering formations from leaking circumferential fractures) is likely to be far greater than more limited contamination proximal to well heads. Freshwater aquifers in

Wayne County, PA extend to at least 665 feet, as observed at the Matoushek #1 well (Stiles, 2010). Permitting the installation of vertical exploration wells needs to be considered in the broader environmental setting where these wells may ultimately be completed as hydrofracked horizontal production wells. Should natural ground motion from earthquakes (and possibly from seismically induced earthquakes from future hydrofracked wells) occur, it is likely that alternate groundwater flow paths will develop. These flow paths will then provide avenues for migration of gas well related contaminants, particularly low density or gaseous ones. Pre-existing joint sets that are already open to gas-rich shales (Jacobi, 2002) will provide pathways and release avenues for methane and any Light Non-Aqueous Phase Liquids that may be present. In this way, vertical fractures extending into overlying bedrock formations may result in the disruption and alteration of natural groundwater flow.

24) Understanding the cumulative impacts of natural gas drilling in the Delaware River Watershed is essential in order to determine how this activity should be regulated. By way of analogy, using a somewhat different but worst case example, solution mining in Tully Valley, New York, demonstrates how alteration of a previously isolated and intact freshwater aquifer was compromised via anthropogenic activities. While not physically observable on the ground surface, the adverse environmental impacts of gas production throughout large portions of the Appalachian Basin, may have much broader and far reaching impacts. The Tully Valley example described below demonstrates the nature and consequences of disrupting a previously intact groundwater flow regime. This analogy is especially applicable to adverse environmental impacts likely to occur with additional well drilling.

25) Deep solution mining of salt beds in Tully Valley, conducted under NYSDEC mining permits, regulation, and oversight has resulted in slow and catastrophic collapse of portions of Tully Valley from depths of 1,700 feet (518 m) to the ground surface. Rubin et al. (1992) document the structural failure of portions of the valley overlying and adjacent to brine cavities where salt was removed. The resulting settlement area is in excess of 550 hectares (~1,360 acres; 2.1 mi^2). It continues to expand outward. Upward fracture propagation eventually resulted in open permeable pathways where fresh aquifer and infiltrating meteoric water began to recharge formerly isolated groundwater flow regimes, thereby establishing new deep flow routes that now result in connate, saline, and turbid water discharge to the ground surface, and Onondaga Creek (see Figure 7).

26) As illustrated in the Tully Valley example, once even a few significant fracture interconnections (i.e., planer, laterally extensive, and potentially interconnected with Fracture Intensification Domains) are established between target shale beds and the ground surface, naturally isolated groundwater flow systems then become accessible for commingling of formation waters, for transmission of contaminants, for the unnatural and increased recharge of deeper formations, and for the establishment of new groundwater flow routes. Much as methane can be released upward to lower pressure formations from exploration wells, so will LNAPLs rise upwards along fault and fracture pathways as more wells are drilled and developed, thereby broadly contaminating freshwater aquifers. Then, as new groundwater circulation pathways develop in response to repeated hydro-fracturing and newly available freshwater hydraulic/pressure heads, more and more commingling of freshwater and contaminant-laden, saline, water is likely. Thus, extensive natural fractures present throughout the Delaware River

Basin and broader Appalachian Basin may provide vectors for new interconnected groundwater circulation pathways.

27) With time, methane (and hydro-fracturing chemicals as gas production is permitted) will move with groundwater flow, down valley, toward zones of lower hydraulic head, particularly valley bottoms, major streams, and principal aquifers. Areas with higher groundwater flow velocities are likely to develop groundwater circulation patterns along Fracture Intensification Domains (i.e., high permeability pathways), especially where hydro-fracturing has opened elongate fracture pathways that have high hydraulic gradients between watershed uplands and valleys. To a large degree, these new circulation pathways will resemble those illustrated in the Figure 7 Tully Valley example – albeit fracture aperture width may be narrower and associated catastrophic collapse less likely.

28) While the focus of this testimony does not directly extend to horizontally hydraulically fractured gas production wells, it is not prudent to ignore the overall physical setting within which exploration well installations may ultimately fit. Since it has been shown above that many of the environmental risks normally attributed only to horizontal gas wells directly relate to unfracked vertical exploration wells (e.g., seismic risk, grout shrinkage, vertical flow pathways into freshwater formations), it is prudent to at least cursorily review broader gas production based environmental considerations. While gas field fracture aperture may be narrower than the disrupted Tully Valley example, it is important to recognize that the hydraulic transmissivity of fractures increases by the cube of the effective fracture width, thereby pointing out the likely increased risk associated with repeated hydro-fracturing. The combination of excessive pressure associated with hydro-fracturing and lubricated fault planes may lead to increased faulting and seismicity, followed by increased groundwater circulation between formerly isolated hydrologic horizons. Northrup (2010), for example, references a hydro-fracturing induced earthquake in Cleburne, Texas – the likely tip of the iceberg. Once these new groundwater circulation pathways are established, it will be impossible to restore the integrity of adversely impacted freshwater groundwater flow systems, contaminant migration and dispersal will expand, and plugging and abandonment procedures of gas production wells will have little impact on retarding water quality degradation throughout irreparably compromised aquifer systems.

29) Cumulative impact studies must address potential adverse environmental impacts associated with both exploratory wells and the overall long-term plan for the installation of hundreds or thousands of horizontal hydraulically fractured wells throughout the Delaware River Basin. Naturally occurring excursion of methane gas via faults and fractures has long been recognized. Recent studies are now beginning to confirm that methane, drilling chemicals, and hydro-fracking chemicals are migrating upward along hydro-fractured fracture pathways to freshwater aquifers and homeowner water supplies. For example, Lustgerten (2009) references scientific work conducted on methane gas excursions in Garfield County, Colorado where a three-year study used sophisticated scientific techniques to match methane from water to a deep gas-rich bedrock layer stating:

> *"The Garfield County report is significant because it is among the first to broadly analyze the ability of methane and other contaminants to migrate underground in drilling areas, and to find that such contamination was in fact occurring. It examined more than*

700 methane samples from 292 locations and found that methane, as well as wastewater from the drilling, was making its way into drinking water not as a result of a single accident but on a broader basis. As the number of gas wells in the area increased from 200 to 1,300 in this decade, methane levels in nearby water wells increased too. The study found that natural faults and fractures exist in underground formations in Colorado, and that it may be possible for contaminants to travel through them. Conditions that could be responsible include vertical upward flow along natural open-fracture pathways or pathways such as well-bores or hydraulically-opened fractures …"

30) What we are just beginning to understand is the fact that repeated fracturing at each well will further amplify all of these risks. Reaping maximum gas production from horizontal gas wells commonly requires repeated hydro-fracturing of wells (see discussion by Northrop, 2010). With each successive hydro-fracturing event, more toxic contaminants are introduced into subsurface formations, including those already aggravated and potentially opened in the first fracturing cycle. In addition, as gas companies expand their operations, they may turn to the new, more effective, multilateral drilling technology to selectively tap multiple target zones in adjacent areas. This will necessarily result in multiple wellheads and multiple fracturing operations in close proximity. Through these processes, it is highly likely that new, previously unconnected, fractures will be integrated into the area influenced by each production well.

31) David Kargbo et al. (2010), U.S. EPA Region III, recently cautioned about the particular challenges still unresolved about drilling in tight shale formations:

"The control of well bore trajectory and placement of casing become increasingly difficult with depth…At the Marcellus Shale, temperatures of 35-51°C (120-150°F) can be encountered at depth and formation fluid pressures can reach 410 bar (6000 psi) (8). This can accelerate the impact of saturated brines and acid gases on drilling at greater depths. In addition, the effect of higher temperature on cement setting behavior, poor mud displacement and lost circulation with depth makes cementing the deep exploration and production wells in the Marcellus Shale quite challenging. For example following a recent report by residents of Dimock, PA, of natural gas in their water supplies, inspectors from the Pennsylvania Department of Environment Protection (PADEP) discovered that the casings on some gas wells drilled by Cabot Oil & Gas were improperly cemented, potentially allowing contamination to occur….During drilling into the tight Marcellus Shale, there is a slight risk of hitting permeable gas reservoirs at all levels. This may cause shallow gas blowouts and underground blowouts between subsurface intervals. Other geo-hazards that may pose challenges to drillers in the Marcellus Shale include: (1) disruption and alteration of subsurface hydrological conditions including the disturbance and destruction of aquifers, (2) severe ground subsidence because of extraction, drilling, and unexpected subterranean conditions, and (3) triggering of small scale earthquakes."

32) With each additional well and well activity, all of the "challenges" noted by Kargbo, Wilhelm, and Campbell of necessity multiply and increase. See also the BP internal report reported September 9, 2010, attributing fault for the 2010 Deepwater Horizon oil rig explosion to

unexpected cementing problems at pressures less than those of the average shale gas frack. Studies have not yet been done regarding the effect of depth and pressure on casing failure rates in tight shale formations nor on the repeated fracturing re-pressurization under such temperature and depth conditions on cement casings and joints. Nor have studies or plans been developed for remedial action should the casings and joints fail at extreme depth.

33) Risks of casing failure are further compounded by the frequency (or spacing) of casing couplings which may be on the order of every 100 feet or less. Zhou et al. (2010) assessed casing pipes in oil well construction and the risk that they may suddenly buckle inward as their inside and outside hydrostatic pressure difference increases. They point out the importance of measuring the stress state of casing pipe, complete with real-time monitoring and state-of-the-art warning system installations. Consideration should be given to evaluating cost-effective and reliable sensing technologies and installation techniques for long-term monitoring and evaluation of casing pipe before issuing gas well related regulations. Most deeply buried casings are difficult to repair or replace and, as such, can lead to aquifer contamination. Even a small percent casing or grout failure can be effectively irremediable at deep depths and irreparably harm ground and surface water sources.

34) Repeated hydraulic fracturing may activate pre-existing faults or induce shifting or settlement along lubricated fractures. Parts of Pennsylvania and New York State within and near the Delaware River Basin are seismically active. Excessive lubrication of faults and fractures with highly pressurized hydraulic fracturing fluids, bolstered by repeated hydrofracturing episodes, may result in fault activation and bedrock settlement. This, in turn, may result in catastrophic shearing of production well boreholes and casing strings even in the absence of natural seismic activity. Pre-existing old and poorly abandoned oil and gas wells may also provide additional contaminant migration pathways. Unlike the British Petroleum well that was finally plugged, once the structure of the bedrock has been compromised by faulting and/or hydraulic expansion of joints, and formation waters have commingled, aquifer restoration will not be possible.

35) The risk of ground collapse as a result of repeated fracturing cycles should also be studied prior to issuing regulations. "*Severe ground subsidence*" may occur "*because of extraction, drilling, and unexpected subterranean conditions*", as may "*disruption and alteration of subsurface hydrological conditions including the disturbance and destruction of aquifers*" (Kargbo et al., 2010).

36) Homeowner wells do not need to be near gas production wells to be adversely impacted from the upward migration of methane gas and Light Non-Aqueous Phase Liquid contaminants from gas-rich shales. Neither discussion of known fracture frequency nor existing maps depicting massive fracturing throughout the Delaware River Basin appear to have been incorporated into the well permitting review process. As such, many of the real risks attendant to vertical exploratory well installations, or future horizontal hydraulic fracturing of gas-rich shale beds, have not been addressed. As some vertical fractures are widened and opened via hydrofracturing, they will and most probably have already, in some cases, provided a hydraulic avenue where methane is released upward into and throughout these well-integrated Fracture Intensification Domains. Thus, fractures enlarged by hydrofracturing will provide lower

pressure gas release points or routes. Once vertical and lateral fracture pathways are open, even a limited number, natural gas and LNAPLs will migrate extensively throughout formerly isolated upper bedrock and freshwater aquifer groundwater flow systems. As methane is released upward along vertical borehole pathways, and along future hydrofractured boreholes and their interconnected fractures, homeowner wells will provide a final open fracture and cased pathway to the ground surface from methane contaminated aquifers. Because horizontal components of gas wells extend may thousands of feet and may intersect numerous planar vertical pathways, large-scale aquifer degradation is possible. Initially, aquifer degradation can be expected above and adjacent to boreholes with poor grout seals. With time and successive hydrofracturing episodes conducted in individual wells, methane and LNAPLs that are released upward through fault planes and related fractures will widely contaminate freshwater aquifers and surface water receptors.

37) Some of the contaminated groundwater in areas now undergoing hydraulic fracturing is far removed from gas production wellheads, thus strongly indicating that groundwater contamination is already occurring along vertical fault and fracture pathways, distant from potential poor wellhead grout jobs or casing failures. This topic is discussed here because understanding the cumulative impacts of natural gas drilling in the Delaware River Watershed is essential in order to determine how this activity should be regulated. Fractures extend from gas-rich shales to the ground surface and naturally leak methane gas. Repeated hydraulic fracturing is likely to exacerbate this situation. Repeated hydraulic fracturing within numerous individual wells will serve to expand and extend these existing fractures through freshwater aquifers. This will increase upward migration of methane to aquifers, streams, homes, and wellheads. Dimock, Pennsylvania provides an excellent case in point.

38) It is likely that contaminant dispersal along fault, joint, and fracture pathways will be the more common mechanism whereby natural gas and LNAPL excursions find their way into aquifers, homeowner homes, well houses, and streams – not solely via pathways stemming from poor casing grouting. This mechanism also explains why many of the gas contamination incidents reported to date are far removed from individual gas production wellheads (e.g., up to 1,300 feet in the Dimock, PA area; COP 2009). This contaminant dispersal mechanism also strongly accents why gas companies would much prefer to admit that poor or failed casings or poor grout integrity is the root cause of gas excursion problems. Certainly, in the gas industry, it is far preferable to invoke any gas leak mechanism other than that of widespread, uncontrolled, and undocumented upward and lateral migration of formerly isolated methane gas into and through freshwater aquifers.

39) As in the Tully Valley example above, the loss of natural geologic and hydrologic integrity throughout formerly isolated geologic formations poses an enormous threat to the existing and future way of life in planned gas exploitation areas. However, the disruption of the geologic strata presented in the Tully Valley Figure 7, while having wider fracture apertures and relatively great vertical offset of geologic beds, has occurred in an area far smaller in areal extent than what is planned extensively throughout the Delaware River Basin and much of the Appalachian Basin. Gas excursions are likely to occur throughout the Appalachian Basin, wherever there are mapped and as yet undocumented fractures. Because of the physical nature of existing fractures systems, these excursions, even a few in an area, are likely to degrade freshwater aquifers such that

existing and new homeowner well installations will be degraded.

40) Because permitting of vertical exploration wells may result in numerous adverse environmental impacts (discussed above), it is important to fully consider the broader gas field development picture and related environmental impacts. Radioactive radium present in the Marcellus may also be mobilized in fluids and thus become available for transport in the groundwater flow system. This appears to be particularly true of uranium that University of Buffalo researchers recently determined is released during the hydraulic fracturing process (presented at a GSA meeting on Nov. 2, 2010). Tracy Bank and her colleagues determined that hydrofracking forces toxic uranium into a soluble phase and mobilizes it, along with chemically bound hydrocarbons, thereby making it available for groundwater transport. In addition, uranium tainted flow back water poses the risk of contaminating streams, wetlands, and ecosystems.

41) Fracking contaminants, once mobilized vertically along fault planes and joints, especially under pressurized conditions, can reach freshwater aquifers. Even if all fracking fluids were composed of non-toxic chemicals, the risk of interconnecting deep saline-bearing formations (i.e., connate water) and/or radioactive fluids with freshwater aquifers is great. Any commingling of deep-seated waters, with or without hazardous fracking fluids is unacceptable. Documented gas excursions near existing gas fields demonstrate that vertical pathways are open. If gas can migrate to the surface, it is highly likely that hydrocarbon and contaminant-rich Light Non-Aqueous Phase Liquids will also reach aquifers and surface water resources. These contaminants may then also migrate to down gradient wells, principal aquifers, and waterways.

42) Artificially enlarged and expanded hydrofracked fractures may provide vertical pathways for light, low density, drilling fluid chemicals and radon. Some fracking related contaminants will migrate upwards via fractures into freshwater aquifers - particularly Light Non Aqueous Phase Liquids (i.e., less dense hydrocarbons) inclusive of benzene, a known carcinogen. In addition, increased upward migration of radon is likely to occur. The pathways are already there and functioning, waiting to be further expanded and laced with toxic chemicals.

43) There is a growing catalog of hydro-fracking related accidents in other gas-field plays (see e.g., Hazen and Sawyer, 2009). Accidental spills of fracking fluids and flow-back water has the potential of contaminating ground and surface water. Similarly, lateral and upward migration of hydro-fracturing chemicals pose a real risk to Delaware River Basin aquifers, especially to moderate and high yield unconfined aquifers situated in stream valleys that receive their base flow recharge from up-gradient groundwater aquifers.

44) Excursion of drilling fluids and produced fluids from breached flow-back wastewater containment structures, whether via rupture, leakage, or overflow poses a real threat to surface water quality. Overland flow of flow back fluid chemicals to streams, ponds, wetlands, and waterways poses an immediate water quality and ecosystem concern that should be fully evaluated prior to issuance of draft regulations.

45) In the broader context of fully examining all potential adverse environmental impacts, it is

necessary to not only look at impacts associated with vertical exploration wells, but also planned future horizontal hydrofracked wells. Excursion of frack fluids from breached flow-back wastewater containment structures, whether via rupture, leakage, or overflow, poses a real threat to groundwater quality. Slow infiltration of frack fluid chemicals to groundwater and its potential degradation need to be fully addressed prior to issuance of draft regulations.

46) Poor or failing exploratory and production well construction (e.g., poor grouting, corroded casing) may provide vertical pathways for contaminant excursions from deep shale beds upward into freshwater aquifers. While this has already been documented, increased gas well installations will also increase the number of failed wells and resultant contaminant migration. Apparently, at this time, gas field contaminant excursions are not being treated as outward expanding contaminant plumes that warrant expensive, full-scale, hydrogeologic characterization, groundwater clean-up, and remedial action. The importance of this must be underscored because aquifer restoration on a gas field scale, even if cost were not an issue, may not be possible.

Endangered Species

47) Methane that is released up vertical annular pathways between outer casing walls and bedrock formations almost certainly enters freshwater aquifers. The mechanisms involved are detailed by Dusseault et al. (2000) and pose a risk of groundwater contamination stemming from vertical exploration wells. As methane enters and accumulates in freshwater aquifers, it will move down gradient of its initial release avenues until an open release pathway is encountered (e.g., open joints). A risk that requires further research is that to Dwarf Wedge Mussels and other species present in streamways of the Delaware River Basin. Should methane or other gas field contaminants (e.g., benzene, LNAPLs) bubble up and be released into surface streams, they may compromise surface water quality and jeopardize the survival of an endangered species.

48) Excursions of gas field related contaminants may lead to degradation or loss of endangered and other species. Potential commingling of deep connate waters, hydrofracking fluids, methane, and freshwater aquifers, as a result of disrupted bedrock strata, may lead to new, altered, groundwater flow regimes. Altered flow regimes may, in turn, result in the formation of new aquifer discharge locations that effuse methane and other contaminants to streams, springs, wetlands, or other locations. The potential exists for such contaminants to degrade surface water quality and sensitive ecosystems that support threatened or endangered species (Tzilkowski et al., 2010; NYSDEC and PFBC, 2010), such as the federally endangered Dwarf Wedge Mussel (*Alasmidonta hereroden*). Of the few remaining populations of this species, one is found within the Neversink River, one in the mainstem of the upper Delaware River, and another within a small coldwater tributary of the middle river (Playfoot and Snyder, 2010). Dwarf wedge mussels are protected under the Endangered Species Act. It is critically important that pristine water quality conditions be maintained to protect this species.

49) There are real environmental, water quality, air quality, explosive, health, and endangered species concerns regarding gas exploitation below carbonate beds, inclusive of in caves. Carbonate formations in portions of the Delaware River Basin are recognized among karst

hydrologists as being karstic or cave/conduit bearing in nature. Contaminants that may enter karstic solution conduits, from below or above, would quickly degrade groundwater and surface water quality.

50) Carbonates of the Onondaga Formation and Helderberg group outcrop in portions of the Delaware River Basin (Figure 10; Veni, 2002). These carbonate formations, while stratigraphically lower than the Marcellus shale, overlie other shale beds that are gas rich (e.g., the Utica shale of the Trenton Group). These carbonate formations are recognized among karst hydrologists as being karstic or cave/conduit bearing in nature. An important aspect of karst is its effect on water supply and contaminant transport. Water in solution conduits can travel up to several kilometers per day, and contaminants can move at the same rate. This poses serious problems when monitoring for water quality. Contaminants enter the ground easily through sinkholes and sinking streams, and filtering is virtually non-existent. Even small solution conduits can transmit groundwater and contaminants hundreds of times faster than the typical unenlarged fracture network. Methane or drilling-related contaminants that may enter karstic solution conduits, from below or above, would quickly degrade groundwater and surface water quality. Because karst aquifers are extremely vulnerable, it would be prudent to characterize the environmental risks to them prior to conducting drilling activities.

51) Gas drilling activities may pose a health risk to cave-dwelling species and cavers, including the federally endangered Indiana bat (*Myotis sodalis*). The build up of methane and other toxic chemicals in caves and mines may pose both an explosive and health risk to cavers, cave scientists, and cave-dwelling fauna. People and bats in caves may potentially be overwhelmed by the build up of methane and other toxic chemicals. This could lead to their deaths via inhalation or via explosions similar to those that have occurred at wellheads above gas plays. If methane or LNAPLs were to seep or flow into caves (from below or from leaking surface holding pits) situated above gas-rich shales, caves might in effect become "confined spaces" - toxic to breathe in with great and, possibly, rapid exposure risk. Importantly, cave dwelling animals, such as bats (Figures 8 and 9), might have their already stressed populations (i.e., via White-Nose Syndrome; USGS, 2010) further decimated by gas field related contaminant excursions.

52) The endangered Indiana bat has one or more hibernacula in the Delaware River Basin stratigraphically above the Utica Shale. To protect these bats, the NYS Department of Environmental Conservation (i.e., State of New York) purchased Surprise Cave, located near Mamakating, NY (Sullivan County) some years ago. There may be other bat hibernacula within the Delaware River Basin. Contaminants that may migrate into areas inhabited by the Indiana Bat would constitute unauthorized taking of the bats under the Endangered Species Act.

Conclusions

53) Significant natural seismic activity is well documented in and adjacent to the Delaware River Basin over an extended period of time. Ground motions from even one significant earthquake, among many that occur over time, may catastrophically shear numerous gas exploration and well casings or, at the very least, may result in fracturing and loss of integrity of well casing cement designed to isolate freshwater aquifers from deep saline waters. As such, earthquakes may instantly destroy the integrity of hundreds of gas wells, thereby forever and irreparably compromising the hydrologic integrity of geologic formations that formerly protected freshwater aquifers. Restoration of contaminated freshwater aquifers is probably not possible, thus well failures from any single or combination of mechanisms is likely an irrevocable commitment of natural resources.

54) The installation of exploratory wells that open borehole or nearby joint pathways between formerly separated geologic horizons pose an environmental risk, particularly because the area is seismically active. Ground motion associated with seismic activity has the real potential of instantly shearing multiple well casings throughout gas fields, degrading cement grout designed to isolate geologic horizons (i.e., freshwater aquifers), and thereby opening vertical joint and borehole vectors between formerly separated geologic horizons. Numerous earthquakes have occurred in Pennsylvania, New York, and adjacent states, pointing out that the region of the exploratory wells is seismically active.

55) Vertical exploration wells and related surface activities have the potential to permanently and irreparably harm ground and surface water resources in the Delaware River Basin. Extensive existing fracture and fault networks throughout the Appalachian Basin may provide upward pathways for contaminant and gas migration through geologic zones believed to be physically isolated, based on incomplete data. Although gas producers have asserted publicly that these zones are physically isolated, to date there are no publicly available studies to prove this claim. On the contrary, multiple studies indicate the presence of pervasive natural fracturing that will allow for migration to freshwater aquifers of methane, other hydrocarbons and their constituents, drilling fluids and materials, and naturally occurring hazardous materials including deep saline waters and NORMs. As a result, there are significant health and environmental risks associated with advancing exploratory gas wells in the Delaware River Basin and elsewhere in the Appalachian Basin.

56) The characterization of vertical fractures, faults, seismic hazards, casing and grout failures, contaminant hazards, and methane soil gas in the Delaware River Basin and elsewhere in the Appalachian Basin is not adequate to address potential adverse environmental impacts. Existing information does not sufficiently address pre-existing contaminant (i.e., gas and fluid) pathways that extend from the Marcellus shale to aquifers, surface water bodies, and the ground surface. Vertical exploratory wells, as well as future hydro-fracturing and enhancement of gas-bearing fractures may significantly increase gas excursions to formerly isolated geologic formations. Review of reports and news articles indicate that significant environmental contamination has occurred in geologically similar settings, including explosive hazards and groundwater and surface water contamination. This puts the Delaware River, its tributaries, and watershed at substantial risk of pollution and degradation.

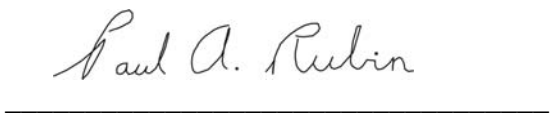
57) Documentation by Jacobi of Fracture Intensification Domains based on methane soil gas anomalies over open fractures reveals evidence that naturally occurring fractures and faults provide upward gaseous migration pathways, even in the absence of deep hydro-fracturing in the Marcellus shale. If fracture and fault networks are intersected by vertical exploratory well completions and/or integrated and enlarged via hydro-fracturing processes, it is likely that methane, LNAPL, and radioactive gas excursions will increase.

58) The reality is that methane gas extraction from tight shale formations, including the Marcellus and similar formations throughout the country, have contaminated ground and surface waters. Reasons for this include poor containment of fracturing fluids, spills of flow-back water, intentional illegal disposal, mixing of different formation waters (e.g., brine and fresh water), inadequately grouted casing, failed grout, spills, and various forms of operator error. Gas production in the Delaware River Basin and elsewhere in the Appalachian Basin would almost certainly result in contaminant excursions, even under the best planned conditions. The presence of confirmed fractures and faults that extend from gas-rich geologic beds to the ground surface, some of which extend laterally for miles and are closely linked with others formed under similar structural conditions, pose potential contaminant pathways to surface waterways, reservoirs, and freshwater aquifers.

59) Because the density, location, aperture width, and length of all fractures (often present and not visible beneath a soil mantle) are not known, it would not be prudent to risk placement of numerous gas wells within sub-basins that contain lakes and reservoirs used for public water supplies. From a water quality standpoint four facts stand out: 1) there is a point at which the actual total number of toxic contaminants introduced into a groundwater flow system no longer matters because the water is unlikely to ever be potable again no matter how much money is spent attempting to remediate it, 2) new groundwater circulation pathways are likely to develop in response to repeated hydro-fracturing and newly available freshwater hydraulic/pressure heads, resulting in commingling of freshwater and contaminant-laden waters, 3) eventually, even deep groundwater flow systems discharge to surface water, albeit it may take many years to occur (i.e., analogous to a slowly ticking time bomb), and 4) it makes little sense to jeopardize the quality of surface and groundwater by intentionally introducing vast quantities of toxic contaminants into the environment, especially where gas-conducting fractures and faults are known to extend from gas-bearing formations to the ground surface.

60) It is important to recognize that once our natural resources have been compromised as a result of an operator error, grout and/or casing failure, a major contaminant excursion, seismic activity, or an unforeseen breaching of geologic beds, that it may be impossible to remediate and restore them to their pre-existing conditions. Failed confining beds and contaminated natural resources often represent an irrevocable commitment of our lands. Our decision to risk natural resources in the Delaware River Basin must weigh all the health and environmental risks against exploitation of relatively short-lived gas reserves and financial gain.

The opinions expressed herein are stated to a reasonable degree of scientific and professional certainty.



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References

Bame, D. and Fehler, M., 1986, Observations of long period earthquakes accompanying hydraulic fracturing. Geophysical Research Letters, v. 13, no. 1, p. 149-152.

Bradley, W.H. and Pepper, J.F., 1938, Structure and gas possibilities of the Oriskany Sandstone in Steuben, Yates, and parts of the adjacent counties, New York: U.S. Geological Survey Bulletin, v. 899-A, p. 68.

COP – Commonwealth of Pennsylvania Consent Order and Agreement with Cabot Oil and Gas Corporation, Nov. 4, 2009. Order addresses failure to properly cement casings and failure to prevent the unpermitted discharge of natural gas, a polluting substance, from entering groundwater.

DCNR (Department of Conservation and Natural Resources, 2006, Earthquake hazard in Pennsylvania, Educational Series 10. First edition, June 1989; second edition, May 2003; slightly revised June 2006. Author: Charles K. Scharnberger, PA Geological Survey.

Dusseault, M.B., Gray, M.N. and Nawrocki, P.A., 2000, Why oilwells leak: cement behavior and long-term consequences. Society of Petroleum Engineers Inc. (SPE 64733). Paper prepared for presentation at the SPE International Oil and Gas Conference and Exhibition in China held in Beijing, China 7-10 November 2000.

Engelder, T., Lash, G.G., and Uzcátegui, 2009, Joint sets that enhance production from Middle and Upper Devonian gas shales of the Appalachian Basin. AAPG Bulletin; July 2009: v. 93; no. 7; p. 857-889.

Evans, M.A., 1994, Joints and decollement zones in Middle Devonian shales; evidence for multiple deformation events in the central Appalachian Plateau: geological Society of America Bulletin, v. 106, p. 447-460.

Feng, Q. and Lees, J.M., 1998, Microseismicity, stress, and fracture in the Coso geothermal field, California. Tectonophysics, v. 289, issues 1-3, p. 221-238.

Hazen and Sawyer, 2009, Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed, Rapid Impact Assessment Report. Sept. 2009. Prepared for NYCDEP.

Horálek, J., Dorbath, L., Jechumtálováa, Z., and Šilenỷ, J., 2009, Source mechanisms of micro-earthquakes induced in hydraulic fracturing experiment at the HDR site Soultz-sous-Forêts (Alsace) in 2003 and their temporal and spatial variations. Geophysical Research Abstracts, v. 11, EGU2009-14008.

Jacobi, R.D., 2002, Basement faults and seismicity in the Appalachian Basin of New York State. Tectonophysics, v. 353, Issues 1-4, 23 August 2002, p. 75-113.

Jacobi, R.D. and Smith, G.J., 2000, Part I. Core and cutting analyses, surface structure, faults and lineaments, and stratigraphic cross-sections based on previous investigations. In: Jacobi, R.D., Cruz, K., Billman, D. (Eds.), Geologic Investigation of the Gas Potential in the Otsego County Region, Eastern New York State: Final Phase One Report to Millennium Natural Resources Development, L.L.C. NYSERDA, Albany, NY, 45 pp.

Kargbo, D.M., Wilhelm, R.G. and Campbell, D.J., 2010, Natural Gas Plays in the Marcellus Shale: Challenges and Potential Contaminants. Environmental Science and Technology, v. 44, pp. 5679 – 5684, June 2, 2010.

Lash, G.G. and Engelder, T., 2009, Tracking the burial and tectonic history of Devonian shale of the Appalachian Basin by analysis of joint intersection style. GSA Bulletin; Jan/Feb 2009; v. 121; no. ½; p. 265-277.

LI, Y-P, 1996, Microearthquake analysis for hydraulic fracturing process. Acta Seismologic Sinica, v. 9, no. 3, p. 377-387.

Lustgarten, A., 4-22-09, Digging at mystery of methane in wells - The Denver Post http://www.denverpost.com/news/ci_12195167#ixzz0ywZqfVcB; Article references work conducted by S.S. Papadopulos and Associates.

NYSDEC and PFBC, 2010, Recommended improvements to the flexible flow management program for Coldwater Ecosystem protection in the Delaware River Tailwaters. Authored by NYS Department of Environmental Conservation and Pennsylvania Fish and Boat Commission, 9 p.

Northrup, J.L., 2010, The Unique Environmental Impacts of Horizontally Hydrofracking Shale. Report of Otsego 2000 prepared for September 2010 public hearing.

Playfoot, K.M. and Snyder, E.M., 2010, Genetic relationships among Federally-endangered Alasmidonta heterodon within the Delaware River Basin. Penn State School of Forest Resources.

Rubin, P.A., Ayers, J.C., and Grady, K.A., 1992, Solution mining and resultant evaporite karst development in Tully Valley, New York. Hydrogeology, Ecology, Monitoring, and Management of Ground Water in Karst Terranes Conference (3rd, Nashville, Tenn., Dec. 1991), Proceedings. National Ground Water Association, Dublin, Ohio, p. 313-328.

Shapiro, S.A. and Dinske, C., 2009, Fluid-induced seismicity: Pressure diffusion and hydraulic fracturing. Geophysical Prospecting, v. 57, p. 301-310.

Stiles, K., 2010, DRBC data request. E-mail dated 1-25-10 to David Kovach detailing drilling summary of Matoushek #1 well.

Taylor, R.G., 2009, Oil, oil and more oil: http://www.usgennet.org/usa/ny/county/allegany/OIL-COUNTY/OIL-OIL-MORE%20OIL.HTM (accessed by Engelder et al. - January 31, 2009)

Tzilkowski, C.J., Callahan, K.K., Marshall, M.R. and Weber, A.S., 2010, Integrity of benthic macroinvertebrate communities in the upper Delaware scenic and recreational river; Eastern rivers and mountains network 2008 summary report. Natural Resource Data Series NPS/ERMN/NRDS – 2010/029.

USGS, 2010, White-Nose Syndrome Threatens the Survival of Hibernating Bats in North America. Web page information from Fort Collins Science Center: http://www.fort.usgs.gov/wns/

Veni, G., 2002, Revising the karst map of the United States. Journal of Cave and Karst Studies, v. 64, no. 1, p. 45-50.

Zhou, Z., He, J., Huang, M., He, J., and Chen, G., 2010, Casing Pipe Damage Detection with Optical Fiber Sensors: A Case Study in Oil Well Constructions; In Advances in Civil Engineering, v. 2010, Article ID 638967, 9 pages.

Figure Listing

Available at http://hydroquest.com/Riverkeeper/

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Available at http://hydroquest.com/Riverkeeper/

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Addendum 2: Pennsylvania Earthquake History
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Paul A. Rubin

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EDUCATION:

M.A. - Geology, May 1983, State University of New York at New Paltz. Major fields of study: Hydrogeology, Water Quality and Pollution, Structural Geology, Photogeologic Interpretation. Thesis topic: *Hydrogeology and Structure of the Shawangunk Mountains, Ulster County, New York.*

B.A. - Anthropology, minor Geology, May 1977. State University of New York at Albany.

SPECIAL SKILLS:

Environmental Impact Statement (EIS) Analyses; Determination & Findings of Significant Impacts or Lack Thereof (e.g., FONSI & Negative Declarations); Environmental Protection; Hydrologic and Geologic Characterizations; Land Use Planning & Characterizations; State Environmental Quality Review Act (SEQRA) reviews; Evaluation of Physical & Human Environments via Remote Sensing, Photogrammetric Analysis & Field Reconnaissance; Habitat and Water Quality Based Analyses specific to Threatened, Endangered & Other Species; Expert Testimony and Litigation Background; Surface Water and Groundwater Quality Evaluations; Sediment Transport; Evaluation of Remedial Technologies; Geotechnical Assessments; Hydrologic Investigations; Aquifer Testing and Analysis; Karst Hydrology; Rosgen Stream Analyses; Flood Return Analyses; GIS Map Making and Analyses; Photogrammetric Analyses; Affidavit and Report Preparation; Educator; Public Speaking; Public Relations; Research Skills; Strategy Development; Leadership.

EXPERIENCE:

HYDROLOGIST/HYDROGEOLOGIST:

1993 - Present

Independent Consultant. Stone Ridge, New York. Consulting firm: *HydroQuest*.
Provide hydrologic, geologic and land use technical consulting services to environmental groups, Towns, business associations, law firms, and individuals. Assist groups in identifying issues and developing strategies designed to protect groundwater and surface water resources, community character, and wildlife habitat.

***HydroQuest* work includes SEQRA reviews, review and fatal flaw analyses of consultant reports and environmental impact statements (EISs); environmental scoping report preparation; direction and oversight of heavy equipment operators for field excavation work for well placements, contaminant characterization, and geologic investigations; technical coordination of scientific case development for environmental groups and attorneys; field characterizations; stream and wetland evaluations; geotechnical analyses; hydrologic and geologic mapping; water quality assessments; watershed delineations; viewshed analyses; slope analyses; aquifer analyses; hydrogeologic analyses; regulatory assessments; GIS map preparation; public presentations; technical presentations to judges; coordination work with attorneys and Technical Committees; direction and coordination of sub-contract work as needed; strategy development; panel member at Town meetings with legislators; press interactions; report and affidavit preparation. Recently provided major report input on gas drilling & hydrofracturing.**

Recent project work examples include oversight and analysis of well field pumping tests (for multiple groups including NRDC, NYPIRG, Riverkeeper, and Trout Unlimited) designed to assess impacts on groundwater and surface water stemming from a planned large-scale Catskill Mountain resort; assessment of a town's water quality problem with corrective recommendations; initial hydrogeologic assessment of a spring water source being considered for bottled water use; hydrogeologic-aquifer analysis of a groundwater supply proposed for a Shawangunk Ridge retreat center; SEQRA assessments; and technical presentations and testimony before administrative law judges.

KARST HYDROLOGIST

Howe Caverns, Inc. Cobleskill, New York. 2nd largest natural tourist attraction in NYS

2004 - April 2007

Conducted hydrologic and geologic research, produced professional GIS maps and figures, developed educational programs and materials, developed new tourist route, trained guides, provided land use assessments and recommendations, advised the Board of Directors on land use concerns including potential water quality degradation and potential blast-related impacts to cave. Developed and proposed revenue generating strategies. Coordinated with outside educational institutions, professional geologists, learning institutions, and scout groups. Formerly worked in this position half-time prior to change in ownership.

INSTRUCTOR:

Jan. 2001- Dec. 2004

SUNY Ulster, Stone Ridge, New York.
Taught ArcGIS, Environmental Geology, Geology, Hydrology, Geography, and Crime Analysis. Coordinator of a Geographic Information Systems certificate program. Developed, obtained, and completed a NYSDEC grant to assess assorted hydrologic and environmental aspects of the Black Creek watershed in Ulster County. Supervision and oversight of numerous professional adult "students", directed GIS-based technical presentations, and coordinated and produced grant products.

College of the Atlantic, Bar Harbor, Maine.
Taught a two week graduate level summer field hydrology and environmental science course for several years, including Rosgen stream assessment.

HYDROLOGIST:

New York City Department of Environmental Protection (NYC DEP), Division of Drinking Water Quality Control, Shokan, New York.

April 1993- Jan. 2001

Conducted research and field studies designed to assess the water quality of watersheds. Responsible for directing geologic research designed to assess the sources, geomorphic context and best management practices (BMPs) related to sediments causing turbidity water pollution problems. Hydrologic and geologic work included geologic mapping of glacial sediments, field evaluation of stream channel armoring, morphologic characterization of stream channels (including Rosgen analyses), bedload transport studies, assessment of critical shear stresses, particle size analysis, stream gauging, water quality sampling and trend analysis, chemical and sediment loading calculations, graphic production, report preparation and technical presentations. Assisted other governmental divisions in evaluating lands for possible purchase, conducted geotechnical assessments of structurally unstable stream reaches, evaluated BMP designs. Supervised several Research Assistants.

RESEARCH SCIENTIST:

Martin Marietta Energy Systems, Inc. April 1993 under contract with the U.S. Dept. of Energy; Oak Ridge National Lab; Environmental Sciences Division, Oak Ridge, TN.

Aug. 1991- April 1993

Responsible for hydrogeologic evaluation of groundwater issues (e.g., characterization, monitoring network setup, data analysis, remedial design evaluation) at multiple Oak Ridge Reservation hazardous waste sites. Developed and documented conceptual model of carbonate and shallow storm flow systems comprising pathways of rapid contaminant transport. Work also involved characterization of hydrologic and geochemical trends

RESEARCH SCIENTIST continued:

and thermal infrared photo analysis. Presented results of research at conferences, as well as to DOE management and State and Federal officials. *Served in a Resource Management Organization as the hydrologic lead for the Environmental Sciences Division.*

HYDROGEOLOGIST:

New York State Attorney General's Office; Environmental Protection Bureau, Albany, New York.

Feb. 1983-Aug. 1991

Responsible for the design, protocols, coordination, implementation, evaluation, characterization and remediation of many major water and soil contamination sites throughout New York State (e.g., Love Canal, Superfund sites). Designed, performed and supervised chemical field sampling at hazardous waste sites. Evaluated geotechnical and chemical data sets.

Primary responsibilities included coordination of multiple companies along with their respective legal and scientific consultants. Worked with all parties involved to produce test plans and consent decrees to facilitate site remediation. Responsible for the management of the testing, site characterization and technical assessment. Worked with attorneys on summary judgment motions, complaints, trial preparation and depositions. Attorney General's spokesperson at public meetings. Expert witness at SEQRA hearings. Testimony given before the Assembly Standing Committee on Environmental Conservation and Grand Jury. Worked with DOL staff and attorneys to develop office initiatives (e.g., Racketeering; bottled water contaminants). Initiation, development and drafting of legislation.

Supervision of personnel: expert witnesses, consultants, research assistants, interns. Responsible for selection, job descriptions, work schedules, and products.

HYDROGEOLOGIST:

Stone & Webster Engineering Corp., Geotechnical Division, Boston, Massachusetts.

Oct. 1981-Feb. 1983

Directly responsible for the planning, preparation, execution, and analysis of pumping tests and a fluid sampling program designed to investigate deep basin groundwater characteristics for the siting of a nuclear waste repository within the Permian Basin of the Texas panhandle. Planned, managed, coordinated, directed, and provided oversight of field operations of a multi-million dollar project. Sub-contractors included Halliburton, Schlumberger, and others.

ACTIVITIES:

Hiking, cave research, and exploration. Former Captain: Albany-Schoharie County Cave Rescue Team. Made a Fellow of the National Speleological Society in recognition of karst research and water resource protection.

PUBLICATIONS & REPORTS

Over 50 technical publications and over 100 reports and affidavits, many for private clients, environmental groups, towns, and law firms. Projects include land, wetland, water quality, and species protection; aquifer and watershed characterization; mine proposals; development proposals; contaminant assessments; stream hydrology grant work; and flood risk. Some reports are confidential. Leader of geology conference field trips for groups including the New York State Geological Association, the American Institute of Professional Geologists, the Hudson-Mohawk Professional Geologists' Association, the National Ground Water Association, the National Speleological Society, and the International Association of Geochemists and Cosmochemists.

ADDENDUM - SELECTED PUBLICATIONS

SELECTED PUBLICATIONS FROM PROFESSIONAL AND PERSONAL RESEARCH

Rubin, P.A., 2009, ***Geological Evolution of the Cobleskill Plateau; New York State, USA,*** in Veni et al. (eds), Proceedings of the Speleogenesis Symposium of the 15th International Congress of Speleology (joint National Speleological Society & Union Internationale de Speleologie); Symposium: Speleogenesis in Regional Geological Evolution and its Role in Karst Hydrogeology and Geomorphology, Kerrville, Texas. Proceedings, Volume 2, Symposia Part 2, pages 972-978 (published July 2009).

Palmer, A.N. and Rubin, P.A., 2007, ***Karst of the Silurian-Devonian Carbonates in Eastern New York State, with emphasis on the Cobleskill Plateau***. Guidebook for the Hudson-Mohawk Professional Geologists' Association Spring 2007 Field Trip, *"Carbonate Geology of the Howes Cave Area, Schoharie County, New York"*, p. 17-35, Trip coleader with Arthur Palmer (April 28, 2007).

Rubin, P.A., Burmeister, K.C. and Folsom, M., 2006, ***Karst Resource Management: groundwater protection and developmental considerations in the Kingston-Rosendale aquifer system***; Ulster County, N.Y., Poster Presentation at the 2005 National Cave and Karst Management Symposium. Report prepared for Scenic Hudson.

Stokowski, S., Rubin, P.A. and Guenther, B., 2006, ***History of resource management: conflict and resolution, Howes Cave, N.Y.***, in Rea, G.T., (ed), Proceedings of the 2005 National Cave and Karst Management Symposium.

Rubin, P.A and Stokowski, S., 2004, ***Karst, Caves, and Quarries***. Guidebook paper for ***the*** American Institute of Professional Geologists (AIPG), Annual Meeting. Field trip co-leader.

Rubin, P.A. and Washington, G., 2004, ***Water quantity and quality considerations specific to development on the flank of the Shawangunk Mountain Ridge***, ***Southeastern NYS.*** Abstracts Northeast Natural History Conference VIII. N.Y. State Museum Circular 66: p. 53.

Rubin, P.A., Adickes, D.M., Cunningham, T., Davidson, D., Hurld, J. Kiyan, J.R., Preuss, P., Ramsay, W., Schultz, B. and Washington, George, 2004, ***Application of GIS technology to assess visual impacts of development: Shawangunk Ridge case study, southeastern NYS***. Abstracts Northeast Natural History Conference VIII. N.Y. State Museum Circular 66: p. 52-53.

Adickes, D.M., Preuss, P., Rubin, P.A., and Thompson, J., 2004, ***GIS assessment and study of rare and threatened avian species living in the Shawangunk Mountains in Southeastern NYS***. Abstracts Northeast Natural History Conference VIII. N.Y. State Museum Circular 66: p. 38.

Kiyan, J.R., Washington, G., and Rubin, P.A., 2004, ***GIS visual impact analysis of a proposed housing development below Minnewaska State Park Preserve in the Shawangunk Mountains of the Mid-Hudson Valley in New York State***. Abstracts Northeast Natural History Conference VIII. N.Y. State Museum Circular 66: p. 47.

Cunningham, T., Davidson, D., Hurld, Rubin, P.A., and Ehrensaft, P., 2004, ***Using GIS technology to project various land-use and economic scenarios for the northern Shawangunk Ridge area; Southeastern NYS***. Abstracts Northeast Natural History Conference VIII. N.Y. State Museum Circular 66: p. 41-42.

Palmer, A.N., Rubin, P.A., Palmer, M.V., Engel, T.D., and Morgan, B., 2003, ***Karst of the Schoharie Valley, New York.*** Guidebook for the New York State Geological Association Diamond Jubilee Field Conference (75th Annual Meeting), p. 141-176, Trip coleader.

Rubin, P.A., Morgan, B., and Palmer, A.N., 2003, ***Howe Caverns resource protection: hydrology and land-use analysis; Schoharie County***, New York State. Abs. Northeastern Science Foundation Silver Jubilee Anniversary Symposium, Proceedings volume, p. 25-26.

Rubin, P.A., Hubsch, R., Albrechtsen, C.A., Black, G., Folsom, M., Keller, J., Morgan, B., Ortega, A., Rodden, M., Schultz, B., Terzella, D., and Washington, G., 2003, ***Watershed management and protection planning based delineation of critical environmental areas via GIS analysis***. Abs. Northeastern Science Foundation Silver Jubilee Anniversary Symposium, Proceedings volume, p. 13.

Hubsch, R., Morgan, B., Black, G., Folsom, France, N., Keller, J., Ortega, A., Post, J., and Rubin, P.A., 2003, ***Development of a GIS-based land-use coverage: Black Creek and Swarte Kill watersheds, southeastern New York State***. Abs. Northeastern Science Foundation Silver Jubilee Anniversary Symposium, Proceedings volume, p. 9-10.

Rubin, P.A., Waines, R., Washington, G., Ortega, A., Albrechtsen, C.A., Hubsch, R., Folsom, M., Keller, J., Morgan, B., and Schultz, B., 2003, ***Hydrology and geology of the Swarte Kill and Black Creek basins, eastern New York State***. Abs. Northeastern Science Foundation Silver Jubilee Anniversary Symposium, Proceedings volume, p. 12.

Rubin, P.A., Engel, T., Nardacci, M. and Morgan, B.E., 2002, ***Geology and paleogeography of Mount Desert Island and surrounding area, Maine.*** Guidebook paper National Speleological Society annual meeting, Camden, Maine, p. 47-91, Trip leader.

Rubin, P.A., Schultz, B. and Haberland, P., 2002, ***Hydrologic, land use, and historic concerns relative to the Rosendale mining industry.*** Abs. National Speleological Society annual meeting, Camden, Maine, p. A-27.

Rubin, P.A. and Morgan, B., 2002, ***Relict sea caves record temporary coastal stillstands.*** Abs. National Speleological Society annual meeting, Camden, Maine, p. A-26-A-27.

Morgan, B., Albrechtsen, C., Dido, R., Hubsch, R., Rubin, P.A., Sheeley, D., Skerritt, F. and Vaeth, L., 2002, ***Development of a GIS-based land-use coverage: Black Creek Watershed, Southeastern NYS.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 50-51.

Hubsch, R., Albrechtsen, C., Dido, R., Morgan, B., Rubin, P.A., Sheeley, D., Skerritt, F., Terzella, D. and Vaeth, L., 2002, ***Critical environmental area delineation in the Black Creek Watershed, NYS via GIS analysis.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 51.

Sheeley, D.A. and Rubin, P.A., 2002, ***Land-use preservation scenarios in the Black Creek Watershed using GIS; NYS.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 51.

Schultz, B., Rubin, P.A. and Haberland, P., 2002, ***GIS-based historic inventory of early cement district industrial artifacts: Southeastern NYS***. Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 40.

Rubin, P.A. and Morgan, B., 2002, ***Geomorphic reconstruction of emerged and submerged coastlines using GIS technology, Mount Desert Island, ME.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 39.

Rubin, P.A. and Privitera, J.J., 1997, ***Engineered and* unregulated degradation *of karst aquifers: Two case studies in New York State, USA.*** *In* The Engineering Geology and Hydrogeology of Karst Terranes, Beck & Stephenson (eds), Proceedings of The Sixth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst; Balkema, Rotterdam; p. 467-476.

Rubin, P.A., Engel, T., and Nardacci, M., 1995, ***Geomorphology, paleoclimatology and land use considerations of a glaciated karst terrain, Albany County, New York.*** Guidebook for joint meeting of the New York State Geological Association (67th Annual) and the American Association of Petroleum Geologists. Trip leader, p. 81-107.

Rubin, P.A., 1995, ***The geology of Clarksville Cave, Albany County, New York.*** Guidebook for joint meeting of the New York State Geological Association (67th Annual) and the American Association of Petroleum Geologists. Trip leader, p. 251-273.

Rubin, P.A., 1995, ***The geology of Cherokee Caverns; Tennessee***. *In* Karst Geohazards (ed. by B. Beck), Proceedings of: The Fifth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst; Sponsors include the National Ground Water Association and the American Society of Civil Engineers, Gatlinburg, TN, p. 541-547.

Rubin, P.A., 1994, ***Paleohydrology of the Kämper Avenue area; Mammoth Cave National Park, Kentucky.*** Mammoth Cave National Park's Third Science Conference; Sponsored by Mammoth Cave National Park and The Cave Research Foundation, Mammoth Cave National Park, Kentucky, p. 265-279.

Rubin, P.A., Zerr, B., Davies, G.J., Lemiszki, P.J., Neuhoff, P.S., and Aiken, J., 1993, ***Preliminary hydrogeologic studies in carbonate aquifers of the Oak Ridge Reservation, Tennessee.*** Abs. Fourth Annual Walker Branch Watershed Research Symposium, Oak Ridge, TN, p. 15-16.

Davies, G.J., Rubin, P.A., and Quinlan, J.F., 1993, ***Indirect observation of the rapid-flow and slow-flow components of recharge to the Knox aquifer, Oak Ridge, Tennessee.*** Abs. Fourth Annual Walker Branch Watershed Research Symposium, Oak Ridge, TN, p. 17.

Rubin, P.A., Lemiszki, P.J., and Poling, R.S., 1992, ***Strategy for definition and protection of East Tennessee karst groundwater basins.*** Tennessee Water Resources Symposium (5th, Nashville, TN., Oct. 1992), Proceedings. American Water Resources Association, Nashville, TN, p.7-10.

Rubin, P.A. and Lemiszki, P.J., 1992, ***Structural and stratigraphic controls on cave development in the Oak Ridge area, Tennessee.*** Tennessee Water Resources Symposium (5th, Nashville, TN., Oct. 1992), Proceedings. American Water Resources Association, Nashville, TN, p. 111-117.

Rubin, P.A., Lietzke, D.A., and Schmidt, V.A., 1992), ***Aspects of the geomorphology of Oak Ridge, Tennessee.*** Abs. National Speleological Society Convention, Salem, IN.

Rubin, P.A., 1992, ***Strategy for aquifer and stream protection in karst terranes.*** Abs. The New York Natural History Conference II, New York State Museum Circular 54, p. 61, Albany, New York.

Rubin, P.A., 1992, ***Karst hydrology of Oak Ridge, Tennessee.*** Abs. Third Annual Walker Branch Watershed Research Symposium, Oak Ridge, TN, p. 34.

Rubin, P.A., 1992, ***Land-use planning and watershed protection in karst terranes.*** Hydrogeology, Ecology, Monitoring, and Management of Ground Water in Karst Terranes Conference (3rd, Nashville, Tenn., Dec. 1991), Proceedings. National Ground Water Association, Dublin, Ohio, p. 769-793.

Rubin, P.A., Ayers, J.C., and Grady, K.A., 1992, ***Solution mining and resultant evaporite karst development in Tully Valley, New York.*** Hydrogeology, Ecology, Monitoring, and Management of Ground Water in Karst Terranes Conference (3rd, Nashville, Tenn., Dec. 1991), Proceedings. National Ground Water Association, Dublin, Ohio, p. 313-328.

Palmer, A.N., Rubin, P.A., and Palmer, M.V., 1991, ***Interaction between karst and glaciation in the Helderberg Plateau, Schoharie and Albany Counties, New York.*** Guidebook for New York State Geological Association Annual Meeting, Oneonta, New York, p. 161-190.

Palmer, A.N., Palmer, M.V., Porter, C.O., Rubin, P.A., and Mylroie, J.E., 1991, ***A geological guide to the karst and caves of the Helderberg Mountains, Schoharie and Albany counties, New York.*** Guidebook paper for National Speleological Society annual meeting, Cobleskill, New York, p. 105-167.

Rubin, P.A., 1991, ***Modification of preglacial caves by glacial meltwater invasion in East-Central New York.*** Appalachian Karst Symposium, Proceedings. National Speleological Society, Radford, Virginia, p. 91-100.

Rubin, P.A., 1991, ***Flow characteristics and scallop forming hydraulics within the Mill Pond Karst Basin, East-Central New York.*** Appalachian Karst Symposium, Proceedings. National Speleological Society, Radford, VA., p. 101-108.

Rubin, P.A., 1991, ***Emerged sea caves and coastal features as evidence of glacio-isostatic rebound, Mount Desert Island, Maine.*** Appalachian Karst Symposium, Proceedings. National Speleological Society, Radford, Virginia, p. 75-83.

Rubin, P.A., 1983, ***Structural geology and geomorphology of the Shawangunk Mountain caprock, Southeastern New York.*** Abs. Geol. Soc. Amer. N.E. Ann. Mtg., Kiamesha Lake, New York; and Abs. Mohonk Research Associates Conference, Mohonk Lake, New York.

Rubin, P.A. and Briedis, J., 1982, ***Acid precipitation and volcanism linked to Mesozoic dinosaur extinction.*** Abs. Geol. Soc. Amer. Ann. Mtg., New Orleans, Louisiana.

Rubin, P.A., Smiley, D., and Egemeier, S.J., 1981, ***Acid precipitation in the Shawangunk Mountains, Southeastern New York.*** Abs. AMS/CMOS International Conference on Long-Range Transport of Airborne Pollutants, Albany, New York; and Abs. Geol. Soc. Amer. N.E. Ann. Mtg., Bangor, Maine.

Rubin, P.A., 1981, ***New Aspects of the stratigraphy and structure of the Shawangunk Mountains, Southeastern New York.*** Abs. Geo. Soc. Amer. N.E. Ann. Mtg., Bangor, Maine.

Egemeier, S.J., Liff, C.I., Smiley, D., and Rubin, P.A., 1981, ***The safe yield of the "sky" lakes of the Shawangunk Mountains of Southeastern New York***. Abs. Geol. Soc. Amer. N.E. Ann. Mtg., Bangor, Maine.

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Earthquake Hazards Program

Pennsylvania

Earthquake History

Record of early earthquakes in the Northeastern United States provide limited information on effects in Pennsylvania until 1737, 55 years after the first permanent settlement was established. A very severe earthquake that centered in the St. Lawrence River region in 1663 may have been felt in Pennsylvania, but historical accounts are not definite. Likewise, a damaging shock at Newbury, Massachusetts, in 1727 probably affected towns in Pennsylvania. A strong earthquake on December 18, 1737, toppled chimneys at New York City and was reported felt at Boston, Massachusetts, Philadelphia, Pennsylvania, and New Castle, Delaware. Other shocks with origins outside the State were felt in 1758, 1783, and 1791. In 1800, two earthquakes (March 17 and November 29) were reported as "severe" at Philadelphia. On November 11 and 14, 1840, earthquakes at Philadelphia were accompanied by a great and unusual swell on the Delaware River.

Dishes were thrown from tables (intensity V) at Allentown by a strong shock on May 31, 1884. Thirty towns from Hartford, Connecticut, to West Chester, Pennsylvania, reported fallen bricks and cracked plaster from an earthquake apparently centered near New York City on August 10, 1884. A tremor, described as lasting 10 seconds, was felt on March 8, 1889, at Harrisburg, Philadelphia, Reading, York, and other towns in that area. The intensity was estimated at V. An extremely local earthquake on May 31, 1908, at Allentown shook down a few chimneys (VI). The disturbance was not felt over more than 150 square kilometers.

On October 29, 1934, a shock of intensity V was felt at Erie. Buildings swayed, people left theaters, and dishes were thrown from cupboards. The earthquake was felt with lesser intensity at Edinboro, Girard, Mill Village, North East, and Waterford. Another shock with very localized effects occurred in southern Blair County on July 15, 1938. Broken dishes and fallen plaster (VI) were reported at Clover Creek and Henrietta. Wells were affected in Clover Creek Valley.

The area around Sinking Spring, west of Reading, experienced minor damage from an earthquake on January 7, 1954. Plaster fell from walls (VI), dishes and bottles tumbled from shelves, and furniture was upset. Other slight damage to several brick and frame buildings was reported. The tremor was felt in western Berks County and eastern Lancaster County. During the rest of the month, many smaller shocks were felt in the vicinity of Sinking Spring.

A local disturbance probably caused by subsidence of an underground coal mine caused damage estimated at $1 million in a five-block residential area of Wilkes-Barre on February 21, 1954. Occupants fled into the street. Hundreds of homes were damaged, ceilings and cellar walls split and backyard fences fell over. Sidewalks were pushed sharply upward by a heaving motion and then collapsed. Gas and water mains snapped; methane gas rising from cracks in the earth presented a temporary emergency. Two days later (February 23), a second disturbance was reported from the same section of Wilkes-Barre. More cracks appeared in ceilings and walls of apartment buildings. Curbs pulled away from sidewalks, and street pavements buckled. Additional water and gas mains were broken.

On September 14, 1961, a moderate earthquake that was centered in the Lehigh Valley shook buildings over a broad area and alarmed many residents. There was only one report of damage - loose bricks fell from a chimney at Allentown (V). However, police and newspaper switchboards throughout the area were swamped with calls from citizens. Other places with intensity V effects included Bethlehem, Catasauqua, Coplay, Egypt, Fountain Hill, Freemansburg, Hellertown, and Weaverville.

A similar disturbance occurred on December 27, 1961, in the northeast portion and suburbs of Philadelphia. Buildings shook, dishes rattled, and other objects were disturbed. Police and newspaper offices received many calls from alarmed citizens inquiring about the loud rumbling sounds (V). Several New Jersey communities across the Delaware River experienced similar effects.

A strong local shock, measured at magnitude 4.5, cracked a wall and caused some plaster to fall (VI) at Cornwall on May 12, 1964. Slight landslides were reported in the area. In one building, a radio was knocked from a table and a wall mirror moved horizontally. Workers in an iron mine about 360 meters underground were alarmed by a "quite sever jarring motion."

A small earthquake whose epicenter was in New Jersey caused intensity V effects at Darby, and Philadelphia. The December 10, 1968, shock was measured at magnitude 2.5. Although relatively minor, it broke windows at a number of places in New Jersey. Toll booths on the Benjamin Franklin and Walt Whitman Bridges in Philadelphia trembled during the earthquake.

On December 7, 1972, slight damage (V) was reported at New Holland. In addition, Akron, Penryn, and Talmage experienced intensity V effects. The total area covered approximately 1,200 square kilometers of Berks and Lancaster Counties.

Abridged from Earthquake Information Bulletin, Volume 8, Number 4, May - June 1973, by Carl A. von Hake.

For a list of earthquakes that have occurred since this article was written, use the Earthquake Search.

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Earthquake Hazards Program

New York

Earthquake History

Strong earthquakes in 1638, 1661, 1663, and 1732 in the St. Lawrence Valley and a shock near Newbury, Massachusetts, in 1727 were felt in New York before the first notable tremor centered within the State was recorded. On December 18, 1737, an earthquake near New York City threw down a number of chimneys (intensity VII). This shock was reported felt at Boston, Philadelphia, and at New Castle, Delaware.

Walls vibrated, bells rang, and objects fell from shelves (intensity VI) at Buffalo from a shock on October 23, 1857. Also, a man seated on a chair was reportedly thrown to the ground. At Lockport, rumbling noises were heard for a full minute. This shock was felt as far as Hamilton, Peterborough, and Port Hope, Ontario, Canada; Rochester, New York; and Erie and Warren, Pennsylvania. The total felt area covered approximately 46,000 square kilometers.

A rather severe earthquake centered in northeastern New York caused moderate damage along the St. Lawrence River and in the Lake Champlain area in 1877. Crockery was overturned, ceilings cracked, and chimneys were thrown down (intensity VII) from the November 4 tremor. At Saratoga Springs, buildings were shaken and a roaring sound was heard; at Auburn, windows were damaged. The earthquake was felt throughout a large part of New York and New England and eastern Canada, about 233,000 square kilometers.

On August 10, 1884, an earthquake caused large cracks in walls at Amityville and Jamaica (intensity VII). The shock was felt strongly at New York City. In addition, 30 towns from Hartford, Connecticut, to West Chester, Pennsylvania, reported fallen bricks and cracked plaster. The total felt area was estimated at 181,000 square kilometers.

A shock reported as severe, but with no damage noted (intensity VI), occurred in northeastern New York on May 27, 1897. It was felt over the greater portion of New York and parts of adjacent New England States and Quebec, Canada.

A very large area of the northeastern United States and eastern Canada, about 4,200,000 square kilometers, was shaken by a magnitude 7 earthquake on February 28, 1925 (March 1, universal time). A maximum intensity of VIII was reached in the epicentral region, near La Malbaie, Quebec, Canada. A large portion of New York State experienced intensity IV effects; lesser intensities were noted south of Albany.

Extensive damage occurred in the Attica area from a strong shock on August 12, 1929. Two hundred and fifty chimneys were thrown down, plaster was cracked or thrown down, and other building walls were noticeably damaged (intensity VIII). Many cemetery monuments fell or were twisted. Dishes fell from shelves, pictures and mirrors fell from walls, and clocks stopped. An increased flow at the Attica reservoir was noted for several days after the earthquake; a number of wells near the reservoir went dry. There was some damage at Batavia and other points at similar distances. A wall was cracked at Sayre, Pennsylvania. The earthquake was felt throughout most of New York and the New England states, northeastern Ohio, northern Pennsylvania, and southern Ontario, Canada; a total area of about 250,000 square kilometers. Strong aftershocks were felt at Attica on December 2 and 3; dishes fell from shelves and clocks stopped.

The opposite end of the State experienced similar damage from another shock less than 2 years later. On April 20, 1931, an earthquake centering near Lake George threw down about 20 chimneys at Warrensburg and twisted a church spire (intensity VII). A small landslide was reported on McCarthy Mountain. At Glen Falls, walls were cracked, dished broken, and clocks stopped. At Lake George, buildings swayed and store goods fell from shelves. At Luzerne, some Chimneys were damaged and windows broken. The shock was felt over 155,000 square kilometers, but with less intensity in the Catskills than at equal distances in other directions. This anomaly was also noted in the August 12, 1929, Attica earthquakes.

The magnitude 6 1/4 earthquake centered near Timiskaming, Quebec, Canada, on November 1, 1935, caused slight damaged at many points in New York. The damage was limited, in general, to plaster cracks, broken windows, and cracked chimneys. The shock was felt throughout New York, as far south as Washington, D.C., and as far west as Wisconsin. An earthquake centered near Lake Ossipee, New Hampshire on December 24, 1940, caused widespread, though slight, damage in the epicentral region, extending into Maine, Massachusetts, Rhode Island, and Vermont. Reports from Dannemora, New York, noted plaster and windows cracked and some dishes broken. The shock was felt over all of New York State.

On September 4, 1944, an earthquake centered about midway between Massena, New York, and Cornwall, Ontario, Canada, caused an estimated $2,000,000 damage in the two cities. The shock destroyed or damaged about 90 percent of the chimneys at Massena (intensity VIII), with similar effects at Cornwall. In addition, masonry, plumbing, and house foundations were damaged at Massena. Many structures were rendered unsage for occupancy until repaired. Press reports indicated a large number of wells in St. Lawrence County went dry, causing acute hardship. Brick masonry and concrete structures were damaged at Hogansburg; some ground cracking was also noted at nearby towns. This earthquake was felt over approximately 450,000 square kilometers in the United States, including all the New England States, Delaware, Maryland, New Jersey, Pennsylvania, and portions of Michigan and Ohio. A few points in Illinois, Indiana, Virginia, West Virginia, and Wisconsin also reported feeling the tremor.

A magnitude 4.7 disturbance on January 1, 1966, caused slight damage to chimneys and walls at Attica and Varysburg. Plaster fell at the Attica State Prison and the main smokestack was damaged (intensity VI). The total felt area was about 46,500 square kilometers.

Abridged from Earthquake Information Bulletin, Volume 7, Number 4, July - August 1975, by Carl A. von Hake.

http://earthquake.usgs.gov/earthquakes/states/new_york/history.php

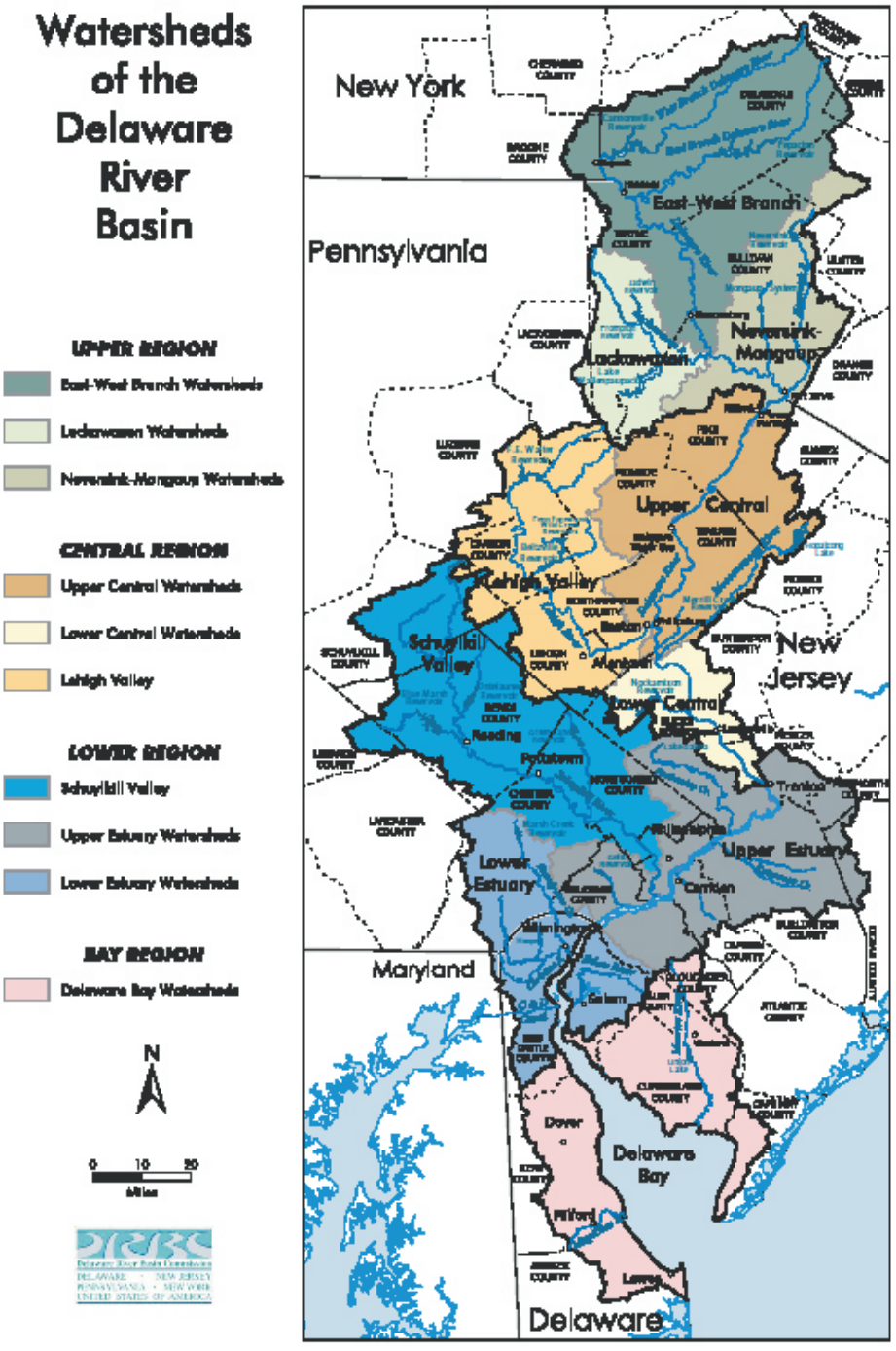


Figure 1: Watersheds of the Delaware River Basin. Source: Delaware River Basin Commission.

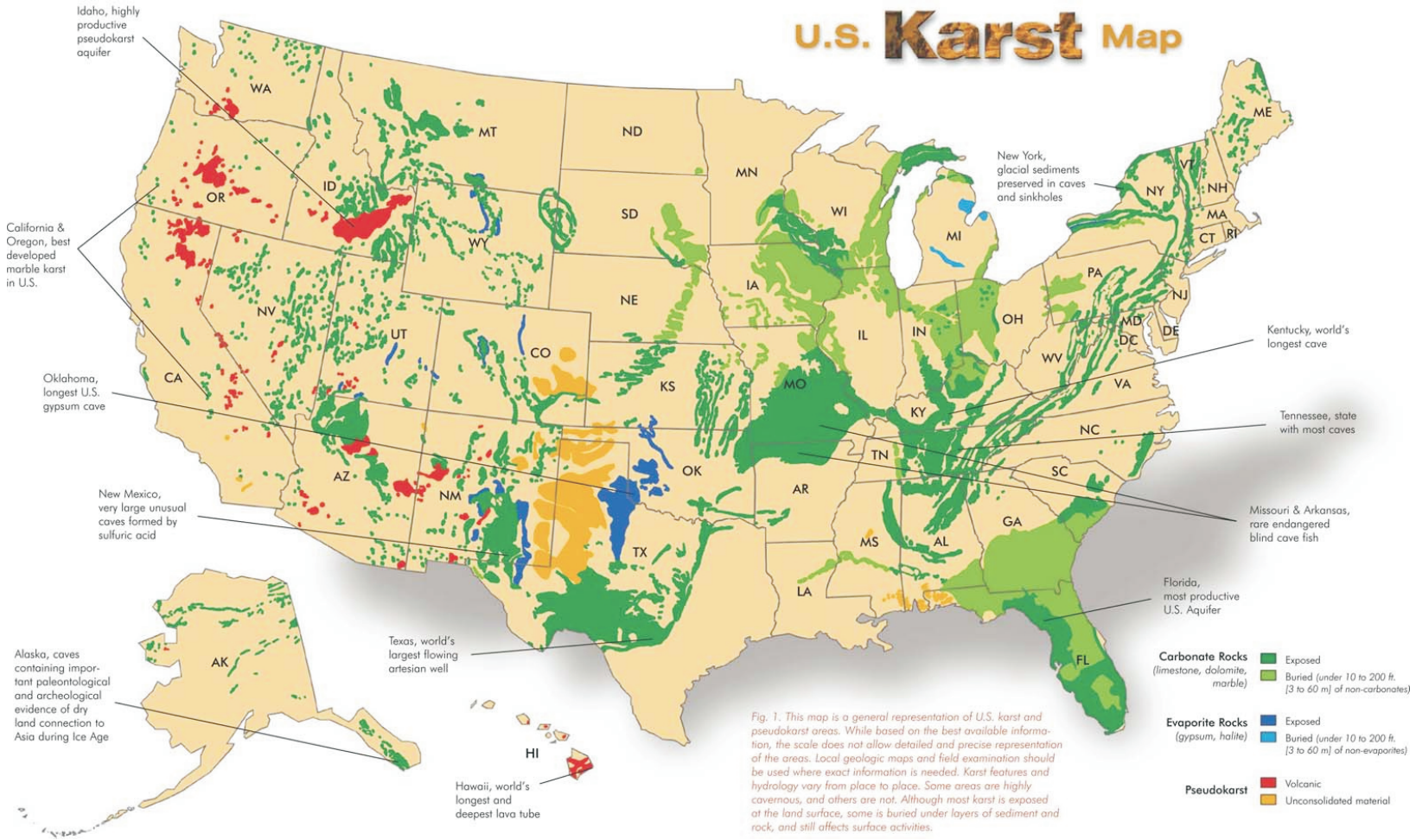


Figure 10: Karst map of the US published by AGI (Veni et al. 2001).

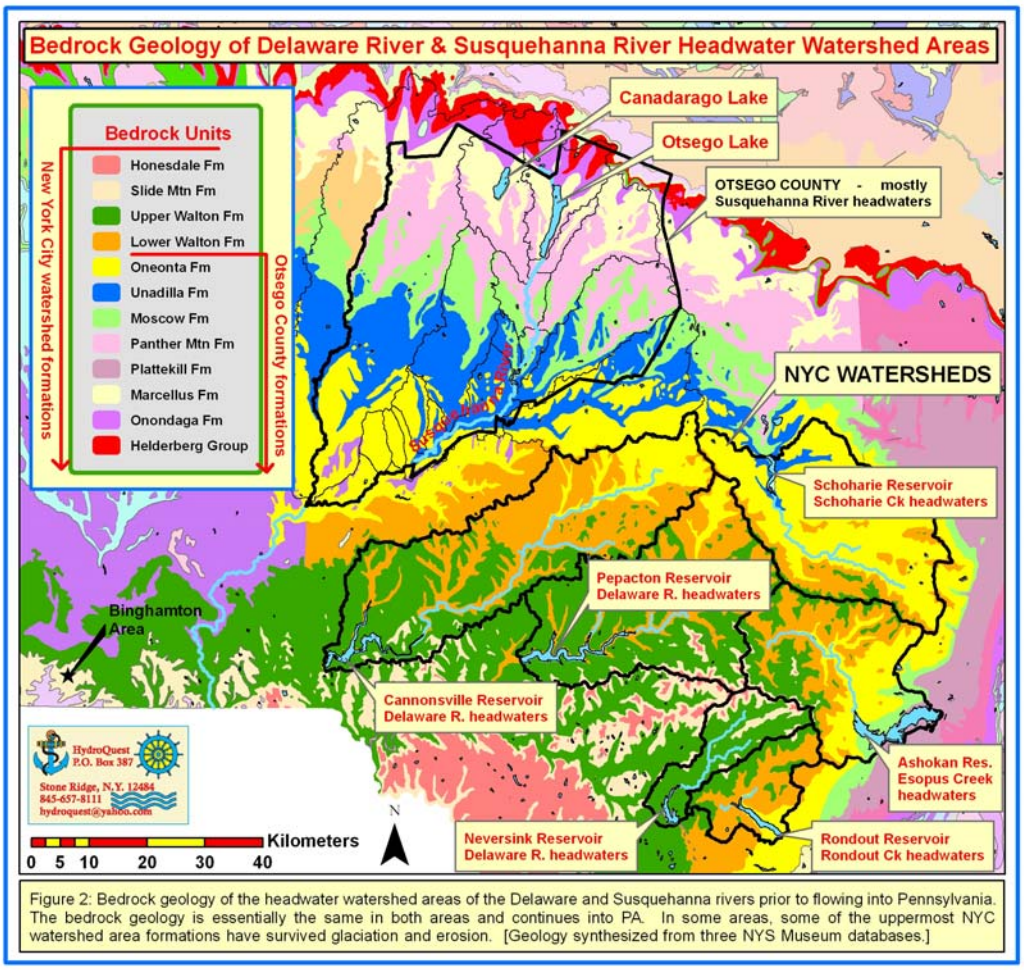


Figure 2: Bedrock geology of the headwater watershed areas of the Delaware and Susquehanna rivers prior to flowing into Pennsylvania. The bedrock geology is essentially the same in both areas and continues into PA. In some areas, some of the uppermost NYC watershed area formations have survived glaciation and erosion. [Geology synthesized from three NYS Museum databases.]

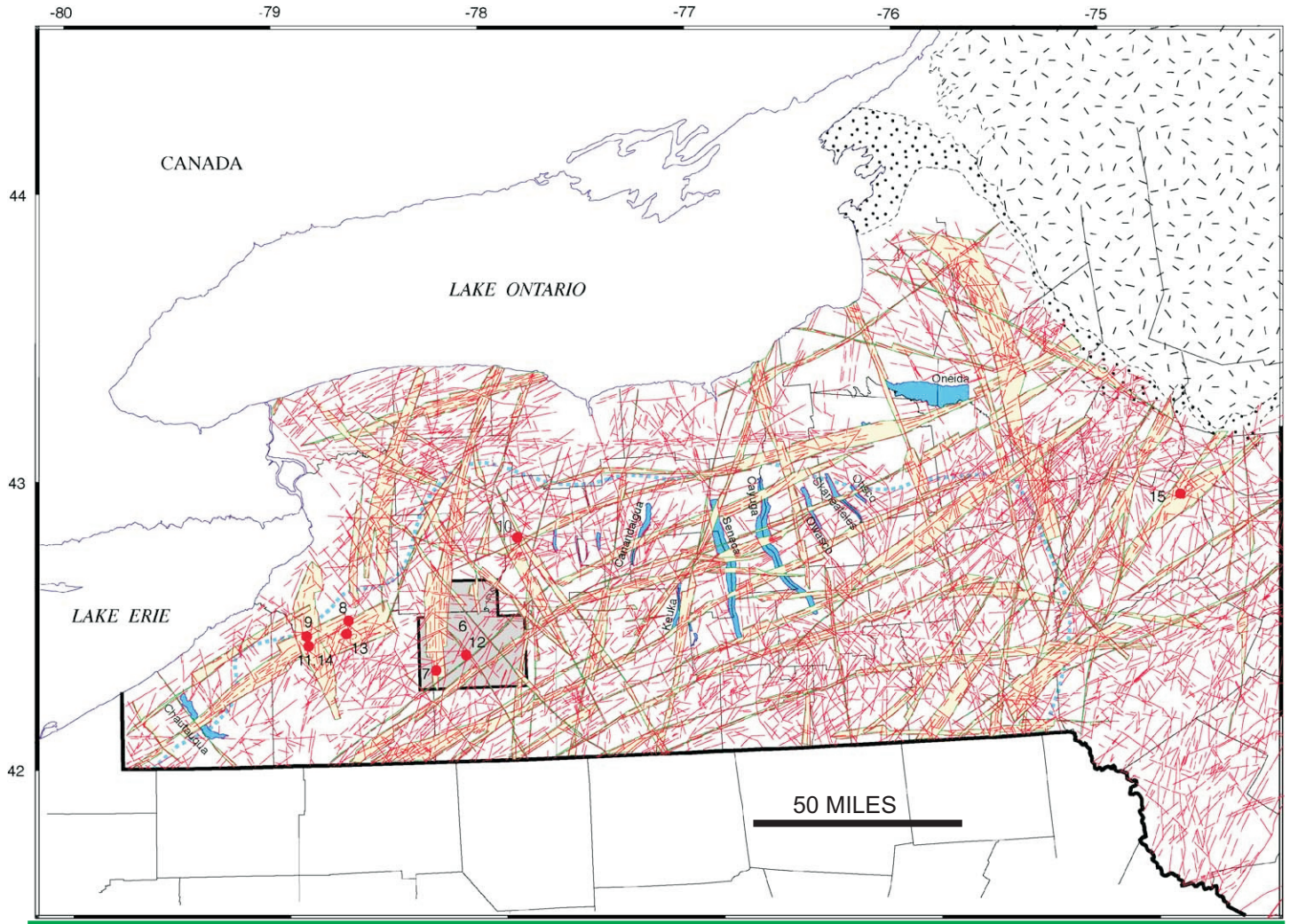
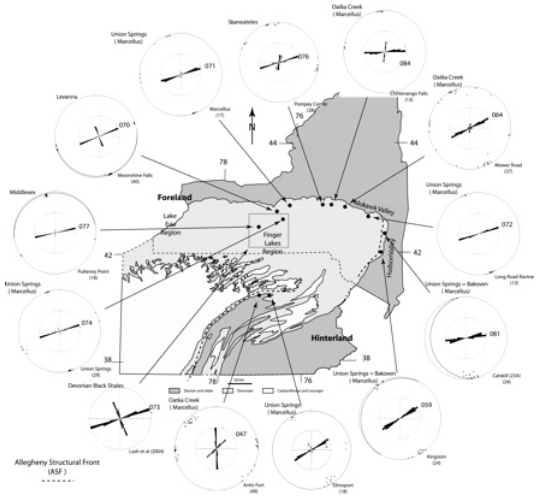
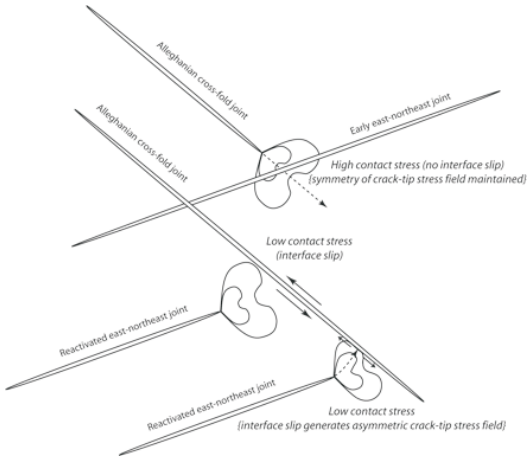


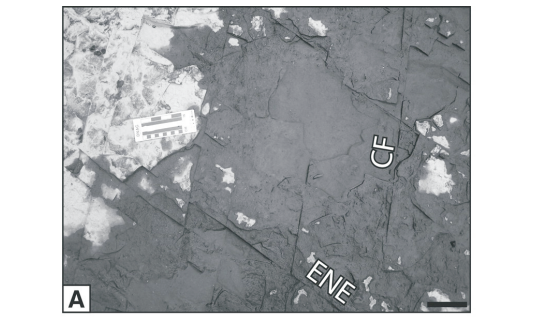
Figure 3: 1997 Landsat lineaments (red lines) as portrayed in Robert D. Jacobi's Figure 2 (2002). Lineaments and faults are widespread throughout the Appalachian Basin in New York State. These fractures and basement faults were examined via analysis of Landsat images, DEM data, aerial photography, side-looking aperature radar, hyperspectral imaging, soil gas anomalies, and field groundtruthing. Jacobi demonstrates that many of these features are seismically active. As portrayed above, many of these fractures are documented in the NYS portion of the Delaware River Basin where Jacobi conducted his geologic work. There is little doubt that similar mapping, if conducted in PA, would reveal similar fracture networks. These and other closely spaced fractures may provide pathways for upward methane and radioactive gas migration when encountered by vertical exploration wells or, later, after hydrofracturing. Similarly, high angle faults may provide upward pathways for pressurized, contaminant-laden, hydrofracturing fluids to reach freshwater aquifers.



From Engelder et al. (2009)



From Lash and Engelder (2009)



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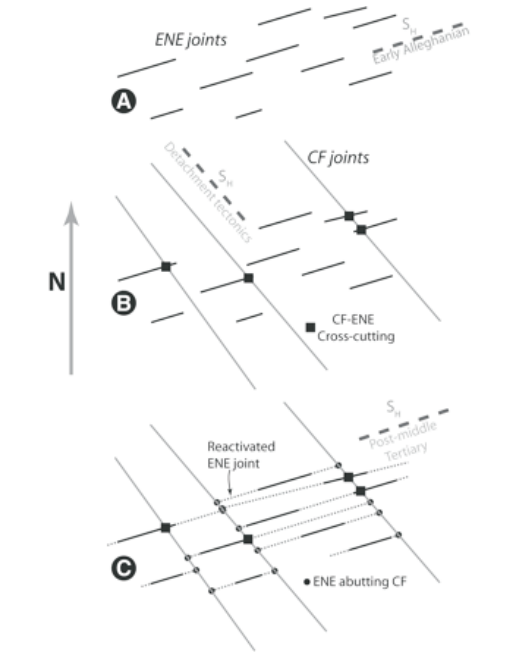


From Lash and Engelder (2009)

Figure 4. Figures from Engelder et al. (2009) and Lash and Engelder (2009) depict dominant joint orientations throughout the Appalachian Basin. Major joints strike east-northeast (J1 joint set) with younger cross-fold joints striking northwest (J2 joint set). The J1 joint set is more closely spaced and permeable than the J2 set. Exploration and other gas wells seek to intersect as many joint sets as possible, thereby maximizing productivity.

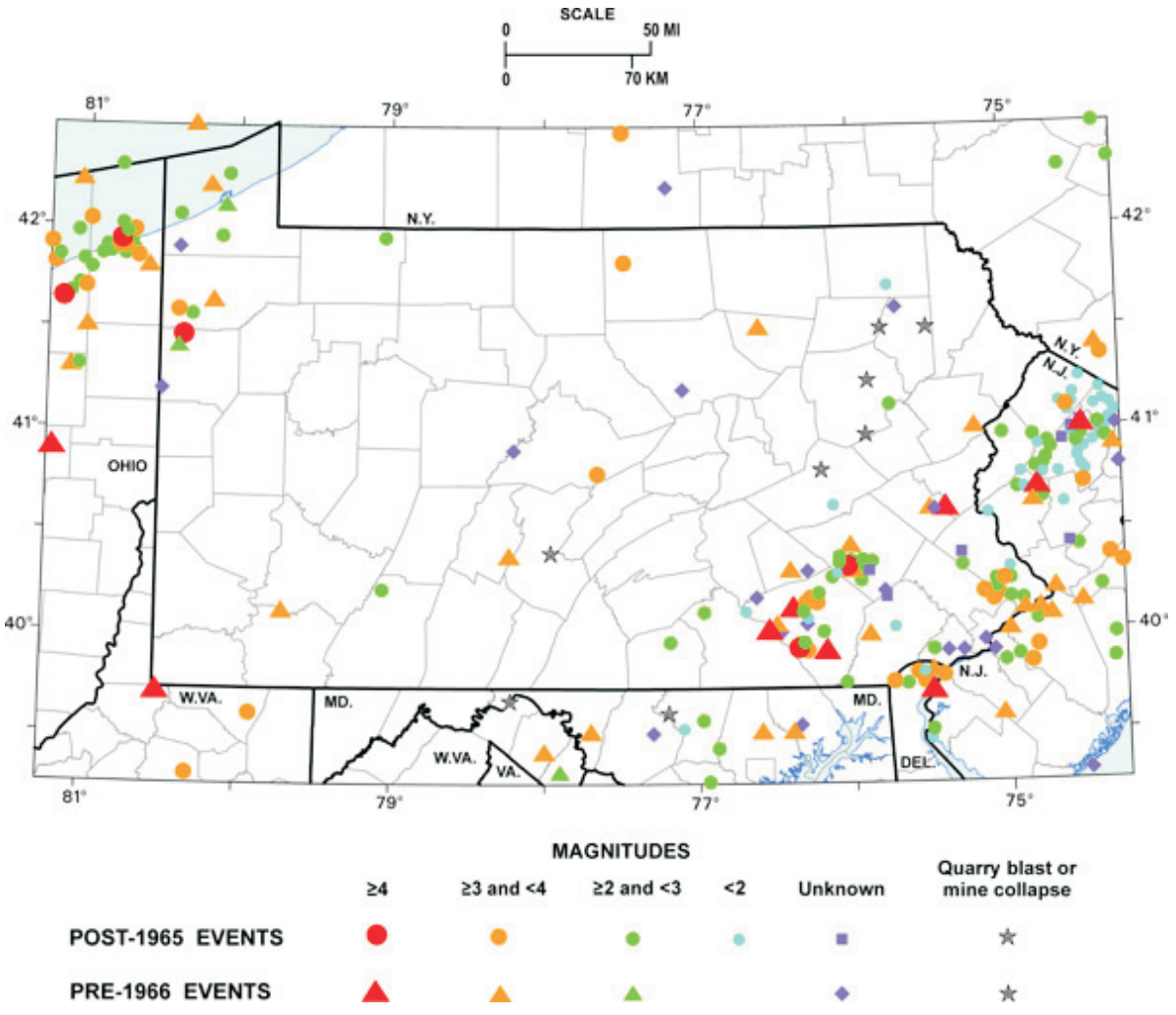
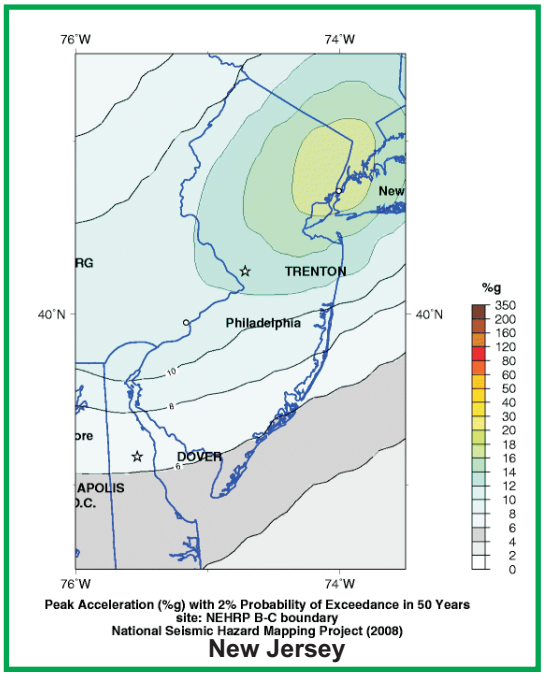
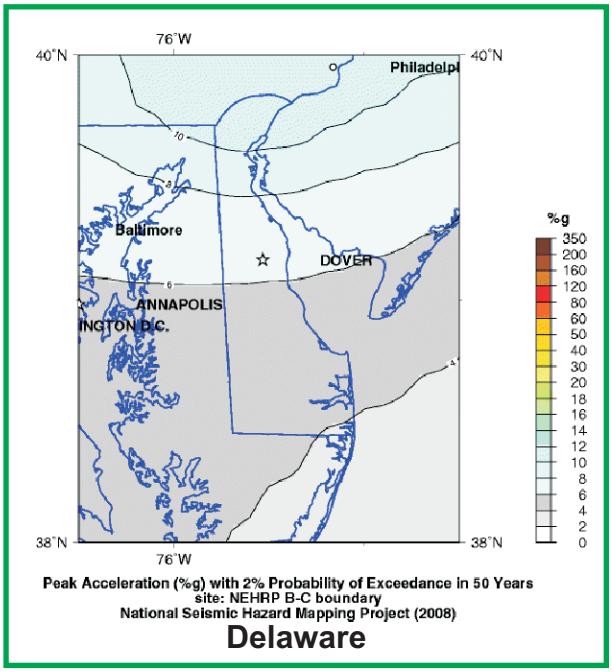
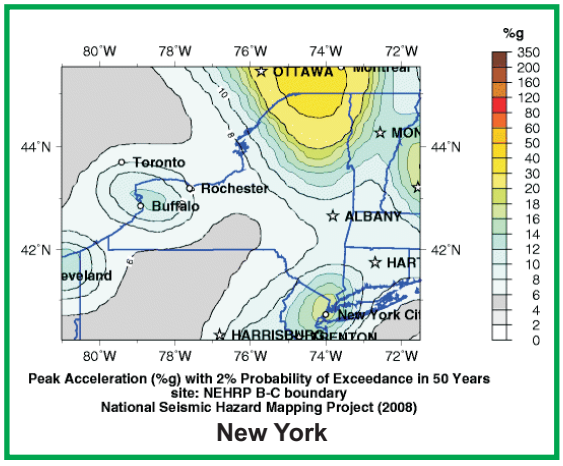


Figure 5: Earthquake epicenter map of PA and surrounding states showing the location of historical earthquakes. Source: PA Department of Conservation and Natural Resources. Compiled by geologist Rodger T. Faill using data through 7-31-03.







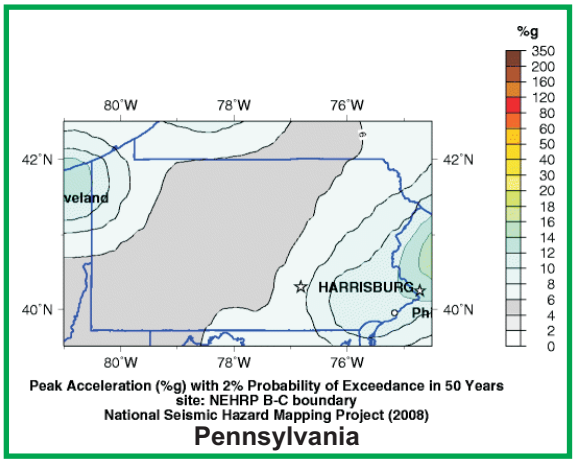


Figure 6: Seismic Hazard Maps. Source USGS (2009). Earthquake Hazards Program.

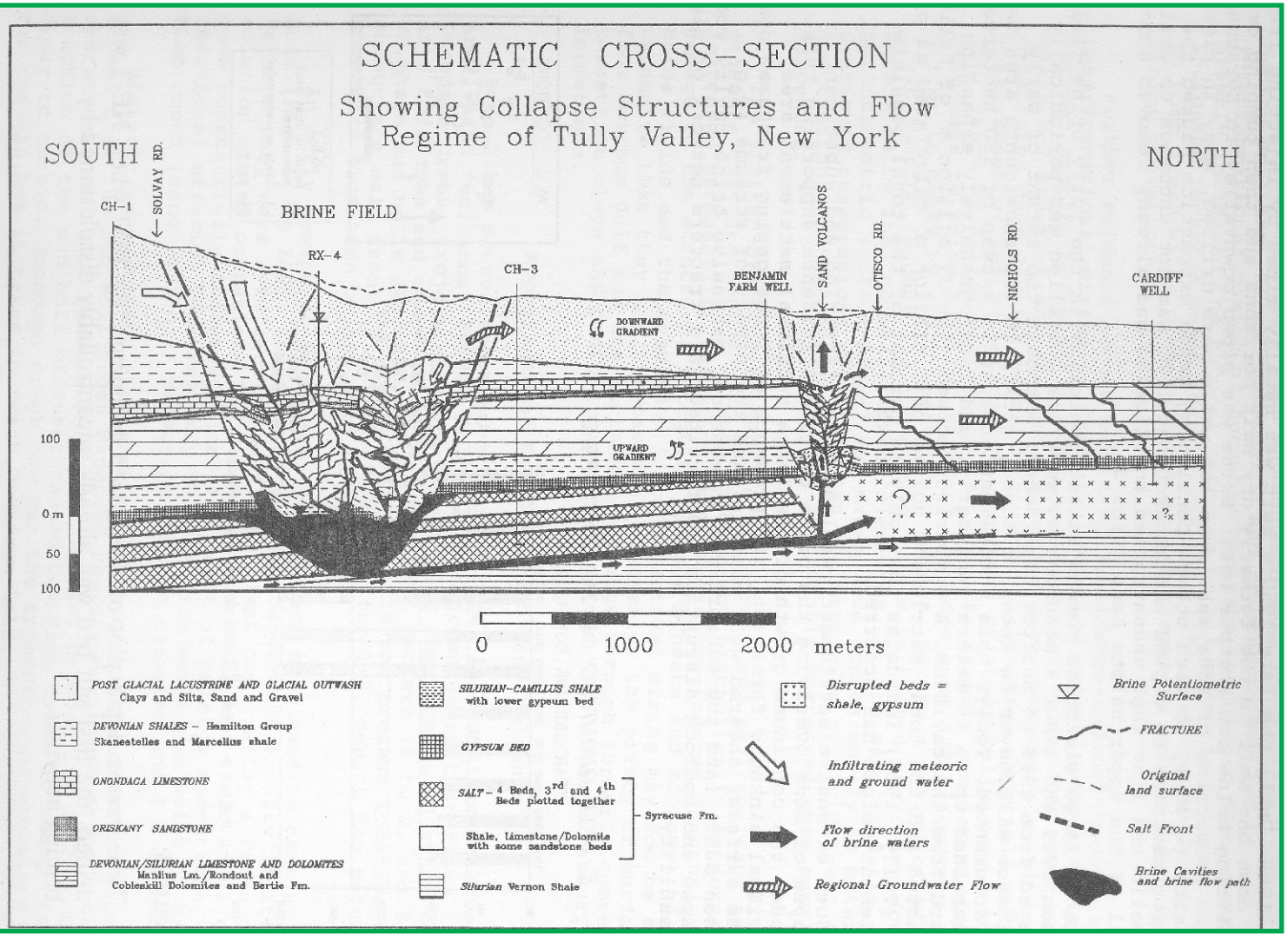


Figure 7: Structural collapse and anthropogenic alteration of a groundwater flow regime caused by solution mining, ground settlement, upward fracture propagation, and unnatural deep groundwater recharge from overlying freshwater aquifers (Fig. 2 of Rubin et al.). By analogy, hydraulic fracturing and chemical treatment of horizontal boreholes serves to integrate gas-rich shale beds by connecting joint sets, faults, and bedding planes over long distances. Upward expansion of even a small number of vertical fractures into overlying bedrock formations may result in a similar disruption and alteration of natural groundwater flow. Once this occurs, as in the Tully Valley example, plugging and abandonment of wells will do nothing to restore pre-existing aquifer and groundwater flow conditions.

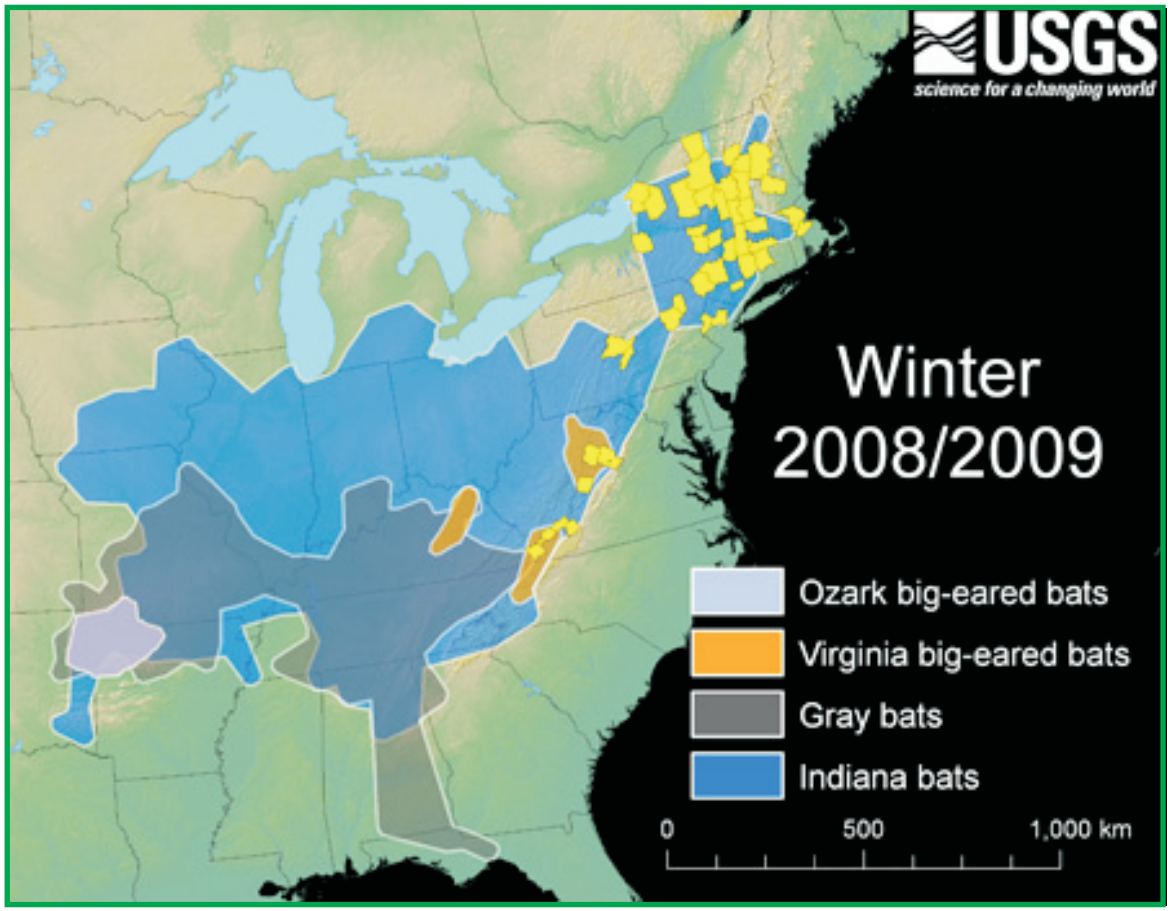
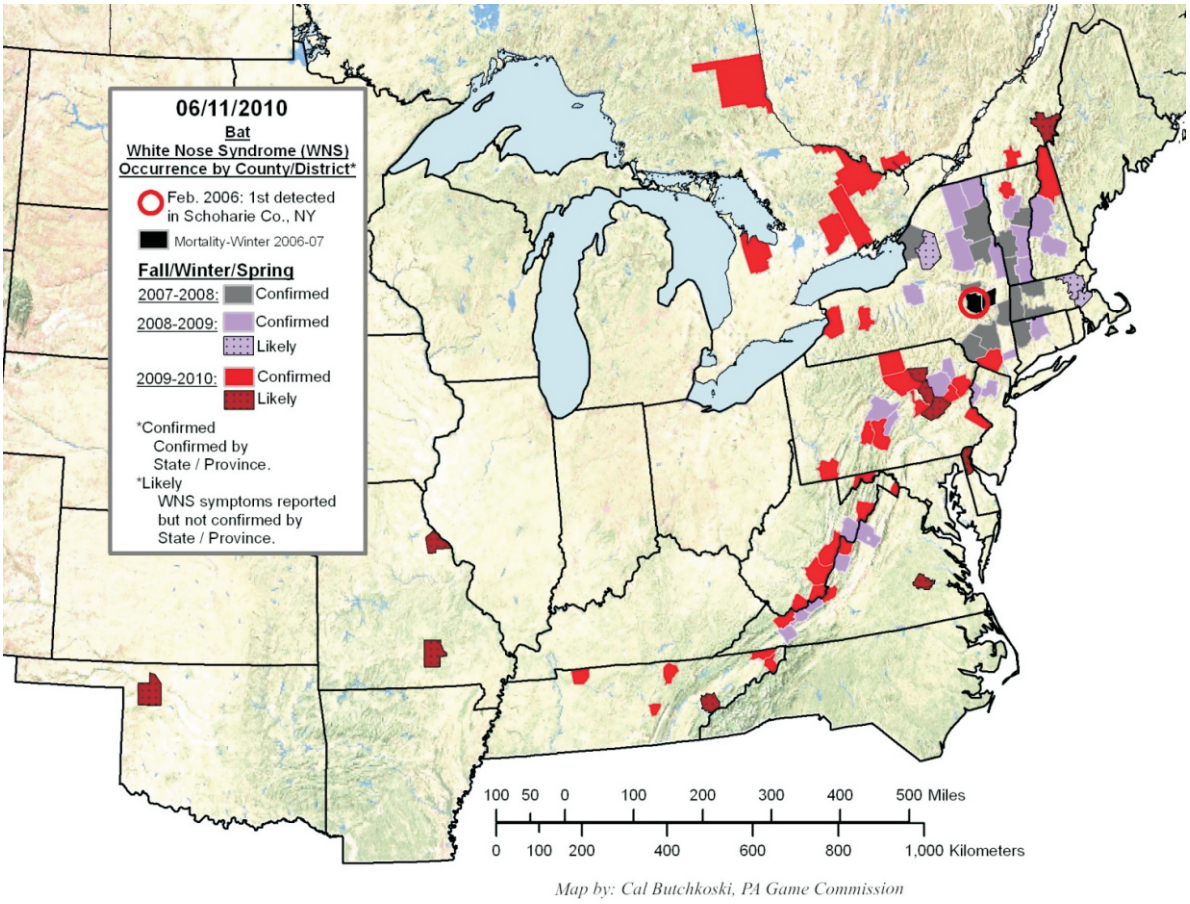


Figure 8: Map illustrating the ranges of endangered species of hibernating bats in the eastern U.S. A portion of the range of the endangered Indiana bat lies within the Delaware River Basin. Map data compiled by Cal Butchkoski, Pennsylvania Game Commission and presented in a USGS publication (White-Nose Syndrome Threatens the Survival of Hibernating Bats in North America; 2010).



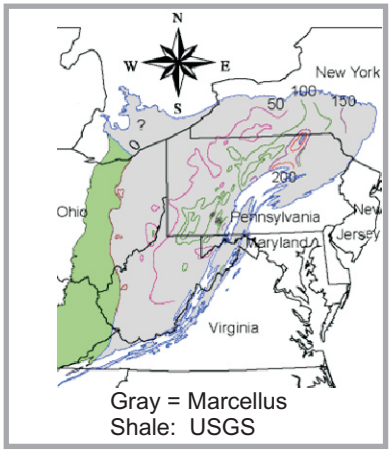


Figure 9: The spread of White-Nose Syndrome (WNS) in bats in the eastern U.S. Caves in the Delaware River Basin may have been adversely impacted by WNS. Methane and other gas field contaminants pose a potential risk to bat populations in caves situated above the Utica Shale. Map by Cal Butchkoski, PA Game Commission.

Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells

Report to:

Delaware Riverkeeper Network

And

Damascus Citizens for Sustainability

Prepared by:

Daniel Thau Teitelbaum, M.D.,P.C.

355 Ogden St.

Denver, CO 80218

(303) 355-2625

November 19, 2010

As a toxicologist and physician specializing in environmental medicine and public health, I have been asked by the Delaware Riverkeeper Network and Damascus Citizens for Sustainability to provide my professional opinion on the potential toxicological effects that may result from exposure to chemicals and substances that may be released from natural gas wells, including certain "grandfathered" exploratory wells, that have been or may be drilled in the drainage area of the Special Protection Waters of the Delaware River Basin.

In my professional opinion, due to the multiple known risks to human health from exposure to such chemicals and substances, such exploratory well drilling should not be done until the consequences of such exposure are thoroughly examined in a comprehensive health effects study for the Delaware River Basin. The necessity for such a study, before drilling begins, has been established in our research and in that of others in the western United States, especially in the Battlement Mesa area of Garfield County, Colorado. In Garfield County we found in 2008 that there was a total lack of research into the health effects from gas development activities. As a result of this study, a comprehensive Health Impacts Assessment was commissioned by Garfield County and completed in September, 2010. It is imperative that a similar study be performed for the Delaware River Basin before any gas development – including the grandfathered wells – is allowed to proceed.

One of the most glaring omissions of the gas drilling process has been the exclusion of consideration of human health impacts. Only through anecdotal reports can impacts to human health in the Delaware River Basin be presumed as no epidemiological or environmental health studies have been done in the Basin. This is necessary before drilling proceeds in the Basin in part because the Delaware River supplies water to more than 15 million people. In addition to the potential toxicological effects from exposure to water contaminated by pollutants released from gas drilling activities, there are significant air pollution issues which also may become water pollution issues due to downwash. We have studied these potential water and air pollution issues in certain areas in the western United States, but such studies have not been done in the significantly more densely populated northeastern United States.

In preparation for our September 2010 Health Impact Assessment (HIA) report on Battlement Mesa in Garfield County, Colorado (http://www.garfield-

county.com/index.aspx?page=1408 and copy attached), in 2008 my colleagues and I reviewed previously completed studies from the general area of Garfield County and concluded that there were major gaps in public health information. At the request of the Garfield County Board of Commissioners, the Colorado School of Public Health (working in conjunction with the Garfield County Health Department) undertook a public health impacts assessment of the gas development activities underway or planned for this area. We conducted a qualitative and quantitative analysis of existing environmental, exposure, health and safety data for the Battlement Mesa community. We offered specific recommendations and produced a Health Impact Assessment (HIA) which involved several defined steps. The HIA looked at health stressors specific to gas development and rated them. Our results are in the HIA report, a copy of which is being submitted with this report.

The health effects on the Battlement Mesa residents were based on a careful study of the area population and the locations of gas development activity. The general conclusions of this HIA can be extrapolated from the study of the Battlement Mesa area to other areas with similar gas development activity across the county, including the northeastern United States. However, it is necessary to additionally look at the unique characteristics of any particular area, such as the Delaware River Basin including its geology and subsurface faulting and jointing, radioactivity of the underlying layers, water resources in proximity and downstream or down gradient from gas development areas and, of course, the unique population of that area. Therefore a study similar to the HIA should be done for the Delaware River Basin before exploratory drilling and gas development occurs and in preparation for any issuance of regulations. This study must precede permits, not the other way around, including any "test" or "exploratory" wells. These wells will include all the stressors we found, and perhaps additional ones, to a greater or lesser degree, depending on the unique population and geology of the potentially affected areas of the Delaware River Basin. Therefore it is imperative to study these issues before allowing gas drilling and development to proceed.

As part of the 2008 preliminary review that led to the 2010 HIA, my colleagues and I undertook an extensive review of the professional literature on the toxicology of the types of chemicals being used by the gas development industry and the substances being brought to the surface by gas drilling activities. As part of this report and my professional opinion in this matter, I

am incorporating that 2008 literature review, entitled "Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008)," into this report. The toxicology assessment in this literature review is just as relevant for the Delaware River Basin as it is for western Colorado. The same sorts of chemicals and substances are involved in gas drilling and development activities in the Delaware River Basin as are involved in such activities in western Colorado. Moreover, the toxicological effects of exposure to these various chemicals and substances do not change based on the location where the exposure occurs. For this same reason, references throughout the Literature Review to natural gas "exploration," "extraction," or "production" are essentially interchangeable as related to toxicity of chemicals and substances that may be released into the environment anywhere during these activities. The one exception to the applicability of the Literature Review to this hearing is that the portion of that Review related to chemicals used exclusively in fracking operations would not be relevant to this hearing related only to the drilling of exploratory wells. Everything else in the Literature Review is relevant to the issues involved in this hearing.

I have attached as appendices the 2008 White Paper and Literature Review Appendices listing all of the professional publications that were included in the literature review. I have also attached for completeness the 2010 report entitled, "Health Impact Assessment for Battlement Mesa, Garfield County Colorado."

The opinions provided in this report are stated to a reasonable degree of scientific and professional certainty.

/s/ Daniel Thau Teitelbaum

Daniel Thau Teitelbaum, M.D., P.C.

Attachments:

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003 – 2008)

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review Appendices

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper

Health Impact Assessment for Battlement Mesa, Garfield County, Colorado

Potential Exposure-Related Human Health Effects of Oil and Gas Development:

A Literature Review (2003-2008)

Prepared by:
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Gregory Kinney[1], MPH, Doctoral Candidate in Epidemiology
Daniel Teitelbaum[1], MD, Adjunct Professor
Lee Newman[1], MD, MA, Professor

August 1, 2008

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Introduction and Background

The purpose of the literature review is to:

1. Review the known contaminants associated with oil and gas exploration, drilling, extraction and production.
2. Review the available medical literature regarding the health effects associated with oil and gas extraction and the health effects of the hazardous substances associated with oil and gas extraction and production.
3. Review the community and occupational injury rates associated with oil and gas extraction and production.
4. Review the literature regarding the potential social and psychological risks of increased oil and gas drilling on a community.

The United States and global energy needs have driven up prices for fossil fuels, with no relief in sight. In addition, political instability in major energy producing countries around the world has driven a US energy policy to increase domestic production of all types of energy, in particular fossil fuels. The combination of skyrocketing demand, interest in domestic supplies and new technology has made fuels previously unattainable or too costly now worthy of recovery. The American West has large reserves of extractable oil and gas. The West has therefore seen a dramatic increase in drilling for oil, gas, coal, and coal bed methane.

As pressures for increased fossil fuel production rises, areas that had previously been considered too sensitive for drilling are now being drilled. These previously sensitive sites have included an increasing number of oil and gas drills that are in close proximity to native and local populations. Human residence and activity close to oil and gas production sites increases the likelihood that people will be exposed to the hazardous chemicals, emissions and pollutants associated with these activities.

Hazardous chemicals are known to be used and produced by oil and gas extraction processes. Subsurface land formations are “fractured” (known as “fracking or frac’ing) by injection of fluids and/or solids into the ground under high pressure. Some of the chemicals used in this process are brought to the surface, potentially contaminating soil, air and water, while some of the chemicals are left underground, potentially contaminating subsurface aquifers. Other chemicals may also be used in the drilling fluids. These fluids may be fresh or salt water based muds, oil based muds or synthetic materials that contain esters, olefins, paraffins, ethers and alkulbenzenes, among others. The drilling fluids may also contain additives such as metals, acrylic polymers, organic polymers, surfactants, and biocides.(Occupational Safety and Health Administration)

Drilling sludge brought to the surface can contain fracking fluid, drilling mud, radioactive material from the subsurface land formation, hydrocarbons, metals, volatile organic compounds. When left to dry on the surface in waste pits, sludge can potentially contaminate air, water and soil. Sludge may also be removed to waste disposal sites (but usually not hazardous wastes sites) or sludge may be tilled into the soil in “land farms”. These practices potentially contaminate soil, air and surface water.

Produced water can be brought to the surface during the extraction process. This water is usually contaminated with salts, hydrocarbons, radioactive material, metals, drilling fluids and muds. The produced water is often left on the surface to evaporate, or it may be re-injected into the ground or released into surface waters. All of these disposal methods threaten air, water and soil quality. Additionally, spills of oil and gas wastes and/ or chemicals used in production can pollute ground and surface water and soil.

Air surrounding oil and gas production areas is particularly vulnerable to toxic emissions. Fugitive natural gas emissions may contain many contaminants. Some of these such as methane and other hydrocarbons (ethane, propane, butane) and water vapor are of relatively low human toxicity. Others such as hydrogen sulfide (H2S) are of more significant toxicity. Some natural gas wells produce a condensate which can contain complex hydrocarbons and aromatic hydrocarbons such as benzene, toluene, ethyl benzene and xylene (BTEX). These substances are important human toxics with multiple non-cancer and cancer endpoints. Natural gas flaring can produce many hazardous chemicals including polycyclic aromatic hydrocarbons (PAHs, including naphthalene), benzene, toluene, xylenes, ethyl benzene, formaldehyde, acrolein, propylene, acetaldehydehexane. Glycol dehydrators, used to remove water from natural gas can produce BTEX leaks into the air.

Most of the hazardous chemicals associated with oil and gas production are well documented to produce adverse health effects in individuals. Some literature exists that demonstrates adverse health effects on populations exposed to these chemicals in other industrial or in urban settings. However, little research exists regarding the effects of these exposures on local populations as a whole in the setting of oil and gas extraction. Our review is an attempt to summarize what is known about these hazardous chemicals' effects on populations and to identify gaps medical and public health knowledge. A list of contaminants derived from the Oil and Gas Accountability Project website is listed in the next section. (Oil and Gas Accountability Project 2006) Our review may not include chemicals used in drilling muds and fracking fluids as these compounds are often considered proprietary and not available to the public.

Oil and gas drilling is associated with an influx of workers and resources to often rural or isolated communities. These changes can bring about stresses to the local people and may be reflected in changes in crime, social diseases, and psychological outcomes. We reviewed available literature regarding the psychosocial effects of oil and gas drilling on local communities. We also identified significant gaps in knowledge regarding the demographics and the psychosocial effects of oil and gas drilling on local populations.

Oil and Gas Contaminants

Contaminant Inventory	
Particulates	PM10 (diameter </= 10 microns) PM2.5 (diameter </= 2.5 microns) Ultrafine particles (diameter </= 1 micron)
Nitrous oxides (NOx)	
Sulfuric oxides (SOx)	
Ozone	
Hydrogen Sulfide (H2S)	
Volatile Organic Compounds (VOC)	BTEX (Benzene, Toluene, Ethyl benzene, Xylene) Methylene Chloride Tetrachloroethene Trichloroethene 1,4-dichlorbenzene m,p-xylenes 2-hexanone
Diesel fuel/exhaust	
Metals	Arsenic Barium Cadmium Chromium Lead Mercury Selenium Zinc
Polyaromic hydrocarbons (PAH)	
Produced water	
Fracturing chemicals (Fracking, Frac'ing chemicals)	
Radiation	Radon Radium Uranium
Noise pollution	
Light pollution	

Methodology

Literature Search

The literature search was performed by Paul Blomquist at the University of Colorado Denver Health Sciences Library after discussion with the work group to define the scope and extent of the searches. The bibliographic retrieval on May 13, 2008 included four different searches related to oil and gas drilling as follows: search 1 covered adverse reactions to various chemicals and events; search 2 retrieved impacts of fracking and fracturing; search 3 covered implications of produced water; and finally search 4 retrieved injuries related to oil and gas drilling. All searching in Ovid Medline excluded the pre-indexed component of Medline.

The first search covering adverse reactions to various chemicals and events related to oil and gas drilling was limited to the years 2003 through 2008 and for humans only. In this search, an initial set, limited by the subheading for adverse effects, was created for MeSH (Medical Subject Headings) terms that included "air pollution" and the subjacent MeSH term "air pollution, radioactive", the exploded term "Particulate matter," and the exploded term "environmental pollution." Also, "Waste products" included all subjacent MeSH terms other than "medical waste." Other exploded MeSH terms with adverse effects subheading included "water pollution," "noise," and "light." Finally three subheadings--adverse effects, poisoning, and toxicity--were applied to MeSH terms for both "vehicle emissions" and the exploded "Environmental Pollutants". From this initial aggregated set, citations were eliminated for the exploded MeSH terms of "household articles," "household products," "pest control," "swimming pools," "seasons," "weather," "smoking," "tobacco," and "tobacco smoke pollution." Also citations were eliminated with truncated free text terms for "offshore$" and "cigarette$."

The final aggregated retrieval for the first search strategy was parsed into 28 sets by concepts for adverse events or chemicals related to oil and gas drilling that included truncated full text terms, acronyms, and exploded MeSH terms supplemented with chemical registry numbers where appropriate. The MeSH terms used for parsing did not limit with subheadings except for the concept of diesel fuel in which the subheadings for toxicity, poisoning and adverse effects were applied to MeSH terms "vehicle emissions" and "gasoline." It is suggested that alternate searching could be formulated that applies subheadings for poisoning, toxicity, or adverse effect to the MeSH terms for the chemicals that comprised a large portion of the 28 concepts.

In the second search on the impact of fracking and fracturing in oil and gas drilling, an initial set was created of full text terms for "fracturing" or the truncated "frack$." This retrieval was narrowed to citations with exploded MeSH terms for either "environmental pollution" or "water supply." This set was further narrowed to citations pertaining to oil and gas drilling with a combination of fulltext terms and MeSH terms as follows: restriction to citations that contain exploded MeSH terms for both "extraction and processing industry" or "petroleum"; or restriction to citations containing fulltext terms for either "oil" or "gas" adjacent to any of the three truncated terms "drill$" or "indust$" or "explor$." Citations with truncated fulltext term "offshore$" was excluded from the final set of this retrieval.

For the third search on the implications of produced water in oil and gas drilling, an initial retrieval of citations included exploded MeSH terms for either "water supply," or "environmental pollution." Added to this set were citations that had both exploded MeSH terms for "extraction and processing industry" and "petroleum." A final aggregation included citations with fulltext terms of either "oil" or "gas" adjacent to any of three truncated terms: "drill$" or "indust$" or "explor$." This final set was narrowed to only citations containing the fulltext term "produced water," and citations containing the truncated term "offshore$" were eliminated.

In the fourth search on injuries related to gas and oil drilling, an initial set of retrieved citations of exploded MeSH terms for "extraction and processing industry" combined with "petroleum." To this set was added citations with full text terms of "oil" or "gas" adjacent to any of three truncated terms: "drill$" or "industry$" or "explore$." The aggregated set was narrowed to citations that had exploded MeSH terms for either "wounds and injuries" or "accidents." Finally, citations containing the truncated term "offshore$" were eliminated.

Summary of databases searched:

U.S. National Library of Medicine: Ovid Medline (R) 1950 to present.
Social/Psychological Databases: Psychological: PyschInfo, Web of Science
Medical: ScienceDirect, PubMed, MEDLINE OCLC, CINAHL
Public Health: American Journal of Public Health, Annual Reviews
Educational: EBSCO Academic Search Premier, ERIC, OCLC

Refining the Literature Review

After identifying potentially relevant literature, each paper was reviewed at the abstract or full text level for relevance. We reviewed English language, human studies published between 2003 and the present. Papers were excluded from further review based on the following criteria: foreign language literature; animal research; publication prior to 2003; laboratory based, experimental research studies; off shore drilling and exploration studies; reviews other than meta analyses; case reports; commentaries, editorials, letters to the editor and other opinion pieces. Exceptions to these rules are specifically noted in each subsection.

Having refined the list of potentially relevant literature, papers were reviewed and summarized according to exposure category. These reviews are a summary of relevant literature, taking into account the strength of evidence and study design. No attempt was made to rate individual articles.

Table 1. Overview of search results and literature reviewed

Category	Initial number of references identified by Search	Number of references Excluded (see criteria above)	Total number of references Reviewed	Appendix
VOC	247	147	100	1
Diesel Exhaust	197	144	53	2
Nitrogen oxides (NOx)	243	192	51	3
Sulfuric oxides (SOx)	118	85	33	3
Ozone	217	125	94	3
Particulate matter	510	183	327	3
PAH	276	245	31	4
Metals	299	224	75	5
H2S	85	65	20	6
Fossil Fuels	305	279	26	7
Fracking	234	234	0	-
Noise	881	857	24	8
Light	297	291	6	9
Occupational Injuries	40	31	9	10
Social/Psychological	1114	1093	21	11
Total	5063	4239	831	

Limitations

This literature review has a number of possible limitations:

- It relied on single reviewers for each section.
- It only considered literature published within the past 5 years, possibly missing important, relevant literature published prior to 2003.
- It may have excluded meritorious research published in foreign languages.
- Studies were considered without reference to their funding sources or their potential conflicts of interest.
- Use of additional search terms may have generated different results.
- Use of additional databases may have yielded different results.
- It did not use formal criteria to assess each individual paper for strength of evidence and study design.
- It relied on the major, known exposures of potential concern. There may be other exposures that should have been considered.
- Additional chemicals, used in proprietary formulas, may not have been included.
- In many cases papers focused on single exposures. This may fail to take into account potential health effects of these exposures when they are part of a complex mixture.

Contaminants and Health

Volatile Organic Compounds (VOCs)

Volatile organic hydrocarbon exposures as a result of emissions from production in the oil and gas industries are complex. These are composed of materials used in the production activities, and emissions from the produced material. Both point source releases at the well pads, and transportation activities to and from the drilling sites contribute volatile hydrocarbon loads to the resident and transient populations in the drilling regions. Because there is limited information on the distribution of population in the affected regions, it is not possible to define the distances of interest from the well heads and traffic patterns of concern. This makes it difficult to search the literature for exposure concentrations by source distance. Since dose and dose rate are important in assessing the relevance of the literature of VOCs to human information, the absence of this demographic information limits the interpretation of the found literature.

Terms utilized in the search are summarized above. A total of 247 studies were recovered. One-hundred and forty-seven studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). Because reviews and comments were excluded for this study, known and theoretical issues of diseases suspected or proved to be causally associated with the materials of interest in past studies are not included in this paper. The search for VOC literature included the BTEX chemicals (benzene, toluene, and xylenes) and also included low molecular weight halogenated hydrocarbons. A total of 62 studies were selected for review dealing with benzene. Four relevant studies were reviewed for xylene. Studies relating to toluene were subsumed under the benzene and xylene rubric. No meaningful studies that dealt with dichlorobenzene were found. Two studies that met the search criteria were reviewed for dichloromethane [methylene chloride]. Ten relevant studies were reviewed for perchloroethylene. Twenty-two relevant studies were reviewed for trichloroethylene. These citations are collected in Appendix 1.

Chronic, low level exposure

The literature on the impact of volatile organic compounds including the BTEX group, and the low molecular weight halogenated hydrocarbons were reviewed for cancer and non-cancer endpoints in humans. Although there is an extensive occupational toxicology literature on these substances, little meaningful information on chronic, low level, exposure in the general environment has been developed.

High Concentration Exposure

It is well known that all of the chemicals in this group are neurotoxins. They impact the central and peripheral nervous system. They have significant cognitive and behavioral effects in

occupationally exposed groups. They are known hepatotoxins. Most have been identified as reproductive toxins both in males and females. They are recognized as fetotoxins, and have been associated with teratogenesis and fetal wastage following large or critically timed occupational or accidental exposures. All are dermatotoxins. These effects have primarily been identified in persons who had exposures at levels or dose rates that are not found in the general environment, although widespread general environmental exposure to these chemicals occurs, few studies have been conducted at environmental exposure concentrations.

Occupational Exposures

Although much of the toxicological information on benzene in particular has been developed in the downstream petrochemical industries such as shipping, processing and refining, and distribution of the finished products, no studies on the impact of the BTEX group or the low molecular weight halogenated hydrocarbons in the upstream petrochemical industries were found. No data on exposure to these substances to occupational groups in the process of exploration or production were recovered. No studies of exposures to adjacent populations were found. This is a major data gap. All relevant studies selected for review and relevance then are removed from the oil and gas production activities and must be used as analogous to these activities.

A number of very low level occupational exposure studies that demonstrate positive outcomes are likely relevant to the exposures to resident local populations in the oil and gas exploration and extraction areas. For example, a statistically significant incidence of acute myeloid leukemia at doses and dose rates as low as 0.8ppm and 2ppm/years was demonstrated in the case control study portion of the Australian Health Watch Study. This important finding suggests that benzene may have adverse health effects at lower dose rates than previously thought and current exposure limits may not be protective.

It is necessary to extrapolate the occupational information which has been developed in healthy, midlife, mostly male workers to the broader universe of humans, including women, children, and the infirm. Because the body of literature recovered in the searches is not informative on these populations, it is immediately apparent that a major data gap exists in any attempt to characterize risk beyond the workplace. Broad general assumptions must be made about adjustments to dose response curves for use in risk assessment in non-occupational populations such as the target groups of concern in this review. Physical and psychological stressors that may influence the impact of exposure and outcome are unaddressed.

Biomarkers

A growing literature on the identification and quantification of biomarkers of exposure to volatile organics, and sub-clinical effect of these exposures was developed in this review. This literature offers some hope that biomarkers may provide meaningful data on exposure at very low levels to non-occupational populations. Papers recovered that deal with genetic diversity and metabolic variations in the handling of these chemicals in large groups of humans may indicate that in the future such measurable parameters will give early clues to adverse effects. Because there is a peer reviewed body of information that indicates that children are at increased

risk for adverse toxicological outcomes following exposure to many synthetic organic chemicals, including the volatile organics, the absence of environmental toxicology data on childhood environmental exposure and outcome is particularly troubling.

Molecular epidemiologic investigation of biomarkers that have been identified in the occupational and para-occupational groups as a result of exposure to the BTEX and low molecular weight halogenated hydrocarbons should be done in the environmentally exposed persons based upon the material recovered in this review. Molecular epidemiologic studies may prove to be of great value. Such investigation may yield exposure information not currently available for these environmentally exposed persons. If registries of these findings are developed, maintained and properly analyzed, and linked to long term outcome follow up studies, they may prove to be characteristic and predictive of adverse health outcomes.

Epidemiology

Extensive epidemiologic, basic science, and mechanistic information has been collected and peer reviewed about each of the materials of concern in this part of the review. More of this information supports the classification of benzene as a known human carcinogen, trichloroethylene as a probable human carcinogen, and dichloromethane as a probable human carcinogen, than addresses the non-cancer endpoints that have been identified following occupational exposure to this group of chemicals. In the material recovered in this review, some of the well-known cancer endpoints and some of the lesser known toxic endpoints have been demonstrated in low level exposures in occupational or para-occupational populations. A few studies of exposure at low, general environmental exposure have also shown increased occurrence of the non-cancer endpoints, particularly in the neurological system.

Most of the studies that are relevant to the issues at hand in this review identify serious cancer and non-cancer endpoints in low level, long term occupational or para-occupational studies. For example, benzene or benzene and other volatile organic compound exposure in traffic police and the outcomes in these persons have been analyzed. Some studies have identified biomarker variants in these exposures that might also be found in persons who reside close to a point source of analogous VOC emissions. The biomarkers and outcomes in para-occupational groups provide insight into research findings that may predict outcomes in the environmentally exposed groups.

Summary

Based upon the material reviewed in this study, some conclusions are appropriate:

1. Benzene is a human leukemogen at airborne exposures lower than have been reported in past times. This may imply that persons residing close to sources of benzene from oil and gas production are at risk of leukemia from those exposures. Some evidence for the occurrence of a broad spectrum of hematological disorders exists. The scope of these diseases should be the subject of study. In addition, the low molecular weight halogenated hydrocarbons are noted to cause liver, kidney and neurological disease, and

likely increase renal and other cancers. Persons exposed to these materials in the oil patch should be evaluated for adverse effects.

2. Biomarkers that may be clinically relevant have been identified in numerous studies of human exposure to most of the chemical compounds in this review. An evaluation of the relevance and predictive value of these biomarkers should be undertaken. Selection and examination of the most useful biomarkers in this population and a registry of the findings should be developed for this population. The biomarkers may be indicative of exposure to the materials of interest and therefore may be predictive of increased risk of adverse outcome in the exposed population.
3. Evidence of cognitive and behavioral abnormalities, alterations in special sense function such as impairment of color vision and perception have been reported in occupationally exposed workers from these materials. Screening for cognitive function impairment, behavioral disorders and disorders of the special senses is appropriate in the population exposed to oil and gas activities.
4. Very limited evidence that children are at increased risk of adverse outcomes and that fetal and neonatal impact of these chemicals was found. Screening for such effect in early childhood and registry of birth outcomes in the exposed population is advised.

Diesel exhaust

As discussed above, diesel exhaust exposures from both stationary and mobile sources are among the categories of exposures of concern. Diesel exhaust is a complex mixture of diesel exhaust particulate matter (see section on particulate matter), metals, thousands of organic compounds especially solvents, and other chemicals. As such, we have examined the medical literature to identify published research on the human health impact of diesel exhaust a) specifically in relation to oil and gas exploration activities and b) generally in relation to people with environmental exposure to diesel exhaust. Much of this literature comes from studies of occupationally exposed individuals as well as studies of those exposed environmentally because of their proximity to major roads and diesel exhaust sources.

Key search terms are summarized in the methods section above. A total of 197 studies were recovered. One-hundred and forty-four studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.) A total of 53 papers were reviewed. See the list of these citations in Appendix 2.

As elsewhere in this literature review, this section will focus on those published studies that directly examine the human health impact of oil and gas exploration – generated diesel exhaust. Much of this exposure is anticipated to be related to increased vehicular traffic. In addition, we provide an overview of the body of evidence regarding diesel exhaust-related health effects in the general population. The section will include a set of conclusions based on this literature review.

Among the 53 reviewed papers published between 2003 and 2008, we identified no research studies that directly examined the human health impact of diesel exhaust emissions associated

with oil and gas exploration activities. However, a number of studies are noteworthy because they reflect the health impact on communities when diesel vehicular traffic rises.

Notably, numerous epidemiologic and experimental studies have shown generally consistent relationships between diesel exhaust exposure and adverse human health outcomes. Health effects may vary some by the source of diesel exhaust as well as the chemical composition of the diesel fuel, metal content, and chemical composition. Diesel particulate matter has a center core of carbon and a variety of adsorbed organic compounds that include some known human carcinogens such as polycyclic aromatic hydrocarbons (PAH) and nitro-PAHs, as well as nitrate, sulfate, trace elements, and metals. Diesel particulate matter is composed of small particles including a high percentage of ultrafine particles (</= 1 micron diameter) which are of particular concern. These particles easily enter deep into the respiratory tract and have a large surface area where organic compounds can easily attach. Both stationary (e.g. industrial sources) as well as mobile sources (e.g. diesel fuel combustion emissions from vehicles and traffic density) contribute to risk. In some circumstances, increased risk may be due to a combined effect of diesel exhaust and the myriad of other pollutants that may also be in the air. Exposure to diesel exhaust can cause irritant symptoms, neurological, respiratory, and asthma-like symptoms, and can both increase the risk for developing allergic disorders and worsen allergenic responses to known environmental allergens. Lung cancer risk (independent of smoking status) is elevated among those with occupations where diesel engines have been used.

The majority of the studies reviewed are relevant in considering how increases in diesel exhaust from oil and gas exploration activities may affect health outcomes. The data are generally consistent. They show that many of the health risks that are associated with various forms of diesel exhaust disproportionately affect susceptible populations including those with lung disease, those with allergic disorders, and the elderly. As a major contributor to ambient particulate air pollution, the section in this document that refers to particulate matter is generally applicable to diesel exhaust as well.

Several references in the literature are particularly noteworthy. In 2002, the U.S. EPA released a health assessment document regarding diesel engine exhaust, based on data from the 1990s. This assessment concluded that long-term exposure to inhaled diesel exhaust is a lung cancer hazard in humans, based on epidemiologic and animal research. In addition, non-cancer chronic human health risks identified included lung inflammation, irritation, allergies, and asthma.

Although not specific to diesel exhaust emissions from oil and gas exploration and extraction, a paper by Gabrovska and Friedman (2004) is relevant to the concept of how increased diesel exhaust due to traffic around an industrial site affects health. In that study, community respiratory complaints were assessed during the closure of a community dump, in relation to dust exposure and measured or estimated diesel emissions. People living nearest to and downwind of the site were at increased risk of having respiratory symptoms. After the site closed, one-third of residents reported improvement of symptoms. The authors linked the rates of respiratory symptoms to changes in diesel emission and ambient dust levels.

In a study published in the New England Journal of Medicine in 2007, McCreanor and Cullinan demonstrated the respiratory effects of exposure to diesel traffic in people with asthma. They observed that increased diesel traffic is associated with worse lung function and worse lung inflammation in asthmatics.

In addition to these reports, the body of literature reviewed is sufficient to conclude that as exposures to airborne diesel exhaust rise, human risks increase for the following:

- **Cardiovascular disease:** See section on "Particulate matter."
- **Respiratory disease:** Including respiratory disease-related hospital admission, mortality due to respiratory disease, premature death from respiratory disease including lung cancer, worsening of illness in people with lung disorders (e.g. asthma, chronic obstructive pulmonary disease), asthma, bronchiolitis and respiratory infections, reduced lung function (especially in asthmatic children), allergic lung inflammation, allergies, symptoms (e.g. cough)
- **Allergic diseases**
- **Genotoxicity** Damage to chromosomes and DNA
- **Childhood illnesses:** Pediatric allergies and respiratory disorders, exacerbation of existing asthma

Conclusions

1. We identified no published studies in the past five years that directly examined the health impact of diesel exhaust in the population living and working in the vicinity of oil and gas exploration activities. This is a major gap and calls for additional research.
2. No data on the impact of diesel exhaust at environmental concentrations on special populations such as the elderly, pregnant women, healthy and asthmatic children and other special groups was found. This is a major gap and calls for additional research.
3. The absence of studies directly examining diesel's effects in populations surrounding oil and gas exploration facilities does not mean an absence of risk. The independent and generally consistent body of scientific evidence on diesel exhaust that we reviewed provides strong support for the relationship to human disease.
4. Based on the available evidence, it is highly likely that as diesel exhaust exposures rise due to exploration sites and associate diesel vehicular traffic, the health of the surrounding community will be adversely affected.

Criteria Pollutants

Nitrogen oxides (NOx), sulfuric oxides (SOx), ozone, and particulate matter

Sources

Nitrogen oxides (NOx) are released into the air from oil and gas production during flaring, and in exhaust from diesel and gas compressor engines. NOx are also released in automobile exhaust and play a major role in the formation of photochemical smog.

Sulfuric oxides (SOx) are formed during the combustion of coal and oil. SOx may be released during flaring of natural gas, or when fossil fuels are burned to provide power to the pump jack or compressor engines at oil and gas sites.

Ozone is among the exposures of possible concern. A potent respiratory irritant, ozone results from sunlight-driven reactions involving the oxides of nitrogen and volatile organic compounds that are generated by stationary and mobile sources. It is the principal component of photochemical smog.

Particulate matter exposures from both stationary and mobile sources are among the categories of exposures of possible concern.

Review

Terms utilized in the search are summarized above in the methods section. A total of 243 studies were recovered for NOx. One-hundred and ninety-two papers were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). A total of 51 studies were selected for review of NOx exposure. A total of 118 studies were recovered from SOx. Eight-five studies were eliminated from further review following our criteria for inclusion in this literature review. A total of 33 studies were selected for review dealing with SOx. A total of 217 ozone studies were recovered. One-hundred and twenty-five were eliminated from further review following our criteria for inclusion in this literature review. A total of 94 studies for ozone were reviewed. A total of 510 studies were recovered from particulate matter. One-hundred and eighty-three were eliminated from further review following our criteria for inclusion in this literature review. In total, we reviewed a total of 327 studies for particulate matter. These citations are collected in Appendix 3.

As discussed above, these pollutants are among the exposures of possible concern. As such, we have examined the medical literature to identify published research on the human health impact of these air pollutants a) specifically in relation to oil and gas exploration activities and b) generally in relation to people with environmental exposure to ambient particulate matter.

Among the reviewed papers published on NOx, SOx, ozone and particulate matter between 2003 and 2007, we identified no research studies that examined directly the human health impact of these pollutants produced during oil and gas exploration activities. However, in contrast to other parts of this review there is extensive data about general exposure to these substances in the environment outside the workplace, and its impacts on non-occupational populations.

Health Effects

NOx, SOx, and ozone:

Notably, numerous epidemiologic and experimental studies have shown generally consistent relationships between all of these pollutants and adverse human health outcomes. Both stationary (e.g. industrial sources) as well as mobile sources (e.g. fossil fuel combustion emissions from vehicles and traffic density) of ground-level pollutants contribute to risk. Risk may, in some circumstances, be due to a combined effect of these pollutants. In some instances, it has been difficult to separate the independent contribution of each of these pollutants to health risk.

There is clear evidence that nitrogen oxides, sulfur dioxide, and ozone exposures are significant contributors to respiratory disease. There is reasonably strong evidence for its contribution to cardiovascular illness as well. The majority of the studies reviewed are relevant in considering how increases in these pollutants along with other air pollutants from oil and gas exploration activities may affect health outcomes. Special consideration is needed for the young (especially those with asthma) and the elderly (especially those with chronic obstructive pulmonary disease and/or cardiac disease). The data are generally consistent in showing that many of the health risks that are associated with these pollutants disproportionately affect these susceptible populations. In particular, ozone has been clearly associated with increased mortality. (Gryparis 2004, Bell 2005, Bell 2008). The body of literature reviewed is sufficient to conclude that with even small increases in exposure to these pollutants, human risks increase for the following:

- **Respiratory disease**: Including respiratory disease-related hospital admission, mortality due to respiratory disease, worsening of illness in people with lung disorders (e.g. asthma, chronic obstructive pulmonary disease), asthma, bronchiolitis and respiratory infections, reduced lung function (especially in asthmatic children), allergic nasal and airways inflammation, allergies, symptoms (e.g. cough, wheeze, shortness of breath, eye irritation, headache). (Galan 2004, Simpson 2005, Ostro 2006, Quian 2007, Chen 2007, Lee 2007, Yang 2003, Yang 2007, Pacini 2003, Hoffman 2004, Sienra-Monge 2004, Vagaggini 2007, Sole 2007, Kim 2004, Chan 2005, Tager 2005, Qian 2005, Kim 2007, McDonnell 2007, Rojas-Martinez 2007, Alexeeff 2007, Henrotin 2007, Penard-Morand 2005)
- **Childhood Asthma**: Some of the most compelling evidence, reinforced by publications in the past five years, relates to ozone's impact on children with asthma. While there is evidence for some 'adaptation' to the effects of ozone as people age, and heterogeneity in peoples' responses to ozone (that may be related to genetics), the overall impact of ozone related to childhood asthma is noteworthy. It includes increases in pediatric emergency room visits and pediatric hospital admissions, asthma exacerbations of symptoms and use of rescue inhalers, impaired lung development, and airways inflammation in addition to asthma, including bronchiolitis. (Lin 2003, Gent 2003, Sanhueza 2003, Lewis 2005, Hwang 2005, Calderon-Garciduenas 2006)
- **Cardiovascular disease**: Including cardiovascular hospital admission, mortality due to cardiovascular disease, arrhythmias (heart rhythm disturbances, heart rate variability), blood pressure elevation. (Holguin 2003, Ruidavets 2005, Urch 2005, von Klot 2005, Rich 2006, Zhang 2006, Ballester 2006, Sarnat 2006, Larrieu 2007, Peel 2007, Park 2008)
- **Genotoxicity**: Damage to chromosomes and DNA. (Pacini 2003, Tovalin 2006)
- **Fetal and neonatal health**: Preterm birth, low birth weight, hospitalization of newborns, and respiratory illness in infants born to asthmatic mothers who were exposed to ozone during pregnancy. (Dales 2006, Hansen 2006, Triche 2006, Salam 2005)

Particulate matter:

Health effects may vary somewhat by the size of particles. Recent data demonstrates that while particles with diameters </= 10 microns (PM10) pose health risks, particles with diameters </= 2.5 microns (PM2.5) and particles with diameters </= 1 micron (ultrafine particles) contribute disproportionately to human health risks. Due to their small size and large surface area, these smaller particles are carried deeper into the lungs when inhaled, and are capable of carrying toxic pollutants to the lung and elsewhere in the body as they enter the bloodstream. Both stationary (e.g. industrial sources) as well as mobile sources (e.g. fossil fuel combustion emissions from vehicles and traffic density) of particulate matter contribute to risk. Traffic density has, in particular, been confirmed now in multiple studies to confer additional risk, especially for respiratory health consequences. Additional research is needed to better determine the components of particulate matter that induce inflammation and disease. The majority of the studies reviewed are relevant in considering how increases in particulate matter from oil and gas exploration activities may affect health outcomes. The data are generally consistent in showing that many of the health risks that are associated with various forms of particulate matter air pollution disproportionately affect susceptible populations including children, the elderly. The body of literature reviewed is sufficient to conclude that with even small increases in airborne particulate matter exposure, human risks increase for the following:

- **Cardiovascular disease**: Including cardiovascular hospital admission, mortality due to cardiovascular disease, premature death from heart disease, cardiac ischemia (reduce blood flow to the heart), arrhythmias (heart rhythm disturbances, heart rate variability), hypercoagulability, atherosclerosis, myocardial infarction (heart attack), blood pressure.
- **Respiratory disease**: Including respiratory disease-related hospital admission, mortality due to respiratory disease, premature death from respiratory disease including lung cancer, worsening of illness in people with lung disorders (e.g. asthma, chronic obstructive pulmonary disease), asthma, bronchiolitis and respiratory infections, reduced lung function (especially in asthmatic children), allergic lung inflammation, allergies, symptoms (e.g. cough).
- **Fetal and neonatal health**: Preterm birth, restricted fetal growth, lower infant term birth weight, and increased neonatal death especially when it is associated with respiratory illness.
- **Childhood illnesses**: Pediatric allergies, ear/nose/throat and respiratory infections early in life, pediatric emergency room visits and pediatric hospital admissions, impaired lung development in children that affects lung function in adulthood, asthma, bronchiolitis, exacerbation of existing asthma and exacerbation of cystic fibrosis.
- **Geriatric illnesses**: Including exacerbation of chronic obstructive pulmonary disease, congestive heart failure, heart conduction disorders, myocardial infarction and coronary artery disease, and diabetes in the elderly.

Summary

Based upon the material reviewed in this section, some conclusions are appropriate:

1. We identified no published studies in the past five years that directly examined the health impact of nitrogen dioxides, sulfur dioxide, particulate matter, or ozone, in the population living and working in the vicinity of oil and gas exploration activities. This is a major gap in the literature and calls for additional research.
2. The absence of studies directly examining the above air pollutants and effects in populations surrounding oil and gas exploration facilities does not mean an absence of risk. The independent and generally consistent body of scientific evidence on these air pollutants that we reviewed provides strong support for the relationship between sulfur dioxide, nitrous oxides, particulate matter, and ozone, and human disease.
3. Based on the available evidence, it is highly likely that as exposures rise, either alone or along with other air pollutants due to exploration sites and associate vehicular traffic, the respiratory health of the surrounding community will be adversely affected.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are a large group (>100) of organic chemicals, which usually exist as a mixture containing two or more compounds. Airborne PAHs are a result of combustion of fossil fuels, tobacco, and other organic materials Both point source releases and transportation activities to and from the drilling sites contribute PAH loads to the resident and transient populations in the drilling regions. PAHs of concern include: enz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene.

Terms utilized in the search are summarized above. A total of 276 studies recovered. Two-hundred and forty-five studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). A total of 31 published studies were selected for review dealing with PAHs. These citations are collected in Appendix 4.

Among the 31 reviewed papers published between 2003 and 2008, we identified no research studies that examined directly the human health impact of PAHs produced during oil and gas exploration activities; this does not mean however that PAH exposure is not a human health risk.

Environmental exposures

Environmental exposure studies have revealed associations of chronic exposures to PAHs at different levels and alterations of immune responses by causing suppression of T-lymphocyte proliferation and augmentation of NK cell activity. Environmental exposure studies have also revealed that c-PAHs can alter the ability of blood lymphocytes to repair DNA damage and, as a result could potentially lead to effects that are hazardous to human health. (Karakaya, 2004, Cebulska-Wasilewska, 2007). One study measured prenatal exposure to airborne PAHs (low concentration) and birth weight, birth length, and birth head circumference, in two different populations, Krakow, Poland and New York City. The study suggested adverse reproductive effects of relatively low PAH concentrations in both populations. (Choi, 2006)

Occupational Exposures

No data on exposure to PAHs and occupational groups or adjacent populations in the process of exploration or production of oil and gas were recovered. The majority of PAH occupational exposure and effects on human health involve coke oven workers, exposed to PAHs at high concentration and DNA damage in the lymphocytes. Studies suggesting an increased risk of cancer (lung, bladder, skin, and gastrointestinal) in working populations exposed to PAHs are limited due to multiple exposures to carcinogens at work sites. (Wang, 2007, Siwinska, 2007, Chen, 2007, Pavanello, 2007)

Summary

There is very little data available on disease outcomes in non-occupationally exposed human populations. There is a significant gap of research in this area. As findings from this literature review demonstrate, the research in the past five years has been limited. There is some evidence of immune and lymphocyte damage in workers exposed to PAH at high concentrations and very limited evidence of reproductive effects of prenatal exposure to low concentrations of airborne PAHs. Findings from this literature review make it clear that future research is necessary to clarify our understanding of environmental and occupational exposure to PAHs.

Metals

Human activity may release environmental metals, or cause exposure to new metal containing compounds and are thus of concern. Metal exposure can occur through the air, water or soil and can enter the body through the skin, lungs or GI tract. Metals may be essential to life such as Copper(Cu), Iron(I) or Zinc(Zn) or toxic, such as Lead(Pb), Cadmium(Cd) or Arsenic(As). Toxic metals may influence human health by interactions with essential elements. The elderly and children are at a higher risk from metal exposure than the average adult due to developmental and immune factors. We examined the medical literature to identify published research on the human health impact of metals exposure a) specifically in relation to oil and gas exploration activities and b) generally in relation to populations with environmental exposure to toxic metal compounds.

Terms utilized in the search are summarized above. A total of 299 studies were found, including 35 studies related to Arsenic (As), 4 related to Barium(Ba), 23 related to Cadmium (Cd), 67 related to Chromium (Cr), 75 related to lead (Pb), 39 related to Mercury (Hg), 19 related to Selenium (Se) and 37 related to Zinc (Zn). Seventy-five studies were eliminated due to their reporting multiple exposures and thus being identified more than once. One hundred and forty-nine studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). Overall, a total of 75 papers were reviewed. The list of these citations appear in Appendix 5**.**

This section will initially examine those published studies that directly assess the human health impact of oil and gas exploration and the health risks associated with contact, inhaled or water based exposure to eight metals (As, Ba, Cd, Cr, Pb, Hg, Se and Zn) and those eight metals

in combination with one another. It will also offer an overview of the body of evidence regarding health effects related to metal exposure in the general population. The section will include a set of conclusions based on this literature review.

Among the 75 reviewed papers published between 2003 and 2008, we identified no research studies that directly examined the human health impact of metals exposure related to oil and gas exploration activities.

Notably, numerous epidemiologic and experimental studies have shown generally consistent relationships between metals exposure, either individually or in groups and adverse human health outcomes with individual metals showing distinct human health effects for instance exposure to lead and cognitive function. Much of the work in metals exposure involves industrial exposure to workers but there is a large body of literature involving population exposure to remnant industrial waste, for instance mine tailings and drinking water contamination. Many industrial sources do not create unique exposures to individual metals, rather several metals in combination may be an integral part of the industrial process, for instance tin smelting and exposure to As, Cd, Pb, antimony and polonium-210. The human health risks due to exposure to combined metals exposure versus each individual metal are difficult to assess though exposure to the combination is not likely to be protective. In some cases there is evidence that exposure causes damage to DNA but that that damage is subject to repair. The combination of exposure to more than one metal that causes DNA damage or increases oxidative stress (and thus reduces the body's ability to repair itself) can overwhelm inherent repair mechanisms. In other cases increased levels of a metal, such as Se, are found to be protective when examined in the context of a toxic exposure. For instance, Se may mediate ototoxicity caused by Pb exposure. (Chuang, 2007)

The majority of the studies reviewed are relevant in considering how potential metal exposure associated with oil and gas exploration activities may affect health outcomes. There are some examples of disagreement between investigators when specific exposures overwhelm the body's ability to repair itself, as when exposued to Cr and DNA damage (Paustenbach, 2003), Pb and cancer risk or stunting (Cocco, 2007), (Mahram, 2007), Hg and neurobehavioral changes or increased oxidative stress (Bast-Pettersen, 2005, Belanger, 2006) or Se and sperm motility. (Wirth, 2007) But, the consistent theme of metals exposure is there are known effects at the cellular or DNA level and some of these effects are consistent with neurologic, metabolic, immunologic and reproductive effects in individuals with specific exposures. The disagreement tends to occur when translating these known cellular and individual effects into population effects where the exposures are far more difficult to measure and correlate with health outcomes. This body of literature is sufficient to conclude that environmental exposures to metals are associated with the following;

- **Autoimmune disease:** Including Wegener's granulomatosis.
    - **Cr** (Albert, 2005)
- **Cancer:** Including all cancers; lung, stomach, oral and pharyngeal cancers.
    - **Pb, As, Cd, Zn**; (Dynerowicz 2005), (Lee, 2005 Apr), **Cd;** (Wang, 2004), (Satarug, 2003) **As** (Jones, 2007), (Lee,2006), (Vitayavirasak,2005), **As, Cd** (Obiri, 2006), **Cr** (Beaumont, 2008), **Se** (Gromadzinska, 2003), **Hg** (Zadnik, 2007)

- **Cardiovascular disease:** Including increased risk of atherosclerosis, hypertension and lipid abnormalities.
    - **Pb**; (Li, 2006), (Skoczynska, 2007), (Ademuyiwa, 2005), **Cd** (Satarug, 2003), **Hg** (Cortes-Maramaba, 2006)
- **Cognitive function:** Including neurobehavioral and cognitive effects, decreased IQ, cerebral white matter changes.
    - **Pb;** (Carta 2003), (Pusapukdepob, 2007), (Schwartz, 2005), (Bleecker, 2007) **As;** (Rosado, 2007), **Hg** (Carta, 2003)
- **Dermatologic toxicity**: Including occupational contact dermatitis
    - **Cr** (Athavale, 2007)
- **Genotoxicity** Damage to chromosomes and DNA
    - **As, Pb:** (Yanez, 2003), **As** (Jasso-Pineda, 2007), (Paiva, 2006), (Palus 2005), **Cr** (Kuo, 2003)
- **Hematology:** Including humeral and cell mediated immunity, altered levels of immunoglobulins and neutrophilic inflammation.
    - **Pb;** (Di Lorenzo 2007), (Heo, 2004), (Mishra, 2003), **Se** (Huang, 2003)
- **Metabolism:** Including reduced antioxidant capacity, increased oxidative stress, altered bone resorption, pancreatic dysfunction and bone fracture
    - **Pb,As**; (Chlebda 2004), **Pb** (Kasperczyk (2004), (Li 2004), (Li, 2006), (Potula, 2005), **Cd** (Lei, 2007), (Satarug, 2003), ↓Zn (Li, 2004)
- **Neurotoxicity:** Including altered heart rate variability, nerodegenerative disorders (multiple, sclerosis, transmissible spongiform encephalopathies and amyotrophic lateral sclerosis), neuromotor impairment, ototoxicity and visual impairment.
    - **Pb** (Gajek, 2004), (Blond, 2007), (Chuang, 2007), (Schwartz, 2005) **Ba** (Purdey, 2004), **Hg** (Despres, 2005), (Rodrigues, 2007), (Saint-Amour, 2006)
- **Renal dysfunction:**
    - **As, Pb** (Weaver, 2003), **Cd** (Lei, 2007), (Nogue, 2004), (Satarug, 2007), **Cr** (Saraswathy, 2007), **Hg** (Hodgson, 2007)
- **Reproduction, fetal health and development:** Including, growth stunting, reproductive impairment, stillbirth, low birth-weight, childhood under-weight and abnormal sperm morphology.
    - **Pb** (Ignasiak 2007), (Naha, 2006), (Shiau, 2004), (Tang, 2003), **Cd;** (Wang, 2004) **As** (Kwok, 2006), (Kumar, 2005)
- **Respiratory disease:** Including mucosal irritation, interstitial pneumonia, asthma.
    - **Pb, Cd** (Coelho 2007), **Cr** (Hisatomi, 2006), (Onizuka, 2006)

Conclusions

1. We identified no published studies in the past five years that directly examined the health impact of exposure to toxic metals in the population living and working in the vicinity of oil and gas exploration activities. This is a major gap and calls for additional research.
2. The absence of studies directly examining oil and gas exploration related exposure to metals in exposed does not mean an absence of risk. The peer reviewed body of scientific literature related to exposure to specific metals and metals in groups in this review indicates strong associations between metals exposure and specific human diseases.

3. There is disagreement in the literature as to specific human outcomes due to specific exposures though much of that disagreement is likely related to difficulties in measuring individual exposure over long time periods. The preponderance of evidence gleaned from well-controlled studies using clear end-points and measuring exposure precisely indicates an increased risk for individuals exposed. This risk is hard to detect on a population basis for the above mentioned reasons.
4. Based on the available evidence, it is likely that continued exposure to bioavailable metals will increase risk of associated adverse outcomes. Whether through inhaled or water based exposure, each of these metals can cause increased risk of many human diseases.
5. Specific populations are at increased risk for specific toxicities. These populations include children, the elderly and anyone already at increased risk due to other health problems.

Hydrogen Sulfide

Hydrogen sulfide (H2S) gas release to the air occurs in oil and gas drilling and extraction and flaring as well as in many other settings such as industrial, sewage and water maintenance, and agriculture. H2S also enters the air as off-gas naturally in geothermal areas and when organic matter decays such as in swamps. The health effects of hydrogen sulfide gas exposure in relation to oil and gas drilling has been studied infrequently, despite the fact oil and gas drilling near inhabited areas is common through out the world and hydrogen sulfide gas is frequently produced and released in exploration activities.

Terms utilized in the search are summarized above. A total of 85 studies were recovered. Sixty-five studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). A total of 20 studies were selected for review of hydrogen sulfide exposure, acute and chronic. These citations are collected in Appendix 6.

High Level Exposure

Hydrogen sulfide is known to be fatal at high exposure levels and can cause long term sequelae in those that survive acute high level exposure. Most fatal exposures to H2S are occupational and occur in a confined space area or when the worker is near the opening of a confined space. There are several case reports describing fatal accidents for workers exposed to H2S. Furthermore, fatalities in persons attempting to rescue downed workers have also been reported. Persons exposed to high levels of H2S that did lose consciousness and persons exposed that did not lose consciousness both demonstrated neurobehavioral impairments when compared to controls. (Kilburn 2003; Hendrickson, Chang et al. 2004; Kage, Ikeda et al. 2004; Nam, Kim et al. 2004; Nikkanen and Burns 2004; Smith and Cummins 2004; Couch, Martin et al. 2005; Knight and Presnell 2005; Christia-Lotter, Bartoli et al. 2007; Gangopadhyay and Das 2007; Gerasimon, Bennett et al. 2007; Policastro and Otten 2007; Fiedler, Kipen et al. 2008; Yalamanchili and Smith 2008)

Low Level Exposure

There are very few current studies exploring chronic, low level H2S exposure in individuals, although there are a few studies from earlier literature not addressed in this review. Current and earlier literature suggests neuropsychological effects in individuals with chronic low level H2S exposure.

- Depression and hematological changes were reported in people living close to areas polluted by oil and gas drilling in Khozestan province,Iran. (Saadat and Bahaoddini 2004; Saadat, Zendeh-Boodi et al. 2006)
- Oil and gas extraction workers in Canada demonstrated a higher risk of transportation accidents if exposed to H2S gas. (Lewis, Schnatter et al. 2003)
- Persons in Dakota City, Nebraska were exposed to chronic, low levels of H2S from waste water lagoons, a beef slaughter/leather tanning factory and other point sources. Individuals reported a variety of symptoms, including loss of memory and loss of grip strength. (Inserra, Phifer et al. 2004)

Communities exposed to chronic low levels of H2S may experience high hospital admittance for pulmonary disorders in both adults and children.

- Hospitals in Northeast Nebraska reported higher levels of admissions for pulmonary disease, COPD, asthma, pneumonia in both adults and children in days following high levels of Total Reduced Sulfur (TRS) and H2S air pollution. (Campagna, Kathman et al. 2004)
- The city of Rotorua, New Zealand, lies over a geothermal area. Parts of the city lie directly over vents that off gas H2S and parts of the City are downwind. Citizens living in these areas have a higher risk of being admitted to the hospital for pulmonary illness than those citizens not living in the high exposure areas of Rotorua. (Durand and Wilson 2006)

Summary

Studies of exposure to H2S in relation to oil and gas drilling have not been done. The dangers of acute, high level H2S exposure are well documented., Although there is a small body of literature suggesting adverse health effects due to chronic, low level exposure, significant gaps in this literature remain. Given the potential for increased exposure to H2S from oil and gas drilling in proximity to human populations across the world, studies examining the health effects of H2S due to drilling and extraction activities should be planned in the future.

Fossil Fuels

Oil and gas extraction is known to produce multiple toxic contaminants, which may be released to the air, soil or water. Workers involved in oil and gas drilling, extraction, as well as those involved in transportation and refining may be exposed to these chemicals at high levels. Persons living in close proximity to oil and gas extraction sites may also be exposed to toxic levels of chemicals and experience adverse health effects. Available literature regarding the

health effects to persons living and working in close proximity to oil and gas extraction sites demonstrates exposure to the oil and gas extraction process is detrimental to people's health.

Terms utilized in the search are summarized above. A total of 305 studies were recovered. Two-hundred and seventy-nine studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.) A total of 26 studies were selected for review, including 3 studies prior to 2003. These citations are collected in Appendix 7.

Oil and Gas Extraction Exposures

- Residence near oil and gas extraction fields is associated with an increased risk of adult myeloid leukemia and all leukemias when compared to residence in a nearby county in Croatia. (Gazdek, Strnad et al. 2007)
- Residence near the Masjid-i-Sulaiman oilfields in southwest of Iran, where subsurface natural gas and hydrogen sulfide emissions are high is associated with abnormal blood cell indices, including increased red blood sells, and decreased white blood cells. (Saadat and Bahaoddini 2004)
- Residence near a Canadian oil sands community was associated with higher autoantibody titers when compared to residents in a distant community. (Schoenroth and Fritzler 2004)

Studies Prior to 2003

While our search was limited to publications of the last 5 years, some important studies done prior to this time and some studies not revealed by our search criteria deserve mention as they directly address the potential health effects of oil and gas extraction on local populations.

A series of studies reveal multiple elevated heath risks associated with residence proximity to oil and gas extraction in the Amazon rainforest of Ecuador. Children living at close proximity to oilfields are at higher risk of childhood leukemia. Adults are at an increased risk of many types of cancers including stomach, rectum skin, soft tissue, kidney, cervix and lymph nodes. Residence at close proximity to these oil fields is associated with pregnancy ending in spontaneous abortion.

(San Sebastian, Armstrong et al. 2001; Hurtig and San Sebastian 2002; San Sebastian, Armstrong et al. 2002; Hurtig and San Sebastian 2004; San Sebastian and Hurtig 2004)

Other Fossil Fuel Exposures

Literature regarding the health effects of exposures associated with oil and gas extraction is limited. Petro-chemical complexes and refineries, work at coke ovens, and exposure to coal burning can share many of the same toxic exposures with oil and gas extraction sites. These exposures may include, but may not be limited to, benzene and other solvents, polyaromatic hydrocarbons (PAH), particulate matter, noise, air born sulfur oxides, arsenic, and hydrogen sulfide.

Community Exposures

- Pregnant women in the Labin district, Croatia residing near a power plant burning high sulfur coal are at increased risk of poor birth outcomes. High sulfur dioxide emissions during the first two months of pregnancy are associated with preterm delivery and birth of babies with low birth weight. (Mohorovic 2004)
- Prenatal exposure to toxic chemicals is associated with increased risk of fatal childhood cancers and leukemia. Children born to mothers living within 1 km of areas with high levels of carbon monoxide, PM10 particles, VOCs, nitrogen oxides, benzene, dioxins, 1,3-butadiene, and benz(a)pyrene. (Knox 2005)
- Residence in areas with high levels of outdoor air pollution from coal burning sources is associated wit decreased height in children. This study controlled for socioeconomic factors, birth weight and respiratory illness. (Bobak, Richards et al. 2004)
- Incidence rates of wheezing in children living within 3 km of an iron, steel and coke factory in Calarasi, Romania, significantly decreased after the factory closed, from 41% to 24%. The list of known pollutants from the factory is long but contained several pollutants that are known to cause respiratory illness including SOX, NO2, ozone, and particulates. (Cara, Buntinx et al. 2007)
- Residence in areas near a coke oven factory in Cornigliano district, Italy was associated with lung cancer in females and in both males and females in a part of the district where a foundry was operational. (Parodi, Stagnaro et al. 2005)

Occupational Exposures

- Workers at an oil refining plant in Australia have an increased risk of developing nonlymphocytic leukemia and chronic lymphocytic leukemia, due to benzene exposures. These increased risks are in association with their exposure to benzene at levels lower than previously identified as being hazardous. (Glass, Gray et al. 2003; Glass, Gray et al. 2005)
- Workers at petrochemical complexes have been shown to have high exposure to solvents and excess noise. There is an increased prevalence of hearing loss and standard threshold shift in these settings. (De Barba, Jurkiewicz et al. 2005)
- Acute hydrogen sulfide poisoning has been reported in a field operator at a petroleum refinery. (Nam, Kim et al. 2004)
- Workers at a petro-chemical complex have significant risk of respiratory symptoms (cough, phlegm, wheezing and shortness of breath) when exposed to dusts, vapors, metals and organic solvents. (Park, Lee et al. 2006)

Our literature search revealed some studies that do not find association of oil and gas extraction exposures and health effects. (Lewis, Schnatter et al. 2003; Neuberger, Ward-Smith et al. 2003; Buffler, Kelsh et al. 2004; Neuberger, Lynch et al. 2004; Dubnov, Barchana et al. 2007; Sorahan 2007) These negative studies suggest that potentially hazardous exposures related to oil and gas extraction have no health consequence. On the other hand, these negative results may be due to problematic issues such as lack of statistical power, misclassification of exposure, or other study design issues such as limited disease endpoints. Negative studies should not be taken

independently as proof of no ill effects to exposed populations but rather should be placed into context with all available literature regarding the particular chemical, exposure or the process and the health effects. Chemicals known to be toxic in other scenarios are likely to be toxic at similar exposure levels in different scenarios. When discrepancies exist in the literature, further study is warranted. Furthermore, the most conservative course of action with regard to pollution control measures should be undertaken to protect people's health.

Summary

Oil and gas extraction is increasing world wide. Oil and gas extraction is known to produce toxic contaminants. Oil and gas extraction sites are often near peoples' homes and children's schools, putting individuals and communities at risk of adverse health effects due to exposure to toxic contaminants. Studies documenting health effects of oil and gas extraction on individuals and communities are few and more studies should be done in the future.

Fracking Fluids

"Fracturing" "fracking" or frac'ing is a process used by the oil and gas industry to improve well production. Fracking involves the use of high-pressure injection of liquids and/ or solids into the ground, when a well is drilled and often again one or more times after a well is in production. Fracking fluids may be water or may be any combination of hazardous chemicals such as acids, diesel fuel, biocides, metals ethylene glycol, or other chemicals, but oil and gas companies are not required to reveal the chemical composition of fracking fluids. Fracturing of the subterranean land formations can introduce these unknown but possibly hazardous chemicals into underground drinking water sources, potentially exposing people to toxics and causing adverse health effects. Fracking fluids may also be left at the surface with drilling mud and toxics may dry out and be dispersed in the air or enter surface water via run off. Little is known about the potential and actual exposures local populations may have.

Since fracking chemicals are unknown, review of specific chemical literature could not be conducted. Terms utilized in the search are summarized above. A total of 243 studies were recovered. All studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.)

Our literature search (expanded to include all literature regardless of publication date) did not find any studies addressing the health effects of fracturing or fracturing fluids on people, revealing a substantial gap in the medical and public health literature. This gap is especially troubling given the amount of oil and gas extraction occurring world wide in close proximity to human populations. This gap should be addressed. Studies examining the effect of fracturing subterranean land formations on nearby human populations should be conducted. Public disclosure of fracking fluid chemicals would permit studies examining human health effects of these chemicals to be undertaken.

Noise Pollution

We have examined the medical literature to identify published research on the human health impact of noise pollution on the communities surrounding oil and gas development. Specifically in relation to oil and gas exploration activities: drilling, well pumps, compressors, and vehicle traffic.

Terms utilized in the search are summarized above in the methods section of this document. A total of 881 studies were recovered. Eight-hundred and fifty-seven studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). A total of 24 studies were selected for review of noise pollution. These citations are collected in Appendix 8.

Our literature search, expanded to include all literature regardless of publication date, did not find any studies addressing the health effects of noise on communities surrounding oil and gas operations.

Low Frequency Noise

Low frequency noise, produced from oil and gas compressors, may be of concern in the surrounding communities. A small number of studies reported the following symptoms related to low frequency noise: annoyance, stress, irritation, unease, fatigue, headache, adverse visual functions and disturbed sleep. (Berglund, 1999, Pawlaczy-Luszcyniska, 2005)

Traffic related noise

Noise produced from oil and gas activity, also of concern to surrounding communities, has not been studied. Although many papers have been published in the last 5 years suggesting an association of cardiac health effects and noise related to traffic, these studies are restricted to urban settings. The majority of these studies reported annoyance and disturbance due to road traffic noise and associations with a higher incidence of myocardial infarctions, hypertension, ischemic heart disease, and sleep problems. (Babisch, 2003, 2005, Bluhm, 2004, 2007)

Occupational Related Health Effects

Research available on noise and health effects on oil and gas workers is limited. In the last 5 years, only one study has been published in the medical literature describing the health effects of noise among oil and gas workers. The study suggested an increased hearing threshold shift for high frequencies in workers who had chronic noise exposure from more than 15 years. (Chen, 2003) A small number of studies reported findings for workers exposed to noise and chemicals, such as toluene and other solvents (these studies were not specific to the oil and gas industry). Hearing loss was reported in 45.3% of workers from a petrochemical company, where workers had low exposure to solvents, and moderate exposure to noise. (De Barba, 2005) Another study found increased low frequency hearing loss in workers exposed to both noise and the chemical toluene. (Chang, 2006)

Summary

We identified no published studies in the past five years that directly examined the health impact of noise in the population living and working in the vicinity of oil and gas exploration activities. Noise produced from oil and gas operations and the health effects on the surrounding community as well as for workers calls for additional research.

Light Pollution

Light pollution is excess exposure to artificial light and occurs in occupational as well as community settings. Recent studies in the medical literature suggest that light pollution is an emerging public health issue indirectly linked to cancer incidence.

Terms utilized in the search are summarized above. A total of 297 studies were recovered. Two hundred and ninety-one studies were eliminated from further review following our criteria for inclusion in this literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.). A total of 6 studies were selected for review of light pollution. These citations are collected in appendix 9.

In the last 5 years, no studies have been published in the medial literature describing the health effects of light pollution or light exposure at night among oil and gas workers or the communities surrounding oil and gas extraction activities. However, several studies suggest an increased risk of cancer among shift workers and exposure to light at night:

- The disruption of circadian rhythms caused by exposure to light at night is associated with an increased risk of breast and colon cancer in shift workers
- Light pollution interferes with the pineal gland and production of melatonin as well as hormone production
- Reduced levels of melatonin caused by light pollution are linked to tumor growth
- Exposure to magnetic fields while sleeping leads to decreased levels of melatonin and increased levels of reproductive hormones in women

(Anisimov, 2006, Davis, 2006, Pauley, 2004, Schernhammer, 2004, Schernhammer, 2004, Schernhammer, 2004)

Summary

Further investigation is needed to determine the health impacts of light pollution generated by oil and gas activities in workers and the surrounding communities.

Worker Health

Terms utilized in the search are summarized above. A total of 40 studies were recovered. Thirty-one studies were eliminated from further review following our criteria for inclusion in this

literature review (i.e. published within the past 5 years, English language, human; excluding basic mechanistic studies and excluding review articles unless they are meta-analyses.) A total of 9 studies were selected for review of occupational injuries. It is important to note that this final group of studies includes two articles published prior to 2003. These citations are collected in Appendix 10.

Occupational Fatalities

There are multiple safety and health risks associated with oil and gas extraction activities. In the U.S., fatal and nonfatal occupational injuries and illnesses among oil and gas workers are well documented through the Bureau of Labor Statistics (BLS) Census for Fatal Occupational Injuries (CFOI) and the BLS Survey of Occupational Injuries and Illnesses (SOII). However, only one study in the last 5 years has been published in the medical literature describing occupational fatalities among oil and gas workers in the U.S.: (CDC 2008)

- Oil and gas workers in the U.S. experience a disproportional rate of occupational fatalities compared to other high-risk industries and occupations.
- In the U.S., an increase in oil and gas extraction activities is significantly correlated with an increase in the rate of fatal occupational injuries among oil and gas extraction workers.
- The annual rate of fatal occupational injuries in the U.S. in the oil and gas industry from 2003 to 2006 was 30.5 per 100,000 workers.
- Fatal occupational injuries were attributable to transportation incidents and being stuck by equipment and heavy tools.

International Studies

Studies of international oil and gas workers in the last 5 years describe fatal and nonfatal injuries:

- In the Niger Delta, occupational fatalities in the oil and gas industry were attributable to falls, explosions and fires, transportation incidents, and falling objects. (Seleve-Fubara 2006)
- Venezuelan oil and gas workers were found to have chromosomal alterations due to continuous exposure to low levels of ionizing radiation. (Diaz-Valecillos 2004)

Studies Prior to 2003

We expanded our literature review to include studies conducted prior to 2003 providing evidence of fatal and nonfatal occupational injuries in oil and gas workers:

- About a third of minor injuries among oil and gas extraction workers in Venezuela were attributable to ‘not paying attention when walking on or around labor areas’. Common injuries included being struck by equipment and tools, and contusions and crushing of upper and lower arms and legs. (Fernandez 2001)
- In Canada, workers involved in oil and gas drilling and extraction activities are at high risk for occupational injuries. (Guidotti 1995)

- Work-related injuries among international oil workers were higher and more severe than all industries in the US. The most common non-fatal injuries were getting arms 'caught in', 'back strained', 'legs struck', and 'legs injured while slipping' (McNabb 1994)
- Types of work-related injuries among international workers in the oil industry include burns, sprains, and hand injuries. (Sarma 2001)
- Workers in the oil and gas industry in the U.S. experienced a high rate of death related to asphyxiation and poisoning. (Suruda 1989)

Conclusion

Further research is needed to determine the health effects of oil and gas operations on workers.

Social and Psychological Health Effects

While some research has explored the physical health effects related to oil and gas exploration activities, less research has focused on the social and psychological impact of oil and gas development on individuals working or living in industrial communities. As such, we have examined the available literature to identify published research about a) the social and psychological impact of oil and gas development in neighboring communities. b) the socal and psychological impact of industrial development in neighboring communities.

Terms utilized in the search are summarized above. An initial literature search recovered a total of 1,114 studies that were published within the last 5 years (between 2003 and 2008). Based on our established list of inclusion criteria, 1,093 studies were eliminated from further evaluation. Thus, only 21 studies were retained for this literature review. It is important to note that this final group of studies includes two articles published prior to 2003 and two relevant review articles. The full list of these references can be found in Appendix 11.

The body of literature reviewed provides some evidence that exposure to oil and gas activities can have serious negative social and psychological health implications. Conversely, there is some evidence that such industrial activities may be associated with positive social and psychological health outcomes.

Violence and Crime Rates

Communities near industrial development, including oil and gas development, often undergo swift changes in the existing social and cultural norms. These changes may be, at times, associated with high occurrences of violence and crime while at other times, industrial development has been credited with a perceived decrease in local crime. Additionally, when a new industry is brought into a community, there may be a high demand for new laborers. Often times, these workers are blamed for a rise in criminal deviance,. In response to oil development in Louisiana, some local individuals blamed the increase in 'unskilled laborers' for the increase in criminal activities. One local individual claimed that, "during the 70s/80s [oil] boom we had lots of low life…police characters…criminals coming in as labor…they had little work history…when the [oil] bust hit they hung around and caused trouble…". (Forsyth et al., 2007,

p.292) On the other hand, some individuals in these areas believe that oil and gas drilling has helped build and bring their communities closer together, which in turn, has led to a decline in criminal activity. This idea is supported by a resident in Louisiana who stated that "this [community] was all poor white trash until oil came…oil decreased crime…oil and the oil business have caused the cycle of crime to go down". Rapid sociocultural change in Alaska has been associated with increasing rates of social pathology in native populations. Some of these populations have arrest rates for violent crimes 8 to 15 times higher than the overall national rate. (Wernham, 2007)

Sexual Promiscuity and Associated Diseases

Communities involved in oil and as extraction activities have experienced high rates of sexually transmitted diseases. For example, oil and gas communities in British Columbia have witnessed a rise in the occurrence of Chlamydia, and several regions in Africa have had increasing rates of HIV/AIDS since the introduction of oil and gas drilling to their communities. (Frynas, 2004; Goldenberg et al., 2007; Jobin, 2003; Udoh et al., 2007) These effects can be mitigated to some degree through intensive environmental and health management planning on the part of the oil companies. In Chad and Cameroon, companies were able to achieve a reduction in the occurrence of some sexually transmitted diseases in their labor forces by requiring contractors to provide health care for workers.

Rates of Suicide

Communities involved in oil and gas exploration may also experience a rise in suicide rates. Whereas the U.S. general population has an average suicide rate of 11 out of every 100,000 individuals, communities on the northern slope in Alaska experience an average suicide rate of 45 out of every 100,000 individuals. This very high suicide rate is thought to be due to rapid sociocultural change in Inuit communities. High suicide rates are also found in communities associated with offshore oil drilling in Louisiana. (Kettl, 1998; Wernham, 2007; Seydlitz et al., 1993)

Mental Health Concerns

Individuals working or living in communities involved in oil and gas exploration often experience greater mental health concerns than individuals who live in areas not involved in these industrial activities. Some researchers report that individuals in these regions have a certain vulnerability to psychological or psychiatric problems. (Lester & Temple, 2006) For example, oil and gas development has been associated with high rates of mental and psychological stress. Furthermore, increasing mental health concerns such as anxiety and depression, have been linked to communities in Wales, India, and the Peruvian Amazon that are involved in oil and gas drilling activities. (Bhatia, 2007; Gallacher et al., 2007; Izquierdo, 2005; Lester & Temple, 2006; Murthy et al., 2005; Wernham, 2007)

Our literature search also revealed a few studies that did not find an association between oil and gas exploration and social and psychological health effects. In particular, two studies found no relationship between industrial activities and crime rates. (Luthra et al., 2007; Seydlitz et al., 1993) Some researchers believe that much of the research depicting a negative or positive relationship between oil and gas exploration and crime is speculative in nature. Because of methodological weaknesses in many studies in this research area, it seems necessary to conduct controlled, empirical research to verify whether a relationship between oil and gas exploration and social and psychological health does truly exist. Consequently, findings from existing research need to be interpreted with caution.

Summary

Overall, there is an apparent lack of research in this area. As findings from this literature review demonstrate, the research in the past five years has been inconsistent, making it difficult to draw definitive conclusions about the psychological and social implications of oil and gas exploration. However, based on the evidence provided, it is probable that oil and gas exploration activities can have serious effects on people's social and psychological health. Despite this possibility, the oil and gas industries have failed to take reasonable steps to protect these families and communities.

Findings from this literature review make it clear that future research is necessary to clarify our understanding of the social and psychological impact of oil and gas drilling on individuals living in and near industrial communities. By better understanding this relationship, we will be able to more effectively intervene and mitigate these potentially severe social and mental health problems.

Conclusions

As discussed in the medical and public health literature review (attached), few studies have been published on the health effects of oil and gas exploration and extraction on communities living and working in the vicinity of these activities. A lack of specific evidence, however, does not negate the fact that oil and gas operations use and produce toxic contaminants that adversely affect human health. Available studies show that exposure to air pollutants, toxic chemicals, metals, radiation, noise and light pollution cause a range of diseases, illnesses, and health problems, including psychological and social disruption. Neighborhoods, schools, and workers in close proximity to oil and gas activities may be at increased risk for cancer, cardiovascular disease, asthma, and other disorders due to uncontrolled or high exposures. Further research is needed to assess the health impact of oil and gas operations on surrounding communities.

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Potential Exposure-Related Human Health Effects of Oil and Gas Development:

Literature Review Appendices

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Potential Exposure-Related Human Health Effects of Oil and Gas Development: Literature Review Appendices

Appendix 1

Albert, D. A., A. N. Albert, et al. (2005). "Analysis of a cluster of cases of Wegener granulomatosis." JCR: Journal of Clinical Rheumatology **11**(4): 188-93.

Albertini, R. J., R. J. Sram, et al. (2007). "Molecular epidemiological studies in 1,3-butadiene exposed Czech workers: female-male comparisons." Chemico-Biological Interactions **166**(1-3): 63-77.

Alexander, D. D., P. J. Mink, et al. (2006). "A meta-analysis of occupational trichloroethylene exposure and multiple myeloma or leukaemia." Occupational Medicine **56**(7): 485-93.

Anagnostopoulos, G., G. H. Sakorafas, et al. (2004). "Hepatitis caused by occupational chronic exposure to trichloroethylene." Acta Gastroenterologica Belgica **67**(4): 355-7.

Aschengrau, A., S. Rogers, et al. (2003). "Perchloroethylene-contaminated drinking water and the risk of breast cancer: additional results from Cape Cod, Massachusetts, USA." Environmental Health Perspectives **111**(2): 167-73.

Avogbe, P. H., L. Ayi-Fanou, et al. (2005). "Ultrafine particulate matter and high-level benzene urban air pollution in relation to oxidative DNA damage." Carcinogenesis **26**(3): 613-20.

Bahrami, A. R., A. Joneidi Jafari, et al. (2007). "Comparison of benzene exposure in drivers and petrol stations workers by urinary trans,trans-muconic acid in west of Iran." Industrial Health **45**(3): 396-401.

Bakoglu, M., A. Karademir, et al. (2004). "An evaluation of the occupational health risks to workers in a hazardous waste incinerator." Journal of Occupational Health **46**(2): 156-64.

Bloemen, L. J., A. Youk, et al. (2004). "Lymphohaematopoietic cancer risk among chemical workers exposed to benzene." Occupational & Environmental Medicine **61**(3): 270-4.

Booze, T. F., T. E. Reinhardt, et al. (2004). "A screening-level assessment of the health risks of chronic smoke exposure for wildland firefighters." Journal of Occupational & Environmental Hygiene **1**(5): 296-305.

Bruning, T., B. Pesch, et al. (2003). "Renal cell cancer risk and occupational exposure to trichloroethylene: results of a consecutive case-control study in Arnsberg, Germany." American Journal of Industrial Medicine **43**(3): 274-85.

Chang, S.-J., C.-J. Chen, et al. (2006). "Hearing loss in workers exposed to toluene and noise." Environmental Health Perspectives **114**(8): 1283-6.

Chang, Y.-M., C.-F. Tai, et al. (2003). "A cohort mortality study of workers exposed to chlorinated organic solvents in Taiwan." Annals of Epidemiology **13**(9): 652-60.

Chang, Y.-M., C.-F. Tai, et al. (2003). "A cohort mortality study of workers exposed to chlorinated organic solvents in Taiwan." Annals of Epidemiology **13**(9): 652-60.

Chiu, W. A., S. Micallef, et al. (2007). "Toxicokinetics of inhaled trichloroethylene and tetrachloroethylene in humans at 1 ppm: empirical results and comparisons with previous studies." Toxicological Sciences **95**(1): 23-36.

Chiu, W. A., S. Micallef, et al. (2007). "Toxicokinetics of inhaled trichloroethylene and tetrachloroethylene in humans at 1 ppm: empirical results and comparisons with previous studies." Toxicological Sciences **95**(1): 23-36.

Collins, J. J., B. Ireland, et al. (2003). "Lymphohaematopoeitic cancer mortality among workers with benzene exposure." Occupational & Environmental Medicine **60**(9): 676-9.

Crosignani, P., A. Tittarelli, et al. (2004). "Childhood leukemia and road traffic: A population-based case-control study." International Journal of Cancer **108**(4): 596-9.

Davis, S. I., L. Laszlo Pallos, et al. (2005). "ATSDR's trichloroethylene subregistry methods and results: 1989-2000." Archives of Environmental & Occupational Health **60**(3): 130-9.

Fevotte, J., B. Charbotel, et al. (2006). "Case-control study on renal cell cancer and occupational exposure to trichloroethylene. Part I: Exposure assessment." Annals of Occupational Hygiene **50**(8): 765-75.

Fondelli, M. C., P. Bavazzano, et al. (2008). "Benzene exposure in a sample of population residing in a district of Florence, Italy." Science of the Total Environment **392**(1): 41-9.

Forkert, P.-G., L. Lash, et al. (2003). "Identification of trichloroethylene and its metabolites in human seminal fluid of workers exposed to trichloroethylene." Drug Metabolism & Disposition **31**(3): 306-11.

Franco, A., M. A. Costoya, et al. (2007). "Estimating risk during showering exposure to VOCs of workers in a metal-degreasing facility." Journal of Toxicology & Environmental Health Part A **70**(7): 627-37.

Franco, A., M. A. Costoya, et al. (2007). "Estimating risk during showering exposure to VOCs of workers in a metal-degreasing facility." Journal of Toxicology & Environmental Health Part A **70**(7): 627-37.

Fuente, A. and B. McPherson (2006). "Organic solvents and hearing loss: The challenge for audiology." International Journal of Audiology **45**(7): 367-81.

Fuente, A. and B. McPherson (2006). "Organic solvents and hearing loss: The challenge for audiology." International Journal of Audiology **45**(7): 367-81.

Garte, S., T. Popov, et al. (2005). "Biomarkers of exposure and effect in Bulgarian petrochemical workers exposed to benzene." Chemico-Biological Interactions **153-154**: 247-51.

Glass, D. C., C. N. Gray, et al. (2005). "Health Watch exposure estimates: do they underestimate benzene exposure?" Chemico-Biological Interactions **153-154**: 23-32.

Glass, D. C., C. N. Gray, et al. (2003). "Leukemia risk associated with low-level benzene exposure.[see comment]." Epidemiology **14**(5): 569-77.

Glass, D. C., M. R. Sim, et al. (2004). "Leukemia risk and relevant benzene exposure period-Re: follow-up time on risk estimates, Am J Ind Med 42:481-489, 2002.[comment]." American Journal of Industrial Medicine **45**(2): 222-3; author reply 224-5.

Golka, K., A. Wiese, et al. (2004). "Occupational exposure and urological cancer." World Journal of Urology **21**(6): 382-91.

Gonzalez-Yebra, A.-L., C. Kornhauser, et al. (2006). "Occupational exposure to toluene and its possible causative role in renal damage development in shoe workers." International Archives of Occupational & Environmental Health **79**(3): 259-64.

Green, T., J. Dow, et al. (2004). "Biological monitoring of kidney function among workers occupationally exposed to trichloroethylene." Occupational & Environmental Medicine **61**(4): 312-7.

Gu, S.-Y., Z.-B. Zhang, et al. (2007). "Genetic polymorphisms in CYP1A1, CYP2D6, UGT1A6, UGT1A7, and SULT1A1 genes and correlation with benzene exposure in a Chinese occupational population." Journal of Toxicology & Environmental Health Part A **70**(11): 916-24.

Han, X., M. Aguilar-Villalobos, et al. (2005). "Traffic-related occupational exposures to PM2.5, CO, and VOCs in Trujillo, Peru." International Journal of Occupational & Environmental Health **11**(3): 276-88.

Hardin, B. D., B. J. Kelman, et al. (2005). "Trichloroethylene and dichloroethylene: a critical review of teratogenicity." Birth Defects Research **73**(12): 931-55.

Heuser, V. D., B. Erdtmann, et al. (2007). "Evaluation of genetic damage in Brazilian footwear-workers: biomarkers of exposure, effect, and susceptibility." Toxicology **232**(3): 235-47.

Hodgkinson, L. and D. Prasher (2006). "Effects of industrial solvents on hearing and balance: a review." Noise & Health **8**(32): 114-33.

Irons, R. D., L. Lv, et al. (2005). "Chronic exposure to benzene results in a unique form of dysplasia." Leukemia Research **29**(12): 1371-80.

Jacobson, G. A. and S. McLean (2003). "Biological monitoring of low level occupational xylene exposure and the role of recent exposure." Annals of Occupational Hygiene **47**(4): 331-6.

Jacobson, G. A. and S. McLean (2003). "Biological monitoring of low level occupational xylene exposure and the role of recent exposure." Annals of Occupational Hygiene **47**(4): 331-6.

Jacubovich, R. M., D. Landau, et al. (2005). "Facial nerve palsy after acute exposure to dichloromethane.[see comment]." American Journal of Industrial Medicine **48**(5): 389-92.

Johansen, K., H. Tinnerberg, et al. (2005). "Use of history science methods in exposure assessment for occupational health studies.[see comment]." Occupational & Environmental Medicine **62**(7): 434-41.

Kang, S.-K., M.-Y. Lee, et al. (2005). "Occupational exposure to benzene in South Korea." Chemico-Biological Interactions **153-154**: 65-74.

Kim, S. R., F. Dominici, et al. (2007). "Concentrations of vehicle-related air pollutants in an urban parking garage." Environmental Research **105**(3): 291-9.

Kim, Y. J., J. Y. Choi, et al. (2008). "Association of the NQO1, MPO, and XRCC1 polymorphisms and chromosome damage among workers at a petroleum refinery." Journal of Toxicology & Environmental Health Part A **71**(5): 333-41.

Kirkeleit, J., T. Riise, et al. (2006). "Biological monitoring of benzene exposure during maintenance work in crude oil cargo tanks." Chemico-Biological Interactions **164**(1-2): 60-7.

Kirkeleit, J., E. Ulvestad, et al. (2006). "Acute suppression of serum IgM and IgA in tank workers exposed to benzene." Scandinavian Journal of Immunology **64**(6): 690-8.

Kishimoto, A., H. Cao, et al. (2006). "Assessment of exposure to and risk posed by toluene in Japanese residents: combining exposure from indoor and outdoor sources." Environmental Sciences **13**(1): 31-42.

Klaucke, D. and R. Vogt (2005). "A case exercise: outbreak investigation at a Vermont community hospital." Journal of Public Health Management & Practice **11**(4): 301-5.

Knox, E. G. (2005). "Oil combustion and childhood cancers.[see comment]." Journal of Epidemiology & Community Health **59**(9): 755-60.

Kouniali, A., A. Cicolella, et al. (2003). "Environmental benzene exposure assessment for parent-child pairs in Rouen, France." Science of the Total Environment **308**(1-3): 73-82.

Krishnadasan, A., N. Kennedy, et al. (2007). "Nested case-control study of occupational chemical exposures and prostate cancer in aerospace and radiation workers." American Journal of Industrial Medicine **50**(5): 383-90.

Lamb, J. C. and K. L. Hentz (2006). "Toxicological review of male reproductive effects and trichloroethylene exposure: assessing the relevance to human male reproductive health." Reproductive Toxicology **22**(4): 557-63.

Lan, Q., L. Zhang, et al. (2005). "Lymphocyte toxicity and T cell receptor excision circles in workers exposed to benzene." Chemico-Biological Interactions **153-154**: 111-5.

Lan, Q., L. Zhang, et al. (2004). "Hematotoxicity in workers exposed to low levels of benzene.[see comment]." Science **306**(5702): 1774-6.

Lee, E.-H., K. D. Eum, et al. (2007). "Acquired dyschromatopsia among petrochemical industry workers exposed to benzene." Neurotoxicology **28**(2): 356-63.

Lehman, E. J. and M. J. Hein (2006). "Mortality of workers employed in shoe manufacturing: an update." American Journal of Industrial Medicine **49**(7): 535-46.

Leong, S. T. and P. Laortanakul (2003). "Indicators of benzene emissions and exposure in Bangkok street.[retraction in Silbergeld EK. Environ Res. 2004 May;95(1):116; PMID: 15137386]." Environmental Research **92**(3): 173-81.

Leopardi, P., A. Zijno, et al. (2003). "Analysis of micronuclei in peripheral blood lymphocytes of traffic wardens: effects of exposure, metabolic genotypes, and inhibition of excision repair in vitro by ARA-C." Environmental & Molecular Mutagenesis **41**(2): 126-30.

Lynge, E., A. Andersen, et al. (2006). "Cancer in persons working in dry cleaning in the Nordic countries." Environmental Health Perspectives **114**(2): 213-9.

Maffei, F., P. Hrelia, et al. (2005). "Effects of environmental benzene: micronucleus frequencies and haematological values in traffic police working in an urban area." Mutation Research **583**(1): 1-11.

Maniscalco, M., L. Grieco, et al. (2004). "Increase in exhaled nitric oxide in shoe and leather workers at the end of the work-shift." Occupational Medicine **54**(6): 404-7.

Maniscalco, M., L. Grieco, et al. (2004). "Increase in exhaled nitric oxide in shoe and leather workers at the end of the work-shift." Occupational Medicine **54**(6): 404-7.

Mannsaker, B., T. Vikan, et al. (2004). "[Air pollution and cardiovascular disease in Trondheim]." Tidsskrift for Den Norske Laegeforening **124**(10): 1381-3.

Martino-Roth, M. G., J. Viegas, et al. (2003). "Occupational genotoxicity risk evaluation through the comet assay and the micronucleus test.[see comment]." Genetics & Molecular Research **2**(4): 410-7.

Nakajima, T., O. Yamanoshita, et al. (2003). "Generalized skin reactions in relation to trichloroethylene exposure: a review from the viewpoint of drug-metabolizing enzymes." Journal of Occupational Health **45**(1): 8-14.

Naufal, Z., G.-d. Zhou, et al. (2007). "Genotoxicity of organic extracts of house dust from Shanxi, China." Journal of Toxicology & Environmental Health Part A **70**(24): 2080-8.

Osterberg, K., P. Orbaek, et al. (2003). "Annoyance and performance during the experimental chemical challenge of subjects with multiple chemical sensitivity." Scandinavian Journal of Work, Environment & Health **29**(1): 40-50.

Patel, A. S., E. O. Talbott, et al. (2004). "Risk of cancer as a result of community exposure to gasoline vapors.[erratum appears in Arch Environ Occup Health. 2005 Jan-Feb;60(1):53; discussion 53; PMID: 16961009]." Archives of Environmental Health **59**(10): 497-503.

Pedersen, C. B., O. Raaschou-Nielsen, et al. (2004). "Air pollution from traffic and schizophrenia risk." Schizophrenia Research **66**(1): 83-5.

Perrin, M. C., M. G. Opler, et al. (2007). "Tetrachloroethylene exposure and risk of schizophrenia: offspring of dry cleaners in a population birth cohort, preliminary findings." Schizophrenia Research **90**(1-3): 251-4.

Pierce, C., Y. Chen, et al. (2004). "Exponential modeling, washout curve reconstruction, and estimation of half-life of toluene and its metabolites." Journal of Toxicology & Environmental Health Part A **67**(14): 1131-58.

Quitt, M., A. Cassel, et al. (2004). "Autonomous growth of committed hematopoietic progenitors from peripheral blood of workers exposed to low levels of benzene." Journal of Occupational & Environmental Medicine **46**(1): 27-9.

Raaschou-Nielsen, O., J. Hansen, et al. (2003). "Cancer risk among workers at Danish companies using trichloroethylene: a cohort study." American Journal of Epidemiology **158**(12): 1182-92.

Radican, L., D. Wartenberg, et al. (2006). "A retrospective occupational cohort study of end-stage renal disease in aircraft workers exposed to trichloroethylene and other hydrocarbons." Journal of Occupational & Environmental Medicine **48**(1): 1-12.

Ray, M. R., S. Roychoudhury, et al. (2007). "Occupational benzene exposure from vehicular sources in India and its effect on hematology, lymphocyte subsets and platelet P-selectin expression." Toxicology & Industrial Health **23**(3): 167-75.

Richardson, D. B. (2008). "Temporal variation in the association between benzene and leukemia mortality." Environmental Health Perspectives **116**(3): 370-4.

Ruchirawat, M., P. Navasumrit, et al. (2005). "Measurement of genotoxic air pollutant exposures in street vendors and school children in and near Bangkok." Toxicology & Applied Pharmacology **206**(2): 207-14.

Ruchirawat, M., D. Settachan, et al. (2007). "Assessment of potential cancer risk in children exposed to urban air pollution in Bangkok, Thailand." Toxicology Letters **168**(3): 200-9.

Schaper, M., P. Demes, et al. (2003). "Occupational toluene exposure and auditory function: results from a follow-up study." Annals of Occupational Hygiene **47**(6): 493-502.

Seeber, A., M. Schaper, et al. (2004). "Toluene exposure below 50 ppm and cognitive function: a follow-up study with four repeated measurements in rotogravure printing plants." International Archives of Occupational & Environmental Health **77**(1): 1-9.

Seniori Costantini, A., M. Quinn, et al. (2003). "Exposure to benzene and risk of leukemia among shoe factory workers." Scandinavian Journal of Work, Environment & Health **29**(1): 51-9.

Sharanjeet, K., A. Mursyid, et al. (2004). "Effect of petroleum derivatives and solvents on colour perception." Clinical & Experimental Optometry **87**(4-5): 339-43.

Sorahan, T., L. J. Kinlen, et al. (2005). "Cancer risks in a historical UK cohort of benzene exposed workers.[see comment]." Occupational & Environmental Medicine **62**(4): 231-6.

Sorensen, M., H. Skov, et al. (2003). "Urban benzene exposure and oxidative DNA damage: influence of genetic polymorphisms in metabolism genes." Science of the Total Environment **309**(1-3): 69-80.

Steffen, C., M. F. Auclerc, et al. (2004). "Acute childhood leukaemia and environmental exposure to potential sources of benzene and other hydrocarbons; a case-control study." Occupational & Environmental Medicine **61**(9): 773-8.

Sung, T.-I., P.-C. Chen, et al. (2007). "Increased standardized incidence ratio of breast cancer in female electronics workers." BMC Public Health **7**: 102.

Tanaka, K., T. Maeda, et al. (2003). "A survey of urinary hippuric acid and subjective symptoms among occupational low toluene exposed workers." Fukushima Journal of Medical Science **49**(2): 129-39.

Tanios, M. A., H. El Gamal, et al. (2004). "Can we still miss tetrachloroethylene-induced lung disease? The emperor returns in new clothes." Respiration **71**(6): 642-5.

Vermeulen, R., Q. Lan, et al. (2005). "Decreased levels of CXC-chemokines in serum of benzene-exposed workers identified by array-based proteomics." Proceedings of the National Academy of Sciences of the United States of America **102**(47): 17041-6.

Vieira, V., A. Aschengrau, et al. (2005). "Impact of tetrachloroethylene-contaminated drinking water on the risk of breast cancer: using a dose model to assess exposure in a case-control study." Environmental Health: A Global Access Science Source **4**(1): 3.

Wartenberg, D. (2005). "Possible carcinogenicity of trichloroethylene in humans.[comment]." Toxicology **208**(1): 173-4.

Wennborg, H., L. L. Magnusson, et al. (2005). "Congenital malformations related to maternal exposure to specific agents in biomedical research laboratories." Journal of Occupational & Environmental Medicine **47**(1): 11-9.

Wiwanitkit, V., S. Soogarun, et al. (2004). "Urine phenol and myeloperoxidase index: an observation in benzene exposed subjects." Leukemia & Lymphoma **45**(8): 1643-5.

Wiwanitkit, V., S. Soogarun, et al. (2007). "A correlative study on red blood cell parameters and urine trans, trans-muconic acid in subjects with occupational benzene exposure." Toxicologic Pathology **35**(2): 268-9.

Wiwanitkit, V., J. Suwansaksri, et al. (2004). "The urine trans, trans muconic acid biomarker and platelet count in a sample of subjects with benzene exposure." Clinical & Applied Thrombosis/Hemostasis **10**(1): 73-6.

Wiwanitkit, V., J. Suwansaksri, et al. (2005). "Cancer risk for Thai traffic police exposed to traffic benzene vapor.[see comment]." Asian Pacific Journal of Cancer Prevention: Apjcp **6**(2): 219-20.

Wiwanitkit, V., J. Suwansaksri, et al. (2006). "White blood cell sister chromatid exchange among a sample of Thai subjects exposed to toluene, an observation." International Journal of Experimental Pathology **87**(6): 501-3.

Zhang, L., Q. Lan, et al. (2005). "Use of OctoChrome fluorescence in situ hybridization to detect specific aneuploidy among all 24 chromosomes in benzene-exposed workers." Chemico-Biological Interactions **153-154**: 117-22.

Appendix 2

Adelroth, E., U. Hedlund, et al. (2006). "Airway inflammation in iron ore miners exposed to dust and diesel exhaust." European Respiratory Journal **27**(4): 714-9.

Band, P. R., N. D. Le, et al. (2005). "Identification of occupational cancer risks in British Columbia: a population-based case-control study of 1129 cases of bladder cancer." Journal of Occupational & Environmental Medicine **47**(8): 854-8.

Bartra, J., J. Mullol, et al. (2007). "Air pollution and allergens." Journal of Investigational Allergology & Clinical Immunology **17 Suppl 2**: 3-8.

Bastain, T. M., F. D. Gilliland, et al. (2003). "Intraindividual reproducibility of nasal allergic responses to diesel exhaust particles indicates a susceptible phenotype." Clinical Immunology **109**(2): 130-6.

Behndig, A. F., I. S. Mudway, et al. (2006). "Airway antioxidant and inflammatory responses to diesel exhaust exposure in healthy humans." European Respiratory Journal **27**(2): 359-65.

Blomberg, A., H. Tornqvist, et al. (2005). "Exposure to diesel exhaust nanoparticles does not induce blood hypercoagulability in an at-risk population." Journal of Thrombosis & Haemostasis **3**(9): 2103-5.

Boers, D., M. P. A. Zeegers, et al. (2005). "The influence of occupational exposure to pesticides, polycyclic aromatic hydrocarbons, diesel exhaust, metal dust, metal fumes, and mineral oil on prostate cancer: a prospective cohort study." Occupational & Environmental Medicine **62**(8): 531-7.

Bosson, J., J. Pourazar, et al. (2007). "Ozone enhances the airway inflammation initiated by diesel exhaust." Respiratory Medicine **101**(6): 1140-6.

Brauer, M., G. Hoek, et al. (2003). "Estimating long-term average particulate air pollution concentrations: application of traffic indicators and geographic information systems." Epidemiology **14**(2): 228-39.

Burgess, J. L., J. E. Fleming, et al. (2007). "Acute changes in sputum IL-10 following underground exposure to diesel exhaust." Clinical Toxicology: The Official Journal of the American Academy of Clinical Toxicology & European Association of Poisons Centres & Clinical Toxicologists **45**(3): 255-60.

Carlsten, C., J. D. Kaufman, et al. (2007). "Coagulation markers in healthy human subjects exposed to diesel exhaust." Thrombosis Research **120**(6): 849-55.

Chang, Y., S. Senechal, et al. (2006). "Diesel exhaust exposure favors TH2 cell recruitment in nonatopic subjects by differentially regulating chemokine production." Journal of Allergy & Clinical Immunology **118**(2): 354-60.

Davis, M. E., T. J. Smith, et al. (2007). "Driver exposure to combustion particles in the U.S. Trucking industry." Journal of Occupational & Environmental Hygiene **4**(11): 848-54.

Devi, S. S., A. R. Biswas, et al. (2007). "Heavy metal status and oxidative stress in diesel engine tuning workers of central Indian population." Journal of Occupational & Environmental Medicine **49**(11): 1228-34.

Fiedler, N., N. Giardino, et al. (2004). "Responses to controlled diesel vapor exposure among chemically sensitive Gulf War veterans." Psychosomatic Medicine **66**(4): 588-98.

Finkelstein, M. M., D. K. Verma, et al. (2004). "Ischemic heart disease mortality among heavy equipment operators." American Journal of Industrial Medicine **46**(1): 16-22.

Fromme, H., T. Lahrz, et al. (2005). "Elemental carbon and respirable particulate matter in the indoor air of apartments and nursery schools and ambient air in Berlin (Germany)." Indoor Air **15**(5): 335-41.

Gabrovska, Z., L. Friedman, et al. (2004). "Respiratory complaints and medication use following cessation of exposure to construction dust and diesel truck emissions (Neve Yakov, Jerusalem)." International Journal of Occupational Medicine & Environmental Health **17**(4): 441-9.

Garshick, E., F. Laden, et al. (2004). "Lung cancer in railroad workers exposed to diesel exhaust." Environmental Health Perspectives **112**(15): 1539-43.

Gil, L., V. Martinez, et al. (2003). "Occupational and environmental levels of mutagenic PAHs and respirable particulate matter associated with diesel exhaust in Santiago, Chile." Journal of Occupational & Environmental Medicine **45**(9): 984-92.

Gilliland, F. D., Y.-F. Li, et al. (2004). "Effect of glutathione-S-transferase M1 and P1 genotypes on xenobiotic enhancement of allergic responses: randomised, placebo-controlled crossover study.[see comment]." Lancet **363**(9403): 119-25.

Guo, J., T. Kauppinen, et al. (2004). "Risk of esophageal, ovarian, testicular, kidney and bladder cancers and leukemia among finnish workers exposed to diesel or gasoline engine exhaust." International Journal of Cancer **111**(2): 286-92.

Guo, J., T. Kauppinen, et al. (2004). "Occupational exposure to diesel and gasoline engine exhausts and risk of lung cancer among Finnish workers." American Journal of Industrial Medicine **45**(6): 483-90.

Hart, J. E., F. Laden, et al. (2006). "Chronic obstructive pulmonary disease mortality in diesel-exposed railroad workers." Environmental Health Perspectives **114**(7): 1013-7.

Holgate, S. T., T. Sandstrom, et al. (2003). "Health effects of acute exposure to air pollution. Part I: Healthy and asthmatic subjects exposed to diesel exhaust." Research Report - Health Effects Institute(112): 1-30; discussion 51-67.

Hoppin, J. A., D. M. Umbach, et al. (2004). "Diesel exhaust, solvents, and other occupational exposures as risk factors for wheeze among farmers." American Journal of Respiratory & Critical Care Medicine **169**(12): 1308-13.

Ising, H., H. Lange-Asschenfeldt, et al. (2003). "[Effects of long-term exposure to street traffic exhaust on the development of skin and respiratory tract diseases in children]." Schriftenreihe des Vereins fur Wasser-, Boden-, und Lufthygiene(112): 81-99.

Jarvholm, B. and D. Silverman (2003). "Lung cancer in heavy equipment operators and truck drivers with diesel exhaust exposure in the construction industry." Occupational & Environmental Medicine **60**(7): 516-20.

Kongerud, J., M. C. Madden, et al. (2006). "Nasal responses in asthmatic and nonasthmatic subjects following exposure to diesel exhaust particles." Inhalation Toxicology **18**(9): 589-94.

Lee, W. J., D. Baris, et al. (2003). "Multiple myeloma and diesel and other occupational exposures in swedish construction workers.[see comment]." International Journal of Cancer **107**(1): 134-8.

Mamessier, E., A. Nieves, et al. (2006). "Diesel exhaust particles enhance T-cell activation in severe asthmatics." Allergy **61**(5): 581-8.

Mastrangelo, G., E. Clonfero, et al. (2003). "Exposure to diesel exhaust enhances total IgE in non-atopic dockers." International Archives of Occupational & Environmental Health **76**(1): 63-8.

McCreanor, J., P. Cullinan, et al. (2007). "Respiratory effects of exposure to diesel traffic in persons with asthma.[see comment]." New England Journal of Medicine **357**(23): 2348-58.

Mills, N. L., H. Tornqvist, et al. (2007). "Ischemic and thrombotic effects of dilute diesel-exhaust inhalation in men with coronary heart disease.[see comment]." New England Journal of Medicine **357**(11): 1075-82.

Mills, N. L., H. Tornqvist, et al. (2005). "Diesel exhaust inhalation causes vascular dysfunction and impaired endogenous fibrinolysis.[see comment]." Circulation **112**(25): 3930-6.

Mudway, I. S., N. Stenfors, et al. (2004). "An in vitro and in vivo investigation of the effects of diesel exhaust on human airway lining fluid antioxidants." Archives of Biochemistry & Biophysics **423**(1): 200-12.

Muzyka, V., P. T. J. Scheepers, et al. (2004). "Porphyrin metabolism in lymphocytes of miners exposed to diesel exhaust at oil shale mine." Science of the Total Environment **322**(1-3): 41-50.

Oh, S.-M. and K.-H. Chung (2006). "Identification of mammalian cell genotoxins in respirable diesel exhaust particles by bioassay-directed chemical analysis." Toxicology Letters **161**(3): 226-35.

Ohtani, T., S. Nakagawa, et al. (2005). "Cellular basis of the role of diesel exhaust particles in inducing Th2-dominant response." Journal of Immunology **174**(4): 2412-9.

Parent, M.-E., M.-C. Rousseau, et al. (2007). "Exposure to diesel and gasoline engine emissions and the risk of lung cancer." American Journal of Epidemiology **165**(1): 53-62.

Peretz, A., E. C. Peck, et al. (2007). "Diesel exhaust inhalation and assessment of peripheral blood mononuclear cell gene transcription effects: an exploratory study of healthy human volunteers." Inhalation Toxicology **19**(14): 1107-19.

Pourazar, J., A. J. Frew, et al. (2004). "Diesel exhaust exposure enhances the expression of IL-13 in the bronchial epithelium of healthy subjects." Respiratory Medicine **98**(9): 821-5.

Pourazar, J., I. S. Mudway, et al. (2005). "Diesel exhaust activates redox-sensitive transcription factors and kinases in human airways.[see comment]." American Journal of Physiology - Lung Cellular & Molecular Physiology **289**(5): L724-30.

Richiardi, L., D. Mirabelli, et al. (2006). "Occupational exposure to diesel exhausts and risk for lung cancer in a population-based case-control study in Italy." Annals of Oncology **17**(12): 1842-7.

Riedl, M. and D. Diaz-Sanchez (2005). "Biology of diesel exhaust effects on respiratory function." Journal of Allergy & Clinical Immunology **115**(2): 221-8; quiz 229.

See, S. W., R. Balasubramanian, et al. (2006). "Assessing exposure to diesel exhaust particles: a case study." Journal of Toxicology & Environmental Health Part A **69**(21): 1909-25.

Sjodahl, K., C. Jansson, et al. (2007). "Airborne exposures and risk of gastric cancer: a prospective cohort study." International Journal of Cancer **120**(9): 2013-8.

Stenfors, N., C. Nordenhall, et al. (2004). "Different airway inflammatory responses in asthmatic and healthy humans exposed to diesel." European Respiratory Journal **23**(1): 82-6.

Tainio, M., J. T. Tuomisto, et al. (2005). "Health effects caused by primary fine particulate matter (PM2.5) emitted from buses in the Helsinki metropolitan area, Finland." Risk Analysis **25**(1): 151-60.

Takizawa, R., R. Pawankar, et al. (2007). "Increased expression of HLA-DR and CD86 in nasal epithelial cells in allergic rhinitics: antigen presentation to T cells and up-regulation by diesel exhaust particles." Clinical & Experimental Allergy **37**(3): 420-33.

Wichmann, H. E. (2007). "Diesel exhaust particles." Inhalation Toxicology **19 Suppl 1**: 241-4.

Wu, Y.-C. and S. A. Batterman (2006). "Proximity of schools in Detroit, Michigan to automobile and truck traffic." Journal of Exposure Science & Environmental Epidemiology **16**(5): 457-70.

Yip, M., P. Madl, et al. (2006). "Exposure assessment of diesel bus emissions." International Journal of Environmental Research & Public Health [Electronic Resource] **3**(4): 309-15.

Appendix 3

(2003). "Two more reports link air pollution and asthma...and an editorial view." Child Health Alert **21**: 3.

Adamkiewicz, G., S. Ebelt, et al. (2004). "Association between air pollution exposure and exhaled nitric oxide in an elderly population." Thorax **59**(3): 204-9.

Adamowicz, V., R. Dales, et al. (2004). "Report of an expert panel to review the socio-economic models and related components supporting the development of Canada-Wide Standards (CWS) for particulate matter (PM) and ozone to the Royal Society of Canada." Journal of Toxicology & Environmental Health Part B: Critical Reviews **7**(3): 147-266.

Adams, W. C. (2003). "Comparison of chamber and face mask 6.6-hour exposure to 0.08 ppm ozone via square-wave and triangular profiles on pulmonary responses." Inhalation Toxicology **15**(3): 265-81.

Adams, W. C. (2003). "Relation of pulmonary responses induced by 6.6-h exposures to 0.08 ppm ozone and 2-h exposures to 0.30 ppm ozone via chamber and face-mask inhalation." Inhalation Toxicology **15**(8): 745-59.

Adams, W. C. (2006). "Comparison of chamber 6.6-h exposures to 0.04-0.08 PPM ozone via square-wave and triangular profiles on pulmonary responses." Inhalation Toxicology **18**(2): 127-36.

Adams, W. C. (2006). "Human pulmonary responses with 30-minute time intervals of exercise and rest when exposed for 8 hours to 0.12 ppm ozone via square-wave and acute triangular profiles." Inhalation Toxicology **18**(6): 413-22.

Adar, S. D., D. R. Gold, et al. (2007). "Focused exposures to airborne traffic particles and heart rate variability in the elderly." Epidemiology **18**(1): 95-103.

Adedeji, A., T. M. A. Weller, et al. (2004). "Effect of PM10 on H. influenzae and S. pneumoniae." Thorax **59**(6): 542-3.

Aekplakorn, W., D. Loomis, et al. (2004). "Heterogeneity of daily pulmonary function in response to air pollution among asthmatic children." Southeast Asian Journal of Tropical Medicine and Public Health **35**(4): 990-8.

Aekplakorn, W., D. Loomis, et al. (2003). "Acute effect of sulphur dioxide from a power plant on pulmonary function of children, Thailand." International Journal of Epidemiology **32**(5): 854-61.

Afroz, R., M. N. Hassan, et al. (2003). "Review of air pollution and health impacts in Malaysia." Environmental Research **92**(2): 71-7.

Aga, E., E. Samoli, et al. (2003). "Short-term effects of ambient particles on mortality in the elderly: results from 28 cities in the APHEA2 project." European Respiratory Journal - Supplement **40**: 28s-33s.

Alessandrini, F., H. Schulz, et al. (2006). "Effects of ultrafine carbon particle inhalation on allergic inflammation of the lung." Journal of Allergy and Clinical Immunology **117**(4): 824-30.

Alexeeff, S. E., A. A. Litonjua, et al. (2007). "Ozone exposure and lung function: effect modified by obesity and airways hyperresponsiveness in the VA normative aging study." Chest **132**(6): 1890-7.

Alexis, N. E., S. Becker, et al. (2004). "Circulating CD11b expression correlates with the neutrophil response and airway mCD14 expression is enhanced following ozone exposure in humans." Clinical Immunology **111**(1): 126-31.

Alfaro, M. F., W. F. Walby, et al. (2007). "Breath condensate levels of 8-isoprostane and leukotriene B4 after ozone inhalation are greater in sensitive versus nonsensitive subjects." Experimental Lung Research **33**(3-4): 115-33.

Allen, R. W., T. Mar, et al. (2008). "Changes in lung function and airway inflammation among asthmatic children residing in a woodsmoke-impacted urban area." Inhalation Toxicology **20**(4): 423-33.

Analitis, A., K. Katsouyanni, et al. (2006). "Short-term effects of ambient particles on cardiovascular and respiratory mortality." Epidemiology **17**(2): 230-3.

Andersen, Z. J., P. Wahlin, et al. (2007). "Ambient particle source apportionment and daily hospital admissions among children and elderly in Copenhagen." Journal of Exposure Science & Environmental Epidemiology **17**(7): 625-36.

Anderson, H. R., R. W. Atkinson, et al. (2005). "Ambient particulate matter and health effects: publication bias in studies of short-term associations." Epidemiology **16**(2): 155-63.

Annesi-Maesano, I. and W. Dab (2006). "[Air pollution and the lung: epidemiological approach]." M S-Medecine Sciences **22**(6-7): 589-94.

Annesi-Maesano, I., D. Moreau, et al. (2007). "Residential proximity fine particles related to allergic sensitisation and asthma in primary school children." Respiratory Medicine **101**(8): 1721-9.

Arjomandi, M., I. Schmidlin, et al. (2005). "Sputum induction and bronchoscopy for assessment of ozone-induced airway inflammation in asthma." Chest **128**(1): 416-23.

Arjomandi, M., A. Witten, et al. (2005). "Repeated exposure to ozone increases alveolar macrophage recruitment into asthmatic airways." American Journal of Respiratory and Critical Care Medicine **172**(4): 427-32.

Arrieta, D. E., C. C. Ontiveros, et al. (2003). "Aryl hydrocarbon receptor-mediated activity of particulate organic matter from the Paso del Norte airshed along the U.S.-Mexico border." Environmental Health Perspectives **111**(10): 1299-305.

Atlas, M. (2003). "PER pressure: New Jersey's "Population Emissions Ratio" environmental equity screening model." Risk Analysis **23**(1): 69-79.

Aufderheide, M., J. W. Knebel, et al. (2003). "Novel approaches for studying pulmonary toxicity in vitro." Toxicology Letters **140-141**: 205-11.

Aunan, K. and X.-C. Pan (2004). "Exposure-response functions for health effects of ambient air pollution applicable for China -- a meta-analysis." Science of the Total Environment **329**(1-3): 3-16.

Avogbe, P. H., L. Ayi-Fanou, et al. (2005). "Ultrafine particulate matter and high-level benzene urban air pollution in relation to oxidative DNA damage." Carcinogenesis **26**(3): 613-20.

Ayyagari, V. N., A. Januszkiewicz, et al. (2004). "Pro-inflammatory responses of human bronchial epithelial cells to acute nitrogen dioxide exposure." Toxicology **197**(2): 149-64.

Ayyagari, V. N., A. Januszkiewicz, et al. (2007). "Effects of nitrogen dioxide on the expression of intercellular adhesion molecule-1, neutrophil adhesion, and cytotoxicity: studies in human bronchial epithelial cells." Inhalation Toxicology **19**(2): 181-94.

Baan, R. A. (2007). "Carcinogenic hazards from inhaled carbon black, titanium dioxide, and talc not containing asbestos or asbestiform fibers: recent evaluations by an IARC Monographs Working Group." Inhalation Toxicology **19 Suppl 1**: 213-28.

Baccarelli, A., P. A. Cassano, et al. (2008). "Cardiac autonomic dysfunction: effects from particulate air pollution and protection by dietary methyl nutrients and metabolic polymorphisms." Circulation **117**(14): 1802-9.

Baccarelli, A., A. Zanobetti, et al. (2007). "Effects of exposure to air pollution on blood coagulation.[see comment]." Journal of Thrombosis & Haemostasis **5**(2): 252-60.

Baccini, M., A. Biggeri, et al. (2006). "Comparison of alternative modelling techniques in estimating short-term effect of air pollution with application to the Italian meta-analysis data (MISA Study)." Epidemiologia e Prevenzione **30**(4-5): 279-88.

Baeza, A. and F. Marano (2007). "[Air pollution and respiratory diseases: a central role for oxidative stress]." M S-Medecine Sciences **23**(5): 497-501.

Bakke, J. V., B. E. Moen, et al. (2007). "Gender and the physical and psychosocial work environments are related to indoor air symptoms." Journal of Occupational and Environmental Medicine **49**(6): 641-50.

Ballester, F., P. Rodriguez, et al. (2006). "Air pollution and cardiovascular admissions association in Spain: results within the EMECAS project." Journal of Epidemiology & Community Health **60**(4): 328-36.

Basu, R., T. J. Woodruff, et al. (2004). "Comparing exposure metrics in the relationship between PM2.5 and birth weight in California." Journal of Exposure Analysis and Environmental Epidemiology **14**(5): 391-6.

Bates, D. V. (2006). "Ozone--42 years later." Canadian Respiratory Journal **13**(5): 261-5.

Bateson, T. F. and J. Schwartz (2004). "Who is sensitive to the effects of particulate air pollution on mortality? A case-crossover analysis of effect modifiers.[see comment]." Epidemiology **15**(2): 143-9.

Bayer-Oglesby, L., L. Grize, et al. (2005). "Decline of ambient air pollution levels and improved respiratory health in Swiss children." Environmental Health Perspectives **113**(11): 1632-7.

Beelen, R., G. Hoek, et al. (2008). "Long-term effects of traffic-related air pollution on mortality in a Dutch cohort (NLCS-AIR study)." Environmental Health Perspectives **116**(2): 196-202.

Bell, M. L. (2006). "The use of ambient air quality modeling to estimate individual and population exposure for human health research: a case study of ozone in the Northern Georgia Region of the United States." Environment International **32**(5): 586-93.

Bell, M. L., D. L. Davis, et al. (2006). "The avoidable health effects of air pollution in three Latin American cities: Santiago, Sao Paulo, and Mexico City." Environmental Research **100**(3): 431-40.

Bell, M. L. and F. Dominici (2008). "Effect modification by community characteristics on the short-term effects of ozone exposure and mortality in 98 US communities." American Journal of Epidemiology **167**(8): 986-97.

Bell, M. L., F. Dominici, et al. (2005). "A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study.[see comment]." Epidemiology **16**(4): 436-45.

Bell, M. L., K. Ebisu, et al. (2007). "Ambient air pollution and low birth weight in Connecticut and Massachusetts." Environmental Health Perspectives **115**(7): 1118-24.

Bell, M. L., K. Ebisu, et al. (2007). "Ambient air pollution and low birth weight in Connecticut and Massachusetts." Environmental Health Perspectives **115**(7): 1118-24.

Bell, M. L., B. F. Hobbs, et al. (2005). "Metrics matter: conflicting air quality rankings from different indices of air pollution." Journal of the Air and Waste Management Association **55**(1): 97-106.

Bell, M. L., J. Y. Kim, et al. (2007). "Potential confounding of particulate matter on the short-term association between ozone and mortality in multisite time-series studies." Environmental Health Perspectives **115**(11): 1591-5.

Bell, M. L., R. D. Peng, et al. (2006). "The exposure-response curve for ozone and risk of mortality and the adequacy of current ozone regulations." Environmental Health Perspectives **114**(4): 532-6.

Bennett, W. D., M. J. Hazucha, et al. (2007). "Acute pulmonary function response to ozone in young adults as a function of body mass index." Inhalation Toxicology **19**(14): 1147-54.

Berger, A., W. Zareba, et al. (2006). "Runs of ventricular and supraventricular tachycardia triggered by air pollution in patients with coronary heart disease." Journal of Occupational & Environmental Medicine **48**(11): 1149-58.

Bernstein, J. A., N. Alexis, et al. (2004). "Health effects of air pollution." Journal of Allergy and Clinical Immunology **114**(5): 1116-23.

Biggeri, A., M. Baccini, et al. (2005). "Meta-analysis of the Italian studies of short-term effects of air pollution (MISA), 1990-1999." International Journal of Occupational and Environmental Health **11**(1): 107-22.

Billet, S., G. Garcon, et al. (2007). "Ambient particulate matter (PM2.5): physicochemical characterization and metabolic activation of the organic fraction in human lung epithelial cells (A549)." Environmental Research **105**(2): 212-23.

Binkova, B., I. Chvatalova, et al. (2007). "PAH-DNA adducts in environmentally exposed population in relation to metabolic and DNA repair gene polymorphisms." Mutation Research **620**(1-2): 49-61.

Blomberg, A., I. Mudway, et al. (2003). "Clara cell protein as a biomarker for ozone-induced lung injury in humans." European Respiratory Journal **22**(6): 883-8.

Boldo, E., S. Medina, et al. (2006). "Apheis: Health impact assessment of long-term exposure to PM(2.5) in 23 European cities." European Journal of Epidemiology **21**(6): 449-58.

Bonay, M. and M. Aubier (2007). "[Air pollution and allergic airway diseases]." M S-Medecine Sciences **23**(2): 187-92.

Bonde, J. P. (2007). "Ozone and semen quality.[comment]." Environmental Health Perspectives **115**(4): A185; author reply A185-6.

Bosson, J., J. Pourazar, et al. (2007). "Ozone enhances the airway inflammation initiated by diesel exhaust." Respiratory Medicine **101**(6): 1140-6.

Bosson, J., N. Stenfors, et al. (2003). "Ozone-induced bronchial epithelial cytokine expression differs between healthy and asthmatic subjects." Clinical and Experimental Allergy **33**(6): 777-82.

Bothwell, J. E., L. McManus, et al. (2003). "Home heating and respiratory symptoms among children in Belfast, Northern Ireland." Archives of Environmental Health **58**(9): 549-53.

Brauer, M., U. Gehring, et al. (2006). "Traffic-related air pollution and otitis media." Environmental Health Perspectives **114**(9): 1414-8.

Brauer, M., G. Hoek, et al. (2007). "Air pollution and development of asthma, allergy and infections in a birth cohort.[see comment]." European Respiratory Journal **29**(5): 879-88.

Brauer, M., G. Hoek, et al. (2003). "Estimating long-term average particulate air pollution concentrations: application of traffic indicators and geographic information systems." Epidemiology **14**(2): 228-39.

Brauner, E. V., L. Forchhammer, et al. (2007). "Exposure to ultrafine particles from ambient air and oxidative stress-induced DNA damage." Environmental Health Perspectives **115**(8): 1177-82.

Brits, E., G. Schoeters, et al. (2004). "Genotoxicity of PM10 and extracted organics collected in an industrial, urban and rural area in Flanders, Belgium." Environmental Research **96**(2): 109-18.

Brook, R. D., M. S. O'Neill, et al. (2006). "Letter by Brook et al regarding article "Diesel exhaust inhalation causes vascular dysfunction and impaired endogenous fibrinolysis".[comment]." Circulation **113**(24): e871; author reply e872.

Brunekreef, B. and B. Forsberg (2005). "Epidemiological evidence of effects of coarse airborne particles on health.[see comment]." European Respiratory Journal **26**(2): 309-18.

Bull, K., M. Johansson, et al. (2008). "Impacts of the Convention on Long-range Transboundary Air Pollution on air quality in Europe." Journal of Toxicology & Environmental Health Part A **71**(1): 51-5.

Burnett, R. T., D. Stieb, et al. (2004). "Associations between short-term changes in nitrogen dioxide and mortality in Canadian cities." Archives of Environmental Health **59**(5): 228-36.

Burr, M. L., G. Karani, et al. (2004). "Effects on respiratory health of a reduction in air pollution from vehicle exhaust emissions." Occupational and Environmental Medicine **61**(3): 212-8.

Cakmak, S., R. E. Dales, et al. (2006). "Respiratory health effects of air pollution gases: modification by education and income." Archives of Environmental & Occupational Health **61**(1): 5-10.

Cakmak, S., R. E. Dales, et al. (2007). "Air pollution and mortality in Chile: susceptibility among the elderly." Environmental Health Perspectives **115**(4): 524-7.

Calderon-Garciduenas, L., A. Mora-Tiscareno, et al. (2006). "Lung radiology and pulmonary function of children chronically exposed to air pollution." Environmental Health Perspectives **114**(9): 1432-7.

Calderon-Garciduenas, L., R. Vincent, et al. (2007). "Elevated plasma endothelin-1 and pulmonary arterial pressure in children exposed to air pollution." Environmental Health Perspectives **115**(8): 1248-53.

Cancado, J. E. D., A. Braga, et al. (2006). "[Clinical repercussions of exposure to atmospheric pollution]." Jornal Brasileiro De Pneumologia: Publicacao Oficial Da Sociedade Brasileira De Pneumologia E Tisilogia **32 Suppl 2**: S5-11.

Cancado, J. E. D., P. H. N. Saldiva, et al. (2006). "The impact of sugar cane-burning emissions on the respiratory system of children and the elderly." Environmental Health Perspectives **114**(5): 725-9.

Carlsten, C., J. D. Kaufman, et al. (2007). "Coagulation markers in healthy human subjects exposed to diesel exhaust." Thrombosis Research **120**(6): 849-55.

Chahine, T., A. Baccarelli, et al. (2007). "Particulate air pollution, oxidative stress genes, and heart rate variability in an elderly cohort.[see comment]." Environmental Health Perspectives **115**(11): 1617-22.

Chan, C.-C., K.-J. Chuang, et al. (2006). "Urban air pollution and emergency admissions for cerebrovascular diseases in Taipei, Taiwan." European Heart Journal **27**(10): 1238-44.

Chan, C.-C., K.-J. Chuang, et al. (2005). "Association between nitrogen dioxide and heart rate variability in a susceptible population." European Journal of Cardiovascular Prevention & Rehabilitation **12**(6): 580-6.

Chan, C.-C. and T.-H. Wu (2005). "Effects of ambient ozone exposure on mail carriers' peak expiratory flow rates." Environmental Health Perspectives **113**(6): 735-8.

Chang, L.-T., P. Koutrakis, et al. (2003). "Assessing the importance of different exposure metrics and time-activity data to predict 24-H personal PM2.5 exposures." Journal of Toxicology & Environmental Health Part A **66**(16-19): 1825-46.

Chang, L.-T., C.-S. Tang, et al. (2007). "Association of heart rate variability of the elderly with personal exposure to PM 1, PM 1-2.5, and PM 2.5-10." Bulletin of Environmental Contamination and Toxicology **79**(5): 552-6.

Chardon, B., A. Lefranc, et al. (2007). "Air pollution and doctors' house calls for respiratory diseases in the Greater Paris area (2000-3)." Occupational & Environmental Medicine **64**(5): 320-4.

Chattopadhyay, B. P., A. Mukherjee, et al. (2007). "Exposure to vehicular pollution and assessment of respiratory function in urban inhabitants." Lung **185**(5): 263-70.

Chauhan, A. J., H. M. Inskip, et al. (2003). "Personal exposure to nitrogen dioxide (NO2) and the severity of virus-induced asthma in children." Lancet **361**(9373): 1939-44.

Chen, C., M. Arjomandi, et al. (2007). "Effects of chronic and acute ozone exposure on lipid peroxidation and antioxidant capacity in healthy young adults." Environmental Health Perspectives **115**(12): 1732-7.

Chen, G., G. Song, et al. (2008). "Short-term effects of ambient gaseous pollutants and particulate matter on daily mortality in Shanghai, China." Journal of Occupational Health **50**(1): 41-7.

Chen, J.-C., P. H. Stone, et al. (2006). "Personal coronary risk profiles modify autonomic nervous system responses to air pollution." Journal of Occupational and Environmental Medicine **48**(11): 1133-42.

Chen, L., K. Mengersen, et al. (2007). "Spatiotemporal relationship between particle air pollution and respiratory emergency hospital admissions in Brisbane, Australia." Science of the Total Environment **373**(1): 57-67.

Chen, L., K. Verrall, et al. (2006). "Air particulate pollution due to bushfires and respiratory hospital admissions in Brisbane, Australia." International Journal of Environmental Health Research **16**(3): 181-91.

Chen, L. H., S. F. Knutsen, et al. (2005). "The association between fatal coronary heart disease and ambient particulate air pollution: Are females at greater risk?[erratum appears in Environ Health Perspect. 2006 Jan;114(1):A21]." Environmental Health Perspectives **113**(12): 1723-9.

Chen, T.-M., J. Gokhale, et al. (2007). "Outdoor air pollution: nitrogen dioxide, sulfur dioxide, and carbon monoxide health effects." American Journal of the Medical Sciences **333**(4): 249-56.

Chen, T.-M., J. Gokhale, et al. (2007). "Outdoor air pollution: nitrogen dioxide, sulfur dioxide, and carbon monoxide health effects." American Journal of the Medical Sciences **333**(4): 249-56.

Chen, T.-M., J. Gokhale, et al. (2007). "Outdoor air pollution: ozone health effects." American Journal of the Medical Sciences **333**(4): 244-8.

Chen, Y., Q. Yang, et al. (2004). "Influence of relatively low level of particulate ar pollution on hospitalization for COPD in elderly people." Inhalation Toxicology **16**(1): 21-5.

Cheng, M.-F., S.-S. Tsai, et al. (2007). "Air pollution and hospital admissions for pneumonia in a tropical city: Kaohsiung, Taiwan." Journal of Toxicology & Environmental Health Part A **70**(24): 2021-6.

Cheng, T.-J., H.-P. Kao, et al. (2003). "Effects of ozone on DNA single-strand breaks and 8-oxoguanine formation in A549 cells." Environmental Research **93**(3): 279-84.

Chimonas, M.-A. R. and B. D. Gessner (2007). "Airborne particulate matter from primarily geologic, non-industrial sources at levels below National Ambient Air Quality Standards is associated with outpatient visits for asthma and quick-relief medication prescriptions among children less than 20 years old enrolled in Medicaid in Anchorage, Alaska." Environmental Research **103**(3): 397-404.

Chuang, K.-J., C.-C. Chan, et al. (2005). "Effects of particle size fractions on reducing heart rate variability in cardiac and hypertensive patients." Environmental Health Perspectives **113**(12): 1693-7.

Chuang, K.-J., C.-C. Chan, et al. (2005). "Associations between submicrometer particles exposures and blood pressure and heart rate in patients with lung function impairments." Journal of Occupational and Environmental Medicine **47**(11): 1093-8.

Chuang, K.-J., C.-C. Chan, et al. (2007). "Associations between particulate sulfate and organic carbon exposures and heart rate variability in patients with or at risk for cardiovascular diseases." Journal of Occupational and Environmental Medicine **49**(6): 610-7.

Cross, C. E., V. T. Vasu, et al. (2006). "Combating oxidative stress at respiratory tract biosurfaces: challenges yet to be resolved, a commentary on "Vitamin supplementation does not protect against symptoms in ozone-responsive subjects".[comment]." Free Radical Biology and Medicine **40**(10): 1693-7.

Cuesta, N., A. Martinez, et al. (2005). "Identification of adrenomedullin in avian type II pneumocytes: increased expression after exposure to air pollutants." Journal of Histochemistry and Cytochemistry **53**(6): 773-80.

Dales, R., R. T. Burnett, et al. (2004). "Air pollution and sudden infant death syndrome." Pediatrics **113**(6): e628-31.

Dales, R. E., S. Cakmak, et al. (2006). "Gaseous air pollutants and hospitalization for respiratory disease in the neonatal period." Environmental Health Perspectives **114**(11): 1751-4.

Dales, R. E., S. Cakmak, et al. (2006). "Gaseous air pollutants and hospitalization for respiratory disease in the neonatal period." Environmental Health Perspectives **114**(11): 1751-4.

Daniels, M. J., F. Dominici, et al. (2004). "The National Morbidity, Mortality, and Air Pollution Study. Part III: PM10 concentration-response curves and thresholds for the 20 largest US cities." Research Report - Health Effects Institute(94 Pt 3): 1-21; discussion 23-30.

David, G. L., I. Romieu, et al. (2003). "Nicotinamide adenine dinucleotide (phosphate) reduced:quinone oxidoreductase and glutathione S-transferase M1 polymorphisms and childhood asthma." American Journal of Respiratory and Critical Care Medicine **168**(10): 1199-204.

Davidson, K., A. Hallberg, et al. (2007). "Analysis of PM2.5 using the Environmental Benefits Mapping and Analysis Program (BenMAP)." Journal of Toxicology & Environmental Health Part A **70**(3-4): 332-46.

Davila, I., J. Mullol, et al. (2007). "Effect of pollutants upon patients with respiratory allergies." Journal of Investigational Allergology and Clinical Immunology **17 Suppl 2**: 9-20.

Davis, M. E., T. J. Smith, et al. (2007). "Driver exposure to combustion particles in the U.S. Trucking industry." Journal of Occupational & Environmental Hygiene **4**(11): 848-54.

de Hartog, J. J., G. Hoek, et al. (2003). "Effects of fine and ultrafine particles on cardiorespiratory symptoms in elderly subjects with coronary heart disease: the ULTRA study." American Journal of Epidemiology **157**(7): 613-23.

de Kluizenaar, Y., R. T. Gansevoort, et al. (2007). "Hypertension and road traffic noise exposure." Journal of Occupational and Environmental Medicine **49**(5): 484-92.

Delfino, R. J., H. Gong, Jr., et al. (2003). "Asthma symptoms in Hispanic children and daily ambient exposures to toxic and criteria air pollutants." Environmental Health Perspectives **111**(4): 647-56.

Delfino, R. J., P. J. E. Quintana, et al. (2004). "Association of FEV1 in asthmatic children with personal and microenvironmental exposure to airborne particulate matter." Environmental Health Perspectives **112**(8): 932-41.

Diette, G. B., N. N. Hansel, et al. (2007). "Home indoor pollutant exposures among inner-city children with and without asthma." Environmental Health Perspectives **115**(11): 1665-9.

Diez Roux, A. V., A. H. Auchincloss, et al. (2006). "Recent exposure to particulate matter and C-reactive protein concentration in the multi-ethnic study of atherosclerosis." American Journal of Epidemiology **164**(5): 437-48.

Dockery, D. W., H. Luttmann-Gibson, et al. (2005). "Particulate air pollution and nonfatal cardiac events. Part II. Association of air pollution with confirmed arrhythmias recorded by implanted defibrillators." Research Report - Health Effects Institute(124): 83-126; discussion 127-48.

Dokic, D. and H. P. Howarth (2006). "Effects of ozone on the nasal mucosa (epithelial cells)." Makedonska Akademija na Naukite i Umetnostite Oddelenie Za Bioloshki i Meditsinski Nauki Prilozi **27**(2): 115-25.

Dominici, F., A. McDermott, et al. (2005). "Revised analyses of the National Morbidity, Mortality, and Air Pollution Study: mortality among residents of 90 cities." Journal of Toxicology & Environmental Health Part A **68**(13-14): 1071-92.

Dominici, F., A. McDermott, et al. (2003). "National maps of the effects of particulate matter on mortality: exploring geographical variation." Environmental Health Perspectives **111**(1): 39-44.

Dominici, F., R. D. Peng, et al. (2006). "Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases.[see comment]." JAMA **295**(10): 1127-34.

Dominici, F., R. D. Peng, et al. (2007). "Does the effect of PM10 on mortality depend on PM nickel and vanadium content? A reanalysis of the NMMAPS data.[comment]." Environmental Health Perspectives **115**(12): 1701-3.

Dominici, F., A. Zanobetti, et al. (2004). "Hierarchical bivariate time series models: a combined analysis of the effects of particulate matter on morbidity and mortality." Biostatistics **5**(3): 341-60.

Donnay, A. (2004). "Ozone and asthma.[comment]." JAMA **291**(4): 423; author reply 423-4.

Doyle, M., K. G. Sexton, et al. (2007). "Atmospheric photochemical transformations enhance 1,3-butadiene-induced inflammatory responses in human epithelial cells: The role of ozone and other photochemical degradation products." Chemico-Biological Interactions **166**(1-3): 163-9.

Dubnov, J., M. Barchana, et al. (2007). "Estimating the effect of air pollution from a coal-fired power station on the development of children's pulmonary function." Environmental Research **103**(1): 87-98.

Dubowsky, S. D., H. Suh, et al. (2006). "Diabetes, obesity, and hypertension may enhance associations between air pollution and markers of systemic inflammation." Environmental Health Perspectives **114**(7): 992-8.

Dugandzic, R., L. Dodds, et al. (2006). "The association between low level exposures to ambient air pollution and term low birth weight: a retrospective cohort study." Environmental Health: A Global Access Science Source **5**: 3.

Ebelt, S. T., W. E. Wilson, et al. (2005). "Exposure to ambient and nonambient components of particulate matter: a comparison of health effects." Epidemiology **16**(3): 396-405.

Editors and Editors (2005). "On health effects of ozone exposure and exposing the epidemiologic process.[comment]." Epidemiology **16**(4): 425-6.

Eiswerth, M. E., W. Douglass Shaw, et al. (2005). "Impacts of ozone on the activities of asthmatics: revisiting the data." Journal of Environmental Management **77**(1): 56-63.

English, J. S. C., R. S. Dawe, et al. (2003). "Environmental effects and skin disease." British Medical Bulletin **68**: 129-42.

Eninger, R. M. and F. S. Rosenthal (2004). "Heart rate variability and particulate exposure in vehicle maintenance workers: a pilot study." Journal of Occupational & Environmental Hygiene **1**(8): 493-9.

Erbas, B., A.-M. Kelly, et al. (2005). "Air pollution and childhood asthma emergency hospital admissions: estimating intra-city regional variations." International Journal of Environmental Health Research **15**(1): 11-20.

Farhat, S. C. L., R. L. P. Paulo, et al. (2005). "Effect of air pollution on pediatric respiratory emergency room visits and hospital admissions." Brazilian Journal of Medical and Biological Research **38**(2): 227-35.

Fiedler, N., K. Kelly-McNeil, et al. (2008). "Negative affect and chemical intolerance as risk factors for building-related symptoms: a controlled exposure study." Psychosomatic Medicine **70**(2): 254-62.

Fiedler, N., R. Laumbach, et al. (2005). "Health effects of a mixture of indoor air volatile organics, their ozone oxidation products, and stress." Environmental Health Perspectives **113**(11): 1542-8.

Fischer, P., G. Hoek, et al. (2003). "Air pollution and mortality in The Netherlands: are the elderly more at risk?" European Respiratory Journal - Supplement **40**: 34s-38s.

Florida-James, G., K. Donaldson, et al. (2004). "Athens 2004: the pollution climate and athletic performance." Journal of Sports Sciences **22**(10): 967-80; discussion 980.

Forastiere, F., M. Stafoggia, et al. (2007). "Socioeconomic status, particulate air pollution, and daily mortality: differential exposure or differential susceptibility." American Journal of Industrial Medicine **50**(3): 208-16.

Fortoul, T. I., M. Valverde, et al. (2003). "Single-cell gel electrophoresis assay of nasal epithelium and leukocytes from asthmatic and nonasthmatic subjects in Mexico City." Archives of Environmental Health **58**(6): 348-52.

Foucaud, L., A. Bennasroune, et al. (2006). "Oxidative stress induction by short time exposure to ozone on THP-1 cells." Toxicology in Vitro **20**(1): 101-8.

Frampton, M. W. (2007). "Does inhalation of ultrafine particles cause pulmonary vascular effects in humans?" Inhalation Toxicology **19 Suppl 1**: 75-9.

Frampton, M. W., J. C. Stewart, et al. (2006). "Inhalation of ultrafine particles alters blood leukocyte expression of adhesion molecules in humans." Environmental Health Perspectives **114**(1): 51-8.

Franklin, M., A. Zeka, et al. (2007). "Association between PM2.5 and all-cause and specific-cause mortality in 27 US communities." Journal of Exposure Science & Environmental Epidemiology **17**(3): 279-87.

Freitas, C., S. A. Bremner, et al. (2004). "[Hospital admissions and mortality: association with air pollution in Sao Paulo, Brazil, 1993 to 1997]." Revista de Saude Publica **38**(6): 751-7.

Gabelova, A., Z. Valovicova, et al. (2007). "Sensitivity of different endpoints for in vitro measurement of genotoxicity of extractable organic matter associated with ambient airborne particles (PM10)." Mutation Research **620**(1-2): 103-13.

Galan, I., A. Tobias, et al. (2003). "Short-term effects of air pollution on daily asthma emergency room admissions." European Respiratory Journal **22**(5): 802-8.

Galan, I., A. Tobias, et al. (2003). "Short-term effects of air pollution on daily asthma emergency room admissions." European Respiratory Journal **22**(5): 802-8.

Gauderman, W. J., E. Avol, et al. (2004). "The effect of air pollution on lung development from 10 to 18 years of age.[see comment][erratum appears in N Engl J Med. 2005 Mar 24;352(12):1276]." New England Journal of Medicine **351**(11): 1057-67.

Gehring, U., J. Heinrich, et al. (2006). "Long-term exposure to ambient air pollution and cardiopulmonary mortality in women." Epidemiology **17**(5): 545-51.

Gent, J. F., E. W. Triche, et al. (2003). "Association of low-level ozone and fine particles with respiratory symptoms in children with asthma.[see comment]." JAMA **290**(14): 1859-67.

Gil, L., V. Martinez, et al. (2003). "Occupational and environmental levels of mutagenic PAHs and respirable particulate matter associated with diesel exhaust in Santiago, Chile." Journal of Occupational and Environmental Medicine **45**(9): 984-92.

Gilboa, S. M., P. Mendola, et al. (2005). "Relation between ambient air quality and selected birth defects, seven county study, Texas, 1997-2000." American Journal of Epidemiology **162**(3): 238-52.

Gilboa, S. M., P. Mendola, et al. (2005). "Relation between ambient air quality and selected birth defects, seven county study, Texas, 1997-2000." American Journal of Epidemiology **162**(3): 238-52.

Glorennec, P. and F. Monroux (2007). "Health impact assessment of PM10 exposure in the city of Caen, France." Journal of Toxicology & Environmental Health Part A **70**(3-4): 359-64.

Goldston, D. (2008). "Hazy reasoning behind clean air." Nature **452**(7187): 519.

Gong, H., Jr., W. S. Linn, et al. (2005). "Respiratory responses to exposures with fine particulates and nitrogen dioxide in the elderly with and without COPD." Inhalation Toxicology **17**(3): 123-32.

Gong, H., Jr., C. Sioutas, et al. (2003). "Controlled exposures of healthy and asthmatic volunteers to concentrated ambient particles in metropolitan Los Angeles." Research Report - Health Effects Institute(118): 1-36; discussion 37-47.

Gonzales, M., L. Ngo, et al. (2003). "Validation of a questionnaire and microenvironmental model for estimating past exposures to ozone." International Journal of Environmental Health Research **13**(3): 249-60.

Goodman, S. N. (2005). "The methodologic ozone effect.[see comment]." Epidemiology **16**(4): 430-5.

Goss, C. H., S. A. Newsom, et al. (2004). "Effect of ambient air pollution on pulmonary exacerbations and lung function in cystic fibrosis." American Journal of Respiratory and Critical Care Medicine **169**(7): 816-21.

Graham, L. M. (2004). "All I need is the air that I breath: outdoor air quality and asthma." Paediatric Respiratory Reviews **5 Suppl A**: S59-64.

Greene, N. A. and V. R. Morris (2006). "Assessment of public health risks associated with atmospheric exposure to PM2.5 in Washington, DC, USA." International Journal of Environmental Research & Public Health [Electronic Resource] **3**(1): 86-97.

Gryparis, A., B. Forsberg, et al. (2004). "Acute effects of ozone on mortality from the "air pollution and health: a European approach" project." American Journal of Respiratory and Critical Care Medicine **170**(10): 1080-7.

Ha, E.-H., J.-T. Lee, et al. (2003). "Infant susceptibility of mortality to air pollution in Seoul, South Korea." Pediatrics **111**(2): 284-90.

Han, X., M. Aguilar-Villalobos, et al. (2005). "Traffic-related occupational exposures to PM2.5, CO, and VOCs in Trujillo, Peru." International Journal of Occupational and Environmental Health **11**(3): 276-88.

Hanninen, O., H. Kruize, et al. (2003). "EXPOLIS simulation model: PM2.5 application and comparison with measurements in Helsinki." Journal of Exposure Analysis and Environmental Epidemiology **13**(1): 74-85.

Hanninen, O. O., J. T. Tuomisto, et al. (2005). "Characterization of model error in a simulation of fine particulate matter exposure distributions of the working age population in Helsinki, Finland." Journal of the Air and Waste Management Association **55**(4): 446-57.

Hansen, C., A. Neller, et al. (2006). "Maternal exposure to low levels of ambient air pollution and preterm birth in Brisbane, Australia." BJOG: An International Journal of Obstetrics & Gynaecology **113**(8): 935-41.

Hansen, C., A. Neller, et al. (2007). "Low levels of ambient air pollution during pregnancy and fetal growth among term neonates in Brisbane, Australia." Environmental Research **103**(3): 383-9.

Hansen, C. A., A. G. Barnett, et al. (2008). "The effect of ambient air pollution during early pregnancy on fetal ultrasonic measurements during mid-pregnancy." Environmental Health Perspectives **116**(3): 362-9.

Harrison, R. M., D. J. T. Smith, et al. (2004). "What is responsible for the carcinogenicity of PM2.5?[see comment]." Occupational and Environmental Medicine **61**(10): 799-805.

Hart, J. E., F. Laden, et al. (2006). "Chronic obstructive pulmonary disease mortality in diesel-exposed railroad workers." Environmental Health Perspectives **114**(7): 1013-7.

Haynes, R. and A. Savage (2007). "Assessment of the health impacts of particulates from the redevelopment of Kings Cross." Environmental Monitoring & Assessment **130**(1-3): 47-56.

Hazucha, M. J., L. J. Folinsbee, et al. (2003). "Distribution and reproducibility of spirometric response to ozone by gender and age." Journal of Applied Physiology **95**(5): 1917-25.

Heinrich, J., R. Topp, et al. (2005). "Traffic at residential address, respiratory health, and atopy in adults: the National German Health Survey 1998." Environmental Research **98**(2): 240-9.

Helleday, R., B. Segerstedt, et al. (2006). "Exploring the time dependence of serum clara cell protein as a biomarker of pulmonary injury in humans." Chest **130**(3): 672-5.

Henneberger, A., W. Zareba, et al. (2005). "Repolarization changes induced by air pollution in ischemic heart disease patients." Environmental Health Perspectives **113**(4): 440-6.

Henrotin, J. B., J. P. Besancenot, et al. (2007). "Short-term effects of ozone air pollution on ischaemic stroke occurrence: a case-crossover analysis from a 10-year

population-based study in Dijon, France." Occupational & Environmental Medicine **64**(7): 439-45.

Henrotin, J. B., J. P. Besancenot, et al. (2007). "Short-term effects of ozone air pollution on ischaemic stroke occurrence: a case-crossover analysis from a 10-year population-based study in Dijon, France." Occupational & Environmental Medicine **64**(7): 439-45.

Hermann, R. P., F. Divita, Jr., et al. (2004). "Predicting premature mortality from new power plant development in Virginia.[see comment]." Archives of Environmental Health **59**(10): 529-35.

Hermans, C., V. Deneys, et al. (2005). "Effects of ambient ozone on the procoagulant status and systemic inflammatory response." Journal of Thrombosis & Haemostasis **3**(9): 2102-3.

Hinwood, A. L., N. De Klerk, et al. (2006). "The relationship between changes in daily air pollution and hospitalizations in Perth, Australia 1992-1998: a case-crossover study." International Journal of Environmental Health Research **16**(1): 27-46.

Hoffman, C. D., P. K. Henneberger, et al. (2004). "Exposure to ozone gases in pulp mills and the onset of rhinitis." Scandinavian Journal of Work, Environment and Health **30**(6): 445-9.

Hogervorst, J. G. F., T. M. C. M. de Kok, et al. (2006). "Relationship between radical generation by urban ambient particulate matter and pulmonary function of school children.[see comment][reprint in Ned Tijdschr Geneeskd. 2006 Apr 1;150(13):735-40; PMID: 16623348]." Journal of Toxicology & Environmental Health Part A **69**(3-4): 245-62.

Holgate, S. T., R. B. Devlin, et al. (2003). "Health effects of acute exposure to air pollution. Part II: Healthy subjects exposed to concentrated ambient particles." Research Report - Health Effects Institute(112): 31-50; discussion 51-67.

Holgate, S. T., T. Sandstrom, et al. (2003). "Health effects of acute exposure to air pollution. Part I: Healthy and asthmatic subjects exposed to diesel exhaust." Research Report - Health Effects Institute(112): 1-30; discussion 51-67.

Holguin, F., S. Flores, et al. (2007). "Traffic-related exposures, airway function, inflammation, and respiratory symptoms in children." American Journal of Respiratory and Critical Care Medicine **176**(12): 1236-42.

Holguin, F., M. M. Tellez-Rojo, et al. (2003). "Air pollution and heart rate variability among the elderly in Mexico City." Epidemiology **14**(5): 521-7.

Holguin, F., M. M. Tellez-Rojo, et al. (2003). "Air pollution and heart rate variability among the elderly in Mexico City." Epidemiology **14**(5): 521-7.

Hollingsworth, J. W., S. R. Kleeberger, et al. (2007). "Ozone and pulmonary innate immunity." Proceedings of the American Thoracic Society **4**(3): 240-6.

Holloman, C. H., S. M. Bortnick, et al. (2004). "A Bayesian hierarchical approach for relating PM(2.5) exposure to cardiovascular mortality in North Carolina." Environmental Health Perspectives **112**(13): 1282-8.

Hopke, P. K., K. Ito, et al. (2006). "PM source apportionment and health effects: 1. Intercomparison of source apportionment results." Journal of Exposure Science & Environmental Epidemiology **16**(3): 275-86.

Hosseinpoor, A. R., M. H. Forouzanfar, et al. (2005). "Air pollution and hospitalization due to angina pectoris in Tehran, Iran: a time-series study." Environmental Research **99**(1): 126-31.

Hu, S.-W., Y.-Y. Lin, et al. (2006). "Workplace air quality and lung function among dental laboratory technicians." American Journal of Industrial Medicine **49**(2): 85-92.

Hu, Y., Z. Bai, et al. (2007). "Health risk assessment for traffic policemen exposed to polycyclic aromatic hydrocarbons (PAHs) in Tianjin, China." Science of the Total Environment **382**(2-3): 240-50.

Hubbell, B. J., A. Hallberg, et al. (2005). "Health-related benefits of attaining the 8-hr ozone standard." Environmental Health Perspectives **113**(1): 73-82.

Hunt, A., J. L. Abraham, et al. (2003). "Toxicologic and epidemiologic clues from the characterization of the 1952 London smog fine particulate matter in archival autopsy lung tissues.[see comment]." Environmental Health Perspectives **111**(9): 1209-14.

Huynh, M., T. J. Woodruff, et al. (2006). "Relationships between air pollution and preterm birth in California." Paediatric and Perinatal Epidemiology **20**(6): 454-61.

Hwang, B. F., Y. L. Lee, et al. (2005). "Traffic related air pollution as a determinant of asthma among Taiwanese school children." Thorax **60**(6): 467-73.

Iatsyna, I. V., T. A. Konovalova, et al. (2005). "[The epidemiology, risk factors and present-day aspects of allergic disease prevention in an industrial center]." Vestnik Rossiiskoi Akademii Meditsinskikh Nauk(3): 36-9.

Ihorst, G., T. Frischer, et al. (2004). "Long- and medium-term ozone effects on lung growth including a broad spectrum of exposure.[see comment]." European Respiratory Journal **23**(2): 292-9.

Islam, T., W. J. Gauderman, et al. (2007). "Relationship between air pollution, lung function and asthma in adolescents." Thorax **62**(11): 957-63.

Ito, K., W. F. Christensen, et al. (2006). "PM source apportionment and health effects: 2. An investigation of intermethod variability in associations between source-apportioned fine particle mass and daily mortality in Washington, DC." Journal of Exposure Science & Environmental Epidemiology **16**(4): 300-10.

Ito, K., S. Inoue, et al. (2005). "Mechanism of site-specific DNA damage induced by ozone." Mutation Research **585**(1-2): 60-70.

Iwai, K., S. Mizuno, et al. (2005). "Correlation between suspended particles in the environmental air and causes of disease among inhabitants: cross-sectional studies using the vital statistics and air pollution data in Japan." Environmental Research **99**(1): 106-17.

Janes, H., F. Dominici, et al. (2007). "Trends in air pollution and mortality: an approach to the assessment of unmeasured confounding.[see comment]." Epidemiology **18**(4): 416-23.

Jang, A. S., C. H. Yeum, et al. (2003). "Epidemiologic evidence of a relationship between airway hyperresponsiveness and exposure to polluted air." Allergy **58**(7): 585-8.
Jang, A. S., C. H. Yeum, et al. (2003). "Epidemiologic evidence of a relationship between airway hyperresponsiveness and exposure to polluted air." Allergy **58**(7): 585-8.
Janic, B., T. M. Umstead, et al. (2003). "An in vitro cell model system for the study of the effects of ozone and other gaseous agents on phagocytic cells." Journal of Immunological Methods **272**(1-2): 125-34.
Janssen, N. A. H., T. Lanki, et al. (2005). "Associations between ambient, personal, and indoor exposure to fine particulate matter constituents in Dutch and Finnish panels of cardiovascular patients." Occupational and Environmental Medicine **62**(12): 868-77.
Jardim, J. R. and O. Nascimento (2007). "Respiratory health in Brazil." Chronic Respiratory Disease **4**(1): 45-9.
Jedrychowski, W., I. Bendkowska, et al. (2004). "Estimated risk for altered fetal growth resulting from exposure to fine particles during pregnancy: an epidemiologic prospective cohort study in Poland." Environmental Health Perspectives **112**(14): 1398-402.
Jedrychowski, W., E. Masters, et al. (2007). "Pre-pregnancy dietary vitamin A intake may alleviate the adverse birth outcomes associated with prenatal pollutant exposure: epidemiologic cohort study in Poland." International Journal of Occupational and Environmental Health **13**(2): 175-80.
Jerrett, M., R. T. Burnett, et al. (2005). "Spatial analysis of air pollution and mortality in Los Angeles." Epidemiology **16**(6): 727-36.
Jiang, L.-L., Y.-H. Zhang, et al. (2007). "A time series analysis of outdoor air pollution and preterm birth in Shanghai, China." Biomedical and Environmental Sciences **20**(5): 426-31.
Johnson, P. R. S. and J. J. Graham (2006). "Analysis of primary fine particle national ambient air quality standard metrics." Journal of the Air and Waste Management Association **56**(2): 206-18.
Johnston, F. H., R. J. Webby, et al. (2006). "Vegetation fires, particulate air pollution and asthma: a panel study in the Australian monsoon tropics." International Journal of Environmental Health Research **16**(6): 391-404.
Jones, A. Y. M., P. K. W. Lam, et al. (2008). "Respiratory health of road-side vendors in a large industrialized city." Environmental Science & Pollution Research **15**(2): 150-4.
Joseph, P. M. (2007). "Paradoxical ozone associations could be due to methyl nitrite from combustion of methyl ethers or esters in engine fuels." Environment International **33**(8): 1090-106.
Kafoury, R. M. and M.-J. Huang (2005). "Application of quantitative structure activity relationship (QSAR) models to predict ozone toxicity in the lung." Environmental Toxicology **20**(4): 441-8.

Kaiser, R., I. Romieu, et al. (2004). "Air pollution attributable postneonatal infant mortality in U.S. metropolitan areas: a risk assessment study." Environmental Health: A Global Access Science Source **3**(1): 4.

Kan, H. and B. Chen (2003). "Air pollution and daily mortality in Shanghai: a time-series study." Archives of Environmental Health **58**(6): 360-7.

Kan, H., J. Jia, et al. (2004). "The association of daily diabetes mortality and outdoor air pollution in Shanghai, China." Journal of Environmental Health **67**(3): 21-6.

Kan, H., S. J. London, et al. (2007). "Differentiating the effects of fine and coarse particles on daily mortality in Shanghai, China." Environment International **33**(3): 376-84.

Kan, H.-D., B.-H. Chen, et al. (2005). "Relationship between ambient air pollution and daily mortality of SARS in Beijing." Biomedical and Environmental Sciences **18**(1): 1-4.

Karr, C. (2004). "Bronchiolitis poses significant public health burden." Pediatric Annals **33**(7): 454-9.

Karr, C., T. Lumley, et al. (2007). "Effects of subchronic and chronic exposure to ambient air pollutants on infant bronchiolitis." American Journal of Epidemiology **165**(5): 553-60.

Karthikeyan, S., R. Balasubramanian, et al. (2006). "Particulate air pollution from bushfires: human exposure and possible health effects." Journal of Toxicology & Environmental Health Part A **69**(21): 1895-908.

Katsouyanni, K. (2003). "Ambient air pollution and health." British Medical Bulletin **68**: 143-56.

Kelly, F. J. and I. S. Mudway (2003). "Protein oxidation at the air-lung interface." Amino Acids **25**(3-4): 375-96.

Kilabuko, J. H., H. Matsuki, et al. (2007). "Air quality and acute respiratory illness in biomass fuel using homes in Bagamoyo, Tanzania." International Journal of Environmental Research & Public Health [Electronic Resource] **4**(1): 39-44.

Kim, C. S. and P. A. Jaques (2005). "Total lung deposition of ultrafine particles in elderly subjects during controlled breathing." Inhalation Toxicology **17**(7-8): 387-99.

Kim, D. H., Y. S. Kim, et al. (2007). "The effects of on-site measured ozone concentration on pulmonary function and symptoms of asthmatics." Journal of Korean Medical Science **22**(1): 30-6.

Kim, H., Y. Kim, et al. (2003). "The lag-effect pattern in the relationship of particulate air pollution to daily mortality in Seoul, Korea." International Journal of Biometeorology **48**(1): 25-30.

Kim, H., J.-T. Lee, et al. (2004). "Evaluating the effect of daily PM10 variation on mortality." Inhalation Toxicology **16 Suppl 1**: 55-8.

Kim, J. J. and H. American Academy of Pediatrics Committee on Environmental (2004). "Ambient air pollution: health hazards to children." Pediatrics **114**(6): 1699-707.

Kim, J. Y., S. Mukherjee, et al. (2004). "Urinary 8-hydroxy-2'-deoxyguanosine as a biomarker of oxidative DNA damage in workers exposed to fine particulates." Environmental Health Perspectives **112**(6): 666-71.

Kim, S.-Y., J.-T. Lee, et al. (2004). "Determining the threshold effect of ozone on daily mortality: an analysis of ozone and mortality in Seoul, Korea, 1995-1999." Environmental Research **94**(2): 113-9.

Kleeberger, S. R. (2003). "Genetic aspects of susceptibility to air pollution." European Respiratory Journal - Supplement **40**: 52s-56s.

Kleis, S., R. Louis, et al. (2003). "[Ozone exposure and asthma]." Revue Medicale de Liege **58**(3): 132-8.

Klestadt, D., P. Laval-Gilly, et al. (2005). "Influences of ozone exposure upon macrophage responsivity to N-formyl-methionyl-leucyl-phenylalanine: mobility and metabolic changes." Toxicology in Vitro **19**(2): 199-206.

Knox, E. G. (2005). "Childhood cancers and atmospheric carcinogens.[see comment]." Journal of Epidemiology and Community Health **59**(2): 101-5.

Knox, E. G. (2005). "Oil combustion and childhood cancers.[see comment]." Journal of Epidemiology and Community Health **59**(9): 755-60.

Ko, F. W. S., W. Tam, et al. (2007). "Effects of air pollution on asthma hospitalization rates in different age groups in Hong Kong." Clinical and Experimental Allergy **37**(9): 1312-9.

Koenig, J. Q., K. Jansen, et al. (2003). "Measurement of offline exhaled nitric oxide in a study of community exposure to air pollution." Environmental Health Perspectives **111**(13): 1625-9.

Koenig, J. Q., T. F. Mar, et al. (2005). "Pulmonary effects of indoor- and outdoor-generated particles in children with asthma.[see comment]." Environmental Health Perspectives **113**(4): 499-503.

Kongerud, J., M. C. Madden, et al. (2006). "Nasal responses in asthmatic and nonasthmatic subjects following exposure to diesel exhaust particles." Inhalation Toxicology **18**(9): 589-94.

Kranz, B. D., D. L. Simon, et al. (2004). "The behavior and routes of lead exposure in pregrasping infants." Journal of Exposure Analysis and Environmental Epidemiology **14**(4): 300-11.

Krewski, D., R. T. Burnett, et al. (2005). "Reanalysis of the Harvard Six Cities Study, part I: validation and replication." Inhalation Toxicology **17**(7-8): 335-42.

Kruize, H., O. Hanninen, et al. (2003). "Description and demonstration of the EXPOLIS simulation model: two examples of modeling population exposure to particulate matter." Journal of Exposure Analysis and Environmental Epidemiology **13**(2): 87-99.

Krzyzanowski, M. (2008). "WHO Air Quality Guidelines for Europe." Journal of Toxicology & Environmental Health Part A **71**(1): 47-50.

Kulkarni, N., N. Pierse, et al. (2006). "Carbon in airway macrophages and lung function in children.[see comment]." New England Journal of Medicine **355**(1): 21-30.

Kumar, R., J. K. Nagar, et al. (2007). "Association of indoor and outdoor air pollutant level with respiratory problems among children in an industrial area of Delhi, India." Archives of Environmental & Occupational Health **62**(2): 75-80.

Kunzli, N., M. Jerrett, et al. (2005). "Ambient air pollution and atherosclerosis in Los Angeles." Environmental Health Perspectives **113**(2): 201-6.

Lacasana, M., A. Esplugues, et al. (2005). "Exposure to ambient air pollution and prenatal and early childhood health effects." European Journal of Epidemiology **20**(2): 183-99.

Laden, F., J. Schwartz, et al. (2006). "Reduction in fine particulate air pollution and mortality: Extended follow-up of the Harvard Six Cities study.[see comment]." American Journal of Respiratory and Critical Care Medicine **173**(6): 667-72.

Laid, Y., M. Atek, et al. (2006). "Health effects of PM10 air pollution in a low-income country: the case of Algiers." International Journal of Tuberculosis and Lung Disease **10**(12): 1406-11.

Lanki, T., J. J. de Hartog, et al. (2006). "Can we identify sources of fine particles responsible for exercise-induced ischemia on days with elevated air pollution? The ULTRA study." Environmental Health Perspectives **114**(5): 655-60.

Larini, A., L. Bianchi, et al. (2003). "The ozone tolerance: I) Enhancement of antioxidant enzymes is ozone dose-dependent in Jurkat cells." Free Radical Research **37**(11): 1163-8.

Larini, A. and V. Bocci (2005). "Effects of ozone on isolated peripheral blood mononuclear cells." Toxicology in Vitro **19**(1): 55-61.

Larrieu, S., J.-F. Jusot, et al. (2007). "Short term effects of air pollution on hospitalizations for cardiovascular diseases in eight French cities: the PSAS program." Science of the Total Environment **387**(1-3): 105-12.

Laumbach, R. J., N. Fiedler, et al. (2005). "Nasal effects of a mixture of volatile organic compounds and their ozone oxidation products." Journal of Occupational and Environmental Medicine **47**(11): 1182-9.

Lay, J. C., N. E. Alexis, et al. (2007). "Ozone enhances markers of innate immunity and antigen presentation on airway monocytes in healthy individuals." Journal of Allergy and Clinical Immunology **120**(3): 719-22.

Le Tertre, A., J. Schwartz, et al. (2005). "Empirical Bayes and adjusted estimates approach to estimating the relation of mortality to exposure of PM(10).[erratum appears in Risk Anal. 2005 Dec;25(6):1683-4]." Risk Analysis **25**(3): 711-8.

Lee, B. E., E. H. Ha, et al. (2003). "Exposure to air pollution during different gestational phases contributes to risks of low birth weight." Human Reproduction **18**(3): 638-43.

Lee, C. F., J. H. Hsiao, et al. (2007). "Identification of regional air pollution characteristic and the correlation with public health in Taiwan." International Journal of Environmental Research & Public Health [Electronic Resource] **4**(2): 106-10.

Lee, I. M., S.-S. Tsai, et al. (2007). "Air pollution and hospital admissions for chronic obstructive pulmonary disease in a tropical city: Kaohsiung, Taiwan." Inhalation Toxicology **19**(5): 393-8.

Lee, J.-T., H. Kim, et al. (2003). "Air pollution and hospital admissions for ischemic heart diseases among individuals 64+ years of age residing in Seoul, Korea." Archives of Environmental Health **58**(10): 617-23.

Lee, J.-T., J.-Y. Son, et al. (2007). "The adverse effects of fine particle air pollution on respiratory function in the elderly." Science of the Total Environment **385**(1-3): 28-36.

Lee, J.-T., J.-Y. Son, et al. (2007). "A comparison of mortality related to urban air particles between periods with Asian dust days and without Asian dust days in Seoul, Korea, 2000-2004." Environmental Research **105**(3): 409-13.

Lee, S. J., S. Hajat, et al. (2008). "A time-series analysis of any short-term effects of meteorological and air pollution factors on preterm births in London, UK." Environmental Research **106**(2): 185-94.

Lewis, A. C., J. D. Lee, et al. (2004). "Outdoor air pollution: the effects of ozone.[comment]." Lancet **364**(9435): 663.

Lewis, T. C., T. G. Robins, et al. (2005). "Air pollution-associated changes in lung function among asthmatic children in Detroit." Environmental Health Perspectives **113**(8): 1068-75.

Li, R., E. Weller, et al. (2006). "Association of indoor nitrogen dioxide with respiratory symptoms in children: application of measurement error correction techniques to utilize data from multiple surrogates." Journal of Exposure Science & Environmental Epidemiology **16**(4): 342-50.

Liao, D., Y. Duan, et al. (2004). "Association of higher levels of ambient criteria pollutants with impaired cardiac autonomic control: a population-based study." American Journal of Epidemiology **159**(8): 768-77.

Liao, D., G. Heiss, et al. (2005). "Association of criteria pollutants with plasma hemostatic/inflammatory markers: a population-based study." Journal of Exposure Analysis and Environmental Epidemiology **15**(4): 319-28.

Liao, D., G. Heiss, et al. (2005). "Association of criteria pollutants with plasma hemostatic/inflammatory markers: a population-based study." Journal of Exposure Analysis and Environmental Epidemiology **15**(4): 319-28.

Lin, C. A., L. A. A. Pereira, et al. (2004). "Air pollution and neonatal deaths in Sao Paulo, Brazil." Brazilian Journal of Medical and Biological Research **37**(5): 765-70.

Lin, C.-M., C.-Y. Li, et al. (2004). "Increased risks of term low-birth-weight infants in a petrochemical industrial city with high air pollution levels." Archives of Environmental Health **59**(12): 663-8.

Lin, M., Y. Chen, et al. (2003). "Effect of short-term exposure to gaseous pollution on asthma hospitalisation in children: a bi-directional case-crossover analysis.[see comment]." Journal of Epidemiology & Community Health **57**(1): 50-5.

Lin, M., Y. Chen, et al. (2003). "Effect of short-term exposure to gaseous pollution on asthma hospitalisation in children: a bi-directional case-crossover analysis.[see comment]." Journal of Epidemiology & Community Health **57**(1): 50-5.

Linares, C., J. Diaz, et al. (2006). "Impact of urban air pollutants and noise levels over daily hospital admissions in children in Madrid: a time series analysis." International Archives of Occupational and Environmental Health **79**(2): 143-52.

Lipfert, F. W., J. D. Baty, et al. (2006). "PM2.5 constituents and related air quality variables as predictors of survival in a cohort of U.S. military veterans." Inhalation Toxicology **18**(9): 645-57.

Lipsett, M. J., F. C. Tsai, et al. (2006). "Coarse particles and heart rate variability among older adults with coronary artery disease in the Coachella Valley, California." Environmental Health Perspectives **114**(8): 1215-20.

Liu, S., D. Krewski, et al. (2007). "Association between maternal exposure to ambient air pollutants during pregnancy and fetal growth restriction." Journal of Exposure Science & Environmental Epidemiology **17**(5): 426-32.

Liu, S., D. Krewski, et al. (2007). "Association between maternal exposure to ambient air pollutants during pregnancy and fetal growth restriction." Journal of Exposure Science & Environmental Epidemiology **17**(5): 426-32.

Liu, Y., M. A. Woodin, et al. (2005). "Exposure to fuel-oil ash and welding emissions during the overhaul of an oil-fired boiler." Journal of Occupational & Environmental Hygiene **2**(9): 435-43.

Loscalzo, J. (2004). "Ozone--from environmental pollutant to atherogenic determinant." New England Journal of Medicine **350**(8): 834-5.

Loureiro, G., M. A. Rabaca, et al. (2005). "Urban versus rural environment--any differences in aeroallergens sensitization in an allergic population of Cova da Beira, Portugal?" Allergie et Immunologie **37**(5): 187-93.

Lubinski, W., I. Toczyska, et al. (2005). "Influence of air pollution on pulmonary function in healthy young men from different regions of Poland." Annals of Agricultural and Environmental Medicine **12**(1): 1-4.

Luginaah, I. N., K. Y. Fung, et al. (2005). "Association of ambient air pollution with respiratory hospitalization in a government-designated "area of concern": the case of Windsor, Ontario." Environmental Health Perspectives **113**(3): 290-6.

Luttmann-Gibson, H., H. H. Suh, et al. (2006). "Short-term effects of air pollution on heart rate variability in senior adults in Steubenville, Ohio." Journal of Occupational and Environmental Medicine **48**(8): 780-8.

Magas, O. K., J. T. Gunter, et al. (2007). "Ambient air pollution and daily pediatric hospitalizations for asthma." Environmental Science & Pollution Research **14**(1): 19-23.

Maheswaran, R., R. P. Haining, et al. (2005). "Outdoor air pollution, mortality, and hospital admissions from coronary heart disease in Sheffield, UK: a small-area level ecological study." European Heart Journal **26**(23): 2543-9.

Mannes, T., B. Jalaludin, et al. (2005). "Impact of ambient air pollution on birth weight in Sydney, Australia." Occupational & Environmental Medicine **62**(8): 524-30.

Mannsaker, B., T. Vikan, et al. (2004). "[Air pollution and cardiovascular disease in Trondheim]." Tidsskrift for Den Norske Laegeforening **124**(10): 1381-3.

Mar, T. F., K. Ito, et al. (2006). "PM source apportionment and health effects. 3. Investigation of inter-method variations in associations between estimated source contributions of PM2.5 and daily mortality in Phoenix, AZ." Journal of Exposure Science & Environmental Epidemiology **16**(4): 311-20.

Mar, T. F., J. Q. Koenig, et al. (2005). "Fine particulate air pollution and cardiorespiratory effects in the elderly." Epidemiology **16**(5): 681-7.

Mar, T. F., T. V. Larson, et al. (2004). "An analysis of the association between respiratory symptoms in subjects with asthma and daily air pollution in Spokane, Washington." Inhalation Toxicology **16**(13): 809-15.

Martins, M. C. H., F. L. Fatigati, et al. (2004). "Influence of socioeconomic conditions on air pollution adverse health effects in elderly people: an analysis of six regions in Sao Paulo, Brazil.[see comment]." Journal of Epidemiology and Community Health **58**(1): 41-6.

Mautz, W. J. (2003). "Exercising animal models in inhalation toxicology: interactions with ozone and formaldehyde." Environmental Research **92**(1): 14-26.

McConnell, R., K. Berhane, et al. (2006). "Dog ownership enhances symptomatic responses to air pollution in children with asthma." Environmental Health Perspectives **114**(12): 1910-5.

McCreanor, J., P. Cullinan, et al. (2007). "Respiratory effects of exposure to diesel traffic in persons with asthma.[see comment]." New England Journal of Medicine **357**(23): 2348-58.

McCunney, R. J. (2005). "Asthma, genes, and air pollution." Journal of Occupational and Environmental Medicine **47**(12): 1285-91.

McDonnell, W. F. (2004). "Use of submaximal inhalation and spirometry to assess the effects of ozone exposure." Archives of Environmental Health **59**(2): 76-83.

McDonnell, W. F., P. W. Stewart, et al. (2007). "The temporal dynamics of ozone-induced FEV1 changes in humans: an exposure-response model." Inhalation Toxicology **19**(6-7): 483-94.

Medina, S., A. Plasencia, et al. (2004). "Apheis: public health impact of PM10 in 19 European cities." Journal of Epidemiology and Community Health **58**(10): 831-6.

Mehta, A. J., P. K. Henneberger, et al. (2005). "Airflow limitation and changes in pulmonary function among bleachery workers." European Respiratory Journal **26**(1): 133-9.

Meng, Q. Y., B. J. Turpin, et al. (2005). "PM2.5 of ambient origin: estimates and exposure errors relevant to PM epidemiology." Environmental Science & Technology **39**(14): 5105-12.

Migliaretti, G. and F. Cavallo (2004). "Urban air pollution and asthma in children." Pediatric Pulmonology **38**(3): 198-203.

Miller, K. A., D. S. Siscovick, et al. (2007). "Long-term exposure to air pollution and incidence of cardiovascular events in women.[see comment]." New England Journal of Medicine **356**(5): 447-58.

Min, K.-B., J.-Y. Min, et al. (2008). "The relationship between air pollutants and heart-rate variability among community residents in Korea." Inhalation Toxicology **20**(4): 435-44.

Mindell, J. and M. Joffe (2004). "Predicted health impacts of urban air quality management.[erratum appears in J Epidemiol Community Health. 2004 Apr;58(4):355]." Journal of Epidemiology and Community Health **58**(2): 103-13.

Mitis, F., I. Iavarone, et al. (2007). "[Health impact of ozone in 13 Italian cities]." Epidemiologia e Prevenzione **31**(6): 323-32.

Mohorovic, L. (2004). "First two months of pregnancy--critical time for preterm delivery and low birthweight caused by adverse effects of coal combustion toxics." Early Human Development **80**(2): 115-23.

Molitor, J., M. Jerrett, et al. (2007). "Assessing uncertainty in spatial exposure models for air pollution health effects assessment." Environmental Health Perspectives **115**(8): 1147-53.

Morgenstern, V., A. Zutavern, et al. (2007). "Respiratory health and individual estimated exposure to traffic-related air pollutants in a cohort of young children.[see comment]." Occupational and Environmental Medicine **64**(1): 8-16.

Morrison, D., I. Rahman, et al. (2006). "Permeability, inflammation and oxidant status in airspace epithelium exposed to ozone." Respiratory Medicine **100**(12): 2227-34.

Moshammer, H., A. Bartonova, et al. (2006). "Air pollution: a threat to the health of our children." Acta Paediatrica Supplement **95**(453): 93-105.

Moshammer, H., H. P. Hutter, et al. (2006). "Low levels of air pollution induce changes of lung function in a panel of schoolchildren." European Respiratory Journal **27**(6): 1138-43.

Mudway, I. S. and F. J. Kelly (2004). "An investigation of inhaled ozone dose and the magnitude of airway inflammation in healthy adults." American Journal of Respiratory and Critical Care Medicine **169**(10): 1089-95.

Mudway, I. S., N. Stenfors, et al. (2004). "An in vitro and in vivo investigation of the effects of diesel exhaust on human airway lining fluid antioxidants." Archives of Biochemistry and Biophysics **423**(1): 200-12.

Nadadur, S. S., C. A. Miller, et al. (2007). "The complexities of air pollution regulation: the need for an integrated research and regulatory perspective." Toxicological Sciences **100**(2): 318-27.

Naeher, L. P., G. L. Achtemeier, et al. (2006). "Real-time and time-integrated PM2.5 and CO from prescribed burns in chipped and non-chipped plots: firefighter and community exposure and health implications." Journal of Exposure Science & Environmental Epidemiology **16**(4): 351-61.

Naess, O., P. Nafstad, et al. (2007). "Relation between concentration of air pollution and cause-specific mortality: four-year exposures to nitrogen dioxide and particulate matter pollutants in 470 neighborhoods in Oslo, Norway." American Journal of Epidemiology **165**(4): 435-43.

Nafstad, P., L. L. Haheim, et al. (2003). "Lung cancer and air pollution: a 27 year follow up of 16 209 Norwegian men.[see comment]." Thorax **58**(12): 1071-6.

Namdeo, A. and M. C. Bell (2005). "Characteristics and health implications of fine and coarse particulates at roadside, urban background and rural sites in UK." Environment International **31**(4): 565-73.

Nerriere, E., D. Zmirou-Navier, et al. (2005). "Lung cancer risk assessment in relation with personal exposure to airborne particles in four French metropolitan areas." Journal of Occupational and Environmental Medicine **47**(12): 1211-7.

Nickmilder, M., S. Carbonnelle, et al. (2003). "Relationship between ambient ozone and exhaled nitric oxide in children." JAMA **290**(19): 2546-7.

Nickmilder, M., C. de Burbure, et al. (2007). "Increase of exhaled nitric oxide in children exposed to low levels of ambient ozone." Journal of Toxicology & Environmental Health Part A **70**(3-4): 270-4.

Nikasinovic, L., J. Just, et al. (2006). "Nasal inflammation and personal exposure to fine particles PM2.5 in asthmatic children." Journal of Allergy and Clinical Immunology **117**(6): 1382-8.

Nikasinovic, L., I. Momas, et al. (2003). "Nasal epithelial and inflammatory response to ozone exposure: a review of laboratory-based studies published since 1985." Journal of Toxicology & Environmental Health Part B: Critical Reviews **6**(5): 521-68.

Norman, R., E. Cairncross, et al. (2007). "Estimating the burden of disease attributable to urban outdoor air pollution in South Africa in 2000." South African Medical Journal **Suid-Afrikaanse Tydskrif Vir Geneeskunde. 97**(8 Pt 2): 782-90.

Oftedal, B., B. Brunekreef, et al. (2008). "Residential outdoor air pollution and lung function in schoolchildren." Epidemiology **19**(1): 129-37.

Oftedal, B., B. Brunekreef, et al. (2007). "Residential outdoor air pollution and allergen sensitization in schoolchildren in Oslo, Norway." Clinical and Experimental Allergy **37**(11): 1632-40.

Oikonen, M. K. and J.-P. Eralinna (2008). "Beta-interferon protects multiple sclerosis patients against enhanced susceptibility to infections caused by poor air quality." Neuroepidemiology **30**(1): 13-9.

Olin, A. C., E. Andersson, et al. (2004). "Prevalence of asthma and exhaled nitric oxide are increased in bleachery workers exposed to ozone." European Respiratory Journal **23**(1): 87-92.

O'Neill, M. S., D. Loomis, et al. (2004). "Do associations between airborne particles and daily mortality in Mexico City differ by measurement method, region, or modeling strategy?" Journal of Exposure Analysis and Environmental Epidemiology **14**(6): 429-39.

O'Neill, M. S., A. Veves, et al. (2007). "Air pollution and inflammation in type 2 diabetes: a mechanism for susceptibility." Occupational and Environmental Medicine **64**(6): 373-9.

O'Neill, M. S., A. Veves, et al. (2005). "Diabetes enhances vulnerability to particulate air pollution-associated impairment in vascular reactivity and endothelial function.[see comment]." Circulation **111**(22): 2913-20.

Ostro, B., W.-Y. Feng, et al. (2007). "The effects of components of fine particulate air pollution on mortality in california: results from CALFINE." Environmental Health Perspectives **115**(1): 13-9.

Ostro, B. D., H. Tran, et al. (2006). "The health benefits of reduced tropospheric ozone in California." Journal of the Air and Waste Management Association **56**(7): 1007-21.

Pacini, S., L. Giovannelli, et al. (2003). "Association between atmospheric ozone levels and damage to human nasal mucosa in Florence, Italy." Environmental and Molecular Mutagenesis **42**(3): 127-35.

Palmberg, L., B.-M. Larsson, et al. (2004). "Partial protection by respirators on airways responses following exposure in a swine house." American Journal of Industrial Medicine **46**(4): 363-70.

Pan, X., W. Yue, et al. (2007). "Health benefit evaluation of the energy use scenarios in Beijing, China." Science of the Total Environment **374**(2-3): 242-51.

Pandey, M. D. and J. S. Nathwani (2003). "Canada Wide Standard for particulate matter and ozone: cost-benefit analysis using a Life Quality Index.[see comment]." Risk Analysis **23**(1): 55-67.

Panella, M., R. Aina, et al. (2004). "A study of air pollutants and acute asthma exacerbations in urban areas: status report.[comment]." Environmental Pollution **128**(3): 303; author reply 305.

Park, J. W., Y. H. Lim, et al. (2005). "Effects of ambient particulate matter on peak expiratory flow rates and respiratory symptoms of asthmatics during Asian dust periods in Korea." Respirology **10**(4): 470-6.

Park, J. W., Y. H. Lim, et al. (2005). "Effects of ambient particulate matter on peak expiratory flow rates and respiratory symptoms of asthmatics during Asian dust periods in Korea." Respirology **10**(4): 470-6.

Park, S. K., M. S. O'Neill, et al. (2005). "Effects of air pollution on heart rate variability: the VA normative aging study." Environmental Health Perspectives **113**(3): 304-9.

Park, S. K., M. S. O'Neill, et al. (2008). "Air pollution and heart rate variability: effect modification by chronic lead exposure." Epidemiology **19**(1): 111-20.

Parker, J. D., T. J. Woodruff, et al. (2005). "Air pollution and birth weight among term infants in California." Pediatrics **115**(1): 121-8.

Parmet, S., C. Lynm, et al. (2003). "JAMA patient page. Health effects of ozone." JAMA **290**(14): 1944.

Parodi, S., E. Stagnaro, et al. (2005). "Lung cancer in an urban area in Northern Italy near a coke oven plant." Lung Cancer **47**(2): 155-64.

Pattenden, S., G. Hoek, et al. (2006). "NO2 and children's respiratory symptoms in the PATY study." Occupational and Environmental Medicine **63**(12): 828-35.

Payne-Sturges, D. and G. C. Gee (2006). "National environmental health measures for minority and low-income populations: tracking social disparities in environmental health." Environmental Research **102**(2): 154-71.

Pedersen, M., P. Vinzents, et al. (2006). "Cytogenetic effects in children and mothers exposed to air pollution assessed by the frequency of micronuclei and fluorescence in situ hybridization (FISH): a family pilot study in the Czech Republic." Mutation Research **608**(2): 112-20.

Peel, J. L., K. B. Metzger, et al. (2007). "Ambient air pollution and cardiovascular emergency department visits in potentially sensitive groups." American Journal of Epidemiology **165**(6): 625-33.

Peel, J. L., P. E. Tolbert, et al. (2005). "Ambient air pollution and respiratory emergency department visits." Epidemiology **16**(2): 164-74.

Penard-Morand, C., D. Charpin, et al. (2005). "Long-term exposure to background air pollution related to respiratory and allergic health in schoolchildren." Clinical & Experimental Allergy **35**(10): 1279-87.

Penard-Morand, C., D. Charpin, et al. (2005). "Long-term exposure to background air pollution related to respiratory and allergic health in schoolchildren." Clinical & Experimental Allergy **35**(10): 1279-87.

Peng, R. D., H. H. Chang, et al. (2008). "Coarse particulate matter air pollution and hospital admissions for cardiovascular and respiratory diseases among Medicare patients." JAMA **299**(18): 2172-9.

Penttinen, P., M. Vallius, et al. (2006). "Source-specific fine particles in urban air and respiratory function among adult asthmatics." Inhalation Toxicology **18**(3): 191-8.

Percy, K. E. and D. F. Karnosky (2007). "Air quality in natural areas: interface between the public, science and regulation." Environmental Pollution **149**(3): 256-67.

Peters, A., S. von Klot, et al. (2005). "Particulate air pollution and nonfatal cardiac events. Part I. Air pollution, personal activities, and onset of myocardial infarction in a case-crossover study." Research Report - Health Effects Institute(124): 1-66; discussion 67-82.

Pierse, N., L. Rushton, et al. (2006). "Locally generated particulate pollution and respiratory symptoms in young children.[see comment]." Thorax **61**(3): 216-20.

Pilotto, L. S., M. Nitschke, et al. (2004). "Randomized controlled trial of unflued gas heater replacement on respiratory health of asthmatic schoolchildren.[see comment]." International Journal of Epidemiology **33**(1): 208-14.

Pinkerton, K. E., J. R. Balmes, et al. (2007). "Ozone, a malady for all ages." American Journal of Respiratory and Critical Care Medicine **176**(2): 107-8.

Piro, F. N., C. Madsen, et al. (2008). "A comparison of self reported air pollution problems and GIS-modeled levels of air pollution in people with and without chronic diseases." Environmental Health: A Global Access Science Source **7**: 9.

Podda, M. and J. Fuchs (2004). "[Influence of environmental polluting ozone on the the skin]." Hautarzt **55**(12): 1120-4.

Pope, C. A., 3rd, M. L. Hansen, et al. (2004). "Ambient particulate air pollution, heart rate variability, and blood markers of inflammation in a panel of elderly subjects." Environmental Health Perspectives **112**(3): 339-45.

Pope, C. A., 3rd, J. B. Muhlestein, et al. (2006). "Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution.[see comment]." Circulation **114**(23): 2443-8.

Pourazar, J., A. J. Frew, et al. (2004). "Diesel exhaust exposure enhances the expression of IL-13 in the bronchial epithelium of healthy subjects." Respiratory Medicine **98**(9): 821-5.

Powell, K. (2003). "Ozone exposure throws monkey wrench into infant lungs." Nature Medicine **9**(5): 490.

Preutthipan, A., U. Udomsubpayakul, et al. (2004). "Effect of PM10 pollution in Bangkok on children with and without asthma." Pediatric Pulmonology **37**(3): 187-92.

Qian, Z., R. S. Chapman, et al. (2004). "Using air pollution based community clusters to explore air pollution health effects in children." Environment International **30**(5): 611-20.

Qian, Z., Q. He, et al. (2007). "Association of daily cause-specific mortality with ambient particle air pollution in Wuhan, China." Environmental Research **105**(3): 380-9.

Qian, Z., Q. He, et al. (2007). "Short-term effects of gaseous pollutants on cause-specific mortality in Wuhan, China." Journal of the Air & Waste Management Association **57**(7): 785-93.

Qian, Z., D. Liao, et al. (2005). "Lung function and long-term exposure to air pollutants in middle-aged American adults." Archives of Environmental & Occupational Health **60**(3): 156-63.

Rabl, A. (2003). "Interpretation of air pollution mortality: number of deaths or years of life lost?" Journal of the Air and Waste Management Association **53**(1): 41-50.

Ranzi, A., M. Gambini, et al. (2004). "Air pollution and respiratory status in asthmatic children: hints for a locally based preventive strategy. AIRE study." European Journal of Epidemiology **19**(6): 567-76.

Ratto, J., H. Wong, et al. (2006). "Effects of multiday exposure to ozone on airway inflammation as determined using sputum induction." Environmental Health Perspectives **114**(2): 209-12.

Regalado, J., R. Perez-Padilla, et al. (2006). "The effect of biomass burning on respiratory symptoms and lung function in rural Mexican women.[see comment]." American Journal of Respiratory and Critical Care Medicine **174**(8): 901-5.

Rest, K. (2007). "Silenced science: air pollution decision-making at the EPA threatens public health." New Solutions **17**(1-2): 13-6.

Rich, D. Q., M. A. Mittleman, et al. (2006). "Increased risk of paroxysmal atrial fibrillation episodes associated with acute increases in ambient air pollution." Environmental Health Perspectives **114**(1): 120-3.

Riediker, M. (2007). "Cardiovascular effects of fine particulate matter components in highway patrol officers." Inhalation Toxicology **19 Suppl 1**: 99-105.

Riediker, M., W. E. Cascio, et al. (2004). "Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men." American Journal of Respiratory and Critical Care Medicine **169**(8): 934-40.

Riojas-Rodriguez, H., J. A. Escamilla-Cejudo, et al. (2006). "Personal PM2.5 and CO exposures and heart rate variability in subjects with known ischemic heart disease in Mexico City." Journal of Exposure Science & Environmental Epidemiology **16**(2): 131-7.

Rios, J. L. M., J. L. Boechat, et al. (2004). "Atmospheric pollution and the prevalence of asthma: study among schoolchildren of 2 areas in Rio de Janeiro, Brazil." Annals of Allergy, Asthma, and Immunology **92**(6): 629-34.

Ritz, B., M. Wilhelm, et al. (2006). "Air pollution and infant death in southern California, 1989-2000." Pediatrics **118**(2): 493-502.

Rodriguez, C., R. Tonkin, et al. (2007). "The relationship between outdoor air quality and respiratory symptoms in young children." International Journal of Environmental Health Research **17**(5): 351-60.

Rohde, G. (2008). "[The effects of air pollution and climate change on pulmonary diseases]." Deutsche Medizinische Wochenschrift **133**(14): 733-6.

Rojas-Martinez, R., R. Perez-Padilla, et al. (2007). "Lung function growth in children with long-term exposure to air pollutants in Mexico City." American Journal of Respiratory & Critical Care Medicine **176**(4): 377-84.

Romieu, I., M. Ramirez-Aguilar, et al. (2006). "GSTM1 and GSTP1 and respiratory health in asthmatic children exposed to ozone." European Respiratory Journal **28**(5): 953-9.

Romieu, I., J. J. Sienra-Monge, et al. (2004). "Genetic polymorphism of GSTM1 and antioxidant supplementation influence lung function in relation to ozone exposure in asthmatic children in Mexico City.[see comment]." Thorax **59**(1): 8-10.

Rondeau, V., K. Berhane, et al. (2005). "A three-level model for binary time-series data: the effects of air pollution on school absences in the Southern California Children's Health Study." Statistics in Medicine **24**(7): 1103-15.

Roosli, M., N. Kunzli, et al. (2005). "Years of life lost attributable to air pollution in Switzerland: dynamic exposure-response model." International Journal of Epidemiology **34**(5): 1029-35.

Roosli, M., N. Kunzli, et al. (2003). "Single pollutant versus surrogate measure approaches: do single pollutant risk assessments underestimate the impact of air pollution on lung cancer risk?" Journal of Occupational and Environmental Medicine **45**(7): 715-23.

Rosenlund, M., N. Berglind, et al. (2006). "Long-term exposure to urban air pollution and myocardial infarction." Epidemiology **17**(4): 383-90.

Rosenlund, M., S. Jungnelius, et al. (2004). "A 5-year follow-up of airway symptoms after nitrogen dioxide exposure in an indoor ice arena." Archives of Environmental Health **59**(4): 213-7.

Ruckerl, R., A. Ibald-Mulli, et al. (2006). "Air pollution and markers of inflammation and coagulation in patients with coronary heart disease." American Journal of Respiratory and Critical Care Medicine **173**(4): 432-41.

Ruidavets, J.-B., M. Cournot, et al. (2005). "Ozone air pollution is associated with acute myocardial infarction." Circulation **111**(5): 563-9.

Safina, N. F. and I. A. Romanov (2003). "[Effects of ozone on the lipid peroxidation--antioxidation system in blood serum of patients with chronic bronchitis]." Aviakosmicheskaia i Ekologicheskaia Meditsina **37**(4): 40-3.

Sagiv, S. K., P. Mendola, et al. (2005). "A time-series analysis of air pollution and preterm birth in Pennsylvania, 1997-2001." Environmental Health Perspectives **113**(5): 602-6.

Salam, M. T., J. Millstein, et al. (2005). "Birth outcomes and prenatal exposure to ozone, carbon monoxide, and particulate matter: results from the Children's Health Study." Environmental Health Perspectives **113**(11): 1638-44.

Sallsten, G., P. Gustafson, et al. (2006). "Experimental wood smoke exposure in humans." Inhalation Toxicology **18**(11): 855-64.

Salonen, R. O., A. S. Pennanen, et al. (2008). "Health risk assessment of indoor air pollution in Finnish ice arenas." Environment International **34**(1): 51-7.

Samoli, E., G. Touloumi, et al. (2003). "Investigating the dose-response relation between air pollution and total mortality in the APHEA-2 multicity project." Occupational & Environmental Medicine **60**(12): 977-82.

Sanhueza, P. A., G. D. Reed, et al. (2003). "An environmental decision-making tool for evaluating ground-level ozone-related health effects.[see comment]." Journal of the Air and Waste Management Association **53**(12): 1448-59.

Sarnat, S. E., H. H. Suh, et al. (2006). "Ambient particulate air pollution and cardiac arrhythmia in a panel of older adults in Steubenville, Ohio." Occupational & Environmental Medicine **63**(10): 700-6.

Sarnat, S. E., H. H. Suh, et al. (2006). "Ambient particulate air pollution and cardiac arrhythmia in a panel of older adults in Steubenville, Ohio." Occupational & Environmental Medicine **63**(10): 700-6.

Schaumann, F., P. J. A. Borm, et al. (2004). "Metal-rich ambient particles (particulate matter 2.5) cause airway inflammation in healthy subjects." American Journal of Respiratory and Critical Care Medicine **170**(8): 898-903.

Schelegle, E. S., W. F. Walby, et al. (2007). "Time course of ozone-induced changes in breathing pattern in healthy exercising humans." Journal of Applied Physiology **102**(2): 688-97.

Schifter, I., L. Diaz, et al. (2005). "Hazardous air pollutants from mobile sources in the Metropolitan Area of Mexico City." Journal of the Air & Waste Management Association **55**(9): 1289-97.

Schildcrout, J. S., L. Sheppard, et al. (2006). "Ambient air pollution and asthma exacerbations in children: an eight-city analysis." American Journal of Epidemiology **164**(6): 505-17.

Schwartz, J. (2004). "Air pollution and children's health." Pediatrics **113**(4 Suppl): 1037-43.

Schwartz, J., A. Litonjua, et al. (2005). "Traffic related pollution and heart rate variability in a panel of elderly subjects.[see comment]." Thorax **60**(6): 455-61.

See, S. W., R. Balasubramanian, et al. (2006). "Assessing exposure to diesel exhaust particles: a case study." Journal of Toxicology & Environmental Health Part A **69**(21): 1909-25.

Selgrade, M. K., C. G. Plopper, et al. (2008). "Assessing the health effects and risks associated with children's inhalation exposures--asthma and allergy." Journal of Toxicology & Environmental Health Part A **71**(3): 196-207.

Shah, A. P., A. P. Pietropaoli, et al. (2008). "Effect of inhaled carbon ultrafine particles on reactive hyperemia in healthy human subjects." Environmental Health Perspectives **116**(3): 375-80.

Sharma, M., V. N. Kumar, et al. (2004). "Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India." Archives of Environmental Health **59**(7): 348-58.

Shrestha, I. L. and S. L. Shrestha (2005). "Indoor air pollution from biomass fuels and respiratory health of the exposed population in Nepalese households." International Journal of Occupational and Environmental Health **11**(2): 150-60.

Sienra-Monge, J. J., M. Ramirez-Aguilar, et al. (2004). "Antioxidant supplementation and nasal inflammatory responses among young asthmatics exposed to high levels of ozone." Clinical and Experimental Immunology **138**(2): 317-22.

Simpson, R., G. Williams, et al. (2005). "The short-term effects of air pollution on hospital admissions in four Australian cities." Australian & New Zealand Journal of Public Health **29**(3): 213-21.

Simpson, R., G. Williams, et al. (2005). "The short-term effects of air pollution on daily mortality in four Australian cities." Australian & New Zealand Journal of Public Health **29**(3): 205-12.

Singh, V., R. Khandelwal, et al. (2003). "Effect of air pollution on peak expiratory flow rate variability." Journal of Asthma **40**(1): 81-6.

Slama, R., V. Morgenstern, et al. (2007). "Traffic-related atmospheric pollutants levels during pregnancy and offspring's term birth weight: a study relying on a land-use regression exposure model." Environmental Health Perspectives **115**(9): 1283-92.

Slaughter, J. C., E. Kim, et al. (2005). "Association between particulate matter and emergency room visits, hospital admissions and mortality in Spokane, Washington." Journal of Exposure Analysis and Environmental Epidemiology **15**(2): 153-9.

Sokol, R. Z., P. Kraft, et al. (2006). "Exposure to environmental ozone alters semen quality.[see comment]." Environmental Health Perspectives **114**(3): 360-5.

Sokolov, S. M., T. E. Naumenko, et al. (2006). "[Medical problems in the estimation of ozone exposure]." Gigiena i Sanitariia(1): 51-2.

Sole, D., I. C. Camelo-Nunes, et al. (2007). "Prevalence of symptoms of asthma, rhinitis, and atopic eczema in Brazilian adolescents related to exposure to gaseous air pollutants and socioeconomic status." Journal of Investigational Allergology & Clinical Immunology **17**(1): 6-13.

Sole, D., I. C. Camelo-Nunes, et al. (2007). "Prevalence of symptoms of asthma, rhinitis, and atopic eczema in Brazilian adolescents related to exposure to gaseous air pollutants and socioeconomic status." Journal of Investigational Allergology & Clinical Immunology **17**(1): 6-13.

Son, J.-Y., H. Kim, et al. (2006). "[Relationship between the exposure to ozone in Seoul and the childhood asthma-related hospital admissions according to the socioeconomic status]." Journal of Preventive Medicine & Public Health / Yebang Uihakhoe Chi **39**(1): 81-6.

Sorensen, M., H. Autrup, et al. (2003). "Personal exposure to PM2.5 and biomarkers of DNA damage." Cancer Epidemiology, Biomarkers and Prevention **12**(3): 191-6.

Sram, R. J., O. Beskid, et al. (2007). "Chromosomal aberrations in environmentally exposed population in relation to metabolic and DNA repair genes polymorphisms." Mutation Research **620**(1-2): 22-33.

Steck-Scott, S., L. Arab, et al. (2004). "Plasma and lung macrophage responsiveness to carotenoid supplementation and ozone exposure in humans." European Journal of Clinical Nutrition **58**(12): 1571-9.

Stenfors, N., C. Nordenhall, et al. (2004). "Different airway inflammatory responses in asthmatic and healthy humans exposed to diesel." European Respiratory Journal **23**(1): 82-6.

Stephen, G. A., C. McRill, et al. (2003). "Assessment of respiratory symptoms and asthma prevalence in a U.S.-Mexico border region." Archives of Environmental Health **58**(3): 156-62.

Stepnewski, M., E. Kolarzyk, et al. (2003). "Antioxidant enzymes and pulmonary function in steel mill welders." International Journal of Occupational Medicine and Environmental Health **16**(1): 41-7.

Stieb, D. M., M. S. Doiron, et al. (2005). "Estimating the public health burden attributable to air pollution: an illustration using the development of an alternative air quality index." Journal of Toxicology & Environmental Health Part A **68**(13-14): 1275-88.

Stieb, D. M., A. J. Krupnick, et al. (2004). "[Padney, M D and Nathwani J S (2003). Canada wide standard for particulate matter and ozone: cost benefit analysis using a life quality index. Risk Analysis, 23(1), 55-67][comment]." Risk Analysis **24**(2): 305-6; author reply 307-9.

Stolzel, M., S. Breitner, et al. (2007). "Daily mortality and particulate matter in different size classes in Erfurt, Germany." Journal of Exposure Science & Environmental Epidemiology **17**(5): 458-67.

Strand, M., S. Vedal, et al. (2006). "Estimating effects of ambient PM(2.5) exposure on health using PM(2.5) component measurements and regression calibration.[erratum appears in J Expo Sci Environ Epidemiol. 2006 Sep;16(5):471]." Journal of Exposure Science & Environmental Epidemiology **16**(1): 30-8.

Stuckey, H. T. and M. L. Sattler (2003). "Air quality in the 21st century: community outreach in North Central Texas." Environment International **29**(2-3): 341-6.

Su, T.-C., C.-C. Chan, et al. (2006). "Urban air pollution increases plasma fibrinogen and plasminogen activator inhibitor-1 levels in susceptible patients." European Journal of Cardiovascular Prevention & Rehabilitation **13**(5): 849-52.

Suh, Y.-J., B.-M. Kim, et al. (2007). "Cytochrome P450IA1 polymorphisms along with PM(10) exposure contribute to the risk of birth weight reduction." Reproductive Toxicology **24**(3-4): 281-8.

Sullivan, J. H., A. B. Schreuder, et al. (2005). "Association between short term exposure to fine particulate matter and heart rate variability in older subjects with and without heart disease.[see comment]." Thorax **60**(6): 462-6.

Sulzbach, M. (2006). "What's driving Twin Cities air quality?" Minnesota Medicine **89**(5): 36-9.

Sun, H.-L., M.-C. Chou, et al. (2006). "The relationship of air pollution to ED visits for asthma differ between children and adults.[see comment]." American Journal of Emergency Medicine **24**(6): 709-13.

Sunyer, J., F. Ballester, et al. (2003). "The association of daily sulfur dioxide air pollution levels with hospital admissions for cardiovascular diseases in Europe (The Aphea-II study)." European Heart Journal **24**(8): 752-60.

Szyszkowicz, M. (2007). "Air pollution and emergency department visits for ischemic heart disease in Montreal, Canada." International Journal of Occupational Medicine & Environmental Health **20**(2): 167-73.

Szyszkowicz, M. (2008). "Air pollution and daily emergency department visits for headache in Montreal, Canada." Headache **48**(3): 417-23.

Tager, I. B., J. Balmes, et al. (2005). "Chronic exposure to ambient ozone and lung function in young adults.[see comment]." Epidemiology **16**(6): 751-9.

Tainio, M., J. T. Tuomisto, et al. (2005). "Health effects caused by primary fine particulate matter (PM2.5) emitted from buses in the Helsinki metropolitan area, Finland." Risk Analysis **25**(1): 151-60.

Tainio, M., J. T. Tuomisto, et al. (2007). "Parameter and model uncertainty in a life-table model for fine particles (PM2.5): a statistical modeling study." Environmental Health: A Global Access Science Source **6**: 24.

Taylor, A. B., G. M. Lee, et al. (2006). "Changes in the carbon dioxide expirogram in response to ozone exposure." Toxicology and Applied Pharmacology **213**(1): 1-9.

Thurston, G. D. and D. V. Bates (2003). "Air pollution as an underappreciated cause of asthma symptoms.[see comment][comment]." JAMA **290**(14): 1915-7.

Tillett, T. (2006). "Sperm alert.[comment]." Environmental Health Perspectives **114**(3): A177.

Timonen, K. L., G. Hoek, et al. (2004). "Daily variation in fine and ultrafine particulate air pollution and urinary concentrations of lung Clara cell protein CC16." Occupational and Environmental Medicine **61**(11): 908-14.

Timonen, K. L., E. Vanninen, et al. (2006). "Effects of ultrafine and fine particulate and gaseous air pollution on cardiac autonomic control in subjects with coronary artery disease: the ULTRA study." Journal of Exposure Science & Environmental Epidemiology **16**(4): 332-41.

Tolbert, P. E., M. Klein, et al. (2007). "Multipollutant modeling issues in a study of ambient air quality and emergency department visits in Atlanta." Journal of Exposure Science & Environmental Epidemiology **17 Suppl 2**: S29-35.

Tong, D. Q., N. Z. Muller, et al. (2006). "Integrated assessment of the spatial variability of ozone impacts from emissions of nitrogen oxides." Environmental Science & Technology **40**(5): 1395-400.

Touloumi, G., E. Samoli, et al. (2005). "Short-term effects of air pollution on total and cardiovascular mortality: the confounding effect of influenza epidemics." Epidemiology **16**(1): 49-57.

Tovalin, H., M. Valverde, et al. (2006). "DNA damage in outdoor workers occupationally exposed to environmental air pollutants.[see comment]." Occupational and Environmental Medicine **63**(4): 230-6.

Triche, E. W., J. F. Gent, et al. (2006). "Low-level ozone exposure and respiratory symptoms in infants." Environmental Health Perspectives **114**(6): 911-6.

Tsai, S.-S., C.-C. Chen, et al. (2006). "Air pollution and postneonatal mortality in a tropical city: Kaohsiung, Taiwan." Inhalation Toxicology **18**(3): 185-9.

Tsai, S.-S., C.-H. Huang, et al. (2003). "Relationship between air pollution and daily mortality in a tropical city: Kaohsiung, Taiwan." Journal of Toxicology & Environmental Health Part A **66**(14): 1341-9.

Tunnicliffe, W. S., R. M. Harrison, et al. (2003). "The effect of sulphurous air pollutant exposures on symptoms, lung function, exhaled nitric oxide, and nasal epithelial lining fluid antioxidant concentrations in normal and asthmatic adults." Occupational & Environmental Medicine **60**(11): e15.

Urch, B., J. R. Brook, et al. (2004). "Relative contributions of PM2.5 chemical constituents to acute arterial vasoconstriction in humans." Inhalation Toxicology **16**(6-7): 345-52.

Urch, B., F. Silverman, et al. (2005). "Acute blood pressure responses in healthy adults during controlled air pollution exposures." Environmental Health Perspectives **113**(8): 1052-5.

Uysal, N. and R. M. Schapira (2003). "Effects of ozone on lung function and lung diseases." Current Opinion in Pulmonary Medicine **9**(2): 144-50.

Vagaggini, B., S. Cianchetti, et al. (2007). "Prednisone blunts airway neutrophilic inflammatory response due to ozone exposure in asthmatic subjects." Respiration **74**(1): 61-8.

Valacchi, G., V. Fortino, et al. (2005). "The dual action of ozone on the skin." British Journal of Dermatology **153**(6): 1096-100.

Vallejo, M., K. Jauregui-Renaud, et al. (2003). "[Effects of air pollution on human health and their importance in Mexico City]." Gaceta Medica de Mexico **139**(1): 57-63.

Vallejo, M., S. Ruiz, et al. (2006). "Ambient fine particles modify heart rate variability in young healthy adults." Journal of Exposure Science & Environmental Epidemiology **16**(2): 125-30.

van Strien, R. T., J. F. Gent, et al. (2004). "Exposure to NO2 and nitrous acid and respiratory symptoms in the first year of life." Epidemiology **15**(4): 471-8.

Vedal, S. and L. Sheppard (2006). "Ambient ozone and lung function.[comment]." Epidemiology **17**(3): 343-4; author reply 344-5.

Vigotti, M. A., F. Chiaverini, et al. (2007). "Urban air pollution and emergency visits for respiratory complaints in Pisa, Italy." Journal of Toxicology & Environmental Health Part A **70**(3-4): 266-9.

Villeneuve, P. J., R. T. Burnett, et al. (2003). "A time-series study of air pollution, socioeconomic status, and mortality in Vancouver, Canada." Journal of Exposure Analysis and Environmental Epidemiology **13**(6): 427-35.

Vimercati, L., A. Carrus, et al. (2006). "Biological monitoring and allergic sensitization in traffic police officers exposed to urban air pollution." International Journal of Immunopathology & Pharmacology **19**(4 Suppl): 57-60.

Vineis, P., G. Hoek, et al. (2006). "Air pollution and risk of lung cancer in a prospective study in Europe.[see comment]." International Journal of Cancer **119**(1): 169-74.

Vinzents, P. S., P. Moller, et al. (2005). "Personal exposure to ultrafine particles and oxidative DNA damage." Environmental Health Perspectives **113**(11): 1485-90.

Viswanathan, S., L. Eria, et al. (2006). "An analysis of effects of San Diego wildfire on ambient air quality." Journal of the Air and Waste Management Association **56**(1): 56-67.

von Klot, S., A. Peters, et al. (2005). "Ambient air pollution is associated with increased risk of hospital cardiac readmissions of myocardial infarction survivors in five European cities.[see comment][erratum appears in Circulation. 2006 Feb 7;113(5):e71]." Circulation **112**(20): 3073-9.

Wang, G., S. R. Bates-Kenney, et al. (2004). "Differences in biochemical properties and in biological function between human SP-A1 and SP-A2 variants, and the impact of ozone-induced oxidation." Biochemistry **43**(14): 4227-39.

Wang, Q., Y. Liu, et al. (2008). "Atmosphere pollutants and mortality rate of respiratory diseases in Beijing." Science of the Total Environment **391**(1): 143-8.

Weber, R., M. Bergin, et al. (2003). "Short-term temporal variation in PM2.5 mass and chemical composition during the Atlanta Supersite Experiment, 1999." Journal of the Air and Waste Management Association **53**(1): 84-91.

Wellenius, G. A., T. F. Bateson, et al. (2005). "Particulate air pollution and the rate of hospitalization for congestive heart failure among medicare beneficiaries in Pittsburgh, Pennsylvania." American Journal of Epidemiology **161**(11): 1030-6.

Wellenius, G. A., J. Schwartz, et al. (2006). "Particulate air pollution and hospital admissions for congestive heart failure in seven United States cities.[see comment]." American Journal of Cardiology **97**(3): 404-8.

Wellenius, G. A., G. Y. Yeh, et al. (2007). "Effects of ambient air pollution on functional status in patients with chronic congestive heart failure: a repeated-measures study." Environmental Health: A Global Access Science Source **6**: 26.

Weschler, C. J. (2006). "Ozone's impact on public health: contributions from indoor exposures to ozone and products of ozone-initiated chemistry." Environmental Health Perspectives **114**(10): 1489-96.

West, J. J., A. M. Fiore, et al. (2006). "Global health benefits of mitigating ozone pollution with methane emission controls." Proceedings of the National Academy of Sciences of the United States of America **103**(11): 3988-93.

Wheeler, B. W. and Y. Ben-Shlomo (2005). "Environmental equity, air quality, socioeconomic status, and respiratory health: a linkage analysis of routine data from the Health Survey for England." Journal of Epidemiology and Community Health **59**(11): 948-54.

Wilhelm, M. and B. Ritz (2005). "Local variations in CO and particulate air pollution and adverse birth outcomes in Los Angeles County, California, USA." Environmental Health Perspectives **113**(9): 1212-21.

Williams, M. L. (2008). "Air quality risk management." Journal of Toxicology & Environmental Health Part A **71**(1): 9-12.

Wilson, W. E., T. F. Mar, et al. (2007). "Influence of exposure error and effect modification by socioeconomic status on the association of acute cardiovascular mortality with particulate matter in Phoenix." Journal of Exposure Science & Environmental Epidemiology **17 Suppl 2**: S11-9.

Wong, T. W., W. Tam, et al. (2006). "Association between air pollution and general practitioner visits for respiratory diseases in Hong Kong." Thorax **61**(7): 585-91.

Woodruff, T. J., L. A. Darrow, et al. (2008). "Air pollution and postneonatal infant mortality in the United States, 1999-2002." Environmental Health Perspectives **116**(1): 110-5.

Woodruff, T. J., J. D. Parker, et al. (2006). "Fine particulate matter (PM2.5) air pollution and selected causes of postneonatal infant mortality in California." Environmental Health Perspectives **114**(5): 786-90.

Wyzga, R. (2003). "Commentary on the HEI reanalysis of two cohort studies of particulate air pollution and mortality." Journal of Toxicology & Environmental Health Part A **66**(16-19): 1701-4; discussion 1715-22.

Yang, C.-Y., C.-C. Chen, et al. (2007). "Air pollution and hospital admissions for asthma in a subtropical city: Taipei, Taiwan." Journal of Toxicology & Environmental Health Part A **70**(2): 111-7.

Yang, C.-Y., Y.-S. Chen, et al. (2005). "Effects of Asian dust storm events on daily stroke admissions in Taipei, Taiwan." Environmental Research **99**(1): 79-84.

Yang, C.-Y., H.-J. Hsieh, et al. (2006). "Correlation between air pollution and postneonatal mortality in a subtropical city: Taipei, Taiwan." Journal of Toxicology & Environmental Health Part A **69**(22): 2033-40.

Yang, C.-Y., Y.-T. Tseng, et al. (2003). "Effects of air pollution on birth weight among children born between 1995 and 1997 in Kaohsiung, Taiwan." Journal of Toxicology & Environmental Health Part A **66**(9): 807-16.

Yang, I. A., O. Holz, et al. (2005). "Association of tumor necrosis factor-alpha polymorphisms and ozone-induced change in lung function." American Journal of Respiratory and Critical Care Medicine **171**(2): 171-6.

Yang, Q., Y. Chen, et al. (2003). "Association between ozone and respiratory admissions among children and the elderly in Vancouver, Canada." Inhalation Toxicology **15**(13): 1297-308.

Yeatts, K., E. Svendsen, et al. (2007). "Coarse particulate matter (PM2.5-10) affects heart rate variability, blood lipids, and circulating eosinophils in adults with asthma." Environmental Health Perspectives **115**(5): 709-14.

Yue, W., A. Schneider, et al. (2007). "Ambient source-specific particles are associated with prolonged repolarization and increased levels of inflammation in male coronary artery disease patients." Mutation Research **621**(1-2): 50-60.

Zakaria, A. and G. El-Maghrabi (2003). "Assessment of occupational exposures in foundries." Journal of the Egyptian Public Health Association **78**(3-4): 245-64.

Zakaria, A. and O. Labib (2003). "Evaluation of emissions from medical waste incinerators in Alexandria." Journal of the Egyptian Public Health Association **78**(3-4): 225-44.

Zanobetti, A., M. J. Canner, et al. (2004). "Ambient pollution and blood pressure in cardiac rehabilitation patients." Circulation **110**(15): 2184-9.

Zanobetti, A. and J. Schwartz (2005). "The effect of particulate air pollution on emergency admissions for myocardial infarction: a multicity case-crossover analysis." Environmental Health Perspectives **113**(8): 978-82.

Zanobetti, A. and J. Schwartz (2006). "Air pollution and emergency admissions in Boston, MA." Journal of Epidemiology & Community Health **60**(10): 890-5.

Zanobetti, A. and J. Schwartz (2007). "Particulate air pollution, progression, and survival after myocardial infarction." Environmental Health Perspectives **115**(5): 769-75.

Zanobetti, A., J. Schwartz, et al. (2003). "The temporal pattern of respiratory and heart disease mortality in response to air pollution." Environmental Health Perspectives **111**(9): 1188-93.

Zeka, A. and J. Schwartz (2004). "Estimating the independent effects of multiple pollutants in the presence of measurement error: an application of a measurement-error-resistant technique." Environmental Health Perspectives **112**(17): 1686-90.

Zeka, A., J. R. Sullivan, et al. (2006). "Inflammatory markers and particulate air pollution: characterizing the pathway to disease.[see comment]." International Journal of Epidemiology **35**(5): 1347-54.

Zeller, M., M. Giroud, et al. (2006). "[Air pollution and cardiovascular and cerebrovascular disease: Epidemiologic data]." Presse Medicale **35**(10 Pt 2): 1517-22.

Zhang, M., Y. Song, et al. (2007). "A health-based assessment of particulate air pollution in urban areas of Beijing in 2000-2004." Science of the Total Environment **376**(1-3): 100-8.

Zhang, Y., W. Huang, et al. (2006). "Ozone and daily mortality in Shanghai, China." Environmental Health Perspectives **114**(8): 1227-32.

Zhong, W., L. Levin, et al. (2006). "Analysis of short-term influences of ambient aeroallergens on pediatric asthma hospital visits." Science of the Total Environment **370**(2-3): 330-6.

Zhou, Y. and J. I. Levy (2007). "Factors influencing the spatial extent of mobile source air pollution impacts: a meta-analysis." BMC Public Health **7**: 89.

Appendix 4

Binkova, B., I. Chvatalova, et al. (2007). "PAH-DNA adducts in environmentally exposed population in relation to metabolic and DNA repair gene polymorphisms." Mutation Research **620**(1-2): 49-61.

Binkova, B. and R. J. Sram (2004). "The genotoxic effect of carcinogenic PAHs, their artificial and environmental mixtures (EOM) on human diploid lung fibroblasts." Mutation Research **547**(1-2): 109-21.

Bocskay, K. A., D. Tang, et al. (2005). "Chromosomal aberrations in cord blood are associated with prenatal exposure to carcinogenic polycyclic aromatic hydrocarbons." Cancer Epidemiology, Biomarkers & Prevention **14**(2): 506-11.

Bonner, M. R., D. Han, et al. (2005). "Breast cancer risk and exposure in early life to polycyclic aromatic hydrocarbons using total suspended particulates as a proxy measure." Cancer Epidemiology, Biomarkers & Prevention **14**(1): 53-60.

Cebulska-Wasilewska, A., I. Pawlyk, et al. (2007). "Exposure to environmental polycyclic aromatic hydrocarbons: influences on cellular susceptibility to DNA damage (sampling Kosice and Sofia)." Mutation Research **620**(1-2): 145-54.

Cebulska-Wasilewska, A., A. Wiechec, et al. (2005). "Influence of environmental exposure to PAHs on the susceptibility of lymphocytes to DNA-damage induction and on their repair capacity." Mutation Research **588**(2): 73-81.

Chen, M.-L., B.-C. Lee, et al. (2003). "Polycyclic aromatic hydrocarbon-deoxyribonucleic acid (PAH-DNA) adduct levels and exposure to coke oven emissions among workers in Taiwan." Archives of Environmental Health **58**(5): 298-305.

Gagnon, F., T. Tremblay, et al. (2004). "Chemical risks associated with consumption of shellfish harvested on the north shore of the St. Lawrence River's lower estuary." Environmental Health Perspectives **112**(8): 883-8.

Gil, L., V. Martinez, et al. (2003). "Occupational and environmental levels of mutagenic PAHs and respirable particulate matter associated with diesel exhaust in Santiago, Chile." Journal of Occupational & Environmental Medicine **45**(9): 984-92.

Hansen, A. M., H. Wallin, et al. (2004). "Urinary 1-hydroxypyrene and mutagenicity in bus drivers and mail carriers exposed to urban air pollution in Denmark." Mutation Research **557**(1): 7-17.

Hu, Y., Z. Bai, et al. (2007). "Health risk assessment for traffic policemen exposed to polycyclic aromatic hydrocarbons (PAHs) in Tianjin, China." Science of the Total Environment **382**(2-3): 240-50.

Jedrychowski, W., R. M. Whyatt, et al. (2003). "Effect of prenatal PAH exposure on birth outcomes and neurocognitive development in a cohort of newborns in Poland. Study design and preliminary ambient data." International Journal of Occupational Medicine & Environmental Health **16**(1): 21-9.

Kim, M. K., S. Oh, et al. (2004). "Evaluation of biological monitoring markers using genomic and proteomic analysis for automobile emission inspectors and waste incinerating workers exposed to polycyclic aromatic hydrocarbons or 2,3,7,8,-

tetracholrodedibenzo-p-dioxins." Experimental & Molecular Medicine **36**(5): 396-410.

Krishnadasan, A., N. Kennedy, et al. (2007). "Nested case-control study of occupational chemical exposures and prostate cancer in aerospace and radiation workers." American Journal of Industrial Medicine **50**(5): 383-90.

Lemieux, C. L., I. B. Lambert, et al. (2008). "Mutagenic hazards of complex polycyclic aromatic hydrocarbon mixtures in contaminated soil." Environmental Toxicology & Chemistry **27**(4): 978-90.

Marczynski, B., R. Preuss, et al. (2005). "Genotoxic risk assessment in white blood cells of occupationally exposed workers before and after alteration of the polycyclic aromatic hydrocarbon (PAH) profile in the production material: comparison with PAH air and urinary metabolite levels." International Archives of Occupational & Environmental Health **78**(2): 97-108.

Masters, E. T., W. Jedrychowski, et al. (2007). "Relation between prenatal lipid-soluble micronutrient status, environmental pollutant exposure, and birth outcomes." American Journal of Clinical Nutrition **86**(4): 1139-45.

Mielzynska, D., E. Siwinska, et al. (2006). "The influence of environmental exposure to complex mixtures including PAHs and lead on genotoxic effects in children living in Upper Silesia, Poland." Mutagenesis **21**(5): 295-304.

Pavanello, S., A. Pulliero, et al. (2005). "Reduced nucleotide excision repair and GSTM1-null genotypes influence anti-B[a]PDE-DNA adduct levels in mononuclear white blood cells of highly PAH-exposed coke oven workers." Carcinogenesis **26**(1): 169-75.

Perera, F. P., V. Rauh, et al. (2006). "Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children." Environmental Health Perspectives **114**(8): 1287-92.

Pohjola, S. K., M. Lappi, et al. (2003). "DNA binding of polycyclic aromatic hydrocarbons in a human bronchial epithelial cell line treated with diesel and gasoline particulate extracts and benzo[a]pyrene." Mutagenesis **18**(5): 429-38.

Rossner, P., Jr., B. Binkova, et al. (2007). "Air pollution by carcinogenic PAHs and plasma levels of p53 and p21(WAF1) proteins." Mutation Research **620**(1-2): 34-40.

Siwinska, E., D. Mielzynska, et al. (2004). "Association between urinary 1-hydroxypyrene and genotoxic effects in coke oven workers." Occupational & Environmental Medicine **61**(3): e10.

Sram, R. J., O. Beskid, et al. (2007). "Chromosomal aberrations in environmentally exposed population in relation to metabolic and DNA repair genes polymorphisms." Mutation Research **620**(1-2): 22-33.

Staal, Y. C. M., D. G. A. J. Hebels, et al. (2007). "Binary PAH mixtures cause additive or antagonistic effects on gene expression but synergistic effects on DNA adduct formation." Carcinogenesis **28**(12): 2632-40.

Tang, D., T.-y. Li, et al. (2006). "PAH-DNA adducts in cord blood and fetal and child development in a Chinese cohort." Environmental Health Perspectives **114**(8): 1297-300.

Tang, D., A. Rundle, et al. (2003). "Sulfotransferase 1A1 (SULT1A1) polymorphism, PAH-DNA adduct levels in breast tissue and breast cancer risk in a case-control study." Breast Cancer Research & Treatment **78**(2): 217-22.

Tsai, P.-J., T.-S. Shih, et al. (2004). "Urinary 1-hydroxypyrene as an indicator for assessing the exposures of booth attendants of a highway toll station to polycyclic aromatic hydrocarbons." Environmental Science & Technology **38**(1): 56-61.

Tuntawiroon, J., C. Mahidol, et al. (2007). "Increased health risk in Bangkok children exposed to polycyclic aromatic hydrocarbons from traffic-related sources." Carcinogenesis **28**(4): 816-22.

Vera Castellano, A., J. Lopez Cancio, et al. (2003). "Polycyclic aromatic hydrocarbons in ambient air particles in the city of Las Palmas de Gran Canaria." Environment International **29**(4): 475-80.

Wang, H., W. Chen, et al. (2007). "Association between plasma BPDE-Alb adduct concentrations and DNA damage of peripheral blood lymphocytes among coke oven workers." Occupational & Environmental Medicine **64**(11): 753-8.

Appendix 5

Ademuyiwa, O., R. N. Ugbaja, et al. "Plasma lipid profiles and risk of cardiovascular disease in occupational lead exposure in abeokuta, nigeria." Lipids in Health & Disease. 4:19, 2005.

Albalak, R., R. H. McElroy, et al. (2003). "Blood lead levels and risk factors for lead poisoning among children in a mexican smelting community." Archives of Environmental Health **58**(3): 172-83.

Albert, D. A., A. N. Albert, et al. (2005). "Analysis of a cluster of cases of wegener granulomatosis." JCR: Journal of Clinical Rheumatology **11**(4): 188-93.

Alves, M. F., N. A. Fraiji, et al. (2006). "Fish consumption, mercury exposure and serum antinuclear antibody in amazonians." International Journal of Environmental Health Research **16**(4): 255-62.

Athavale, P., K. W. Shum, et al. (2007). "Occupational dermatitis related to chromium and cobalt: experience of dermatologists (epiderm) and occupational physicians (opra) in the u.k. Over an 11-year period (1993-2004)." British Journal of Dermatology **157**(3): 518-22.

Bast-Pettersen, R., D. G. Ellingsen, et al. (2005). "A neurobehavioral study of chloralkali workers after the cessation of exposure to mercury vapor." Neurotoxicology **26**(3): 427-37.

Beaumont, J. J., R. M. Sedman, et al. (2008). "Cancer mortality in a chinese population exposed to hexavalent chromium in drinking water.[See comment]." Epidemiology **19**(1): 12-23.

Belanger, M. C., E. Dewailly, et al. (2006). "Dietary contaminants and oxidative stress in inuit of nunavik." Metabolism: Clinical & Experimental **55**(8): 989-95.

Bleecker, M. L., D. P. Ford, et al. (2007). "The association of lead exposure and motor performance mediated by cerebral white matter change." Neurotoxicology **28**(2): 318-23.

Blond, M. and B. Netterstrom (2007). "Neuromotor function in a cohort of danish steel workers." Neurotoxicology **28**(2): 336-44.

Blond, M., B. Netterstrom, et al. (2007). "Cognitive function in a cohort of danish steel workers." Neurotoxicology **28**(2): 328-35.

Bocio, A., M. Nadal, et al. (2005). "Human exposure to metals through the diet in tarragona, spain: temporal trend." Biological Trace Element Research **104**(3): 193-201.

Carta, P., R. Carta, et al. (2003). "[Cognitive and performance capacity among adolescents living near a lead and zinc smelter]. [Italian]." Giornale Italiano di Medicina del Lavoro Ed Ergonomia **25 Suppl**(3): 43-5.

Carta, P., C. Flore, et al. (2003). "Sub-clinical neurobehavioral abnormalities associated with low level of mercury exposure through fish consumption." Neurotoxicology **24**(4-5): 617-23.

Chlebda, E., J. Antonowicz-Juchniewicz, et al. (2004). "[The effect of occupational exposure to heavy metals and arsenic on serum concentrations of carotenoids in copper foundry workers]. [Polish]." Medycyna Pracy **55**(5): 389-401.

Chou, C. H. and C. T. De Rosa (2003). "Case studies--arsenic." International Journal of Hygiene & Environmental Health **206**(4-5): 381-6.

Chuang, H. Y., C. H. Kuo, et al. (2007). "A case-control study on the relationship of hearing function and blood concentrations of lead, manganese, arsenic, and selenium." Science of the Total Environment **387**(1-3): 79-85.

Cocco, P., D. Fadda, et al. (2007). "Causes of death among lead smelters in relation to the glucose-6-phosphate dehydrogenase polymorphism." Occupational & Environmental Medicine **64**(6): 414-6.

Coelho, P., S. Silva, et al. (2007). "Health impact of living near an abandoned mine--case study: jales mines." International Journal of Hygiene & Environmental Health **210**(3-4): 399-402.

Cortes-Maramba, N., J. P. Reyes, et al. (2006). "Health and environmental assessment of mercury exposure in a gold mining community in western mindanao, philippines." Journal of Environmental Management **81**(2): 126-34.

Dalvie, M. A. and R. Ehrlich (2006). "Community mercury levels in the vicinity of peri-urban waste disposal sites and fossil fuel burning operations." Environment International **32**(4): 493-9.

Despres, C., A. Beuter, et al. (2005). "Neuromotor functions in inuit preschool children exposed to pb, pcbs, and hg." Neurotoxicology & Teratology **27**(2): 245-57.

Di Lorenzo, L., A. Silvestroni, et al. (2006). "Evaluation of peripheral blood neutrophil leucocytes in lead-exposed workers." International Archives of Occupational & Environmental Health **79**(6): 491-8.

Dynerowicz-Bal, E., R. Andrzejak, et al. (2005). "[The influence of occupational exposure to arsenic and heavy metals on the activity of catepsins and their inhibitors in blood serum of copper smelters]. [Polish]." Medycyna Pracy **56**(5): 347-61.

Essumang, D. K., D. K. Dodoo, et al. (2007). "Arsenic, cadmium, and mercury in cocoyam (xanthosoma sagititolium) and watercocoyam (colocasia esculenta) in tarkwa a mining community." Bulletin of Environmental Contamination & Toxicology **79**(4): 377-9.

Franko, A., M. V. Budihna, et al. (2005). "Long-term effects of elemental mercury on renal function in miners of the idrija mercury mine." Annals of Occupational Hygiene **49**(6): 521-7.

Gajek, J., D. Zysko, et al. (2004). "Heart rate variability in workers chronically exposed to lead." Kardiologia Polska **61**(7): 21-30.

Gao, Y., X. Zhang, et al. (2005). "[Effects of ecological environment in qinba mountains on hair trace element contents of local inhabitants]. [Chinese]." Yingyong Shengtai Xuebao **16**(2): 355-9.

Grimsrud, T. K., S. R. Berge, et al. (2005). "Can lung cancer risk among nickel refinery workers be explained by occupational exposures other than nickel?." Epidemiology **16**(2): 146-54.

Gromadzinska, J., W. Wasowicz, et al. (2003). "Oxidative-stress markers in blood of lung cancer patients occupationally exposed to carcinogens." Biological Trace Element Research **91**(3): 203-15.

Heo, Y., B. K. Lee, et al. (2004). "Serum ige elevation correlates with blood lead levels in battery manufacturing workers." Human & Experimental Toxicology **23**(5): 209-13.

Hisatomi, K., H. Ishii, et al. (2006). "Interstitial pneumonia caused by inhalation of fumes of nickel and chrome." Respirology **11**(6): 814-7.

Hodgson, S., M. J. Nieuwenhuijsen, et al. (2007). "Kidney disease mortality and environmental exposure to mercury." American Journal of Epidemiology **165**(1): 72-7.

Huang, Y. C., A. J. Ghio, et al. (2003). "The role of soluble components in ambient fine particles-induced changes in human lungs and blood." Inhalation Toxicology **15**(4): 327-42.

Ignasiak, Z., T. Slawinska, et al. (2007). "Blood lead level and physical fitness of schoolchildren in the copper basin of south-western poland: indirect effects through growth stunting." Annals of Human Biology **34**(3): 329-43.

Jasso-Pineda, Y., G. Espinosa-Reyes, et al. (2007). "An integrated health risk assessment approach to the study of mining sites contaminated with arsenic and lead." Integrated Environmental Assessment & Management **3**(3): 344-50.

Jones, S. R., P. Atkin, et al. (2007). "Lung cancer mortality at a uk tin smelter." Occupational Medicine (Oxford) **57**(4): 238-45.

Kasperczyk, S., A. Kasperczyk, et al. (2004). "Activity of glutathione peroxidase, glutathione reductase, and lipid peroxidation in erythrocytes in workers exposed to lead." Biological Trace Element Research **102**(1-3): 61-72.

Kumar, S., N. G. Sathwara, et al. (2005). "Semen quality of industrial workers occupationally exposed to chromium." Journal of Occupational Health **47**(5): 424-30.

Kuo, H. W., S. F. Chang, et al. (2003). "Chromium (vi) induced oxidative damage to dna: increase of urinary 8-hydroxydeoxyguanosine concentrations (8-ohdg) among electroplating workers." Occupational & Environmental Medicine **60**(8): 590-4.

Kwok, R. K., R. B. Kaufmann, et al. (2006). "Arsenic in drinking-water and reproductive health outcomes: a study of participants in the bangladesh integrated nutrition programme." Journal of Health, Population & Nutrition **24**(2): 190-205.

Lee, J. S., H. T. Chon, et al. (2005). "Human risk assessment of as, cd, cu and zn in the abandoned metal mine site." Environmental Geochemistry & Health **27**(2): 185-91.

Lee, S. W., B. T. Lee, et al. (2006). "Human risk assessment for heavy metals and as contamination in the abandoned metal mine areas, korea." Environmental Monitoring & Assessment **119**(1-3): 233-44.

Lei, L. J., L. Chen, et al. (2007). "Estimation of benchmark dose for pancreatic damage in cadmium-exposed smelters." Toxicological Sciences **97**(1): 189-95.

Li, G. J., L. L. Zhang, et al. (2004). "Occupational exposure to welding fume among welders: alterations of manganese, iron, zinc, copper, and lead in body fluids and the oxidative stress status." Journal of Occupational & Environmental Medicine **46**(3): 241-8.

Li, W. F., M. H. Pan, et al. (2006). "Lead exposure is associated with decreased serum paraoxonase 1 (pon1) activity and genotypes.[See comment]." Environmental Health Perspectives **114**(8): 1233-6.

Mahram, M., N. Mousavinasab, et al. (2007). "Effect of living in lead mining area on growth." Indian Journal of Pediatrics **74**(6): 555-9.

Maramba, N. P., J. P. Reyes, et al. (2006). "Environmental and human exposure assessment monitoring of communities near an abandoned mercury mine in the philippines: a toxic legacy." Journal of Environmental Management **81**(2): 135-45.

Mishra, K. P., V. K. Singh, et al. (2003). "Effect of lead exposure on the immune response of some occupationally exposed individuals." Toxicology **188**(2-3): 251-9.

Naha, N. and A. R. Chowdhury (2006). "Inorganic lead exposure in battery and paint factory: effect on human sperm structure and functional activity." Journal of Uoeh **28**(2): 157-71.

Nogue, S., P. Sanz-Gallen, et al. (2004). "Chronic overexposure to cadmium fumes associated with iga mesangial glomerulonephritis." Occupational Medicine (Oxford) **54**(4): 265-7.

Obiri, S., D. K. Dodoo, et al. (2006). "Cancer and non-cancer health risk from eating cassava grown in some mining communities in ghana." Environmental Monitoring & Assessment **118**(1-3): 37-49.

Onizuka, R., K. Tanabe, et al. (2006). "[A case of chrome asthma induced by exposure to the stone cutter dust]. [Japanese]." Arerugi - Japanese Journal of Allergology **55**(12): 1556-61.

Paiva, L., V. Martinez, et al. (2006). "Sister chromatid exchange analysis in smelting plant workers exposed to arsenic." Environmental & Molecular Mutagenesis **47**(4): 230-5.

Palus, J., D. Lewinska, et al. (2005). "Dna damage in leukocytes of workers occupationally exposed to arsenic in copper smelters." Environmental & Molecular Mutagenesis **46**(2): 81-7.

Paustenbach, D. J., B. L. Finley, et al. (2003). "Human health risk and exposure assessment of chromium (vi) in tap water." Journal of Toxicology & Environmental Health Part A **66**(14): 1295-339.

Potula, V., A. Henderson, et al. (2005). "Calcitropic hormones, bone turnover, and lead exposure among female smelter workers." Archives of Environmental & Occupational Health **60**(4): 195-204.

Purdey, M. (2004). "Chronic barium intoxication disrupts sulphated proteoglycan synthesis: a hypothesis for the origins of multiple sclerosis." Medical Hypotheses **62**(5): 746-54.

Pusapukdepob, J., P. Sawangwong, et al. (2007). "Health risk assessment of villagers who live near a lead mining area: a case study of klity village, kanchanaburi province, thailand." Southeast Asian Journal of Tropical Medicine & Public Health **38**(1): 168-77.

Rodrigues, A. R., C. R. Souza, et al. (2007). "Mercury toxicity in the amazon: contrast sensitivity and color discrimination of subjects exposed to mercury." Brazilian Journal of Medical & Biological Research **40**(3): 415-24.

Rosado, J. L., D. Ronquillo, et al. (2007). "Arsenic exposure and cognitive performance in mexican schoolchildren." Environmental Health Perspectives **115**(9): 1371-5.

Saint-Amour, D., M. S. Roy, et al. (2006). "Alterations of visual evoked potentials in preschool inuit children exposed to methylmercury and polychlorinated biphenyls from a marine diet." Neurotoxicology **27**(4): 567-78.

Saraswathy, C. P. and M. V. Usharani (2007). "Monitoring of cellular enzymes in the serum of electroplating workers at coimbatore." Journal of Environmental Biology **28**(2): 287-90.

Satarug, S., J. R. Baker, et al. (2003). "A global perspective on cadmium pollution and toxicity in non-occupationally exposed population. [Review] [120 refs]." Toxicology Letters **137**(1-2): 65-83.

Schwartz, B. S., B. K. Lee, et al. (2005). "Occupational lead exposure and longitudinal decline in neurobehavioral test scores." Epidemiology **16**(1): 106-13.

Shiau, C. Y., J. D. Wang, et al. (2004). "Decreased fecundity among male lead workers.[See comment]." Occupational & Environmental Medicine **61**(11): 915-23.

Skoczynska, A., K. Gruber, et al. (2007). "[Risk of cadrdiovascular diseases in lead-exposed workers of crystal glassworks. Part i. Effect of lead on blood pressure and lipid metabolism]. [Polish]." Medycyna Pracy **58**(6): 475-83.

Tang, N. and Z. Q. Zhu (2003). "Adverse reproductive effects in female workers of lead battery plants." International Journal of Occupational Medicine & Environmental Health **16**(4): 359-61.

Tsai, J. L., P. H. Horng, et al. (2004). "Determination of urinary trace elements (arsenic, copper, cadmium, manganese, lead, zinc, selenium) in patients with blackfoot disease." Archives of Environmental Health **59**(12): 686-92.

Vitayavirasak, B., K. Rakwong, et al. (2005). "Environmental arsenic exposure of schoolchildren in a former tin mining and smelting community of southern thailand." Environmental Sciences **12**(4): 195-205.

Wang, X. and J. Tian (2004). "Health risks related to residential exposure to cadmium in zhenhe county, china." Archives of Environmental Health **59**(6): 324-30.

Weaver, V. M., B. K. Lee, et al. (2003). "Associations of lead biomarkers with renal function in korean lead workers." Occupational & Environmental Medicine **60**(8): 551-62.

Wirth, J. J., M. G. Rossano, et al. (2007). "Ambient manganese exposure is negatively associated with human sperm motility and concentration." Epidemiology **18**(2): 270-3.

Yanez, L., E. Garcia-Nieto, et al. (2003). "Dna damage in blood cells from children exposed to arsenic and lead in a mining area." Environmental Research **93**(3): 231-40.

Zadnik, V. and V. Pompe-Kirn (2007). "Effects of 500-year mercury mining and milling on cancer incidence in the region of idrija, slovenia." Collegium Antropologicum **31**(3): 897-903.

Appendix 6

Campagna, D., S. J. Kathman, et al. (2004). "Ambient hydrogen sulfide, total reduced sulfur, and hospital visits for respiratory diseases in northeast Nebraska, 1998-2000." Journal of Exposure Analysis and Environmental Epidemiology **14**(2): 180-7.

Christia-Lotter, A., C. Bartoli, et al. (2007). "Fatal occupational inhalation of hydrogen sulfide." Forensic Science International **169**(2-3): 206-9.

Couch, L., L. Martin, et al. (2005). "Near death episode after exposure to toxic gases from liquid manure." New Zealand Medical Journal **118**(1213): U1414.

Durand, M. and J. G. Wilson (2006). "Spatial analysis of respiratory disease on an urbanized geothermal field." Environmental Research **101**(2): 238-45.

Fiedler, N., H. Kipen, et al. (2008). "Sensory and cognitive effects of acute exposure to hydrogen sulfide." Environmental Health Perspectives **116**(1): 78-85.

Gangopadhyay, R. K. and S. K. Das (2007). "Accident due to release of hydrogen sulphide in a manufacturing process of cobalt sulphide - case study." Environmental Monitoring & Assessment **129**(1-3): 133-5.

Gerasimon, G., S. Bennett, et al. (2007). "Acute hydrogen sulfide poisoning in a dairy farmer." Clinical Toxicology: The Official Journal of the American Academy of Clinical Toxicology & European Association of Poisons Centres & Clinical Toxicologists **45**(4): 420-3.

Hendrickson, R. G., A. Chang, et al. (2004). "Co-worker fatalities from hydrogen sulfide." American Journal of Industrial Medicine **45**(4): 346-50.

Inserra, S. G., B. L. Phifer, et al. (2004). "Neurobehavioral evaluation for a community with chronic exposure to hydrogen sulfide gas." Environmental Research **95**(1): 53-61.

Kage, S., H. Ikeda, et al. (2004). "Fatal hydrogen sulfide poisoning at a dye works." Legal Medicine **6**(3): 182-6.

Kilburn, K. H. (2003). "Effects of hydrogen sulfide on neurobehavioral function." Southern Medical Journal **96**(7): 639-46.

Knight, L. D. and S. E. Presnell (2005). "Death by sewer gas: case report of a double fatality and review of the literature." American Journal of Forensic Medicine and Pathology **26**(2): 181-5.

Lewis, R. J., A. R. Schnatter, et al. (2003). "Mortality and cancer morbidity in a cohort of Canadian petroleum workers." Occupational and Environmental Medicine **60**(12): 918-28.

Nam, B., H. Kim, et al. (2004). "Neurologic sequela of hydrogen sulfide poisoning." Industrial Health **42**(1): 83-7.

Nikkanen, H. E. and M. M. Burns (2004). "Severe hydrogen sulfide exposure in a working adolescent." Pediatrics **113**(4): 927-9.

Policastro, M. A. and E. J. Otten (2007). "Case files of the University of Cincinnati fellowship in medical toxicology: two patients with acute lethal occupational

exposure to hydrogen sulfide." Journal of Medical Toxicology: Official Journal of the American College of Medical Toxicology **3**(2): 73-81.

Saadat, M. and A. Bahaoddini (2004). "Hematological changes due to chronic exposure to natural gas leakage in polluted areas of Masjid-i-Sulaiman (Khozestan province, Iran)." Ecotoxicology and Environmental Safety **58**(2): 273-6.

Saadat, M., Z. Zendeh-Boodi, et al. (2006). "Environmental exposure to natural sour gas containing sulfur compounds results in elevated depression and hopelessness scores." Ecotoxicology and Environmental Safety **65**(2): 288-91.

Smith, B. and K. Cummins (2004). "Hydrogen sulfide exposure at a waste treatment facility." Journal of Occupational & Environmental Hygiene **1**(3): D23-5.

Yalamanchili, C. and M. D. Smith (2008). "Acute hydrogen sulfide toxicity due to sewer gas exposure." American Journal of Emergency Medicine **26**(4): 518.e5-7.

Appendix 7

Bobak, M., M. Richards, et al. (2004). "Relation between children's height and outdoor air pollution from coal-burning sources in the British 1946 birth cohort." International Archives of Occupational & Environmental Health **77**(6): 383-6.

Buffler, P. A., M. Kelsh, et al. (2004). "Primary brain tumor mortality at a petroleum exploration and extraction research facility." Journal of Occupational & Environmental Medicine **46**(3): 257-70.

Cara, A. C., F. Buntinx, et al. (2007). "Industrial air pollution and children's respiratory health: a natural experiment in Calarasi." European Journal of General Practice **13**(3): 135-43.

De Barba, M. C., A. L. Jurkiewicz, et al. (2005). "Audiometric findings in petrochemical workers exposed to noise and chemical agents." Noise & Health **7**(29): 7-11.

Dubnov, J., M. Barchana, et al. (2007). "Estimating the effect of air pollution from a coal-fired power station on the development of children's pulmonary function." Environmental Research **103**(1): 87-98.

Gazdek, D., M. Strnad, et al. (2007). "Lymphohematopoietic malignancies and oil exploitation in Koprivnica-Krizevci County, Croatia." International Journal of Occupational & Environmental Health **13**(3): 258-67.

Glass, D. C., C. N. Gray, et al. (2005). "Health Watch exposure estimates: do they underestimate benzene exposure?" Chemico-Biological Interactions **153-154**: 23-32.

Glass, D. C., C. N. Gray, et al. (2003). "Leukemia risk associated with low-level benzene exposure.[see comment]." Epidemiology **14**(5): 569-77.

Goldberg, M., A. Leclerc, et al. (2007). "Cohort profile: the GAZEL Cohort Study." International Journal of Epidemiology **36**(1): 32-9.

Hurtig, A. K. and M. San Sebastian (2002). "Geographical differences in cancer incidence in the Amazon basin of Ecuador in relation to residence near oil fields." Int J Epidemiol **31**(5): 1021-7.

Hurtig, A. K. and M. San Sebastian (2002). "Gynecologic and breast malignancies in the Amazon basin of Ecuador, 1985-1998." Int J Gynaecol Obstet **76**(2): 199-201.

Hurtig, A. K. and M. San Sebastian (2004). "Incidence of childhood leukemia and oil exploitation in the Amazon basin of Ecuador." Int J Occup Environ Health **10**(3): 245-50.

Hurtig, A.-K. and M. San Sebastian (2004). "Incidence of childhood leukemia and oil exploitation in the Amazon basin of Ecuador." International Journal of Occupational & Environmental Health **10**(3): 245-50.

Knox, E. G. (2005). "Childhood cancers and atmospheric carcinogens.[see comment]." Journal of Epidemiology & Community Health **59**(2): 101-5.

Lewis, R. J., A. R. Schnatter, et al. (2003). "Mortality and cancer morbidity in a cohort of Canadian petroleum workers." Occupational & Environmental Medicine **60**(12): 918-28.

Mohorovic, L. (2004). "First two months of pregnancy--critical time for preterm delivery and low birthweight caused by adverse effects of coal combustion toxics." Early Human Development **80**(2): 115-23.

Nam, B., H. Kim, et al. (2004). "Neurologic sequela of hydrogen sulfide poisoning." Industrial Health **42**(1): 83-7.

Neuberger, J. S., S. G. Lynch, et al. (2004). "Prevalence of multiple sclerosis in a residential area bordering an oil refinery.[erratum appears in Neurology. 2005 Jan 25;64(2):223]." Neurology **63**(10): 1796-802.

Neuberger, J. S., P. Ward-Smith, et al. (2003). "Brain cancer in a residential area bordering on an oil refinery." Neuroepidemiology **22**(1): 46-56.

Park, J., C.-G. Lee, et al. (2006). "Factors related to the prevalence of respiratory symptoms in workers in a petrochemical complex." Journal of Occupational Health **48**(3): 216-22.

Parodi, S., E. Stagnaro, et al. (2005). "Lung cancer in an urban area in Northern Italy near a coke oven plant." Lung Cancer **47**(2): 155-64.

Saadat, M. and A. Bahaoddini (2004). "Hematological changes due to chronic exposure to natural gas leakage in polluted areas of Masjid-i-Sulaiman (Khozestan province, Iran)." Ecotoxicology & Environmental Safety **58**(2): 273-6.

San Sebastian, M., B. Armstrong, et al. (2001). "Exposures and cancer incidence near oil fields in the Amazon basin of Ecuador." Occup Environ Med **58**(8): 517-22.

San Sebastian, M., B. Armstrong, et al. (2002). "Outcomes of pregnancy among women living in the proximity of oil fields in the Amazon basin of Ecuador." Int J Occup Environ Health **8**(4): 312-9.

San Sebastian, M. and A. K. Hurtig (2004). "Cancer among indigenous people in the Amazon Basin of Ecuador, 1985-2000." Rev Panam Salud Publica **16**(5): 328-33.

Sorahan, T. (2007). "Mortality of UK oil refinery and petroleum distribution workers, 1951-2003." Occupational Medicine **57**(3): 177-85.

Appendix 8

Babisch, W., B. Beule, et al. (2005). "Traffic noise and risk of myocardial infarction." Epidemiology **16**(1): 33-40.

Babisch, W., H. Ising, et al. (2003). "Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease." Occupational and Environmental Medicine **60**(10): 739-45.

Bluhm, G., E. Nordling, et al. (2004). "Road traffic noise and annoyance--an increasing environmental health problem." Noise & Health **6**(24): 43-9.

Chang, S.-J., C.-J. Chen, et al. (2006). "Hearing loss in workers exposed to toluene and noise." Environmental Health Perspectives **114**(8): 1283-6.

Chang, S.-J., T.-S. Shih, et al. (2003). "Hearing loss in workers exposed to carbon disulfide and noise." Environmental Health Perspectives **111**(13): 1620-4.

Chang, T.-Y., R.-M. Jain, et al. (2003). "Effects of occupational noise exposure on blood pressure." Journal of Occupational and Environmental Medicine **45**(12): 1289-96.

Chen, J.-D. and J.-Y. Tsai (2003). "Hearing loss among workers at an oil refinery in Taiwan." Archives of Environmental Health **58**(1): 55-8.

De Barba, M. C., A. L. Jurkiewicz, et al. (2005). "Audiometric findings in petrochemical workers exposed to noise and chemical agents." Noise & Health **7**(29): 7-11.

de Kluizenaar, Y., R. T. Gansevoort, et al. (2007). "Hypertension and road traffic noise exposure." Journal of Occupational and Environmental Medicine **49**(5): 484-92.

Dement, J., K. Ringen, et al. (2005). "Surveillance of hearing loss among older construction and trade workers at Department of Energy nuclear sites." American Journal of Industrial Medicine **48**(5): 348-58.

Guski, R. (2004). "How to forecast community annoyance in planning noisy facilities." Noise & Health **6**(22): 59-64.

Jakovljevic, B., G. Belojevic, et al. (2006). "Road traffic noise and sleep disturbances in an urban population: cross-sectional study." Croatian Medical Journal **47**(1): 125-33.

King, R. P. and J. R. Davis (2003). "Community noise: health effects and management." International Journal of Hygiene & Environmental Health **206**(2): 123-31.

Korfali, S. I. and M. Massoud (2003). "Assessment of community noise problem in Greater Beirut Area, Lebanon." Environmental Monitoring & Assessment **84**(3): 203-18.

Landen, D., S. Wilkins, et al. (2004). "Noise exposure and hearing loss among sand and gravel miners." Journal of Occupational & Environmental Hygiene **1**(8): 532-41.

Leon Bluhm, G., N. Berglind, et al. (2007). "Road traffic noise and hypertension." Occupational and Environmental Medicine **64**(2): 122-6.

Michaud, D. S., S. E. Keith, et al. (2005). "Noise annoyance in Canada." Noise & Health **7**(27): 39-47.

Michaud, D. S., S. E. Keith, et al. (2008). "Annoyance and disturbance of daily activities from road traffic noise in Canada." Journal of the Acoustical Society of America **123**(2): 784-92.

Pawlaczyk-Luszczyniska, M., A. Dudarewicz, et al. (2005). "The impact of low-frequency noise on human mental performance." International Journal of Occupational Medicine and Environmental Health **18**(2): 185-98.

Penney, P. J. and C. E. Earl (2004). "Occupational noise and effects on blood pressure: exploring the relationship of hypertension and noise exposure in workers." AAOHN Journal **52**(11): 476-80.

Persson Waye, K., J. Bengtsson, et al. (2003). "A descriptive cross-sectional study of annoyance from low frequency noise installations in an urban environment." Noise & Health **5**(20): 35-46.

Ristovska, G., D. Gjorgjev, et al. (2004). "Psychosocial effects of community noise: cross sectional study of school children in urban center of Skopje, Macedonia." Croatian Medical Journal **45**(4): 473-6.

Sobotova, L., J. Jurkovicova, et al. (2006). "Community noise annoyance assessment in an urban agglomeration." Bratislavske Lekarske Listy **107**(5): 214-6.

Stansfeld, S. A. and M. P. Matheson (2003). "Noise pollution: non-auditory effects on health." British Medical Bulletin **68**: 243-57.

Appendix 9

Anisimov, V. N. (2006). "Light pollution, reproductive function and cancer risk." Neuroendocrinology Letters **27**(1-2): 35-52.

Davis, S. and D. K. Mirick (2006). "Circadian disruption, shift work and the risk of cancer: a summary of the evidence and studies in Seattle." Cancer Causes and Control **17**(4): 539-45.

Pauley, S. M. (2004). "Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue." Medical Hypotheses **63**(4): 588-96.

Schernhammer, E. and K. Schulmeister (2004). "Light at night and cancer risk." Photochemistry and Photobiology **79**(4): 316-8.

Schernhammer, E. S., B. Rosner, et al. (2004). "Epidemiology of urinary melatonin in women and its relation to other hormones and night work.[see comment]." Cancer Epidemiology, Biomarkers and Prevention **13**(6): 936-43.

Schernhammer, E. S. and K. Schulmeister (2004). "Melatonin and cancer risk: does light at night compromise physiologic cancer protection by lowering serum melatonin levels?" British Journal of Cancer **90**(5): 941-3.

Appendix 10

Centers for Disease Control and, P. (1993). "Injuries to international petroleum drilling workers, 1988-1990." MMWR - Morbidity & Mortality Weekly Report **42**(7): 128-31.

Centers for Disease Control and, P. (2008). "Fatalities among oil and gas extraction workers--United States, 2003-2006." MMWR - Morbidity & Mortality Weekly Report **57**(16): 429-31.

Diaz-Valecillos, M., J. Fernandez, et al. (2004). "[Chromosome alterations in workers exposed to ionizing radiation]." Investigacion Clinica **45**(3): 197-211.

Fernandez-D'Pool, J. and M. Doos (2001). "Accidents among drillers in the Venezuelan oil industry in 1993." Investigacion Clinica **42**(4): 225-34.

Guidotti, T. L. (1995). "Occupational injuries in Alberta: responding to recent trends." Occupational Medicine **45**(2): 81-8.

McNabb, S. J., R. C. Ratard, et al. (1994). "Injuries to international petroleum drilling workers, 1988 to 1990." Journal of Occupational Medicine **36**(6): 627-30.

Sarma, B. P. (2001). "Epidemiology and man-days loss in burn injuries amongst workers in an oil industry." Burns **27**(5): 475-80.

Seleye-Fubara, D. and E. Bob-Yellowe (2006). "Industrial accidental deaths in the Niger delta region of Nigeria: a study of 32 autopsies in Port Harcourt." Medicine, Science and the Law **46**(4): 342-6.

Suruda, A. and J. Agnew (1989). "Deaths from asphyxiation and poisoning at work in the United States 1984-6." British Journal of Industrial Medicine **46**(8): 541-6.

Appendix 11

Andrew C, R. (2003). "Experts Conclude Oil Drilling Has Hurt Alaska's North Slope." New York Times: 16.

Bhatia, R. (2007). "Protecting health using an environmental impact assessment: a case study of san francisco land use decisionmaking." American Journal of Public Health **97**(3): 406-413.

Chassany, A.-S. (2007). "Total Taps Africa's Oil Reserves In Bid to Outdo Rival's Growth." Wall Street Journal - Eastern Edition **249**(119): A8.

Coelho, K., D. Norbert, et al. (2006). The Footprint of The Offshore Oil Industry on Community Institutions. Research in Economic Anthropology, JAI. **Volume 24:** 123-162.

Forsyth, C. J., A. D. Luthra, et al. (2007). "Framing perceptions of oil development and social disruption." Social Science Journal **44**(2): 287-299.

Frynas, J. G. (2004). "THE OIL BOOM IN EQUATIONAL GUINEA." African Affairs **103**(413): 527-546.

Gallacher, J., K. Bronstering, et al. (2007). "Symptomatology attributable to psychological exposure to a chemical incident: A natural experiment." Journal of Epidemiology & Community Health **61**(6): 506-512.

Goldenberg, S., J. Shoveller, et al. (2007). "Barriers to STI testing among youth in a Canadian oil and gas community." Health Place.

Idreis, H. M., C. E. Siqueira, et al. (2006). "Impact of software and hardware technologies on occupational health and safety policies in Saudi Arabian oil refineries." New Solut **16**(2): 193-216.

Idris, N. A. and N. Dian (2005). "Interesterified palm products as alternatives to hydrogenation." Asia Pacific Journal of Clinical Nutrition **14**(4): 396-401.

Izquierdo, C. (2005). "When 'health' is not enough: Societal, individual and biomedical assessments of well-being among the Matsigenka of the Peruvian Amazon." Social Science & Medicine **61**(4): 767-783.

Jobin, W. (2003). "Health and equity impacts of a large oil project in Africa." Bulletin of the World Health Organization **81**(6): 420-426.

Kettl, P. (1998). "Alaska native suicide: lessons for elder suicide." International Psychogeriatrics **10**(2): 205-211.

Lester, C. and M. Temple (2006). "Health impact assessment and community involvement in land remediation decisions." Public Health **120**(10): 915-22.

Luthra, A. D., Bankston, W.B., et al. (2007). "Economic fluctuation and crime: A time-series analysis of the effects of oil development in the coastal regions of Louisiana." Deviant Behavior **28**(2): 113-130.

Mall, A., Buccino, S., & Nicols, J. (2007). "Protecting western communities from the health and environmental effects of oil and gas production." NRDC: Drilling Down.

Murthy, R. S., J. J. L√≥pez-Ibor, et al. (2005). The experience of the Bhopal disaster. Disasters and mental health. New York, NY, US, John Wiley & Sons Ltd**:** 193-199.

Seydlitz, R. L., S., Spain, D., Triche, E., & Bishop, K. (1993). "Development and social problems: The impact of the offshore oil industry on suicide and homicide rates." Rural Sociology **58**(1): 93-110.

Srinivasan, S., L. R. O'Fallon, et al. (2003). "Creating Healthy Communities, Healthy Homes, Healthy People: Initiating a Research Agenda on the Built Environment and Public Health." Am J Public Health **93**(9 %U http://www.ajph.org/cgi/content/abstract/93/9/1446 %8 September 1, 2003): 1446-1450.

Udoh, I. A. (2007). "Corruption and oil exploration:expert agreement about the prevention of HIV/AIDS in the Niger Delta of Nigeria." Health Educ Res.

Wernham, A. (2007). "Inupiat health and proposed Alaskan oil development: Results of the first integrated health impact assessment/environmental impact statement for proposed oil development on Alaska's north slope." Ecohealth: 500-513.

Potential Exposure-Related Human Health Effects of Oil and Gas Development:

A White Paper

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Executive Summary

Based on the body of scientific evidence, human health risks and social impacts are associated with oil and gas development. This white paper supports the need for an Health Impact Assessment to be included as part of any Environmental Impact Statement or other planning and assessment process when considering oil and gas development, especially in populated areas.

As an illustration of the health issues that should be considered, this white paper focuses on Garfield County, Colorado which has experienced a 39% increase in oil and gas drilling between 2000-2007. A detailed review of the human health literature plus preliminary studies of health status and air and water quality in Garfield County indicate that local residents maybe at risk for adverse health effects and psychological and social impacts.

Data necessary to completely assess the health and social impacts of the oil and gas industry are missing in all areas, including: population demographics, health status, psychological status, social measures, worker health, and environmental exposure. Further monitoring of both the community and the environment of Garfield County is essential. Action to decrease current chemical exposures of concern and improve monitoring should not be delayed. A Health Impact Assessment is an appropriate framework for relating exposure assessment to community health data and for making recommendations to mitigate adverse human health effects.

While this white paper focuses on Garfield County, Colorado as an illustration of the potential exposure-related health impact of oil and gas development, the principles of exposure and the related health issues should be considered generally applicable wherever oil and gas development is occurring.

Introduction

The purpose of the white paper is to:

1. Describe the population of the Western Slope of Colorado potentially exposed to hazards that have been associated with oil and gas exploration and extraction.
2. Describe the baseline health and social parameters of the population that may be at risk.
3. Discuss the possible health, medical, and social issues that face this population in light of the increasing oil and gas drilling and production in close proximity to where they live, work and go to school, using Garfield County, Colorado as an illustration.
4. Provide guidance for future environmental and medical monitoring of the Western Slope population and other similarly affected communities.
5. Weigh the need for conducting a Health Impact Assessment as part of the Environmental Impact Statement (EIS) process and other planning processes for oil and gas development.

Background

United States and global energy needs have driven up prices for fossil fuels. In addition, political instability in major energy producing countries around the world has driven a US energy policy to increase domestic production of all types of energy, in particular fossil fuels. The combination of increasing demand, interest in domestic supplies and new technology has made fuels previously unattainable or too costly now worthy of recovery.

As pressures for increased fossil fuel production increase, areas that had previously been considered too sensitive for drilling are now being drilled. These sites have included an increasing number of oil and gas exploration and extraction facilities, some of which are in close proximity to native and local populations. Human proximity to oil and gas production sites may increase the likelihood that people will be exposed to the hazardous chemicals, emissions and pollutants associated with this activity. (Saadat and Bahaoddini 2004; San Sebastian and Hurtig 2004)

Garfield, Mesa, Rio Blanco and Moffat counties, all on the Western Slope of Colorado, have seen and likely will continue to see dramatic increases in oil and gas drilling. As such, this white paper will focus on Garfield County as a 'case study' for considering the potential health consequences of exposure. Others have reported on the assessment of exposure. (Teresa Coons and Walker 2008) The emphasis of this white paper will be on exposure-related health risks.

Oil and gas development starts with obtaining permits to begin exploration. Development next involves drilling into the land in search for fossil fuels. The drilling process very often involves fracturing subsurface land formations in order to release the fuels in question. If the desired product is found, then extraction processes remove the

fuels. The extraction of the fuels in these active wells may take several decades. Occasionally, in an effort to increase production, wells are fractured again. Once the well has ceased production, the wells are capped

As described below, drilling and fracturing activities may use and produce hazardous materials which could threaten human health. In addition, active wells can continue to pose health hazards due to fugitive air emissions from the wells and from emissions from stationary and vehicular traffic. (Oil and Gas Accountability Project) Abandoned wells may continue to be a source of toxic contaminants if proper capping and maintenance procedures are not used. (URS Corporation 2006)

Hazardous chemicals are used and produced by oil and gas extraction processes. Subsurface land formations are "fractured" (known as "fracking or frac'ing) by injection of fluids and/or solids into the ground under high pressure. Some of the chemicals used in this process are brought to the surface, potentially contaminating soil, air and water, while some of the chemicals are left underground, potentially contaminating subsurface aquifers. Other chemicals may also be used in drilling fluids and other products used by industry. Drilling fluids may be fresh or salt water-based muds, oil-based muds, or synthetic materials that contain esters, olefins, paraffins, ethers and alkulbenzenes, among others. Drilling fluids may also contain additives such as metals, acrylic polymers, organic polymers, surfactants, and biocides. Chemicals used in drilling muds and fracking fluids are often considered proprietary and specific composition of these compounds are generally not available to the public. (Oil and Gas Accountability Project)

Drilling sludge brought to the surface can contain fracking fluid, drilling mud, radioactive material from the subsurface land formation, hydrocarbons, metals, and volatile organic compounds. Sludge is often left to dry on the surface in waste pits, potentially contaminating air, water and soil. Sludge may also be removed to waste disposal sites (but not always to hazardous waste sites) or sludge may be tilled into the soil in "land farms." These practices can potentially contaminate soil, air and surface water. So-called "produced water" is brought to the surface during the extraction process. This water may be contaminated with salts, hydrocarbons, radioactive material, metals, drilling fluids and muds. The produced water is often left on the surface to evaporate, or it may be reinjected into the ground or released into surface waters. All of these disposal methods may threaten air, water and soil quality. (Oil and Gas Accountability Project)

Spills of oil and gas wastes and/or chemicals used in production can pollute ground and surface water and soil. The Colorado Oil and Gas Conservation Commission (COGCC) maintains records of reported spills resulting from oil and gas activities. In the four year period January 2003 – March 2008 there were 1549 spills. These spills involved produced water (767), crude oil or gas condensate (449), other materials (134) and unclassified (201). Twenty percent of the spills involved water contamination. Furthermore, the number of spills has increased as the number of wells has increased. For example, in Garfield County, 5 spills were reported in the year 2003, compared to

55 spills reported in 2007. (Colorado Oil and Gas Conservation Commission, Oil and Gas Accountability Project)

Air surrounding oil and gas production areas is particularly susceptible to toxic emissions. Fugitive natural gas emissions may contain many contaminants, such as methane and other hydrocarbons (ethane, propane, butane), hydrogen sulfide (H2S), and water vapor. These emissions can come from production sites, disposal pits or pipelines. In Garfield County, for example, many of these sites tend to be near population centers and adjacent to streams and other bodies of water (see Garfield County map on page 12 below). Some natural gas wells produce a condensate that can contain complex hydrocarbons and aromatic hydrocarbons such as benzene, toluene, ethyl benzene and xylene (BTEX). Natural gas flaring can produce many hazardous chemicals including polycyclic aromatic hydrocarbons (PAHs, including naphthalene), benzene, toluene, xylenes, ethyl benzene, formaldehyde, acrolein, propylene, acetaldehyde and hexane. Glycol dehydrators, used to remove water from natural gas, can produce BTEX leaks into the air. (Oil and Gas Accountability Project)

Oil and gas exploration and production activities have been exempted from standards created to protect health under a number of Federal statutes, including provisions of the Clean Air Act (CAA), the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or the Superfund Act), and the Emergency Planning and Community Right to Know Act (the Toxics Release Inventory or TRI). These laws are designed to protect the health of the American population by ensuring clean air and water. (Mall 2007)

Because the oil and gas drilling industry is not obliged to comply with certain federal health and environmental regulations (Mall, 2007), there has been virtually no publicly available monitoring of air or water contamination due to the activities of oil and gas drilling and extraction. As drilling for oil and gas moves closer to human populations, hazards associated with these industries are more likely to have a direct effect on the health of those living, working and going to school in proximity to the drilling and production sites. Anecdotal evidence of health effects due to increased drilling has begun to surface. (Oil and Gas Accountability Project) However, in the absence of environmental monitoring data regarding exposure levels and medical evaluation of complaints, it has been scientifically difficult to establish causal relationships between oil and gas activity and health effects. Gaps in the medical literature are profound, as reflected in the literature review that is attached to this white paper. There is a paucity of published literature that directly addresses the health effects of oil and gas exploration and production. However there is a sizeable scientific literature linking many of the exposures to adverse health outcomes in humans.

The National Environmental Policy Act (NEPA) established the Environmental Impact Statement (EIS) as a means for environmental analysis in the United States. When industrial development involving federal resources is proposed, the federal government is tasked to consider effects on the "human environment." In practice, EIS

have traditionally focused on environmental effects, with little consideration of public health effects. When public health is considered, simple compliance with regulatory statutes such as the CAA and CWA are commonly used as a proxy for more substantive analysis. Since industrial projects often have impact on the environment in ways that directly or indirectly affect the health and psychosocial structure of local populations, there is a growing recognition that EIS should include a Health Impact Assessment (HIA) in many cases. (Wernham 2007) This white paper is intended to examine the rationale for an HIA as part of the permitting process for oil and gas drilling on the Western Slope of Colorado and other areas with intensive industrial development. As precedent, an integrated HIA/EIS published in 2007 described the impact of oil development on Alaska's North Slope on the local Inupiat populations. (Wernham 2007) The HIA findings predicted impact on health and social structure. The report provided recommendations for mitigation of these effects, thereby improving the probability that oil development could proceed with less adverse impact on the people who live in the region.

Western Slope of Colorado

The American West has seen a dramatic increase in drilling for oil, gas, and coal bed methane. In Garfield County, on the Western Slope of Colorado, there are presently approximately 4521 active wells. Oil and gas drilling increased by 39% between 2000 and 2007. (Colorado Oil and Gas Conservation Commission) While the total number of drilling permits for 2008 is not yet known, it is estimated that by the end of 2008, approximately 3200 permits are expected to be issued in the county. Looking toward the future, it is estimated that Garfield County will continue on a pace of approximately 1000 new wells per year. It is expected by 2023 there will be between 15,000 and 23,000 wells in Garfield County. (BBC Research & Consulting, 2008) As such, this white paper will focus on Garfield County as an illustrative example of the assessment of potential health hazards due to oil and gas drilling near human populations. It is beyond the scope of this white paper to conduct similar examinations of the other Colorado counties experiencing similar growth in oil and gas activity. Lessons learned in Garfield County are likely to be relevant elsewhere in the region.

As a result of the increased health concerns of residents in Garfield County, County commissioners have commissioned several studies attempting to characterize potential exposures in contaminated air and water. (URS Corporation 2006; Garfield County Public Health Department 2007) This white paper will summarize these and other exposure data available in Garfield County in order to help frame the discussion of potential health consequences. This white paper will include available data characterizing the general population of Garfield County, including those populations that may be more susceptible to the effects of toxic exposures. This white paper will also describe the publicly available health statistics for Garfield County. Such health data can provide public health professionals with an early indication of adverse health trends, some of which might be associated with oil and gas activity. In addition, the white paper examines the available baseline psychosocial characteristics of Garfield County residents. The paper concludes with a discussion of the gaps in knowledge and

the potential role that a Health Impact Assessment (HIA) may have in filling these gaps and ensuring community health.

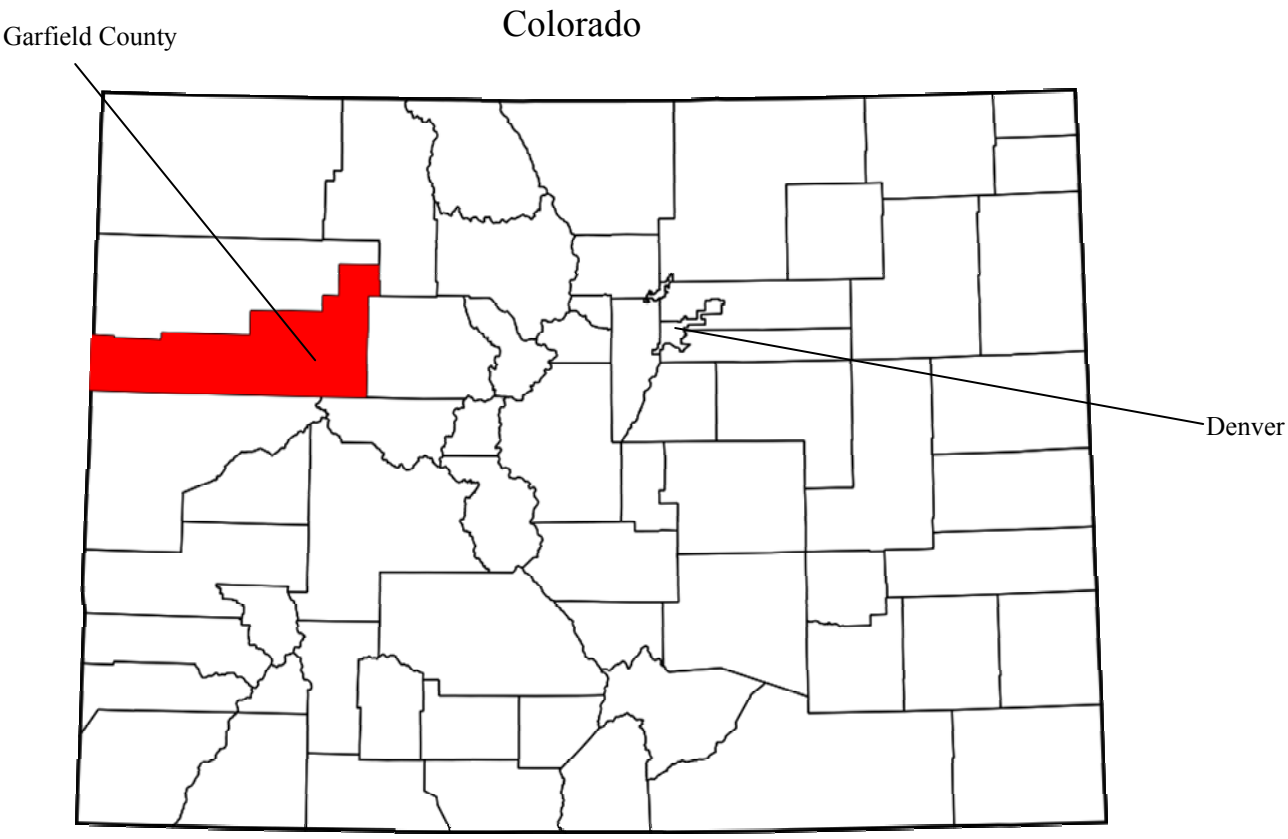
As discussed in the medical and public health literature review (attached), few studies have been published on the health effects of oil and gas exploration and extraction on communities living and working in the vicinity of these activities. A lack of specific evidence, however, does not negate the fact that oil and gas operations use and produce toxic contaminants that adversely affect human health; nor does it negate the potential health effects of the large-scale socio-demographic and economic changes often associated with such projects. Available studies show that exposure to air pollutants, toxic chemicals, metals, radiation, noise and light pollution cause a range of diseases, illnesses, and health problems, including psychological and social disruption. Neighborhoods, schools, and workers in close proximity to oil and gas activities may be at increased risk for cancer, cardiovascular disease, asthma, and other disorders due to uncontrolled or high exposures. Further research is needed to assess the health impact of oil and gas operations on surrounding communities.

Garfield County Community Profile

Understanding the community characteristics can help explain the prevalence of health risk behavior and outcomes. The following sections provide an introduction to Garfield County based on data obtained from a number of publicly available sources. For a complete list of references used for this profile, see Appendix 1. This summary highlights some of the important demographic, geographic, economic, environmental, and social factors that influence many aspects of health.

Geography and Well Locations

Garfield County (2,958 square miles) is located in the northwest region of Colorado, and is bordered to the north by Rio Blanco County, on the east by Eagle County, and on the south by Mesa and Pitkin Counties. Garfield County is made up of six municipalities (listed in decreasing population size): Glenwood Springs, Rifle, Carbondale, New Castle, Silt, and Parachute. Garfield County is primarily a rural county, with most residents (42%), living outside the six major townships. (Garfield County Quick Facts: http://www.garfield-county.com/Index.aspx?page=698)



The Colorado Oil and Gas Conservation Commission provides publicly available data on oil and gas wells in Colorado, such as number of active wells, drilling permits, and location. (Colorado Oil and Gas Conservation Commission: http://oil-gas.state.co.us/)

In 2002, Colorado had just over 22,500 active wells; as of April 7, 2008, the state had 34,734 active wells. Sixty percent of all active wells are located within seven counties throughout Colorado, three of which are located on the Western Slope of Colorado (Garfield, Rio Blanco, and Mesa). (Table 1)

Table 1. Total Active Wells by County (Top 7 drilling counties)

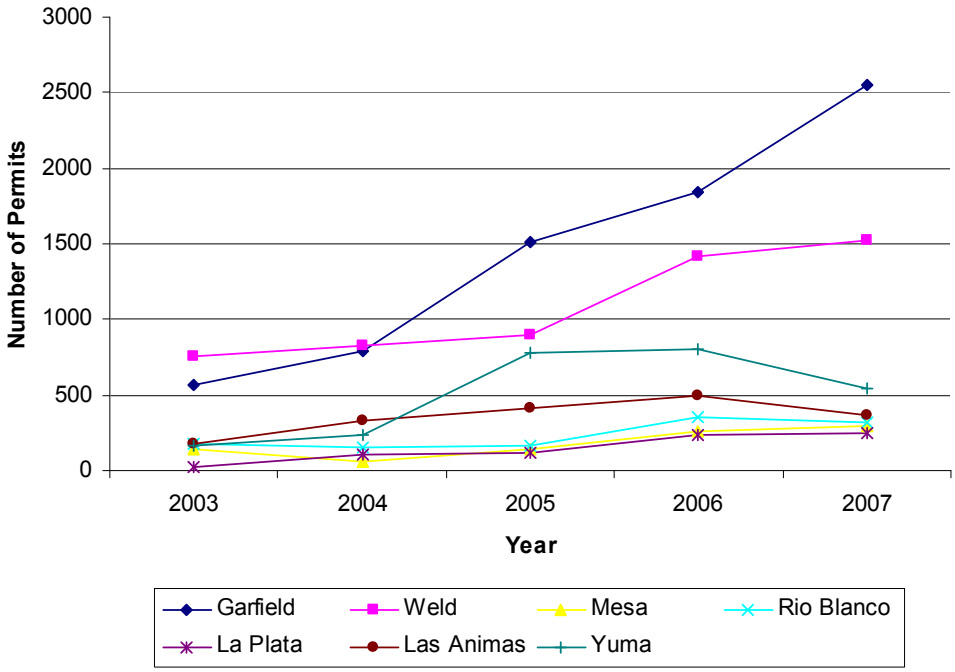
County	**Total Active Wells** (April 7, 2008)
Weld	12,858
Garfield	4,521
Yuma	3,125
Rio Blanco	2,636
La Plata	2,917
Las Animas	2,721
Mesa	660
State Total	34,366

Data Source: Colorado Oil and Gas Conservation Commission

Although close to forty percent of currently active wells are located within Weld County (which is not on the Western Slope), permits for drilling in Garfield County have exceeded permits for all counties since 2005. (Figure 1, Table 2) This dramatic increase in permits demonstrates that Garfield County is rapidly becoming the center of oil and gas extraction activity on Colorado's Western slope. Furthermore, as shown below, many existing wells and permits in Garfield County are located close to population centers, thereby increasing potential human exposure to hazardous chemicals. This white paper focuses on Garfield County as an illustration of the principles and issues that need to be considered when weighing the potential exposure-related health impact of oil and gas development. Similar analyses could be conducted in other counties.

Although we do not yet know the total number of drilling permits issued for the current year, as of May 1, 2008, 1,029 permits, or 35% of all permits issued in the state, have been issued in Garfield County. Currently, most permits issued within the county surround the communities of Rifle, Parachute, and Silt. (Figure 2) It is predicted that by the end of 2008 approximately 3,200 drilling permits will be issued in the county. Looking toward the future, it is estimated that Garfield County will continue at a pace of approximately 1,000 new wells per year. It is expected that by 2023 there will be approximately 15,000 to 23,000, or 3 to 5 times the amount of wells in Garfield County. (BBC Research & Consulting, 2008)

Figure 1. Drilling Permits by County 2003-2007



Data Source: Colorado Oil and Gas Conservation Commission

Consistent with the expansion of oil and gas wells in Garfield County, the number of drilling rigs running per week has also exceeded all counties within the state. On average, during 2007, 58 drilling rigs were running per week. In comparison, Weld County, on average, had 19 drilling rigs running per week during the 2007 year. In the early months of 2008 (January 3-March 25), on average 66 rigs were running in Garfield County per week, compared to Weld County, with an average of 18 drill rigs running per week.

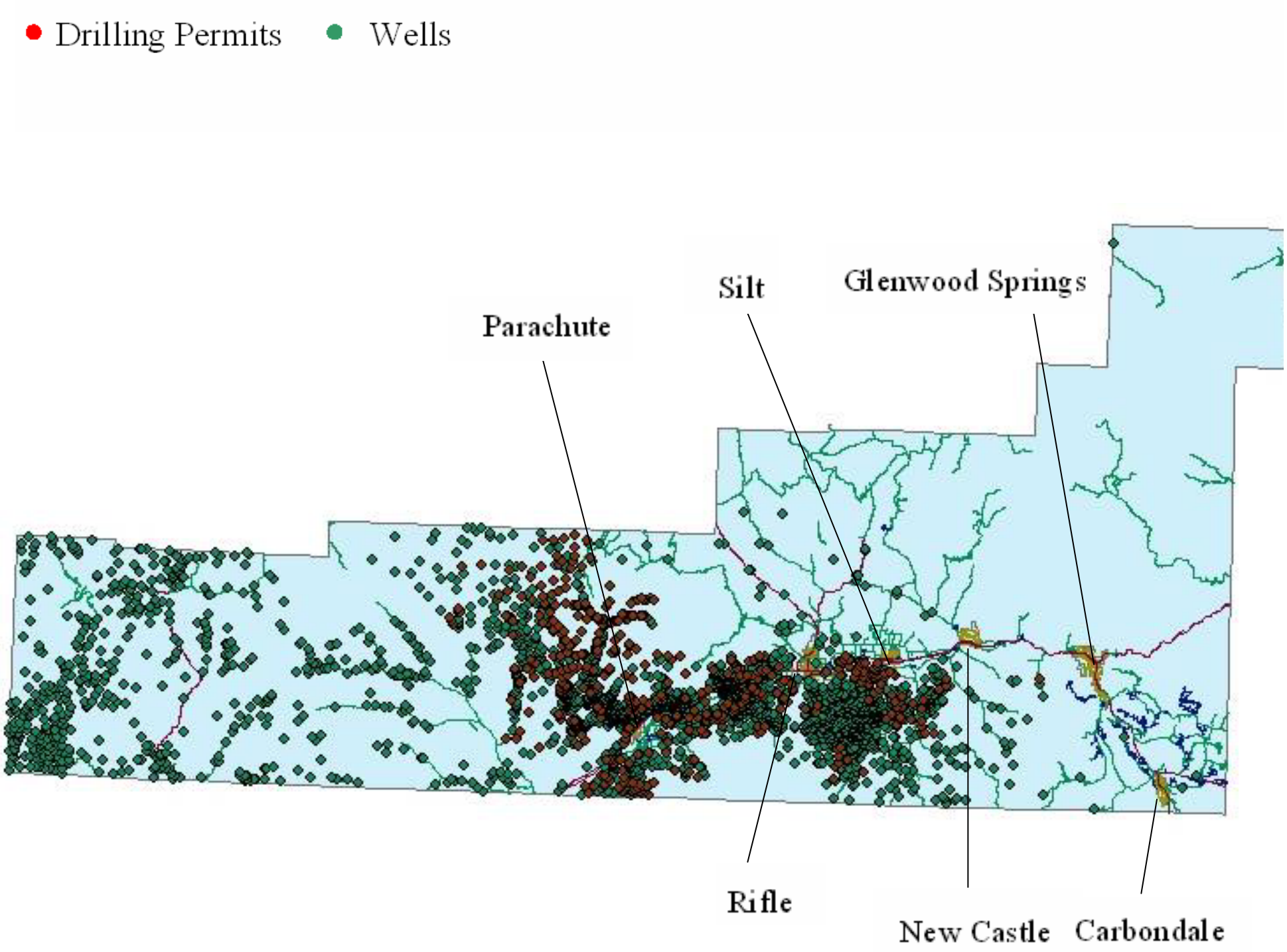
It is important to note that these statistics on drilling do not necessarily reflect the scope, intensity, and location of oil and gas production activity in the state. Some drilling sites can be expected to be active extraction sites, while others may not.

Table 2. Drilling Permit Totals for the Top Seven Counties by Year

County	**2003**	**2004**	**2005**	**2006**	**2007**	**2008** (June 2, 2008)
Garfield	566	796	1,508	1,844	2,550	1,029
Weld	757	832	901	1418	1,527	708
Mesa	138	54	136	265	293	225
Rio Blanco	180	154	161	360	321	200
La Plata	27	102	117	235	251	175
Las Animas	179	332	413	500	362	159
Yuma	162	237	782	798	541	148

Data Source: Colorado Oil and Gas Conservation Commission

Figure 2. Garfield County Wells and Drilling Permits as of April 2008



Demographics

Garfield County has experienced consistent growth since 1970, with the most rapid growth in recent years as local energy development draws in new workers and households to Garfield County. The 2006 population of Garfield County was estimated to be 53,020 people, an increase of 21 percent from the population reported in 2000. An annual growth rate of 3.2 percent (as compared to the state's 1.9%) made Garfield County the fastest-growing county on Colorado's Western Slope. Within Garfield County, the fastest growing community was the town of New Castle, which had an annual growth rate of 9.4 percent, during 2005 to 2006. (Table 3) As energy development increases in Garfield County, the population is projected to increase significantly. By 2035, Garfield County is projected to have a population of 136,697. (BBC Researching & Consulting, 2008)

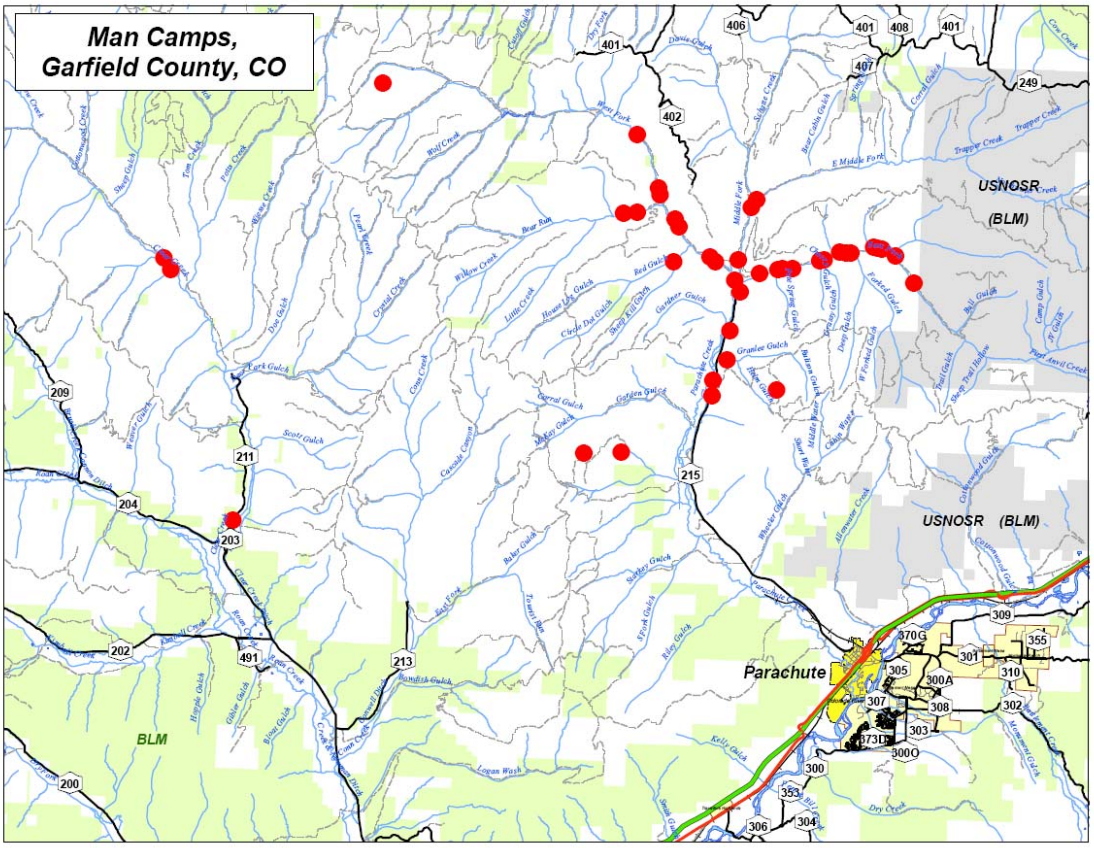
Table 3. Garfield County, Colorado Municipality Populations: 2000-2006

County	2000	2001	2002	2003	2004	2005	2006	Annual Growth Rate 2005-2006
Carbondale	5,196	5,509	5,565	5,689	5,767	5,881	6,088	3.5%
Glenwood Springs	7,736	8,135	8,301	8,406	8,517	8,603	8,743	1.6%
New Castle	1,984	2,268	2,604	2,825	2,949	3,148	3,443	9.4%
Parachute	1,006	1,269	1,297	1,320	1,338	1,360	1,486	9.3%
Rifle	6,784	7,079	7,349	7,541	7,760	8,118	8,706	7.2%
Silt	1,740	1,901	2,039	2,089	2,184	2,319	2,416	4.2%
Unincorporated area	19,345	20,012	20,286	29,526	20,810	21,244	22,138	4.2%
Total Population[1]	43,791	46,173	47,275	57,126	49,325	50,673	53,020	4.4%

Data Source: Colorado Department of Local Affairs. [1]Total population derived by adding each column

Oil and gas development has increased population densities, some of which is the result of an increase in the number of temporary and transient workers. The western slope has a large number of temporary workers living in motel rooms, RV campgrounds, and temporary camps, often called "man camps," in the region. (Figure 3) While there are no data on the exact number of temporary workers, it is estimated that 20 percent of the natural gas workforce is comprised of workers who do not have a permanent residence within the region or the surrounding counties. (BBC Research & Consulting, 2008) In 2006, approximately 6,300 jobs were oil and gas-related (not including supporting jobs) in a four county region (Garfield, Mesa, Moffat, and Rio Blanco). It has been predicted that by 2035 there will be almost 10,000 oil and gas workers in the four county region. (BBC Research & Consulting, 2008) The lack of precise information on this population affects the ability to accurately assess the current and future health of the community.

Figure.3 "Man Camps" Garfield County, Colorado



Source: Garfield County Website: Download Central

According to 2000 U.S. census estimates, 49 percent of the Garfield County population was female and 51 percent male. The median age was 34.2 years. Twenty-seven percent of the population were under 18 years of age, 8 percent under 5 years, and 9 percent were 65 years and older. Fifteen percent of the general population in Garfield County did not have health insurance in 2000. Twelve percent of children under the age of 18 in Garfield County did not have health insurance in 2000. For people reporting race in Garfield County, 92 percent identified as white alone; 0.5 percent identified as Black or African American; 0.7 percent identified as American Indian and Alaska Native; and 0.4 percent identified as Asian. Two percent identified as two or more races. Seventeen percent of the people reporting for Garfield County identified as Hispanic or Latino. Again, there are no demographic data on the temporary oil and gas workers, most of which moved into Garfield County since 2000. These data suggest that approximately one-third of the population, in the year 2000, may be considered to be more susceptible to certain exposures, based on age (27% children and 9% elderly).

Currently, 9533 students pre-kindergarten through 12th grade are enrolled in Garfield County schools across three school districts: Roaring Fork RE-1 (Glenwood Springs, Carbondale), Garfield 16 (Parachute), and Garfield RE-2 (Rifle, Silt, and New Castle). The Roaring Fork RE-1 district is the largest, housing 14 schools and a total of

4864 students. Garfield RE-2 has a total of 7 schools, and a total of 3695 students. The last district, Garfield 16, is made up of 4 schools and a total of 974 students. Colorado Department of Education trend data (2003-2007) show a 12 percent increase in enrollment for the county. Enrollment for the Roaring Fork RE-1 district serving the towns of Glenwood Springs and Carbondale has increased by approximately 6 percent. Enrollment in the RE-2 school district serving the towns of Rifle, Silt, and New Castle, has increased by approximately 15 percent. Enrollment in the Garfield 16 district, serving the town of Parachute, has increased by over 31 percent. These data suggest an increasing population of young people, who are potentially at increased risk for adverse health effects from certain exposures. (http://www.cde.state.co.us/index_stats.htm, http://www.cde.state.co.us/cdereval/rv2007pmlinks.htm)

The energy development boom has increased jobs in Garfield and surrounding Western Slope counties, which in turn has increased the demand for housing, driving home and land values up in the recent years. Housing costs in Garfield County were roughly 35 percent below comparable Denver metropolitan area costs just six years ago. Now the costs often match or exceed Denver area prices. (BBC Research & Consulting, 2008) Housing is also difficult to find in Garfield County. Vacancy rates are at 5%, compared to rates exceeding 25% in 1985. Since 2003, building permits have climbed each year in Garfield County. In particular, the town of Rifle had a 50 percent increase in building permits. This contributes to an understanding of the potential impact of oil and gas industry expansion on infrastructure and social systems.

Traffic congestion in Garfield County increased by 39 percent during the time period of 2000 to 2007, compared to an increase of 11 percent for the state (Northwest Colorado Socioeconomic Analysis and Forecasts, 2008). Surrounding Western Slope Counties experienced a similar increase in traffic congestion: Rio Blanco, 35%, Mesa, 25 %, and Moffat, 23%. Contributing to traffic congestion are a number of important factors, including the increase in vehicular traffic volume due to oil and gas industry activity as well as increased population. As discussed above, the lack of housing within the county for oil and gas employees contributes to commuter traffic and congestion in the county. As discussed in the literature review and elsewhere in this white paper, vehicular traffic contributes to injury rates as well as to air pollution associated health risks.

Conclusions and Recommendations

1. There is a lack of precise demographic data on the Garfield County population. This affects the ability to accurately assess the current and future health of the community.
2. There are no demographic data on the number of temporary oil and gas workers. Most moved into Garfield County since 2000.
3. The available data suggest that approximately one-third of the population may be more susceptible to certain oil and gas industry-related exposures, if exposed.

4. There is a rising population of children, who are potentially at increased risk for adverse health effects from these exposures, if exposed.

Exposure: Known Garfield and Four County contaminants

The purpose of this section is to summarize available exposure data. It is not intended to be a comprehensive analysis of exposure, but rather to provide sufficient information and background for the discussion of potential health effects of interest. In order to be able to determine the impact of oil and gas exploration and extraction activity on the health of a neighboring community, it is necessary to have sufficient exposure data. To be useful, these data must be collected in a systematic, accurate, and current manner. Such data must also be publicly available and provided in a form that can facilitate their use in assessing the relationship between exposure and human health outcomes.

The Western Slope of Colorado has seen a dramatic increase in oil and gas extraction activity. Despite this activity there are very few data regarding the air and water quality impact. Because of citizen concerns, a few, very limited studies have been undertaken. These studies are reviewed below. It should be noted that even with limited sampling and a very limited list of chemicals tested the results of the air sampling demonstrated potentially hazardous levels of benzene. Other volatile organic compounds have also been detected in Garfield County air, as discussed below. Methane has been detected in well water in areas near drilling sites. This study is also reviewed below. Water samples measured at sites removed from active drilling sites had no detectable contaminants. There has been no testing or monitoring of soil quality in Garfield County. These results demonstrate that more comprehensive and ongoing air, water and soil monitoring should be conducted.

Please note: there may be additional sources of exposure information that we were unaware of or were not able to obtain prior to preparing this white paper. If, for example, private corporations or public agencies have conducted sampling that is not in the public domain, we have not had the opportunity to review and include such data sets.

AIR QUALITY

ATSDR 2005-2007

The Colorado Department of Public Health and Environment (CDPHE), in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), undertook an air sampling project from 2005-2007 to assess possible air quality impacts posed by increasing oil and gas activities in Garfield County, Colorado. Intermittent twenty-four hour sampling occurred at 14 fixed sites, coinciding with an EPA air sampling schedule, over a 24 month period. A total of 232 samples were taken (averaging 24 hours of sampling at each site every 45 days). In addition, twenty-seven 10-15 second grab samples (averaging 10 – 15 seconds of sampling every 27 days) were taken during "odor events," when odors felt to be caused by oil and gas activities were noted by local citizens.

The study used EPA risk assessment tools to examine carcinogenic and noncarcinogenic effects. For carcinogenic concerns, EPA Region 3 Risk Based Concentrations (RBC) were used in the risk analysis. Chemicals were listed as Contaminants of Potential Concern (COPC) if levels measured could produce greater than 1 excess cancer in one million. For noncancer health effects, if levels were found to be greater than Massachusetts Allowable Ambient Limits (ALLs) or above ATSDR Chronic, Intermediate, Acute Minimal Risk Levels (MRLs) in at least 5% of samples the chemical was listed as a COPC. It should be noted that recent literature suggests adverse health effects due to benzene may occur at lower levels than previously thought.

Results of the limited sampling indicate that local populations may be exposed to chemicals at levels hazardous to health. Benzene was identified at COPC levels at 12 of 14 sites and at 7 of the 8 oil and gas sites. Excess cancer risks ranged from 5-58 cancers/million. Four urban sites had cancer risks ranging from 15-22 cancers/ million and 1 rural site at 8 cancers/million. The Brock oil and gas site had benzene levels associated with excess cancer risk of 58 per million. The Brock site recorded a 24-hour sample of 49 ug/m3. This site also recorded the highest grab sample for benzene at 180 ug/m3 (3 ug/m3=1 ppb). Measurements here and at other locations also exceeded all minimum levels for noncancer health effects as well as for cancer health effects. While the Brock site is highlighted because it had the highest levels of benzene, it should be remembered that 12 of the 14 sites had potentially hazardous levels of benzene, indicating that potential for benzene exposure is the rule and not the exception. Although 86% of the sites tested demonstrated hazardous benzene levels, the CDPHE and ATSDR determined that benzene posed only an intermediate health risk because of lack of data and the hypothesis that other unnamed sources could be contributing to the measured benzene levels. No action is recommended by ATSDR other than a call for more monitoring.

In addition to benzene, other chemicals were found at elevated, potentially hazardous, levels. Methylene chloride (1 site), tetrachoroethene (2 sites), trichloroethene (1 site), 1,4-dichlorobenzene (8 sites), m,p-xylenes (6 sites) and 2-hexanone (3 sites) were noted at levels that could produced carcinogenic or non carcinogenic health effects. Toluene and acetone were also detected, frequently but at levels that did not reach cut-offs set for COPC. Based on these data, in its report ATSDR concluded that these chemicals were unlikely to be a significant hazard.

This conclusion may be problematic for several reasons. First, relatively few samples were obtained relative to the geographic area and the time period of concern. When chemicals are detected using an infrequent sampling scheme, there is no way of knowing if the results are truly representative of exposure. A conservative, precautionary approach would dictate that these results be considered as warnings that these chemicals exist, at levels as yet undetermined. Second, the quantitative measure of concentration for these chemicals may not be accurately represented. There is no way of knowing with certainty if the levels recorded were minimum, maximum or

somewhere in between. The grab samples are especially problematic, since they represent only a 10-15 second snapshot, without any information as to how high the levels may actually have reached, nor for how long levels may have been elevated. Similarly, the 24-hour samples may have been taken at a peak, nadir or somewhere in between. In conclusion, the actual level and extent of chemical contamination remains unknown.

The ATSDR did not look at levels of other air toxics that would be expected to be found. Potentially hazardous airborne chemicals associated with oil and gas extraction include particulate matter, nitrogen oxides, sulfur oxides, hydrogen sulfide, ground level ozone, metals (lead, arsenic, mercury, selenium, barium, cadmium, chromium, zinc). Although drilling permits may be granted based upon projected discharges and modeling, in the absence of actual, publicly available data, true exposures remain unknown.

Garfield County and CDPHE have responded to the ATSDR study with plans to continue air monitoring. The CDPHE has released its plan for this monitoring effort. Particulate monitoring will be reduced to only one sampling site, either in Rifle or Parachute, Colorado. They will, however, begin monitoring for particulate matter <2.5 micron diameter (PM2.5), based on accepted literature that has found that PM2.5 is more highly associated with human health risk than is particulate matter <10 micron diameter (PM10) (See Literature Review). Monitoring for hazardous ultrafine airborne particles is not planned, although there is compelling scientific evidence that ultrafine particles (<0.1 micron diameter) pose a particularly high human health risk. Nonmethane organic compounds (NOMC total and 54 species of chemicals) will be monitored for 24 hours every 6 days (264 samples in next year) and low molecular weight carbonyl compounds (LOMCC, e.g. formaldehyde, acetaldehyde, acetone, acrolein, and others) will be sampled for 24 hours every 12 days (180 samples in the next year) at Rifle, Parachute, Bell Ranch and a fourth fixed or mobile location (Rada, 2008).

While this plan represents an improvement in the amount and scope of sampling to be taken at a given site (60 samples per site for NOMC and 30 samples per site for LMWCC), the number of sites has been decreased 70%. Furthermore, the site that registered the highest levels of benzene in the ASTDR study is not included in future monitoring plans. The planned air monitoring also does nothing to address the already documented hazardous levels of benzene.

United States Forest Service Ozone Monitoring 2006-Current

Little is known about ozone levels in the rural, Western Slope of Colorado. Because ozone is highly toxic to plants, the U.S. Forest Service monitors ozone in some forests, including locations in this region. The U.S. Forest Service uses both passive and solar-powered battery-operated continuous monitors to measure ozone. Although new National Ambient Air Quality Standards (NAAQS) for ozone is 75 ppb, the EPA

acknowledges that for O3 (and PM2.5) levels substantially below NAAQS are still associated with increased mortality, cardiovascular events, and respiratory problems.

The preliminary results indicate that ozone in the Colorado high country is detected at concentrations that, at times, exceed National Ambient Air Quality Standards. Ozone concentrations on Ajax Mountain in Aspen ranged from 40 parts per billion (ppb) to almost 80 ppb during the months April-August, 2007. Additionally, ozone monitors on the Bell Ranch near Rifle found ozone levels averaging in the 40-50 ppb range, with spikes in ozone levels surpassing 75 ppb throughout the summer months of 2007. These results demonstrate that air quality in these areas may actually be hazardous to humans and that further monitoring by agencies tasked to protect human health is warranted.

Secondary findings are also important. The U.S. Forest Service found that ozone concentrations increase with altitude. CDPHE is installing ozone and PM monitors in Rifle (elevation 5130 f), Cortez (elevation 6201 f), and Palisade (elevation 4728 f). These locations may not be indicative of the ozone levels of communities at higher elevations (Musselman and Korfmacher 2008).*EPA Ozone Monitoring, La Plata County, 2007*

The EPA has two stationary ozone monitors in La Plata County; the first one is located a mile from Ignacio on County Road 517 and the second is on Highway 5505. The first location recorded spikes in ozone levels above 75 ppb and 8 hour average levels in the 58-71ppb range. The second location recorded ozone exceeding NAAQS (82 ppb) on one occasion and the next three highest levels (73, 73, 71 ppb) approached the limits of the standard (75 ppb). The monitoring in La Plata County demonstrates that air quality in some of Colorado's rural areas approaches and may at times exceed established Federal health standards (United States Environmental Protection Agency 2007).

CDPHE Air Quality monitoring

CDPHE has conducted limited air quality monitoring on the Western Slope. In 2006 there were 11 sites monitoring PM10 (Delta, Parachute, Rifle, New Castle, three ranches near Silt, Glenwood Springs, Durango, Grand Junction, and Telluride). In addition, Grand Junction had monitors for PM2.5, carbon monoxide (CO) and meteorological measurements. In 2006, none of the monitors recorded particulate levels exceeding NAAQS, with the exception of those associated with natural occurrence events (high winds or forest fires). It should be noted, however, that particulate levels in Parachute, Rifle and New Castle (towns in areas of the largest growth of oil and gas drilling in Garfield County) have recorded the highest monthly averages for particulate matter and have been trending upward over the last few years. For 2008, CDPHE has added PM2.5, ozone and meteorological monitors in Rifle and ozone and meteorological monitors in Palisade and Cortez. (Colorado Department of Public Health and Environment 2006; Garfield County Public Health Department 2007; Colorado Department of Public Health and Environment 2008)

WATER QUALITY

Garfield County Hydrogeologic Study 2006

In 2006 a report commissioned by the Garfield County Board of County Commissioners was released. This report contained a compilation of existing hydrogeologic data for a 110 square mile area which included the Mamm Creek gas field, south of Rifle and Silt and south of the Colorado River. (URS Corporation 2006)

The results of this report demonstrate many domestic wells, water wells, irrigation wells, monitoring wells, air sparging wells, springs, seeps, ponds, and rivers had detectable levels of methane. Out of 184 locations, 135 locations had detectable levels of methane (73% of locations); 872 samples were taken and 656 samples had detectable levels of methane (75% of samples). In the eastern portion of the study, the West Divide creek area recorded several wells with elevated levels of methane (>2 mg/l) and some with much higher levels (10-26 mg/l). Data from COGCC indicate that at least some of the groundwater and surface water contaminated with methane has been a result of gas development activities, while other sources of methane in domestic water wells remains unknown or is likely due to biogenic sources. In the southeast portion of the study area, domestic water contamination is likely due to older, abandoned wells that have been leaking for almost 30 years.

This study also reports on benzene and other organic compounds in surface waters. Benzene and methane levels in excess of MCL (5 ug/L and 1000ug/L, respectively) have been recorded in seeps in the study area. The two highest benzene recordings were in the West Divide Creek seep area (360 ug/L and 150 ug/L) and these two locations also recorded the highest ethylbenzene (10 and 16 ug/L) and some of the highest toluene (28-130 ub/L), xylene (17-110ug/L) and methane (1.2-12mg/L) measurements.

While this study is preliminary, it demonstrates that hazardous substances are present in the area's surface and subsurface water. The authors of this hydrogeologic report also point out that water sources with high levels of benzene, toluene, ethylene, and xylene (BTEX) chemicals also contain high levels of methane from gas well sources. They propose BTEX measurements as a method for determining gas well contamination of water sources. The authors also note that parts of the study area have undergone extensive oil and gas development, but there are few current data available regarding the groundwater quality in the same area. Some of the recommended follow up (Phase 2) studies include: further evaluation of wells with elevated methane levels, develop a long-term groundwater and surface water sample collection program, sample all domestic water wells on a two-year frequency for methane, major ions, selenium, fluoride and bromide, as well as other recommendations. (URS Corporation 2006)

Garfield County Phase IV Baseline Water Quality Study 2007

The Colorado Oil and Gas Conservation Commission (COGCC) contracted for a water quality field study in July and August of 2006. Seventy domestic water supply wells in Garfield County, between New Castle and Rifle north of the Colorado River were tested for inorganic, organic chemicals and 29 wells were tested for gas composition. Methane, BTEX and Methyl Tertiary Butyl Ether **(**MTBE) were not detected in any samples tested at STL Laboratories, but methane was detected in some water samples using gas chromatography methods used by the Isotech laboratory.

While this study provided some evidence that wells in the study area did not have the chemicals tested for at the time, it should be noted that the study area of this report differs significantly from that of the 2006 Hydrogeologic Report study area. The 2007 COGCC report study area is *north* of the Colorado River, whereas the report commissioned by Garfield County in 2006 studied an area *south* of the Colorado River. It should be noted that the greater extent of gas drilling in this area is taking place south of the Colorado River. This report illustrates the need not only for further water quality studies in Garfield County, but also for studies that are relevant to the areas where the most drilling activity is occurring. (Garfield County IT Department 2007; S.S. Papadpipulos & Associates 2007)

NOISE

La Plata County Impact Report 2002

Elevated noise levels are associated with all stages of oil and gas development: construction, vehicle noise, pumps and condensers all contribute to well pad noise. COGCC uses the State of Colorado noise guidelines for oil and gas monitoring. According to COGCC Rule 802, sound from oil and gas activities should not exceed the noise levels for predominant land use in the zone where a well exists and noise should be measured 25 feet beyond the property line or at a residential home.

La Plata County did an extensive County Impact Report (CIR) in 2002, assessing the impacts of proposed gas drilling. Contained in this report were measurements of ambient noise in rural residential, subdivision residential, and transportation land use areas in La Plata County. The average residential noise levels ranged from 42-46 decibels (dBA) and were substantially less than those allowed by State of Colorado Noise Guidelines (50 dBA at night and 55 dBA in the day). The La Plata report also used published noise levels for drilling activities to model well pads layouts to meet COCGG requirements. The final staff report made recommendations to change the noise level requirements to reflect the ambient noise of the county. (La Plata County 2002)

We were unable to find any publicly available data that directly measured noise levels associated with oil and gas development activities on the Western Slope. If such information exists, it is not readily available. Noise can contribute to a variety of adverse health effects, as discussed in the accompanying literature review. Of particular note, when noise exposure occurs in combination with exposure to volatile organic compounds, hearing loss can develop at lower levels than with just noise alone. As oil and gas development continues to increase in close proximity to populated areas, noise monitoring and mitigation should be implemented.

Conclusions and Recommendations

1. There are major gaps in the past assessment of air and water quality related to oil and gas development on the Western Slope.
2. Air and water quality studies conducted to date indicate that potential exposures to hazardous emissions exist.
3. Many air toxics are essentially unmeasured in Garfield County, despite the increase in oil and gas development known to produce these chemicals. Air quality measurements should not be considered complete until monitoring of all known potential hazardous substances is performed.
4. Current plans for further air sampling may not be comprehensive enough to enable public health officials to determine the community health impact of oil and gas development.
5. There are no plans for comprehensive and systematic monitoring of surface and subsurface waters. Water monitoring must occur and results made public, in order to protect human health.
6. Although some levels of harmful chemicals in both air and water measured in Garfield County may not fall within a specific regulatory standard, adverse health impacts are known to occur at levels below standards. As discussed in the attached literature review, this must be taken into account when mitigation measures aimed at reducing health impacts are undertaken. (Glass, Gray et al. 2003; Glass, Gray et al 2005)
7. Environmental monitoring must be relevant to the areas where oil and gas development activity is occurring.
8. Environmental monitoring results must be readily available to the public. Unbiased interpretation of the results must occur in a timely manner and be made available to the public.
9. There are no available studies examining the impact of oils and gas development on the noise levels in Garfield County. These studies should be conducted to assess and mitigate adverse effects of increased noise levels.
10. There are no available studies examining the impact of oil and gas development on soil quality in Garfield County. These studies should be conducted to assess and mitigate adverse affects of soil contaminants on human health.

Garfield County Health Status

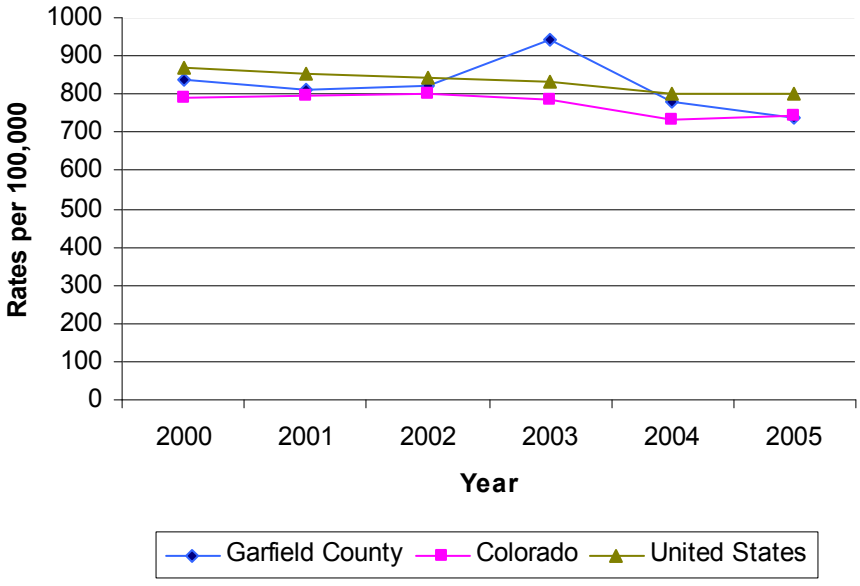
We examined heath status data publicly available for Garfield County residents; outlined below are some of the health status and determinants. A complete list of references can be found in Appendix 1. It is important to note that this is publicly available data. The data have significant limitations, the most notable being that oil and gas development in Garfield County did not start to rapidly expand until 2003. Most publicly available data for the county are still not available for the most recent years. Also, most of the data are population based, therefore lacking the ability to identify rare and individual health events. Listed below are the publicly available data we recovered for Garfield County, Colorado.

- Mortality Data (General, Infant): 1990-2005
- Cause of Death: 1990-2005
- Cancer Statistics: 1992-2002
- Cardiovascular Disease: 2000-2006
- Low Birth Weight: 2006-2006
- Asthma: 1993-2001
- Chronic Obstructive Pulmonary Disease (COPD): 1990-2006

Mortality

Mortality rates in Garfield County declined during the five-year period (2000-2005) with the exception of 2003, when the oil and gas industry started to rapidly expand in Garfield County, and the rates were higher than both U.S. and Colorado rates. (Figure 4.) Infant mortality rates are consistently lower in Garfield County (5/1,000) when compared to statewide rates (6.2/1,000), providing a good baseline health status when examining more recent years.

Figure 4. General Mortality Rates 2000-2005



Data Source: Garfield County Births and Deaths 2006

According to the Colorado Health Information Dataset: Death Statistics Section, the leading causes of death in 2006 for Garfield County closely mimicked those for the leading causes of death across the state and surrounding Western Slope Counties, with Garfield County having slightly higher mortality rates for heart disease, unintentional injuries, cerebrovascular diseases, Alzheimer's disease, suicide, and diabetes mellitus, compared to state rates. Although, cardiovascular disease was the number one cause of death in Garfield County in 2006, age-adjusted rates for the county have declined since 2000. In 2000 age-adjusted mortality rates for cardiovascular disease were 269.2/100,000. All four counties on the Western Slope had higher age-adjusted mortality rates for: diabetes mellitus, Alzheimer's disease, unintentional injuries and suicide when compared to state mortality rates. (Table 4)

Table 4. Leading Causes of Death for Garfield County Colorado (2006)

Cause of Death	**Age-Adjusted Rate** (Colorado)	**Age-Adjusted Rate** (Garfield)
Heart Disease	157.8	163.4
Malignant neoplasm's	158.8	138.4
Unintentional Injuries	42.0	63.1
Cerebrovascular diseases	40.5	46.2
Chronic lower respiratory diseases	50.4	43.7
Alzheimer's disease	29.7	42.3
Suicide	14.9	15.8
Diabetes mellitus	17.0	20.6

Data Source: Colorado Health Information Dataset: Death Statistics

In the remainder of this section, the white paper addresses five major health conditions: cancer, cardiovascular disease, low birth weight, asthma, and chronic obstructive pulmonary disease (COPD). We have emphasized these five because of their potential importance. Based on the literature review, these are among the likely health conditions that may potentially be caused by or aggravated by the contaminant exposures encountered in oil and gas exploration and extraction. As such, it is important to have accurate baseline and prospective data on these and other such health outcomes of concern. It is important to note that since latency periods exist for some diseases (especially for many cancers) and their significant exposures, even current health statistics may not reflect the current population health status.

Cancer

As indicated in the literature review, certain exposures seen in oil and gas exploration and extraction are considered significant cancer risks. Since 1992, both cancer incidence and mortality rates have declined in Garfield County. Garfield County overall cancer incidence rates were significantly higher in males compared to state incidence rates, for all years that public data were available. Overall cancer mortality rates for males were higher in Garfield County when compared to the state for the time periods of 1992-1998 and1999-2000, but were slightly lower in the 2000-2001 time

period than state rates. Overall females in Garfield County have lower rates of cancer incidence and mortality than state rates. Specific cancer incidence and mortality rates showed males with higher lung cancer mortality rates compared to state rates and higher prostate cancer incidence rates, and both males and females having higher bladder cancer incidence rates compared to state rates. (Figures 5,6.)

Figure 5.

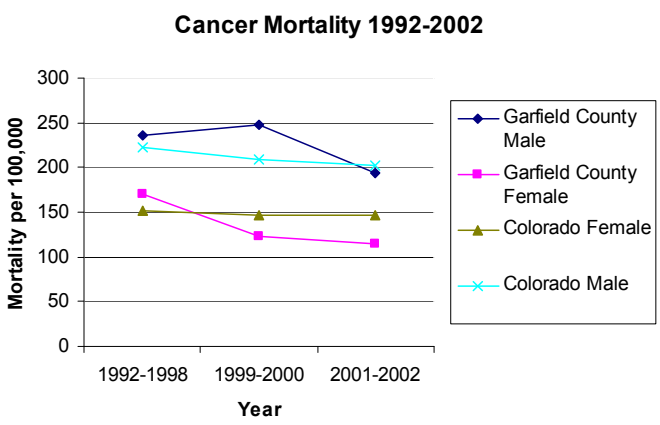
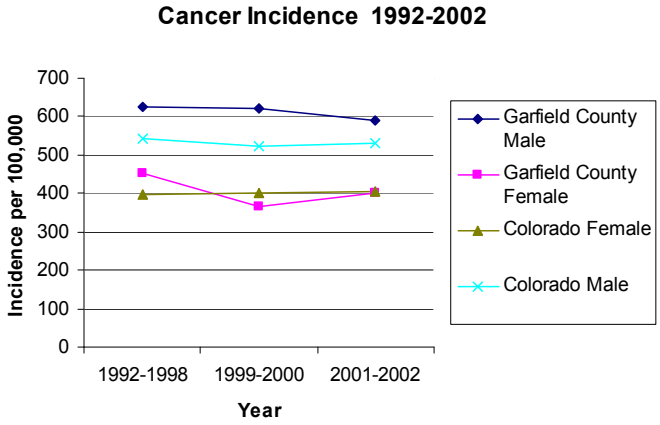


Figure 6.



Data Source: Cancer in Colorado: 1992-2002

Low Birth Weight

As indicated in the literature review, certain exposures seen in oil and gas exploration and extraction are considered significant risk factors for fetal outcome, including low birth weight. As such, this is an outcome of potential importance for tracking purposes. Colorado has a relatively higher percentage of low weight births than the United States overall. Garfield County has consistently has a lower percentages of low weight births then Colorado state percentages. The percentage of low birth rates in Garfield County, in 2005 was 6.8 percent, falling below the state percentage of 9.3 percent. In 2005, the percentage in Garfield County rose to 8.8 percent, still lower then state percentages, but increasing from the prior year. Continued monitoring of low birth weight infants in Garfield County is needed, as low weight infants are at a much higher risk for long-term morbidity, susceptibility to respiratory problems, and early death.

Asthma

Literature examining health effects of air pollutants produced by both stationary (e.g. industrial sources) as well as mobile sources (e.g. fossil fuel combustion emissions from vehicles and traffic density) have shown clear relationships with respiratory disease, most notably asthma and chronic obstructive pulmonary disease. A recent health study completed by the Saccomano Institute reported that children in Garfield County had an increased asthma rate, as discussed below in more detail. Asthma incidence in Colorado is mostly estimated by use of hospital discharge records. The age adjusted rate for asthma, obtained from hospital discharge records (principal diagnosis),

in Garfield County for the nine-year period of 1993 to 2001 was 7.9/10,000. The age-adjusted rates for surrounding counties were similar with Moffat having a slightly higher incidence, 12.8/10,000 and Mesa and Rio Blanco having a slightly lower incidence of 7.5/10,000 and 6.7/10,000, respectively. Publicly available data are only available through the year 2001. Because oil and gas development activities did not rapidly expand in the region until the year 2003, asthma data for more recent years such as increased rates reported in the Saccomano Institute study are of more value. It is also important to note that not all asthma related incidents are accounted for with hospital discharge data, as not all asthma related incidents will require admittance to hospitals. Emergency room visit data and outpatient clinic data for asthma incidence and prevalence in Garfield County would also be of more use.

Chronic Obstructive Pulmonary Disease (COPD)

As mentioned above, clear relationships have been established through literature between COPD and air pollutants given off by stationary and industrial sources. Currently there are no true COPD prevalence data for the state of Colorado. Recent data on COPD mortality specific to Garfield County are not publicly available. However, we do know that during the years 1990 to 2004 Garfield County had age adjusted rates of 90-70 deaths due to COPD per 100,000 residents. We also know COPD mortality rates in Colorado are one of the highest in the nation, despite being one of the states with the lowest smoking prevalence, and that rural and frontier counties in Colorado, like Garfield County, have higher mortality rates compared to urban regions in Colorado. In the recent study conducted by the Saccomano Institute, they reported residents of Silt had an increased rate of COPD compared to the rest of Garfield County.

Summary of recent "Community Health Risk Assessment"

The Saccomanno Institute in Grand Junction, Colorado recently completed a two-year study of the health trends in Garfield County. Although this study is as yet unpublished, the major findings have been the subject of public presentations. Because of its relevance to Garfield County and as an illustration of the type of research that is needed, this white paper summarizes the major conclusions and considers the available information from this project. ("Community Health Risk Assessment: An assessment of risk related to the natural gas industry in Garfield County Part II: Health Study.")

This study was completed in two parts: one focusing on exposure, the other on health. In the health study, four-county (Mesa, Garfield, Montrose, Delta) comparisons were made using seven sets of available statistics from the Colorado Department of Public Health and Environment (birth statistics, death statistics, birth defects, adolescent health measures, reportable conditions, West Nile virus, and Cancer statistics), as well as data from a behavioral risk factor study survey and injury hospitalization and death rates/causes, hospital and medical insurance data sets. In addition, the researchers conducted a telephone and mailed household survey to obtain self-reported health status information (participation rate of 18%).

The authors of this study observed some trends of illness in Garfield County, as compared to other Western Colorado counties. According to the authors, a number of the trends may be important indicators to track prospectively, including alcohol and drug disorders, birth and pregnancy outcomes, children in Garfield county having an increased seizure and headache hospital admittance, bronchitis and asthma rates, and respiratory infections and inflammation. The authors of this study have recommended a prospective medical monitoring system to identify any changes in baseline data or trends. (Teresa Coons and Walker 2008)

A critical assessment of the study design, methodology, results and conclusions will have to await a more complete release of the data.

Conclusions and Recommendations

1. Publicly available information about health status of Garfield County residents is incomplete.
2. Recent data, which is most important, are lacking and often delayed in public distribution.
3. Trends from the Saccomonno Institute study support the need for better prospective monitoring. According to those authors, these trends include alcohol and drug disorders, birth and pregnancy outcomes, increased seizure and headache diagnoses for hospital admittance of children, bronchitis and asthma rates, and respiratory infections and inflammation.
4. In light of the rapid pace of oil and gas activities in Garfield County, and the lack of recent available data, one is not able to make any definitive conclusions about the health status of Garfield County residents.
5. At this point in time, there are many uncertainties regarding the health effects of oil and gas industry activity on general markers of health within the surrounding communities.
6. This lack of information, combined with the lack of comprehensive, systematic health and exposure monitoring and recording, make it difficult to draw any definitive conclusions about the causality and severity of these effects.
7. Ongoing surveillance of both asthma and COPD in Garfield County is needed. A way to measure and subsequently monitor both incidence and prevalence for the county should be implemented. These are diseases that occur in great enough frequency to act as meaningful sentinel events for monitoring purposes.
8. Continued monitoring and interpretation of data concerning low birth weight is warranted.
9. By improving our measurement and monitoring of health outcomes in Garfield County, it should be possible to better intervene and mitigate any adverse impact resulting from oil and gas development.

Worker Health

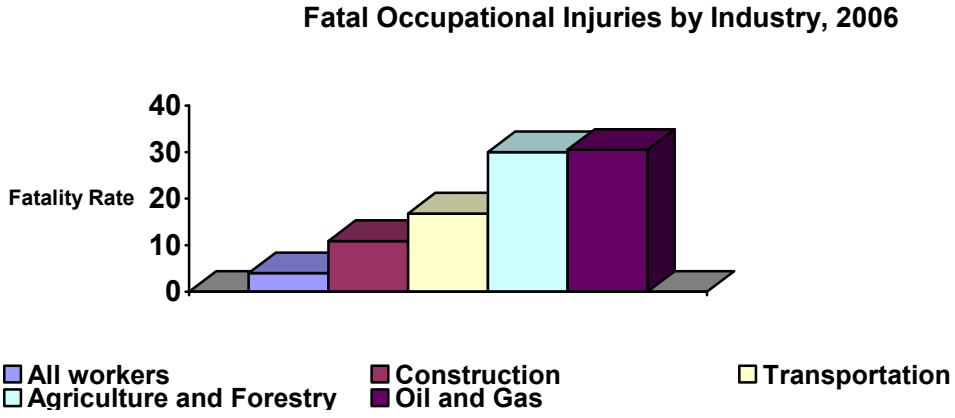
Although the majority of this white paper addresses exposures to neighboring communities, it is important to note that the health impact on the community includes those who work in the oil and gas industry or who work in industries that support this development.

Occupational Fatalities

An increase in oil and gas production has led to a rise in employment in this industry. Nationwide, the average number of workers employed in the oil and gas industry has increased almost 32% from 2003 to 2006, as discussed in the accompanying literature review. An increase in oil and gas extraction activities has been significantly correlated with an increase in the rate of fatal occupational injuries among oil and gas extraction workers employed in the U.S. The average annual rate of fatal occupational injuries in the U.S. in the oil and gas industry from 2003 to 2006 was 30.5 per 100,000 workers. This rate is high compared to the overall national rate of 4.0 fatalities per 100,000 workers for all workers for these same years. Fatalities that occurred in the oil and gas industry for this time period were attributable to transportation incidences and being struck by machinery or equipment. (MMWR April 25, 2008 / 57(16); 429-431)

The oil and gas industry is considered a high risk industry for fatality as demonstrated by the rates above. Oil and gas workers in the U.S. experience a disproportional rate of occupational fatalities compared to other industries except agriculture and forestry. In 2006, compared to other high-risk industries, the fatality rate per 100,000 workers was 31.9 for the oil and gas industry, 30.0 for agriculture and forestry, 16.8 for transportation, and 10.9 for construction. Notably, fatalities among oil and gas workers accounted for nearly two-thirds of the fatalities in the mining industry as a whole. (MMWR April 25, 2008 / 57(16); 429-431; http://www.bls.gov/iif/oshwc/cfoi/cfch0005.pdf)

Figure 7.



Further detail describing fatalities among oil and gas workers can be obtained by accessing the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI). Occupational fatalities are classified by industry, event or exposure, including transportation incidents, assaults and violent acts, contact with objects and equipment, falls, exposure to harmful substances and fires/explosions. CFOI does not report fatalities caused by occupational illnesses due to latency issues.
(http://www.bls.gov/iif/oshcfoi1.htm)

The Colorado Department of Public Health and Environment provides detailed data describing occupational fatalities in Colorado by selected industry. Fatalities in the mining industry (all mining) from 2003 to 2006 have represented approximately 5% of all work-related fatalities in Colorado for those years. Fatality rates for the oil and gas industry specifically are not available in Colorado. Fatalities in the mining industry in Colorado have been lower than other high risk industries.
(http://www.bls.gov/iif/oshstate.htm#CO)

Occupational Injuries and Illnesses

Survey of Occupational Injuries and Illnesses (SOII)

The BLS Survey of Occupational Injuries and Illnesses (SOII) reports incidence rates of non-fatal occupational injuries and illnesses by industry. In the U.S. the overall rate of non-fatal injuries and illnesses among private industry employees in 2006 was 4.4 per 100 full-time workers. Comparing goods-producing industries, the injury and illness rate was 3.5 for mining, 5.9 for construction, and 6.0 for both agriculture and manufacturing.
(BLS, USDL 07-1562 http://www.bls.gov/iif/oshwc/osh/os/osnr0028.pdf)

Injury characteristics reported in the SOII include days away from work, the 'physical' nature of the injury such as a sprain or burn, part of the body affected, source of injury such as chemical, machinery, tools or equipment, and the 'physical' event or exposure such as fall or transportation incident. In the U.S. in 2006, industry sectors experiencing the most injuries were manufacturing (20%), health care and social assistance (16%), and retail (15%). Within the goods-producing industry, 20% of non-fatal injuries occurred in manufacturing, 10% in construction, 1.3% in agriculture and forestry, and 0.6% in mining. Illnesses categories in the SOII include skin diseases or disorders, respiratory conditions, poisonings, and 'all other illnesses.' In the U.S. in 2006, mining accounted for 0.4% of all non-fatal occupational illnesses. (BLS, USDL 07-1562
http://www.bls.gov/iif/oshwc/osh/os/osnr0028.pdf)

Nationwide non-fatal injury and illness data are reported for sectors within the mining industry, as reported below. These data, however, are not comparable to other

industry sectors due to differences in data collection and reporting standards. Therefore, comparisons are not made.

The average incidence rates reported by mining subsector (per 10,000 full time workers) of nonfatal occupational injuries from 2003 to 2006 nationwide was 2.0 for oil and gas extraction workers, 5.3 for workers involved in drilling oil and gas wells, and 3.1 for workers performing support activities for oil and gas operations. (SOII Table SNR05 for years 2003 – 2006 http://www.bls.gov/iif/oshsum.htm)

The average incidence rates by mining subsector (per 10,000 full time workers) of nonfatal occupational illnesses from 2003 to 2006 nationwide was 13.5 for oil and gas extraction workers, 13.6 (excluding 2004) for workers involved in drilling oil and gas wells, and 8.8 for workers performing support activities for oil and gas operations. (SOII Table SNR08 for years 2003-2006 http://www.bls.gov/iif/oshsum.htm) Since Colorado is one of seven states that do not participate in the Survey of Occupational Illnesses and Injury, comparison of state data with national data cannot be accomplished.

Colorado Workers' Compensation Data

The Colorado Division of Workers' Compensation collects data on employer/employee submitted work-related injury and illness claims, providing another source of data with which to estimate health impact in workers. Occupational injuries and illnesses can be described by industry, county, part of the body, nature of injury and illness and cause of injury or illness.

Data are currently available and reported for the calendar years 2001 to 2003. In Colorado, the mining industry represented 0.6% of total average annual employment. Approximately 1% of all lost-time claims filed with the state were from the mining industry, including fatalities. The fatality rate for the mining industry per 10,000 employed decreased from 7.79 in 2001 to 2.29 in 2003.

When separated into mining subsectors, workers in the support activities had the highest number of lost-time claims (1%) compared to mining (except oil and gas) (0.5%) and oil and gas extraction (0.1%). Fatality rates were not available by sub-sector.
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_03.pdf
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_02.pdf
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_01.pdf

Colorado Hospital Association Data

The Colorado Hospital Association collects data on hospitalizations occurring in Colorado. Estimates of work-related hospitalizations need to be determined by identifying hospitalizations for which workers' compensation is the payer. Although we

have requested this information, the data were unavailable at the time of completion of this white paper.

Conclusions and Recommendations

1. In any assessment of health impact on a region, occupational fatalities, injuries and illnesses should be taken into account along with the health impact on the local community.
2. National data indicate significant rates of occupational illness, injury and fatality associated with the oil and gas industry.
3. We were unable to obtain specific fatality rates for the oil and gas development-associated subsectors in Colorado. Further analysis is needed to determine the fatality rates in oil and gas extraction, drilling oil and gas wells, and support industries, such as construction trades.
4. We were unable to obtain data on the rates of nonfatal occupational injuries and illnesses for Colorado. These data need to be determined in Colorado. At this time, Colorado is one of only seven states that do not participate in the SOII.
5. Workers' compensation and hospital discharge data may be important additional sources that can be used to estimate the health impact of the oil and gas industry for workers.

Social and Psychological Health Effects

While limited research has examined the physical health consequences associated with oil and gas development, even less research has focused on the social and psychological health effects of these activities (Mall, 2007). A review of the available literature about the social and psychological implications of oil and gas exploration reveals some interesting trends found in industrial communities throughout the world.

The literature review attached to this paper suggests a number of social and psychological concerns that may be associated with industrial activity moving into populated areas. These concerns include possible increases in domestic violence, rape, assault, child abuse, suicide, homicide and crime. (Bhatia, 2007, Srinivasan, 2003, Wernham, 2007, Forsyth, 2007, Luthra, 2007, Seydlitz, 1993, Kettl, 1998) Given the limited number of studies and the mixed nature of the results, further study in this area is warranted.

Garfield County Crime Rates

Crime rates for Garfield County, for years 2000-2005, were calculated using data describing the number of arrests made in the county (Lowden, 2007) and the population information described above. In Garfield County, between 2000 and 2005, the total number rate of adult violent arrests continually increased. (Table 5) Although there are some fluctuations from year to year, there is an overall increase in the rate of violent crime arrests and drug violations in Garfield County from 2000-2005. While the cause of these increases remains to be determined, this finding is consistent with studies finding that violent crime rates can increase in communities involved in rapid growth of industrial activity. Nonviolent crime rates did not increase across the same time period. (Table 6)

Table 5. Rate per 10,000 residents (Number) of Arrests for Violent Crimes and Drug Violations, Garfield County, 2000-2005

Year	Popula-tion	Murder	Rape	Other Sex Crimes	Rob-bery	Aggravated Assault	Violent crimes total	Drug violations
2000	43,791	0 (0)	.68 (3)	.23 (1)	0 (0)	7.54 (33)	8.45 (37)	19.41 (85)
2001	46,173	0 (0)	.65 (3)	1.52 (7)	.86 (4)	9.31 (43)	12.34 (57)	23.39 (108)
2002	47,275	0 (0)	.85 (4)	2.32 (11)	.21 (1)	10.15 (48)	13.54 (64)	29.83 (141)
2003	57,126	.18 (1)	.35 (2)	1.05 (6)	.18 (1)	6.65 (38)	10.15 (48)	22.06 (126)
2004	49,325	0 (0)	.61 (3)	1.01 (5)	.20 (1)	14.60 (72)	16.42 (81)	20.48 (101)
2005	50,673	0 (0)	1.18 (6)	1.18 (6)	.20 (1)	17.17 (87)	19.73 (100)	39.67 (201)

Table 6. Rate per 10,000 residents (Number) of Arrests for Nonviolent Crimes, Garfield County, 2000-2005

Year	Popula-tion	Burglary	Larceny/Theft	Motor Vehicle Theft	Arson	Nonviolent crimes total
2000	43,791	2.97 (13)	31.74 (139)	1.60 (7)	0 (0)	36.31 (159)
2001	46,173	4.55 (21)	16.46 (76)	1.95 (9)	.87 (4)	23.82 (110)
2002	47,275	5.08 (24)	25.38 (120)	.63 (3)	.21 (1)	31.31 (148)
2003	57,126	2.63 (15)	19.43 (111)	1.58 (9)	0 (0)	23.63 (135)
2004	49,325	3.65 (18)	18.04 (89)	.81 (4)	.41 (2)	22.91 (113)
2005	50,673	5.92 (30)	17.37 (88)	2.76 (14)	.20 (1)	26.25 (133)

Conclusions and Recommendations

1. The literature supports the concept that rapid industrial change can have deleterious effects (in addition to possible positive effects) on the psychosocial welfare of a local population.
2. The data shown above indicate that there has been an increase in violent crimes and drug violations in Garfield County. Further study is needed to determine if industrial development, in the form of oil and gas drilling, is contributing to this increase, especially since literature suggests that this is possible.
3. At this point in time, there are many unknowns about the effects of oil and gas industry activity on psychosocial health outcomes. This lack of information, combined with the lack of a comprehensive, systematic health and exposure monitoring make it impossible to draw any definitive conclusions about the causality and severity of these effects.
4. Improved monitoring of the psychosocial health Garfield County residents is needed in order to intervene and mitigate any adverse impact resulting from oil and gas development.

White Paper Conclusions and Recommendations

Community at Risk

1. There is a lack of precise demographic, exposure and health information on the Garfield County population. This affects the ability to accurately assess the current and future health of the community.
2. There are no demographic data on the temporary oil and gas workers. Most moved into Garfield County since 2000.
3. The available data discussed above suggest that approximately one-third of the Garfield County population (27% children and 9% over 65) may be more susceptible to certain oil and gas industry-related exposures.
4. As discussed above, there is an increasing population of children in Garfield County, who are potentially at increased risk for adverse health effects from these exposures.

Hazardous Exposure Information

1. There are major gaps in the past assessment of air and water quality related to oil and gas development on the Western Slope.
2. Air and water quality studies conducted to date indicate that potential exposures to hazardous emissions exist.
3. Many air toxics are essentially unmeasured in Garfield County, despite the increase in oil and gas development known to produce these chemicals. Air quality measurements should not be considered complete until monitoring of all known potential hazardous substances is performed.
4. Current plans for further air sampling may not be comprehensive enough to enable public health officials to determine the community health impact of oil and gas development.
5. There are no plans for comprehensive and systematic monitoring of surface and subsurface waters. Water monitoring must occur and results made public, in order to protect human health.
6. Although some levels of harmful chemicals in both air and water measured in Garfield County may not fall within a specific regulatory standard, adverse health impacts are known to occur at levels below standards. As discussed in the attached literature review, this must be taken into account when mitigation measures aimed at reducing health impacts are undertaken. (Glass, Gray et al. 2003; Glass, Gray et al 2005)
7. Environmental monitoring must be relevant to the areas where oil and gas development activity is occurring.
8. Environmental monitoring results must be readily available to the public. Unbiased interpretation of the results must occur in a timely manner and be made available to the public.
9. There are no available studies examining the impact of oil and gas development on the noise levels in Garfield County. These studies should

be conducted to assess and if necessary, mitigate adverse effects of increased noise levels.

10. There are no available studies examining the impact of oil and gas development on soil quality in Garfield County. These studies should be conducted to assess and if needed, mitigate adverse affects of soil contaminants on human health.

Health Status of the Community

1. Publicly available information about health status of Garfield County residents is incomplete.
2. Recent data, which is most important, are lacking and often delayed in public distribution.
3. Trends from the Saccomonno Institute study support the need for better prospective monitoring. According to those authors, these trends include alcohol and drug disorders, birth and pregnancy outcomes, increased seizure and headache diagnoses for hospital admittance of children, bronchitis and asthma rates, and respiratory infections and inflammation.
4. Sources of health statistics are available only up to years 2001 (asthma), 2002 (cancer), 2005 (mortality), and 2006 (cardiovascular disease, COPD, low birth weight) Changes in health may not yet be apparent in these statistics. Since drilling has been rapidly increasing since 2003, the health of the residents of Garfield County may be impacted, yet this may not yet be reflected in the available data.
5. At this point in time, there are many uncertainties regarding the health effects of oil and gas industry activity on general markers of health (such as mortality, birth outcomes, cancer, etc) within the surrounding communities.
6. This lack of information, combined with the lack of comprehensive, systematic health and exposure monitoring and recording, make it difficult to draw any definitive conclusions about the causality and severity of these effects. Given the marked anticipated expansion of oil and gas activities, the current lack of information will seriously impede adequate planning for protecting human health.
7. Ongoing surveillance of both asthma and COPD in Garfield County is needed. Implementation of effective monitoring systems, such as reporting to the county health department, should be established. These are diseases that occur in great enough frequency to act as meaningful sentinel events for monitoring purposes.
8. Continued monitoring and interpretation of data concerning low birth weight is warranted.
9. By improving measurement and monitoring of health outcomes in Garfield County, it should be possible to better intervene and mitigate any adverse impact resulting from oil and gas development.

Worker Health

1. In any assessment of health impact on a region, occupational fatalities, injuries and illnesses should be taken into account along with the health impact on the local community.
2. As noted above, national data indicate significant rates of occupational illness, injury and fatality associated with the oil and gas industry.
3. We were unable to obtain specific fatality rates for the oil and gas development-associated subsectors in Colorado. Further analysis is needed to determine the fatality rates in oil and gas extraction, drilling oil and gas wells, and support industries, such as construction trades, since national statistics suggest they could be significant.
4. We were unable to obtain data on the rates of nonfatal occupational injuries and illnesses for Colorado. Without these data rates of occupational illness and injury due to oil and gas activities in Colorado are unknown. At this time, Colorado is one of only seven states that do not participate in the Survey of Occupational Illness and Injury (SOII).
5. Workers' compensation and hospital discharge data may be important additional sources that can be used to estimate the health impact of the oil and gas industry for workers.

Psychological and Social Impact

1. The literature supports the concept that rapid industrial change can have deleterious effects (in addition to possible positive effects) on the psychosocial welfare of a local population.
2. The data shown above indicate that there has been an increase in violent crimes and drug violations in Garfield County. Further study is needed to determine if industrial development, in the form of oil and gas drilling, is contributing to this increase, especially since literature suggests that this is possible.
3. At this point in time, there are many unknowns about the effects of oil and gas industry activity on psychosocial health outcomes. This lack of information, combined with the lack of a comprehensive, systematic health and exposure monitoring make it impossible to draw any definitive conclusions about the causality and severity of these effects.
4. Improved monitoring of the psychosocial health Garfield County residents is needed in order to intervene and mitigate any adverse impact resulting from oil and gas development.

General Conclusions/Recommendations:

1. The literature review conducted in parallel with this white paper yielded important information regarding the impact of exposure on human health and welfare. A more comprehensive literature review that includes foreign language literature, older studies, reviews, formal assessment of quality of

evidence, and conflict of interest considerations would be expected to yield additional useful information.

2. The available data and lines of evidence indicate that there is an acute problem with toxic emissions of uncertain proportions and a possible emergent problem for the health of the citizens of Garfield County.
3. The available data regarding the health and social impact of oil and gas development need further analysis.
4. Data, such as air and water quality data collected by the oil and gas companies, that may have been collected but are not in the public domain should be made available for analysis and publication.
5. In the interest of public health, the credible evidence currently available about the impact on the health and welfare of the population by oil and gas development requires action now as outlined in this white paper. It is important not to ignore what is already known.
6. There is an immediate need for specific information on exposures and the impact from oil and gas development on all aspects of human health. This white paper and literature review indicate a number of fertile areas for further study.
7. An adequate monitoring program should be developed through a rigorous scientific process that addresses all currently recognized data gaps and health risks. This process should be developed in a transparent and explicitly unbiased way.
8. A Health Impact Assessment (HIA) is a practical tool to evaluate future impacts, alternatives and appropriate strategies to promote and protect human health. An integrated HIA/EIS published in 2007 described the impact of oil development on Alaska's North Slope on the local Inupiat populations. (Wernham 2007) The HIA findings predicted impact on health and social structure. The report provided recommendations for mitigation of these effects, thereby improving the probability that oil development could proceed with less adverse impact on the people who live in the region.
9. An HIA could provide a framework for exposure assessment (from air and water quality monitoring), health data collection and monitoring (for example asthma, COPD incidence and prevalence, birth outcomes), and recommendations for mitigation of potential adverse effects.
10. Given that oil and gas extraction activities are known to use and produce chemicals that are hazardous to human health and that these activities are occurring in close proximity to human populations in Garfield County, a Health Impact Assessment of oil and gas development in Colorado should be done. At the present time there is no systematic collection of air or water quality data, assessment of exposure, nor of health or social outcomes. Through an HIA, air and water quality monitoring systems and health and social outcome monitoring systems could be established. Given that even limited air and water quality studies revealed dangerous levels of benzene and other chemicals of potential concern, continued ignorance of the status of the air and water quality and the potential health impacts in Garfield County should not be considered acceptable. An HIA should be a critical

component of planning for future expansion of oil and gas activities, so that these activities do not put local residents at risk. Because an Environmental Impact Statement is intended to consider the effects of the development in question on the "human environment," an HIA should be considered a necessary part of a complete Environmental Impact Statement. An HIA, or a similar assessment, should be a part of any oil and gas permitting process that occurs near human populations. Without an HIA, a comprehensive EIS should be considered incomplete.

11. While this white paper focuses on Garfield County, Colorado as an illustration of the potential exposure-related health impact of oil and gas development, the principles of exposure and the related health issues should be considered generally applicable wherever oil and gas development is occurring.

Closing Statement

Oil and gas development has the potential to impact human health when toxic chemicals are released into the air and water near human population centers. Without precise demographic, exposure and health information of the Garfield County population, assessment of the current and future health of the community is compromised. Air and water quality studies conducted in Garfield County demonstrate that potential exposures to hazardous emissions exist. As noted above and in the literature review, although some levels of harmful chemicals in both air and water measured may not fall within a specific regulatory standard, adverse health impacts are known to occur at levels below standards. This must be taken into account when mitigation measures aimed at reducing health impacts are undertaken. Furthermore, publicly available information about the health status of Garfield County residents is incomplete. This lack of information, combined with the lack of comprehensive, systematic health and exposure monitoring and recording make it impossible to draw any definitive conclusions about the causality and severity of health effects. Given the marked anticipated expansion of oil and gas activities, the current lack of information will seriously impede adequate planning for protecting human health. Additionally, in any assessment of health impact on a region, occupational fatalities, injuries and illnesses should be taken into account along with the health impact on the local community, given that national data indicate significant rates of occupational illness, injury and fatality associated with the oil and gas industry. Also, the literature supports the concept that oil and gas boom and bust cycles have deleterious effects on the psychosocial welfare of a local population. Further data collection, analysis and subsequent recommendations could mitigate the psychological and social impacts oil and gas drilling. A Health Impact Assessment of oil and gas development in Colorado should be done as a critical component of planning for future expansion of oil and gas activities and as such would be essential to an adequate Environmental Impact Statement and other planning and assessment processes. A comprehensive EIS must include an HIA in order to be considered complete.

Furthermore, the principles of exposure and the related health issues should be considered generally applicable wherever oil and gas development is occurring.

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Appendix 1. References

Introduction & Background References

Colorado Department of Public Health and Environment (2006). Colorado Air Quality Data Report. C. D. o. P. H. a. Environment. Denver, CO.

Colorado Department of Public Health and Environment (2008). Colorado Annual Monitoring Network Plan. C. D. o. P. H. a. Environment.

Garfield County IT Department (2007). Gas Wells, Well Permits & Pipleines, Including Public lands, Western Garfield County, Colorado. Glenwood Springs, Colorado**:** Composed Utilizing Colorado Oil and Gas Conservation Commission Well Site, Permit GIS Data Downloaded 11-7-07.

Garfield County Public Health Department (2007). Garfield County Ambient Air Quality Monitoring Study June 2005-May 2007. G. C. P. H. Department. Garfield County, CO.

Garfield County Public Health Department (2007). Garfield County Ambient Air Quality Monitoring Study June 2005-May 2007. G. C. P. H. Department. Garfield County, CO.

Glass, D. C., C. N. Gray, et al. (2003). "Leukemia risk associated with low-level benzene exposure.[see comment]." Epidemiology **14**(5): 569-77.

Glass, D. C., C. N. Gray, et al. (2005). "Health Watch exposure estimates: do they underestimate benzene exposure?" Chemico-Biological Interactions **153-154**: 23-32.

La Plata County (2002). La Plata County Final Oil and Gas Impact Report.

Musselman, R. and J. Korfmacher (2008). Focus: Air Quality in Mountain Ecosystems-Ozone. Air, Water and Aquatics Environments Science Program. Fort Collins, Co, United States Forest Service, Rocky Mountain Research Station.

Oil and Gas Accountability Project. (2006). "Colorado Oil and Gas Industry Spills A review of COGCC data (June 2002 – June 2006)." Retrieved 5-15-08, from http://www.bettermines.org/pubs/Spills.pdf.

S.S. Papadpipulos & Associates, I. (2007). Piceance Basin Phase IV
Baseline Water Quality Study –
Garfield County, Colorado. Boulder, Colorado 80303.

Saadat, M. and A. Bahaoddini (2004). "Hematological changes due to chronic exposure to natural gas leakage in polluted areas of Masjid-i-Sulaiman (Khozestan province, Iran)." Ecotoxicology & Environmental Safety **58**(2): 273-6.

San Sebastian, M. and A. K. Hurtig (2004). "Cancer among indigenous people in the Amazon Basin of Ecuador, 1985-2000." Rev Panam Salud Publica **16**(5): 328-33.

Teresa Coons, P. and R. Walker, PhD (2008). Community Health Risk Assessment An Assessment of Risk Related to the Natural Gas Industry in Garfield County
Part I: Risk Study. Power Point Presentations From the Community Presentation June 17th, 2008. West Garfield Colorado Mountain College 3695 Airport Road, Rifle.

Part II: Health Study. Power Point Presentations From the Community Presentation June 17th, 2008. West Garfield Colorado Mountain College 3695 Airport Road, Rifle.

United States Environmental Protection Agency (2007). Monitor Values Report - Criteria Air Pollutants, La Plata County, CO.

URS Corporation (2006). Phase I Hydrogeologic Characterization of the Mamm Creek Field Area in Garfield County Denver Colorado.

Wernham, A. (2007). "Inupiat Health and Proposed Alaskan Oil Development: Results of the First Integrated Health Impact Assessment/ Environmental Impact Statement for Proposed Oil Development on Alaska's North Slope." EcoHealth **4**: 500-513.

Garfield County Contaminant References**:**

Colorado Department of Public Health and Environment (2006). Colorado Air Quality Data Report. C. D. O. P. H. a. Environment. Denver, CO.

Colorado Department of Public Health and Environment (2008). Colorado Annual Monitoring Network Plan. C. D. O. P. H. a. Environment.

Garfield County IT Department (2007). Gas Wells, Well Permits & Pipleines, Including Public lands, Western Garfield County, Colorado. Glenwood Springs, Colorado**:** Composed Utilizing Colorado Oil and Gas Conservation Commission Well Site, Permit GIS Data Downloaded 11-7-07.
Garfield County Public Health Department (2007). Garfield County Ambient Air Quality Monitoring Study June 2005-May 2007. G. C. P. H. Department. Garfield County, CO.

La Plata County (2002). La Plata County Final Oil and Gas Impact Report.

Musselman, R. and J. Korfmacher (2008). Focus: Air Quality in Mountain Ecosystems-Ozone. Air, Water and Aquatics Environments Science Program. Fort Collins, Co, United States Forest Service, Rocky Mountain Research Station.

S.S. Papadpipulos & Associates, I. (2007). Piceance Basin Phase IV Baseline Water Quality Study –Garfield County, Colorado. Boulder, Colorado 80303.

United States Environmental Protection Agency (2007). Monitor Values Report - Criteria Air Pollutants, La Plata County, CO. http://iaspub.epa.gov/airsdata/adaqs.monvals?geotype=co&geocode=08067&geoinfo=co~08067~La+Plata+Co%2C+Colorado&pol=O3&year=2007&fld=monid&fld=siteid&fld=address&fld=city&fld=county&fld=stabbr&fld=regn&rpp=25

URS Corporation (2006). Phase I Hydrogeologic Characterization of the Mamm Creek Field Area in Garfield County Denver Colorado.

Demographic References:

Colorado Oil and Gas Conservation Commission:
http://oil-gas.state.co.us/

Colorado Department of Local Affairs:
http://www.dola.state.co.us/dlg/demog/pop_cnty_estimates.html

Garfield County Quick Facts:
http://www.garfield-county.com/Index.aspx?page=698

Garfield Public and Private Schools:
http://colorado.schooltree.org/Garfield-County-Schools.html

Colorado Education Statistics:
http://www.cde.state.co.us/index_stats.htm
http://www.cde.state.co.us/cdereval/rv2007pmlinks.htm

Headwaters Economics (2007). A SocioEconomic Profile: Garfield County, Colorado.
http://www.headwaterseconomics.org/profiles/colorado.html

National Center for Health Statistics: National Vital Statistics:
http://www.cdc.gov/nchs/products/pubs/pubd/nvsr/nvsr.htm

Northwest Colorado Socioeconomic Analysis and Forecasts. BBC Researching & Consulting, April 4, 2008. www.bbcresearch.com

Population, Employment, Poverty and Demographic from the 2000 U.S. Census. Sonoran Institute, 2003. http://www.sonoran.org/

Garfield County Health Data:

2007 Colorado Chronic Obstructive Pulmonary Disease Surveillance Report: http://www.lungcolorado.org/pdf/Colorado%20COPD%20Strategic%20Plan%202007.pdf

Finch, J. Cancer in Colorado: 1992-2002 Incidence and Mortality by County, 2005.

Colorado Information Dataset: Death Statistics, Injury Statistics, and Behavioral Risk Factor Statistics: http://www.cdphe.state.co.us/cohid/

Colorado Asthma Surveillance Report 2004. http://www.cdphe.state.co.us/ps/asthma/asthmahom.asp

Colorado Chronic Obstructive Pulmonary Disease Surveillance Report: 2007 http://www.coloradocopdcoalition.org/pdf/2007%20Colorado%20COPD%20Surveillance%20Report.pdf

Colorado Department of Public Health and Environment. Hospitalizations for Asthma: Colorado Asthma Program Quarterly Data Brief. http://www.cdphe.state.co.us/ps/asthma/health_statistics.html

Garfield County Births and Deaths 2006 (Health Statistics Section of CDPHE) http://www.cdphe.state.co.us/hs/county2006/Garfield00.pdf

National Center for Health Statistics (National Vital Statistics) http://www.cdc.gov/nchs/nvss.htm

National Vital Statistics Report, Vol. 50, No. 15, September 16, 2002. http://www.cdc.gov/nchs/data/nvsr/nvsr50/nvsr50_15.pdf

Worker Health References:

Occupational Fatalities:
MMWR April 25, 2008 / 57(16); 429-431
http://www.bls.gov/iif/oshwc/cfoi/cfch0005.pdf
http://www.bls.gov/iif/oshcfoi1.htm
http://www.bls.gov/iif/oshstate.htm#CO

Occupational Injuries and Illnesses:

http://www.bls.gov/iif/oshwc/osh/os/osnr0028.pdf

http://www.bls.gov/iif/oshwc/osh/os/osnr0028.pdf
http://www.bls.gov/iif/oshsum.htm

Colorado Workers Compensation:
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_03.pdf
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_02.pdf
http://www.coworkforce.com/dwc/PUBS/Work_Related_Injuries_01.pdf

Psychology/Social References**:**

Bhatia, R. (2007). "Protecting health using an environmental impact assessment: a case study of san francisco land use decisionmaking." American Journal of Public Health **97**(3): 406-413.

Forsyth, C. J., A. D. Luthra, et al. (2007). "Framing perceptions of oil development and social disruption." Social Science Journal **44**(2): 287-299.

Kettl, P. (1998). "Alaska native suicide: Lessons for elder suicide." International Psychogeriatrics **10**(2): 205-211.

Lowden, K., English, K., Harrison, L., Pasini-Hill, D., Lounders, P. (2007). "Crime and Justice in Colorado, 2006", http://cdpsweb.state.co.us/cccjj/PDF/complete_Crime_Justice-2006.pdf

Luthra, A. D., W. B. Bankston, et al. (2007). "Economic fluctuation and crime: A time-series analysis of the effects of oil development in the coastal regions of Louisiana." Deviant Behavior **28**(2): 113-130.

Mall, A., Buccino, S., & Nichols, J. (2007). "Protecting western communities from the health and environmental effects of oil and gas production." NRDC: Drilling Down.

Seydlitz, R., Laska, S., Spain, D., Triche, E., & Bishop, K. (1993). "Development and social problems: The impact of the offshore oil industry on suicide and homicide rates." Rural Sociology **58**(1), 93-110.

Srinivasan, S., L. R. O'Fallon, et al. (2003). "Creating Healthy Communities, Healthy Homes, Healthy People: Initiating a Research Agenda on the Built Environment and Public Health." American Journal of Public Health **93**(9): 1446-1450.

Wernham, A. (2007). "Inupiat health and proposed Alaskan oil development: Results of the first integrated health impact assessment/environmental impact statement for proposed oil development on Alaska's north slope." EcoHealth: 500-513.

Health Impact Assessment for Battlement Mesa, Garfield County Colorado

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Executive Summary

This Health Impact Assessment (HIA) was conducted by members of the faculty and staff of the Department of Environmental and Occupational Health, Colorado School of Public Health (CSPH) at the request of the Garfield County Board of County Commissioners (BOCC), to help address community concerns regarding future land use decisions. The purpose of this HIA is to provide the BOCC with specific health information and recommendations relevant to Antero Resources Corporation (Antero) plans for natural gas development and production in the residential community of the Battlement Mesa Planned Urban Development (PUD), Garfield County, Colorado. To this end, CSPH worked in collaboration with Garfield County Public Health (GCPH) to conduct a qualitative and quantitative analysis of existing environmental, exposure, health, and safety data pertinent to the Battlement Mesa community. CSPH offers the BOCC specific recommendations for its consideration in Antero drilling permit decisions. In addition, the HIA provides baseline information for use in the design of a future prospective exposure and health monitoring project.

ES1 Introduction

Recent domestic energy production has brought industrial processes, and potentially exposures, into close proximity of residential urban, suburban and rural communities across the United States. Garfield County, Colorado is at the epicenter of natural gas development in the Piceance Basin and experienced rapid growth of the industry from 2003 – 2008, and a sudden downturn in 2009. Now, in 2010, permitting for the purpose of development and production is resuming and is expected to continue to increase.

Natural gas development and production is known to produce a variety of physical and chemical hazards that may cause negative health effects. In 2008, CSPH completed a white paper and literature review, outlining potential environmental hazards, vulnerable populations, and possible health outcomes in Garfield County. The 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado (referred to as the Saccomanno Study) documented baseline health status and negative health outcome trends potentially linked to natural gas development in Garfield County. Air monitoring in Garfield County has documented levels of some air toxics in ambient air that increase the risk of negative health effects for citizens. Furthermore, recent review of large scale "boom and bust" natural gas development in small and rural communities, such as those found in Garfield County, have the potential to affect community infrastructure. Taken together, this information suggests that natural gas permitting decisions within the residential community of Battlement Mesa has the potential to adversely affect health.

Battlement Mesa is community with a large number of retired citizens as well as young families. According to the 2000 United States Census estimates, the total population of the Battlement

Mesa/Parachute zip code was 5,041; the median age was 37.five years; 26.0 percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. In 2000, the County population was 43,791, rising 30% to 56,298 in 2009.

The Antero project is anticipated to include 200 natural gas wells on 9 pads, a centralized water storage facility with a covered/lined waste pit, and 8.4 miles of water and gas pipeline. Preliminary plans indicate that well pads and pipelines will be distributed throughout the PUD, raising the probability that health impacts could affect the entire community.

Community groups, including Battlement Mesa Service Association (BMSA, the homeowners association) and Battlement Mesa Concerned Citizens (BCC) and Grand Valley Citizens Alliance, expressed concerns about the proximity of natural gas development to homes, recreational areas and schools. At stakeholder meetings, citizens have expressed concerns regarding airborne volatile organic compounds (VOCs), diesel and other particulate matter (PM); hydraulic fracturing (also know as fracking) fluid, hydrocarbons, and VOCs in soil and water; increased risk of fires, explosions, and motor vehicle accidents; and changes in community "livability."

In November 2009, Battlement Mesa Concerned Citizens formally requested BOCC and GCPH address health concerns before Antero development activities begin. (Attachment 1) The BOCC expressed a desire for the HIA to be conducted by CSPH expeditiously, so that results could be available prior to permitting decisions. At that time, it was anticipated that Antero would be submitting their Major Land Use Impact Review (also known as MLUIR) and Comprehensive Drilling Plan in late spring 2010 and that these documents would be available as part of the basis for the HIA. At this time, however, Antero had not submitted either document. Therefore, we have used public meeting minutes, slides from power point presentations, the Surface Use Agreement with the surface owners the Battlement Mesa Company (BMC) and other information provided to us by Antero as sources for this report. Should Antero ultimately submit permit proposals that substantially differ from this information, our assessments may not necessarily reflect those differences.

The stakeholders for the Antero drilling plan include the residents and citizen groups of Battlement Mesa and nearby communities, Antero and other operators, GCPH, BOCC, the Battlement Mesa Consolidated Metropolitan District which provides drinking water and waste water services to Battlement Mesa, BMC, the Grand River Hospital District and other medical services providers, Colorado Department of Public Health and Environment (CDPHE), and Colorado Oil and Gas Conservation Commission (COGCC). There has been broad support for the HIA from all stakeholders, reflecting a common search for a means to address the concerns of potentially impacted residents in a systematic and impartial manner.

GCPH has been extremely instrumental in helping CSPH accomplish the HIA, by facilitating meetings with stakeholders and Antero; providing local contacts and context, environmental data, review and input on the scope, and analysis of the HIA; acting as the liaison between the

CSPH and the BOCC; providing web support for HIA related minutes, presentations, and this report; and providing information to local media. In addition, at the CSPH, the Mountain and Plains Educational and Research Center has provided outreach support. The Pew Health Impact Project provided funding for consultation with Habitat Health Impact Consulting, a Canadian firm with expertise in HIAs related to resource extraction.

ES2 The HIA Process

An HIA involves several defined steps: screening, scoping, assessment, recommendations and implementation, reporting and monitoring.

This HIA was screened and scoped using information from the white paper and literature review previously conducted by CSPH, concerns raised by the citizens (Table 3), the 2008 Saccomanno Report, as well as input from the BOCC, GCPH, CDPHE, COGCC and Antero obtained in meetings over the course of the last nine months. As a result, the HIA focuses on eight areas of health concern (stressors) associated with natural gas development and production: air emissions, water and soil contaminants, truck traffic, noise/light/vibration, health infrastructure, accidents and malfunctions, community wellness, and economics/employment.

Assessment of each stressor includes a review of its general impact on physical, mental and/or social health as described in relevant medical and social science literature; a compilation and analysis of existing environmental and health data describing current conditions in Battlement Mesa; the means by which Antero plans for drilling might alter the current conditions, and finally a characterization of the stressor's impact on health. Several physical health outcomes linked to potential exposures are considered, including respiratory, cardiovascular, cancer, psychiatric, and injury/motor vehicle-related impacts on vulnerable and general populations in the community. The Battlement Mesa Baseline Health Profile (Appendix C) provides supporting documentation of baseline physical and social health determinants. In addition, a Human Health Risk Assessment (Appendix D) provides a comprehensive review of available air quality and water contamination data and a systematic assessment of related health risk.

The HIA offers recommendations to the BOCC to help it address mitigate some of impacts of the Antero plan. It is important to recognize that it is not possible to mitigate all impacts. We have provided a relative rank for each stressor, to help emphasize where the most important impacts may occur.

Adoption of any recommendations of the HIA is at the discretion of the BOCC. We will assist in implementation, if requested by the BOCC, by continuing with stakeholder and professional presentations. We will continue to monitor how this HIA is used, in order to measure its value as a public health tool.

ES3 Battlement Mesa Baseline Health Profile

Several measures of health are best determined by using zip code to define a community. We use the zip codes 81635 and 81636, which are used by the residents of Battlement Mesa, Parachute and surrounding areas. Because these zip codes are shared, Parachute is included along with Battlement Mesa in the descriptions of physical health determinants and some social health determinants. Some of the social health determinant measurements were not available at a zip code level and so we provide descriptions of these at a county level. While the assessments of stressors focus on the impacts to those living within the Battlement Mesa PUD, others living nearby may experience some effects as well. The Battlement Mesa Baseline Health Profile is available in Appendix C.

ES3.1 Vulnerable Populations

Greater than 45% of the population may be considered to be more vulnerable to certain exposures, based on age. Additional factors, such as pre-existing disease, pregnancy and behaviors such as smoking history, alcohol use, nutrition, and genetic factors can also influence vulnerability to disease. Furthermore, occupational and residential exposures may also contribute to risk of disease. Although these factors can contribute considerably to vulnerability to disease, such information was not available to the HIA team and represents an important information gap that will need to be addressed in the future.

ES3.2 Physical Determinants of Health

To assess the baseline physical health of the Battlement Mesa/Parachute area, the CSPH team obtained and analyzed inpatient hospital diagnoses, cancer, birth, and death information from the CDPHE for the years 1998-2008. The analysis included health diagnoses, birth outcomes, and causes of death with a known association between disease and the exposures of concern, as well as those for which community members voiced concerns of elevated occurrence of disease. Major categories of disease and death included depression and those involving the nervous system, ear/nose/throat, vascular system and pulmonary system. Major categories of cancer included: Hodgkin lymphoma and non-Hodgkin lymphoma, multiple myeloma, leukemia, melanoma, breast cancer, prostate cancer, bladder cancer, colorectal cancer, and cancer of the adrenal gland. Birth outcomes included low birth weight and preterm delivery. Health for Battlement Mesa/Parachute residents was compared to the health of Colorado residents.

Overall, the citizens of Battlement Mesa appear to be generally healthier than other citizens of Colorado. They experienced fewer hospitalizations and fewer deaths. Battlement Mesa women experienced the same rates of cancer and of negative birth outcomes as other women in Colorado. In Battlement Mesa men, we observed a slightly higher than expected rate of prostate cancer, which we felt is an observation likely due to variability of small numbers or statistical chance (when multiple independent tests are compared, there is a statistical probability that 5 % of the tests will be abnormal by chance alone). No other differences were noted between men in Battlement Mesa when compared with other Colorado men.

ES3.3 Social Determinants of Health

To evaluate the baseline community health in Battlement Mesa/Parachute, the CSPH team obtained available information regarding sexually transmitted infections, crime, substance abuse, and education. Where information concerning Battlement Mesa was not available, we looked at Garfield County data.

Overall, the incidence of sexually transmitted infections in Garfield County rose during the years 2005- 2008, peaking between 2007 and 2008. Between the years 1992-2005, for adults, violent crime arrests doubled; property arrests fluctuated throughout the period, and increased slightly; and drug violations increased almost ten-fold. In the same time period, for juveniles, violent crime arrests increased; property arrests fluctuated but did not change significantly; and drug violations increased almost ten-fold. Substance abuse information extracted from the GCPH's 2006 assessment on community needs indicates depression, anxiety and stress along with tobacco smoking and alcohol abuse appear to be the top indicators of the burden of mental health and substance abuse, respectively, in Garfield County.

ES4 Assessment of Health Impacts

The HIA team developed a method for assessing and comparing potential health impacts for several areas of concern (stressors) by identifying and defining seven attributes relevant to the importance of potential health effects: direction of potential health effects (i.e., a positive or negative impact on health); the relationship of geography to health effects (i.e. proximity to natural gas development and production activities); the likelihood of health effects occurring as a result of Antero development plans; the presence of people considered especially vulnerable to the effects of the stressor; the estimated duration of exposure; the frequency of exposure when it does occur; and severity of the potential health effect.

To assist in characterizing the relative importance of health effects within this HIA, we assigned a numerical rank to each stressor. The lowest possible rank is 6 and the highest possible rank is 15 (six stressors are assigned values of 1 to 2 or 1 to 3). A negative (-) number indicates that the stressor is likely to produce negative health effects, a positive (+) number indicates that the stressor is likely to produce positive health effects. Some stressors may produce both negative and positive health effects and are therefore given a mixed (+/-) numerical rank. These rankings may be used to help describe the relative importance of each potential health effect within the context of this HIA only. It is important to note that these ranks do not represent a quantitative estimate of risk and have no relevance outside the context of this HIA.

These assessments take into account Antero's proposed control plans and mitigation strategies, to the extent that they are known (from public presentations, Surface Use Agreement, and other

information provided by Antero). Any significant deviation from the available information will not necessarily be reflected in this HIA.

ES4.1 Summary of Air Quality Assessment

The Air Quality Assessment relies upon the Human Health Risk Assessment (Appendix D) to determine the potential for air quality compromise. Plans for drilling throughout the community suggest that all areas within the PUD have the potential to be impacted by local emissions.

The Antero natural gas development plan is likely to change air quality and produce undesirable health impacts in residents living in close proximity throughout the community. Air quality is most likely to be acutely impacted during well pad construction and well completion stages and by truck traffic. Long term compromise of air quality is possible if fugitive emissions from production equipment are not controlled and the impacts to air quality are expected to occur constantly and/or reoccur. Children, older adults, and individuals with respiratory diseases may be more vulnerable to the air contaminants and could experience short-term and/or long-term disease. Health impacts may include respiratory disease, neurological problems, and there may be an increased risk of cancer. Medical attention would be necessary for some of these conditions. Some of these health consequences would not be reversible, and therefore should be considered moderate to high magnitude impacts. Using the numerical ranking scheme, air quality impacts on health are expected to produce a negative rank of -14.5 on a scale of ±6-15.

ES4.2 Summary of Water and Soil Quality Assessment

The primary drinking water source for Battlement Mesa is the Colorado River and the intake is upstream of areas potentially impacted by the Antero drilling plan. The primary drinking water source is therefore not likely to be impacted by Antero's Battlement Mesa natural gas development and production plans. The secondary water source is a series of ground water wells located "downhill" from some of the planned well sites. Since the hydrology of the area is not well understood, the likelihood that these wells could be compromised by drilling in the PUD is unclear, but their location suggests that they could be compromised by natural gas development and production activities.(See Appendix D for supporting documentation).

Impact on water quality in Battlement Mesa is not expected to occur frequently and it is unlikely that contamination of drinking water will occur as a result of Antero development plans. However, should water and soil contaminant exposures occur, these changes would produce undesirable health impacts. Areas in close proximity to the development areas would be most likely to show contamination of soil and shallow water. Impacts could be community-wide, should the need for compromised secondary water wells arise. Localized effects of wind erosion and surface run-off may impact children more than adults. Children, older adults, and individuals with pre-existing illnesses may be more vulnerable to water and soil contaminants. Reversal of water quality degradation could take years, and thus any impacts could be enduring. Should exposure occur, health impacts may include cancer, skin and eye irritation, neurological

problems. It is likely that medical attention would be needed for some of these resulting conditions and that some of these health consequences would not be reversible; therefore an impact would be considered moderate to high in magnitude. Using the numerical ranking scheme, compromise to water and soil quality would produce a negative rank of -11.5 on a scale of ±6-15.

ES4.3 Summary of Traffic Assessment

The traffic assessment relies on estimated average traffic counts provided to us by Antero. While such numbers are somewhat useful for the purpose of this HIA, the estimates may not reflect true numbers of vehicles on any given day. The Garfield County Geographic Information Systems Services is working on a map with the traffic routes Antero anticipates using for their natural gas development and production. This map also will contain information concerning school bus stops in Battlement Mesa, provided to the CSPH team by the Garfield County District 16 transportation office.

When considering safety risks to residents of Battlement Mesa, increased traffic is likely to create negative health impacts. Because the haul routes include the entire circle of the Battlement Mesa Parkway as well as other roads within and on the perimeter of the PUD, the impact of the traffic is likely to be community wide. Certain parts of the community will experience a greater impact for the entire duration of the Antero project (i.e., those homes next to CR300/Stone Quarry Road) while others will be impacted by very high volume traffic during the construction of some of the pads (i.e., along River Bluff Road). Because children often walk and ride bicycles and are not as safety conscious, children are considered more vulnerable than most adults to the impacts of traffic. The duration of exposure to increased traffic will likely be long, spanning the entire duration of the development the gas wells, at this time expected to be at least five years. The traffic will be frequent in some cases (River Bluff Road) where it is estimated that several hundred trucks passing a day for several months. Increased traffic is associated with increased risk of traffic accidents. Traffic accidents can cause minor to severe/fatal injuries and as such, there is wide range of potential health impacts. Using the numerical ranking scheme, impact due to traffic produces a negative rank of -13 on a scale of ±6-15.

ES4.4 Summary of Noise, Vibration, and Light Assessment

Anticipated noise, vibration and light exposures associated with the Antero development within the PUD may produce negative health effects. Of the three, noise is likely to have the most important impact on health. Increased noise is expected to be associated with construction and development phases and with truck traffic on haul routes. While all or most parts of the community may be near noise sources at different times, it is not likely that the entire community will be affected by noise during the development of an individual pad or by truck traffic. There are some residences that are close to haul routes and may experience elevated noise due to truck traffic for the entire development period (five years). Children may be more vulnerable to noise disturbance associated with truck traffic passing by the St. John Elementary School and the

Grand Valley Middle School during school hours. In addition, persons working at home may also be more vulnerable to noise disturbance. The elderly, particularly those with impaired hearing, may also be more vulnerable to noise pollution. Pad development will last several months, while nearby truck traffic may last several years for some residents, and thus, duration of exposure is expected to be medium to long, depending on location. On the other hand, major elevations in noise levels are not expected to occur during normal production phases in the 20 years subsequent to well development. Should well maintenance (workover) be conducted, noise levels are expected to increase during the reworking phase, which can last several days per well. When noise occurs, it is expected to be constant (e.g. diesel generators) and/or frequently reoccurring (e.g. truck traffic), depending upon the source. It is unlikely that noise exposure will cause noise-induced hearing loss or other noise-related health effects. In general, health impacts are likely to result from annoyance due to noise above background and may cause sleep disturbance, displeasure, fatigue, etc. It is not likely that medical attention will be necessary for most people, although some may seek medical assistance. Therefore the impacts are rated as low- medium magnitude. It is possible that in some individuals, noise levels will produce significant annoyance and may produce larger health effects. Using the numerical ranking scheme, impacts to safety due to noise, vibration, and light increases produces a negative rank of -10.5 on a scale of +/-6-15.

ES4.5 Summary of Community Wellness Assessment

Community wellness is difficult to define and more difficult to measure. We describe crime rates, mental health, substance abuse and suicide, occurrence of sexually transmitted infection and enrollment in K-12 education as measures of community wellness. Other factors, such as recreational opportunities and social cohesion do not lend themselves to measurement, but were considered in the assessment. Antero estimates an average of 120-150 persons to be working in Battlement Mesa. This estimate was used to evaluate the impacts on these aspects of community wellness.

Effects on community wellness are expected to be mixed. Positive effects might include less stress over finances, if increased demand for local business benefits the local economy, and increased access to social resources, services and infrastructure that expand to support a growing and changing population. For example, increased school enrollment can lead to more educational opportunity (Jacquet, 2009). Negative effects may include increased substance abuse, crime, sexually transmitted infection, demands on the education system beyond current capacity, interference with recreational activity and decreased social cohesion. Community impacts would be expected to be community wide, affecting the entire geographic extent of the Battlement Mesa PUD. It is possible that the elderly or youth of the community are more vulnerable to impacts on community well-being. Elderly may be more vulnerable to crimes of theft or burglary, and are the likely group most affected by changes in social service availability and accessibility. Children would be most affected by changes in school enrollment and class size. They may also be affected by changes in outdoor areas used for play, which may overlap with areas prone to more industrial activity or along haul routes. We expect the community impacts

to continue for the duration of the development phase of Antero's project (five years). However, because the Antero project is relatively small, it is expected that exposure to factors that impact community wellness will actually be infrequent and unlikely. If impacts do occur, they are anticipated to have low to medium impacts on citizens in the community. The overall magnitude of negative health effects are expected to be low to medium and may be related to distress over changes to the community, to increased availability of illegal substances, and more widespread sexually transmitted infection. The overall magnitude of positive health effects are expected to be low and related to decreased financial stress for some residents and possible increased resources for schools. Given adequate coverage and support offered by social infrastructure, we expect the residents of Battlement Mesa will be able to successfully adjust to the impact on community well-being. Using the numerical ranking scheme, impacts to community wellness produce a mixed rank of ± 11.5 on a scale of ±6-15.

ES4.6 Summary of Economic and Employment Assessment

The economic and employment assessment is based upon Antero's estimate of an average of 120-150 workers, (both direct Antero employees and subcontracted workers) for a 2 rig operation over the five year development period. It is important to note that these numbers represent an estimate of the average number of workers and may not reflect employment on any given day.

The economic and employment changes related to Antero gas development in Battlement Mesa may produce mixed health effects. Positive effects would be related to higher wages for some residents, while negative effects would be related to higher inflation and no wage increase for others. Economic impacts would be experienced community wide and those on fixed incomes would be more vulnerable to the negative effects of inflation. The impacts of increased economic activity are likely to last the duration of the five year development period. The frequency health impact (stress, sleep disturbance) as a result of the economic activity is likely to be infrequent to constant, depending upon the individual circumstances. It is, however, unlikely that there will be large positive or negative economic impacts from the Antero development, given the relatively small economic scale of project and the probability that such impacts will be absorbed into Garfield County as a whole. Health impacts due to changing economic conditions are expected to be of low magnitude. Using the numerical ranking scheme, impacts on the economy and employment produce a mixed rank of ± 10.5 on a scale of ± 6-15.

ES4.7 Summary of Health Infrastructure Assessment

The assessment of changes to health infrastructure impacts on health is also based upon Antero's estimate of an average of 120-150 workers, on a two rig operation over the five year development period.

Changes to local health infrastructure associated with an increase in workforce and population in Battlement Mesa and the associated potential increase in health care utilization could have mixed

health impacts on Battlement Mesa community. Positive impacts could occur if the workers are insured and therefore support the existing healthcare system when it is used. On the other hand, if workers are uninsured, their use of medical services could strain the health system. However, like the economic impacts, health care system impacts are anticipated to be small given that Antero estimates an average workforce of 120-150 workers. Health care utilization is likely to be spread into Garfield County, depending upon where the workers live. Impacts of uninsured workers are likely to be noted by providers, but it is unclear that this would reach a level that would negatively impact either clinical or public health services. The potential for increased utilization of the health care services to strain existing services is small unless a large number of workers are uninsured and they all utilize the same services. It is not expected that the extent of such a strain would lead to decreased availability and quality of clinical services. Likewise, insured workers will support local health services but the extent of such support may not be sufficient to lead to increased availability and quality of services. Local tax revenues from the Antero project will contribute to the overall county fund, but are not likely to be large enough to directly impact public health services in Battlement Mesa. Should health services be impacted in Battlement Mesa, the impacts would affect the entire community, and those that utilize health care services most frequently such as the elderly, young children and disabled may be more vulnerable to negative impacts such as decreased availability. Likewise, those groups would benefit from expanded health care services. Should health service impacts occur, they are likely to be noted in the first few years of Antero's project as the health infrastructure adjusts to new needs. Impacts to the health care infrastructure are not anticipated to last the entire duration of the project. The frequency of both positive and negative on impacts the health care system and therefore on the community are likely to be sporadic, given that the relatively small number of workers and families associated with the project. It is possible that large financial strain to local providers, particularly emergency care providers, could occur should expensive emergent care become necessary for an uninsured worker, but this is anticipated to be an infrequent event. Potential impact to vulnerable groups, the community at large and the multiple years of potential exposure create a relatively high ranking, however, it is unlikely that Battlement Mesa citizens will experience positive or negative health impacts as a result of changes to the health care infrastructure related to the project. Any impacts to health as a result of changes to the health care infrastructure are expected to be low. Using the numerical ranking scheme, impacts on the economy and employment produce a mixed rank of ± 10 on a scale of ±6-15.

ES4.8 Summary of Accidents and Malfunctions Assessment

The assessment of accidents and malfunctions relies on a review of past accidents and malfunctions in Garfield County, Colorado from the COGCC incident database and individual cases in other areas. The very nature of accidents and malfunctions makes it difficult to predict whether or how an incident may impact health. Review of several years of COGCC data however, indicates that reportable incidents occur in approximately 6% of wells permitted, state wide, in Garfield County and for Antero's previous operations, as well. Therefore, it is possible to predict that with 200 wells being drilled in Battlement Mesa, there may be approximately 12 incidents that could be considered an accident or malfunction.

When considering the possible health impacts due to an accident or malfunction, the impacts are likely to be negative. Depending upon the size and nature of the incident, health and safety impacts may be felt by those only in close proximity, or throughout the PUD. Again, depending upon the nature of the incident, certain populations may be more vulnerable to health impacts. For instance, elderly or frail and those living in the assisted living facility, may have difficulty evacuating an area quickly. Children in school may also be slower to evacuate. Those with underlying medical conditions such as pulmonary or cardiovascular disease may have negative health effects related to fires or air emissions at levels that are may not have significant impact to others. Accidents and malfunctions are likely to be short in duration and infrequent. Given the 6% rate of incidents in the industry and within Antero's other operations in Garfield County, incidents are likely to occur and it is possible that health impacts will occur. The health impacts will be low to high in magnitude, potentially ranging from minor irritation to more severe exacerbation of underlying health conditions to severe injury or death. Using the numerical ranking scheme, impacts to health due to accidents and malfunctions produce a negative rank of -10 on a scale of ±6-15.

ES5 Recommendations

At the end of each assessment we have provided several recommendations aimed at decreasing negative public health impacts, improving positive ones, and filling information gags. The summary recommendations that could be acted upon in the near future are listed below, and more long term summary recommendations are listed in the following section.

- **Promote Pollution Prevention:** Require Antero to use best available technology and rapidly adapt new technology, to reduce emissions of air, water and soil pollutants as well as noise reduction and control. Establish a system for short-term odor monitoring and reduction during gas well completion.

- **Protect Public Safety:** Review pipeline system for routes that avoid proximity to homes, schools or other areas used by residents. Require best available technology to avoid accidents and malfunctions and regular inspection of facilities and pipelines. Review emergency response plans and periodically test emergency response system.

- **Address Boomtown Effects**: Develop plans to address temporary and permanent population influx that may affect demand and capacity of social services, schools and other key community facilities and programs. Identify gaps in access to public health or social services and implement monitoring of community health needs.

ES6 Next Steps and Conclusions

This HIA used the compiled baseline health characteristics of Battlement Mesa, current ambient environmental conditions in Garfield County and Antero's proposed gas development and production plans to evaluate probable and possible health impacts of Antero's project to the residents of Battlement Mesa. Through this process we have attempted to address the concerns of the citizens outlined in the BCC petition.

At the end of each assessment we have provided recommendations aimed at decreasing potential negative health impacts, based upon existing information. However, we also identified numerous gaps in information that limited this evaluation and may limit future evaluations of health in Battlement Mesa. Recommendations intended to address some of these gaps are provided in the HIA. Some of these issues will be addressed in an environmental health monitoring study (EHMS) currently being developed by CSPH investigators. These "next steps" recommendations can be summarized as follows:

- **Establish Baselines:** Improve monitoring of environmental exposures and health effects. Past environmental monitoring (i.e., air, traffic) and public health tracking (e.g., substance abuse, mental health) are insufficient to establish current health impacts among Battlement Mesa/Garfield County residents during gas development and production.

- **Enhance Environmental Monitoring**: Establish monitoring and data systems to conduct ongoing measurement of environmental exposures. Such exposures include 1) pollution of air, water and soil impacts; 2) physical hazards such as traffic, noise, vibration and light, and 3) psychosocial and community changes. Where feasible, tie environmental monitoring to risk-based environmental standards.

- **Improve Health Effects Tracking Systems:** Develop a robust health tracking system for Battlement Mesa/Garfield County so that providers report health conditions potentially related to natural gas development and production to the county health department.

- **Ensure Transparency:** Make exposure and health monitoring data from all public and industry interventions and monitoring available to the Battlement Mesa/Garfield County residents public in a timely manner.

- **Enhance Current Regulations:** Utilize findings of the HIA and future studies to complement ongoing state and local efforts to protect public health.

Because natural gas development and production will continue to grow in Garfield County, other parts of the region and state, as well as other parts of the country, the results of this HIA and the

future EHMS will likely have application beyond the study area and will contribute to filling many knowledge gaps about natural gas development and production and health.

In addition, because the domestic natural gas resource is part of the national policy to increase domestic energy production and reduce greenhouse gas emissions, a high level discussion of the health implications of this policy needs to take place. While municipal, county and state governments have begun to respond to citizen concerns, a national discussion of the benefits and risks associated with this policy is due. As outlined in this HIA, in addition to potential local economic benefits of energy development, there are potential local negative impacts to the physical and social health of the community. It will be important to understand public health implications in the context of national priorities for domestic energy production.

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Annotated Acronym Definitions

Antero: Antero Resources Corporation

BCC: Battlement Concerned Citizens: Grassroots citizen group formed in response to the Antero gas project.

bgs: below ground surface

BMC: Battlement Mesa Company: Owner of mineral and surface rights in Battlement Mesa.

BMSA: Battlement Mesa Service Association: Home owners association for Battlement Mesa residential communities.

BOCC: Garfield County Board of County Commissioners: Requested county environmental health to develop proposals to respond to citizens health concerns. Have indicated that HIA and health study proposals will satisfy this request.

BTEX: Benzene, Toluene, Ethyl-benzene, Xylene

CDPHE: Colorado Department of Public Health and Environment: Has consultative responsibility to the state permitting agency for comment health and environmental concerns, but has no regulatory responsibilities.

COGCC: Colorado Oil and Gas Conservation Commission: Colorado regulatory and permitting agency. Maintains databases for water quality, spills, and well locations Databases include federal and tribal lease owners as well as state lease owners. Provides permitting for state lease owners only.

CR: County Road

CSPH: Colorado School of Public Health: Faculty within the school, in the Division of Occupational and Environmental Health are primary investigators.

dB: decibel

EHMS: Environmental and Health Monitoring Study

EnCana: EnCana Oil and Gas (USA) Incorporated

EPA: United States Environmental Protection Agency

GCPH: Garfield County Public Health Department: county health agency with environmental health program. Environmental health program directed to respond to citizen concerns and has strong ties to all stakeholder groups. Environmental health program considered a regional leader in health and gas E&P.

HIA: Health Impact Assessment

µg/L: micrograms per liter

µg/m^3: micrograms per cubic meter

PM: Particulate Matter

$PM_{2.5}$: Particulate Matter of 2.5 microns or less

PM_{10}: Particulate Matter of 10 microns or less

PAH: polycyclic aromatic hydrocarbon

ppb: parts per billion

PUD: Planned Urban Development

RV: Recreational Vehicle

Saccomanno Study 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado

SGM: Schmueser/Gorden/Meyer Inc.

SIR: Standardized Incidence Ratio

tpy: tons per year

VdB: vibration decibels

VOC: Volatile Organic Compound

vt/d: vehicle trips per day

USGS: United States Geological Survey

Part One: Health Impact Assessment

Preface

HIA is used to evaluate objectively the potential health effects of a project or policy before it is built or implemented. HIA can provide recommendations to increase positive health outcomes and minimize adverse health outcomes. The HIA framework is used to bring potential public health impacts and considerations to the decision-making process for plans, projects, and policies that fall outside of traditional public health arenas, such as transportation and land use. - Centers for Disease Control [1]

The health of an individual human being is determined by a complex interaction of social, economic, genetic, and environmental factors which he or she experiences throughout life. Income, access to clean drinking water, unpolluted air, social support from friends and family, healthy food, access to education, and a whole host of other factors combine to have a profound effect on the health of an individual.

Similarly, when social, economic, and environmental conditions are common to a group of people, those conditions can influence the health of the population as a whole. Public policies have the potential to impact population health. While there are public programs and policies designed to influence population health (e.g. food safety regulations), population health is not accounted for in all or even most of the policies that can impact health. To improve the accessibility and utility of existing scientific knowledge as it applies to program and policy development, public health researchers have developed the Health Impact Assessment (HIA) approach. While HIAs vary in their goals and methods, the general approach is consistent across HIAs: A group of public health experts works with community stakeholders to identify the potential health risks and potential benefits to public health of a proposed policy, program, or project. The HIA team then collects information to assess how likely public health will be impacted. Based on the potential impacts and the estimated likelihood of those impacts, the HIA team offers recommendations to maximize public health gains and minimize negative effects of the program, project or policy at hand.

While the goal of an HIA is to anticipate and provide recommendations that advance public health, it cannot be expected to prevent all negative health impacts of a given decision. A HIA is an approach to incorporating public health into decision-making processes. As opposed to costly retrofitting and remediation, HIAs are proactive and preventive public health tools that have the potential to save health care costs in the long-term. HIAs are open processes that necessarily include stakeholder participation, review, and input as an essential part of the methods. Through this open dialogue, the HIA seeks to generate realistic and broadly supported recommendations to protect public health.

A HIA differs from a scientific epidemiological study in that an epidemiological study typically evaluates the effects of exposures on populations after the exposures have occurred, whereas, a

HIA is conducted before a project or policy is started, with the ultimate goal of identifying potential exposures and determining if there are needs to mitigate their impact on health. Both kinds of investigations provide valuable information to those concerned with understanding and protecting public health.

Regarding Ozone and Human Health

The impact of ground level ozone and ozone precursors are not included in this HIA. The Antero project itself will contribute ozone precursors (volatile organic compounds (VOCs) and nitrogen oxides), however, it is the sum of the ozone precursors produced in the county that contributes to ozone levels county wide. Ozone can cause important negative health effects and should be the considered when discussing public health in Garfield County. However, the impact of Antero's contribution to ozone on the health of Battlement Mesa citizens is not discussed in this assessment.

Regarding Climate Change and Human Health

This Health Impact Assessment does not account for the potential health effects of climate change. There is reason to believe that fossil fuel combustion has changed the global climate[2]. There is also reason to believe that climate change will impact human health[2]. However, it is in the opinion of the HIA authors that while this specific natural gas development contributes to climate change, is not likely to influence the global climate enough to have a measurable impact on the health of Battlement Mesa residents.

1 Introduction

This report summarizes the Battlement Mesa HIA commissioned by the Garfield County Board of County Commissioners (BOCC) with the Colorado School of Public Health (CSPH). The introductory section provides context for the HIA, a site description, and Antero Resources Corporation's (Antero) plans for Battlement Mesa.

1.1 The Battlement Mesa Community

The Battlement Mesa Planned Urban Development (PUD) is a 3,200-acre unincorporated jurisdiction divided into several neighborhoods, the names of which are:

- The Reserve
- Battlement Creek Village
- Willow Creek Village
- Willow Ridge Apartments
- Willow Park Apartments
- Eagles Point
- Valley View Village
- Fairway Villas
- Stone Ridge Village
- Monument Creek Village
- Canyon View Village
- Mesa Ridge
- Mesa Vista
- Tamarisk Village
- Tamarisk Meadows
- Saddleback Village

The community sits on a 500 foot mesa approximately to the south of Colorado River and mesas continue to rise above the community for another 500-1000 feet. There has been natural gas development and production going on for the last several years outside the PUD.

A 2005 academic study describes Battlement Mesa's transformation from a company town to a retirement community. Depending on the neighborhood, homes range from $85,000 to $450,000 in price and from 1,500 square feet to 4,400 square feet in size. While the community is often thought of as a "retirement community" (4), in fact there are also many families with children that live in Battlement Mesa. [3]

1.1.1 Parachute

Because the town of Parachute shares a zip code with Battlement Mesa, the HIA includes Parachute in several sections, including the health outcomes baseline analysis. Parachute is a small town adjacent to Battlement Mesa. Parachute sits at the base of the Parachute Creek valley, between the Battlement Mesa PUD to the south and a large natural gas field to the north, at an elevation of 5,000 feet. Both Interstate-70 and the Colorado River run through the town. Parachute has a population of approximately 1,300 people and there are small family ranches outside the town limits. There is significant industrial activity in Parachute Creek valley and on the surrounding mesas, including natural gas development and production, a gas processing plant and a bicarbonate of soda plant.

1.1.2 Demography[4]

According to the 2000 United States Census estimates, there total population of the Battlement Mesa/Parachute zip code was 5,041; 49.3 percent of the Battlement Mesa/Parachute population was female and 50.7 percent male. The median age was 37.5 years. 26.0 percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. For people reporting race in Battlement Mesa/Parachute, 93.4 percent identified as White, 0.5 percent as Black or African American; 9.7 percent of the population identified as Hispanic or Latino (of any race). In Colorado in 2000, 9.7 percent of the population was 65 years and over compared to 19.8 percent of the population in the Battlement Mesa/Parachute zip code.

Demographics
Population Battlement Mesa/Parachute, 2000 Total population: 5, 041 Males: 2,487 (49.3) Females: 2,554 (50.70) Mean age 37.5 Garfield County 2000 Total population: 43,791 2009 Total population estimate: 56,298 % change 2000-2009: 28.6%

Demographics
Vulnerable populations Battlement Mesa/Parachute Under 18: 1,311 (26.0) Over 65: 998 (19.8) Total <18, >65: 2309 (45.8)

Although the Battlement Mesa PUD is often described as a "retirement community", it is difficult to precisely define a "retirement community". Several objective measures reflect the characteristics of Battlement Mesa's population. In 2000, the percentage of Battlement Mesa residents, excluding Parachute, aged 65 years and older was approximately twice the national average (24.5 % vs. 12.4%, respectively). Furthermore, whereas 63.9% of the United States population (aged 16 years and older) was participating in the labor force, only 48.9% of Battlement Mesa residents were either working or looking for work in 2000.

While the lower labor force participation rate of Battlement Mesa residents and the higher proportion of people aged 65 years and over are likely indicators of a high retiree population in the PUD, almost half of the PUD residents aged 16 years and over were either working or looking for work. More than a quarter of the family households in Battlement Mesa had children under the age of 18 years (27.2%). So, while the Battlement Mesa PUD is home to higher proportions of people aged 65 years and over than the United States as a whole, the community is not homogeneously "retired."

1.1.3 Economy

Currently, the Battlement Mesa community is entirely residential. The only businesses in the PUD support the local residents. While several natural gas operators drill extensively the area surrounding the PUD, there are currently only two natural gas wells in the PUD itself. The businesses within the PUD include:

- A grocery store
- Two gas stations
- Several medical facilities
- A public golf course
- Banks
- A café
- A recreation center (paid for by homeowner association dues)
- A local newspaper

In addition to the local businesses, the PUD is home to two churches (with five others in Parachute), a 40-unit assisted living facility in the Battlement Mesa PUD serving seniors of low to moderate income,[3] and three schools – Underwood Elementary School (grades 1-3), St. John Elementary School (grades 4-5) and Grand Valley Middle School (grades 6-8). Battlement Mesa students attend the Early Childhood Center for pre-kindergarten and kindergarten and Grand Valley High School in Parachute for grades 9-12. These schools are all in Garfield County District 16.

1.2 Antero's Plan to Drill Within the Battlement Mesa PUD

The combination of technological advances (e.g. hydraulic fracturing), Federal and State economic incentives to develop natural gas resources and population growth in previously uninhabited (or sparsely inhabited) areas have contributed to a relatively new phenomenon. Whereas oil and gas development has historically taken place in locations that are geographically distant from human habitation (other than, perhaps, the housing for oil and gas workers themselves), it is increasingly common for drilling activities to occur in rural, suburban and urban areas close to where people otherwise unaffiliated with the industry live, work and play[5]. Throughout the country and in Garfield County, the residents in close proximity to drilling activities are raising concerns about the potential impacts drilling may have on air quality, water quality, public safety and public health[6]. The human health impact natural gas development and production has not been thoroughly studied.

In the Spring of 2009, Antero announced plans to purchase surface rights and mineral rights from the Battlement Mesa Community (BMC), as well as its intent to develop natural gas within the Battlement Mesa PUD[7]. The contract that establishes the PUD requires the Garfield County BOCC to review and any proposed land-use changes within the Battlement Mesa PUD through a *Major Land Use Impact Review* (also know as the MLUIR) process. The Garfield County BOCC has the authority to require modifications to the plans outlined in a given Major Land Use Impact Review application. Because its plans pertain to the Battlement Mesa PUD, Antero will submit a Major Land Use Impact Review to the BOCC before initiating their drilling activities. In addition to county review, Antero will also submit plans through a state permitting process, conducted by the Colorado Oil and Gas Conservation Commission (COGCC). Under a 2008 rule[8], natural gas operators may submit Comprehensive Drilling Plans to COGCC[9]. If Antero submits a Comprehensive Drilling Plan to COGCC, COGCC will review the development project as a whole, which streamlines permitting for individual wells within Antero's project. The Comprehensive Drilling Plan has not been submitted as of the date of this HIA report. Antero has, however, entered into a legally-binding Surface Use Agreement with the BMC. This Surface Use Agreement outlines characteristics of its natural gas drilling plans for the Battlement Mesa PUD. While not as detailed as a Major Land Use Impact Review or Comprehensive Drilling Plan, the Surface Use Agreement between Antero and the BMC provides some information regarding Antero's plans for the Battlement Mesa project. Furthermore, Antero held several community meetings during 2009 and 2010 where plans for Antero's project were

described and the power point presentations from these meetings are available online[10-11]. These sources of information plus information provided to the CSPH team are used to as a basis for this HIA. Appendix A includes a summary of the natural gas drilling process. Appendix B includes a review of energy development in the Piceance basin and the Surface Use Agreement between Antero and BMC.

1.3 Community Concerns

After Antero announced its intentions to drill within the Battlement Mesa PUD, community members living in Battlement Mesa expressed concern regarding potential environmental, health, and safety impacts. Citizen concerns have included but are not limited to:

- The proximity of drilling and gas production to homes, recreational areas and schools
- "Vulnerable" populations with diminished immune capacity
- Exposure to airborne volatile organic compounds (VOCs), diesel emissions, particulate matter (PM) and other air contaminants
- Exposure to fluids used in the fracking process, hydrocarbons and VOCs through soil or water exposure routes
- Potential increased risk of fires, explosions and/or motor vehicle crashes
- Changes in community "livability"

A grassroots advocacy organization, the Battlement Mesa Concerned Citizens (BCC) formed under a parent organization, the Grand Valley Citizens Alliance. In November 2009, the BCC submitted a citizen petition to the Garfield County BOCC requesting that BOCC require Antero to address health concerns before drilling for natural gas within the Battlement Mesa PUD (Attachment 1).

While the human health impacts of natural gas development and production have not been specifically studied using state-of-the-art public health epidemiologic research methods, there has been substantial research related to exposures of potential concern in the natural gas industry. For instance, drilling for natural gas has the potential to increase occupational and community exposures to VOCs such as benzene, toluene, ethyl-benzene and xylene (BTEX). Heavy metals released in drilling activities, particulate matter (PM) generated by transportation activities and diesel fuel combustion, and ozone precursors (ozone formation) are also known to be associated with natural gas development. Some constituents of fracking chemicals may pose health risks to workers or community members.

Sufficient exposures to these chemical compounds are associated with serious negative health outcomes such as lung disease in children and adults (i.e., asthma, chronic bronchitis, obstructive disease), cardiovascular disease, poor birth outcomes (premature birth, low birth weight), various cancers, and other long and short-term health issues [12-16]. Environmental contaminants to which

people may be exposed include air emissions, ground and surface water pollution and soil contamination. In addition, physical hazards can include increased truck traffic and domestic explosions associated with gas seepage into domestic water supplies. Social hazards can include a variety of community disruptions associated with boom-and-bust cycles, itinerant workforces and industrialization of residential areas[17].

1.4 Initial Responses to Community Concerns

In response to community concerns, Antero has held several informational community meetings[11] and has responded to community concerns by modifying its some the drilling plans, for example the removal of drilling pad C (replaced by the Parks and Rec pad). The Surface Use Agreement between Antero and BMC includes some measures which are intended to reduce the impact on the community's health and quality of life.

Even before it commissioned the HIA, Garfield County had undertaken many steps in response to community concerns regarding natural gas development and production in the county. Garfield County Public Health Department (GCPH), the county health department, initiated and managed the Saccommano Report and currently manages on-going ambient air monitoring stations at several locations in Garfield County. The Garfield County Oil and Gas Department initiated and managed an intensive study water quality and hydrology of the Mamm Creek Gas Field. GCPH also has participated in numerous Colorado Department of Public Health and Environment (CDPHE), COGCC, and United States Environmental Protection Agency (EPA) air and water studies documenting:

- Air toxics (e.g. benzene) in ambient air, at levels higher than levels measured in a neighboring county with no gas development [18]
- Evidence of ground-level ozone formation, which once exceeded the EPA 8 hour standard of 75 parts per billion (ppb) in 2008 [19]
- Ground water containing thermogenic methane in natural gas development and production areas [20-22]
- Trends in health impacts consistent with potential exposures (via a county-wide health assessment) [23]
- Citizen concerns over oil and gas impacts to health (via county-wide surveys)[24]

More recently, the BOCC instructed GCPH to address the BCC's concerns raised in its citizen petition. GCPH approached the CSPH with a request to collaborate on a HIA. Subsequently, the BOCC agreed to contract with the CSPH to conduct this HIA. Through funding from the Pew Health Impact Project, a Canadian HIA consultation firm with experience in resource development projects, Habitat Health Impact Consulting has provided technical assistance to the CSPH for this HIA.

2 HIA Methods

Methods for the HIA were based upon guidelines provided by the Pew Health Impact Project[25], as well as those found in the Merseyside Guidelines for HIA[26]. There are seven steps for this HIA, including scoping, screening, assessment, recommendations, implementation, reporting, and evaluation.

2.1 Screening

This HIA is was performed in response to a citizen petition to the Garfield County BOCC requesting a health an environment study be conducted to evaluate potential health impacts of Antero's natural gas project in Battlement Mesa. Garfield County has several years of experience with natural gas development and production and with community concerns over air and water degradation and the potential health impact. The county has responded by initiating ongoing ambient air monitoring and had previously commissioned the 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado (referred to as the Saccomanno Study) [23]. Based upon the results of the air monitoring and the recommendations of the Saccomanno Study, GCPH determined that an HIA could be used to provide decision makers (the BOCC) with valuable information that could allow them to respond to citizen concerns and help them in making informed decisions.

2.2 Scoping

The Scope of the HIA was defined in part by the requests outlined in the BCC petition (Attachment 1). The CSPH team determined that assembly and analysis of baseline health, environmental, and social data were possible within the framework of a HIA. In order to further elucidate specific stakeholder concerns, the CSPH team conducted a series of stakeholder meetings with citizens, the industry state regulatory agency, the state health department, and Antero representatives (Tables 1 and 2). As a result of this stakeholder process, a Scope of Work was written that was informed by citizen concerns in order to provide a framework for the HIA. This work ultimately led to a focus on eight areas of health concern (stressors) specific to natural gas development and production: air emissions, water and soil contaminants, truck traffic, noise/light/vibration, health infrastructure, accidents and malfunctions, community wellness, and economics/employment.

2.3 Assessment

The assessment of the stressors began with a demographic characterization of the population of Battlement Mesa and a baseline health characterization of the community by compiling information from a variety of sources. A Battlement Mesa Baseline Health Profile is included in

Appendix C. This information was used to describe the general population, as well as identify potentially high risk sub-populations. A health literature review, previously conducted by members of the CSPH team, was used to identify potential health risks and vulnerable subpopulations associated with natural gas development and production [27-28]. A human health risk assessment was conducted using longitudinal air and water quality data (Appendix D). All this information was used to develop assessments of air quality, water and soil quality, traffic, noise, community wellness, economics/employment, health infrastructure, and accidents/malfunctions.

Each assessment of the stressors includes a review of its general impact on physical, mental and/or social health as described in relevant medical and social science literature; a compilation and analysis of existing environmental and health data describing current conditions in Battlement Mesa; the means by which Antero's plans for drilling could alter the stressor; and finally a characterization of the stressor's impact on health. Several physical health outcomes linked to potential exposures are considered, including respiratory, cardiovascular, cancer, psychiatric, and injury/motor vehicle-related impacts on vulnerable and general populations in the community. The Battlement Mesa Baseline Health Profile (Appendix C) provides supporting documentation of baseline physical and social health determinants. In addition, the Human Health Risk Assessment (Appendix D) provides a comprehensive review of available air quality and water and soil contamination data and a systematic assessment of related health risk.

Of note, as of the date of this report, Antero had not submitted a Major Land Use Impact Review to Garfield County nor had they submitted a Comprehensive Drilling Plan to the COGCC. As such, based on consultation with GCPH, this HIA has been conducted based upon information provided by Antero to the public in community meetings and provided to the CSPH, by request, from Antero. If the ultimate Major Land Use Impact Review/Comprehensive Drilling Plan presented by Antero differs from the information available to the CSPH team, then it is possible that there will be other risks/benefits not identified in this report.

2.4 Recommendations

At the end of each assessment we have summarized what is known and not known about the impact of the Antero plans on the stressor. We then have provided several recommendations aimed at decreasing negative impacts or improving positive ones. In general, recommendations focus on continued monitoring of air and water sheds and strict enforcement of existing regulations; use of best available current technology and rapid adoption of new technologies to decrease emissions; traffic and noise mitigation; economic benefits used locally to mitigate negative local effects; and planning for the impacts of increased population, as well as for the loss of economic activity when development ends in five years should help decrease social impacts.

2.5 Reporting

This document represents the Draft HIA and Recommendations. This Draft HIA will be delivered to the Garfield County BOCC, and will be presented at a BOCC meeting. The GCPH will post this report on their Battlement Mesa HIA website for public review. There will be a 30-day public comment period, after which stakeholder review and input will be considered in the preparation of the final HIA. There will be a presentation to the community after the report is finalized. External review was provided by Habitat Health Impact Consulting and Dr. Teresa Coons, co-author of the Saccomanno Study. CDPHE provided review of the sections describing Physical Health Determinants and the Human Health Risk Assessment.

2.6 Implementation

Implementation of any recommendations in this report is the responsibility of the BOCC. The CSPH team will assist the BOCC with dissemination and education of the community regarding the findings of the report as needed by conducting community meetings.

2.7 Evaluation

In order to determine the value of this HIA and HIA process to the Garfield County BOCC and stakeholder groups, the CSPH will monitor Antero's project permitting process at both the county and state level. Our evaluation of HIA effectiveness will be, in part, determined by whether potential health impacts and mitigation strategies were considered when the permitting process occurs. In addition, CSPH will seek specific comments from GCPH and Garfield County BOCC on their assessment of the HIA and HIA process. Furthermore, the CSPH will present the HIA and descriptions of the HIA process at several scientific, professional, and community meetings in 2010-2011. Finally, an evaluation report will be delivered to the BOCC by December 31, 2010.

3 Summary of Battlement Mesa Baseline Health Profile

The health of a community can be estimated by measuring a variety of outcomes, including physical health outcomes, social outcomes, rates of injuries, educational climate, and others. There are many factors that can influence health status, such as age, genetic background, personal habits, employment, and environmental exposures or other hazards. The BCC requested that baseline health of the Battlement Mesa community be assessed prior to drilling within the PUD.

In order to determine the baseline health of citizens and the Battlement Mesa/Parachute community, both physical and social health were considered. Where available, information specific to the Battlement Mesa/ Parachute was obtained. Because of the shared zip codes (81635 and 81636), it was not possible to distinguish between the two areas. In some instances, zip code level information was not available in which case county level data are presented. The physical health of Battlement Mesa citizens, based on zip codes, is described by standardized incidence ratios (also known as an SIR). The standardized incidence ratio is a fraction: the proportion of people with a particular health condition divided by the expected proportion of people who have that same health condition. The state of Colorado was used as the reference (expected) population for these comparisons. The health of the community is described by available zip code level statistics for sexually transmitted infection; county level statistics for crime, substance abuse and motor vehicle crashes; and School District 16 educational information. The full and more detailed Battlement Mesa Baseline Health Profile is available in Appendix C.

3.1 Vulnerable populations

It is important to note that within a population there are individuals and groups of individuals which are at increased risk or which are more vulnerable to disease and to injury. Increased vulnerability is dependent upon a number of factors that can be categorized as demographic factors, genetic factors, and acquired factors. Age is an important factor in determining health risk. According to the 2000 United States Census data for the 81635 zip code, greater than 45% of the population may be considered to be more vulnerable to certain exposures, based on age (26 % under the age of 18 and 19.8 % over the age of 65). Acquired factors such as pre-existing disease, pregnancy, and behaviors such as smoking history, alcohol use, and nutrition, as well as genetic factors, can also influence vulnerability to illness and injury. Furthermore, occupational and residential exposures may also contribute to risk of illness and injury. Although these factors can contribute significantly to vulnerability, such information is not available to the HIA team. Future characterization of the prevalence of the factors that influence health would greatly enhance our understanding of this community, especially if that information can be collected prospectively.

3.2 Physical determinants of health

To assess the baseline physical health of the Battlement Mesa/Parachute area, the CSPH team obtained and analyzed inpatient hospital diagnoses, cancer, and death information from the CDPHE for the years 1998-2008. Inpatient hospital diagnosis data were derived from the Colorado Hospital Association Discharge Dataset. Birth data were calculated by the CSPH team using Colorado Birth Registry Data for the years 1998 - 2008. Aggregated counts and the standardized incidence ratio of select diagnoses, birth outcomes, and cancer types are presented in Appendix C. The CSPH team chose to analyze health diagnoses, birth outcomes, and causes of death that are understood to be associated with exposures related to natural gas processes, as well as those for which community members voiced concerns of elevated occurrence of disease. Major categories of disease and death include depression and those involving the nervous system, ear/nose/throat, vascular system and pulmonary system. Major categories of cancer include cancers with known association with exposures of concern, cancers for which there has been community concern, and the five most common cancers in Colorado. These cancers included: Hodgkin and non-Hodgkin lymphoma, multiple myeloma, leukemia (all types), melanoma, breast cancer, prostate cancer, bladder cancer, colorectal cancer, and cancer of the adrenal gland. It is important to keep in mind that just because an exposure to a contaminant is associated with a cancer, it does not mean an individual exposed to the contaminant will get that cancer. The amount of exposure and length of exposure to a contaminant also are important factors in determining the risk of cancer and other diseases. Birth outcomes analyzed included low birth weight and preterm delivery.

Within the hospital data analysis, we looked at several discharge diagnoses and determined that people living in the Battlement Mesa/Parachute zip codes had fewer or equal rates of these

diagnoses as their counterparts in Colorado. Battlement Mesa/parachute men and women had fewer than expected diagnoses involving the nervous system, ear/nose/throat and the vascular system and the pulmonary system. Within the cancer data, men in Battlement Mesa/Parachute had a slightly higher than expected prostate cancer rate. This finding is felt to be likely due to slight variation in a small number of cancers. Another possibility is that this slight elevation could simply be due to the fact that when comparing multiple independent health outcomes, there is the likelihood that 5 % of the tests will be abnormal by chance alone. Women had no higher than expected cancer incidence. There were no lower than expected cancer incidences in men or women. Fewer Battlement Mesa men and women died when compared with other Colorado residents. There were fewer deaths associated with nervous system diseases, and major cardiovascular diseases. There were no more negative birth outcomes than expected for the Battlement Mesa/Parachute zip codes.

Physical determinants of health
Hospitalization diagnoses Higher than expected: None Lower than expected: Females: Nervous system, ENT, Vascular, Pulmonary Males: Depression, Vascular, Pulmonary
Cancer Higher than expected: Prostate (felt to be a statistical variation) Lower than expected: None
Mortality Higher than expected: None Lower than expected: Females: Total deaths, Cardiovascular Males: Total deaths
Birth outcomes Higher than expected: None Lower than expected: None

3.3 Social determinants of health

To assess the baseline community health in Battlement Mesa/Parachute the CSPH team obtained available information regarding sexually transmitted infections, crime, substance abuse, motor vehicle crashes, and education from a variety of sources, as summarized in Appendix C.

Information regarding sexually transmitted infections for the years 2005-09 was obtained from the Disease Control and Environmental Epidemiology Division, CDPHE. During this time period, the incidence of chlamydia and gonorrhea in Garfield County rose, peaking between 2007 and 2008. Other sexually transmitted infections (syphilis and HIV) had three or fewer cases each year in Garfield County, and no cases in Battlement Mesa/Parachute.

Information regarding crime was obtained from the Colorado Bureau of Investigation as reported Parachute Police Department for the years 2000-2009, data for the year 2001 was not available. Due to its close proximity and similar community composition, data were analyzed as a surrogate for criminal activity in Battlement Mesa. For the years obtained, total arrests peaked in 2008, with a total of 339 arrests. All categories of arrests: violent offenses, nonviolent offenses, prostitution/sex offenses, substance use offenses, and the category of other offenses fluctuated throughout the period, with an increase in all categories of arrest during the years of 2005-2008.

Significant efforts were made to obtain data on mental health, substance abuse, and suicide specific to residents of Battlement Mesa. We were unable to obtain primary data, however, substance abuse information is publicly available for Garfield County from the Community Health Initiative website. Substance abuse data were extracted from the Garfield GCPH Department's 2006 assessment on community needs. From these data, depression, anxiety, and stress along with tobacco smoking and alcohol abuse appear to be the top indicators of the burden of mental health and substance abuse, respectively. It is important to note that the survey respondents were self-selected through survey distribution at libraries, city halls, community centers, health clinics, and mailings to some randomly selected homes.

Data on school enrollment were collected from the Colorado Department of Education. In 2009, at which time there were 1,229 students enrolled in Colorado School District 16, there was an increase of nearly 400 students (19.0%) since 2005 and 35.7% since 2000. While total enrollment increased significantly, proportional enrollment by grade remained relatively stable. Since 2000, there was a shift in the racial and ethnic profile of students enrolled in the district schools. The percentage of Hispanic children doubled from approximately 15% in 2000 to 30% in 2009 and the percentage of Caucasian, non-Hispanic children decreased from 82% to 65%. Proportions of African American, American Indian, and Asian children are small and remained stable. Student teacher ratios remained stable through the initial period of the oil and gas boom in 2003, with the highest student-teacher ratio seen in the early education setting. Student teacher ratios are not available beyond 2004.

Social determinants of health
Sexually transmitted infections (number of cases, baseline →peak) Battlement Mesa/Parachute Chlamydia: Females: 4→12 Males: 2→7 Garfield County Females: 39→93 Males: 13→27
Crime Violent Crime: 10→18 Nonviolent Crime : 34→40 Prostitution/sex offenses: 0→1 Substance use offenses: 69→46 Other offenses: 63→76
Hospitalization for Alcohol/Drug Abuse and Suicidal Behavior Garfield County 2003-05: 275 persons
Education, Garfield County District 16 Enrollment 2000: 906 2005: 1033 2009: 1,229 (35.7% increase)

3.4 Limitations

Limitations for the data described in the Battlement Mesa Baseline Health Profile section of this document can be found in the Appendix C.

4 Assessment of Health Impacts

Eight potential stressors to health were identified and assessed: air quality; water and soil quality; traffic and transportation; noise, vibration and lighting; community wellness; employment and economy; health system infrastructure; and accidents and malfunctions. These assessments take into account Antero's proposed control plans and mitigation strategies, to the extent that they are known (from public presentations, Surface Use Agreement, and other information provided by Antero). Any significant deviation from the available information will not necessarily be reflected in this assessment. Each stressor was then characterized based on seven attributes relevant to public health: direction of health effects; geographic extent; likelihood; vulnerable populations; duration of exposure; frequency of exposure; and magnitude/severity of health effects. For each attribute, consistent definitions were created and numerical values were assigned to each level of the attributes, as shown in the tables below. The characterization consists of describing and ranking each potential health impact in terms of each attribute. To compare the relative importance of the potential stressors to one another, these numeric rankings were summed for each health impact to create a relative rank. Both the numerical value assigned to each attribute level and the summed rank are qualitative with the sole purpose of helping to describe the relative importance of each potential health impact to the other potential health impacts identified in this HIA. As such, any individual ranking is only meaningful when used in context with another ranking within this HIA. The numeric levels and summed ranks do not represent a quantitative estimate of risk, nor should they be used to compare health impacts identified in this HIA to other HIAs, risk assessments, or health standards.

Direction of Potential Health Effects

Positive	Changes that may improve health in the community	+
Negative	Changes that may detract from health in the community	-

Geographic Extent of Health Effects

Localized	Effects mainly occur in close proximity to drilling or other related activities	1
Community-wide	Effects occur across most or all of the Battlement Mesa PUD	2

Presence of Vulnerable Populations within Battlement Mesa

Yes	Disproportionately affects subpopulations that are more vulnerable to health impacts (e.g. children, the elderly or people with pre-existing health conditions)	2
No	Affects all subpopulations evenly	1

Duration of Exposure

Short	Lasts less than one month	1
Medium	Lasts at least one month but less than one year	2
Long	Lasts one year or more	3

Frequency of Exposure

Infrequent	Occurs sporadically or rarely	1
Frequent	Occurs constantly, recurrently and/or numerously	2

Likelihood of Health Effects

Unlikely	There is little evidence that health effects will occur as a result of this the Antero drilling in the PUD	1
Possible	Evidence suggests that health effects may occur, but are not common in similar situations	2
Likely	Evidence suggests that health effects commonly occur in projects of this type	3

Magnitude/Severity of Health Effects

Low	Causes health effects that can be quickly and easily managed or do not require treatment	1
Medium	Causes health effects that necessitate treatment or medical management and are reversible	2
High	Causes health effects that are chronic, irreversible or fatal	3

EXAMPLE:

The following characterization of a hypothetical health impact from Antero's plan illustrates how attribute levels are assigned and then summed to provide a relative ranking for the potential health.

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Hypothetical	Negative:-	Localized: 1	No: 1	Short: 1	Infrequent: 1	Unlikely: 1	Low: 1	-6

The hypothetical health impact may produce **negative health effects** only in areas in close proximity to the development areas and is **localized.** No particular pollution is more vulnerable to the health effect. The duration of the hypothetical impact is expected to be less than a month, **short,** and only occur once, **infrequent**. It is **unlikely** to occur and any health effects could be

easily managed at home and would be **low**. The hypothetical health impact is has a ranking of -6 out of 15.

The following sections provide an assessment, characterization, and recommendations for each potential health impact.

4.1 Assessment of Air Quality on Health in Battlement Mesa

> "What happens if the air is so bad that I have to close all my windows and shut off my swamp cooler?"
> *June 15 stakeholder meeting*

Exposure to airborne contaminants from natural gas development and production is a major concern to Battlement Mesa residents. There is the potential for release of hundreds of airborne contaminants during most if not all natural gas development and production. The potential for release of contaminants to air increases with well installation errors, blow outs, or well fires. Sources of contaminants during these operations include the natural gas resource itself, chemicals used in well development operations, such as fracking, wastes from well development activities such as produced water, and diesel exhaust from trucks and generators.

4.1.1 Air Quality and Health

Natural gas development and production and the diesel engines used to support them have the potential to release hundreds of hydrocarbons, carbonyls, and other contaminants into the air. People can be exposed to these contaminants as they breathe ambient air in and outside of their homes. Some of these contaminants, such as benzene, diesel exhaust, and $PM_{2.5}$, are human carcinogens. Others, such as carbonyls, alkanes, ground-level ozone, and 1,2,4-trimethylbenzene, can act as irritants of the eyes, skin, and respiratory tract or cause neurological effects[29-30]. In addition, hydrocarbons, carbonyls, and nitrogen oxides serve as precursors for ground level ozone formation. The health effects of many other of the potential contaminants are not known. Descriptions of health effects of the air contaminants of potential concern are presented in Section 4 of the Human Health Risk Assessment (Appendix D). The Human Health Risk Assessment reviews ambient air data collected in Garfield County between 2002 and 2009.

In addition to the effects that each of these substances can produce by itself, there is also the possibility of complex health reactions occurring as a result of the interaction of multiple substances. There is some indication that complex mixtures can act additively or synergistically to increase effects on human health. For example, studies on air pollution indicate that continuous exposure of healthy human adults to sulfur dioxide or nitrogen dioxide increases ozone absorption, suggesting that co-exposure to other gaseous pollutants in the ambient air may enhance ozone absorption. Studies that evaluated response to allergens in asthmatics (allergic and dust-mite sensitive) suggest that ozone enhances response to allergen challenge. Other

studies have reported increased response (lung tissue injury, inflammatory and phagocytosis) to the mixture of PM and ozone compared to either PM or ozone alone[30-31].

4.1.2 Current Air Quality Conditions

There are several sources of air emissions that currently affect air quality in Battlement Mesa. The main sources are vehicle emissions and natural gas development and production, as described below.

Battlement Mesa residences are located one mile from Interstate-70, which likely has some impacts on the current ambient air quality. The Garfield County emissions inventory indicates that highway vehicles were a primary contributor to carbon monoxide, sulfur dioxide, and nitrogen dioxide emissions in 2007[32]. The current traffic in the Battlement Mesa PUD, described in Antero's traffic analysis, also has impact on the current ambient air quality.

With the exception of two natural gas wells, Battlement Mesa does not currently house any industrial activity. While there are many gas wells located to the north, east, and south of the PUD boundaries, the impact on the ambient air quality within the PUD is estimated to be similar to other rural locations in Western Garfield County without significant natural gas development and production. There currently is no baseline air quality data specific to Battlement Mesa, although the GCPH plans to begin collecting air quality data (carbonyls, SNOMCs, and meteorology) in Battlement Mesa beginning in the Fall of 2010. Therefore, this can be verified when the results from the ambient air sampling in Battlement Mesa are available.

The air quality measurements and risks determined for the Silt-Daley and Silt-Cox monitoring sites in the Human Health Risk Assessment performed with the 2005-2007 ambient air study data and background samples collected in the 2008 Garfield County Air Toxics study were employed to estimate baseline air quality and risk within the Battlement Mesa PUD[33-34]. The Silt-Daley and Silt-Cox monitoring sites are described as rural sites without natural gas development and production.

The average PM_{10} levels at Silt-Daley (9.2 $\mu g/m^3$) and Silt-Cox (13.6 $\mu g/m^3$) were well below the 150 $\mu g/m^3$ National Ambient Air Quality Standard. Chemical speciation of the PM_{10} samples indicated that the main source of carbon in the samples is most likely from a combination of oil and gas production and building heating[18]. The 24-hour average $PM_{2.5}$ levels measured in background samples the Garfield County Air Toxics Study Summer 2008 ranged from 4.9 to 10. 3 $\mu g/m^3$, and were well below the 35 $\mu g/m^3$ National Ambient Air Quality Standard [34].

Baseline cancer risk estimates ranged from 6.2 excess cancers per 1 million individuals at Silt-Daley to 21 excess cancers per 1 million individuals at Silt-Cox, after adjusting for a 30-year exposure duration and 350 day/year exposure frequency. The difference in cancer risk between the two sites is because different contaminants are driving the risk. The cancer risk at Silt-Daley

is driven by benzene, which was not detected at Silt-Cox. The cancer risk at Silt-Cox is driven by 1,4-dichlorobenzene, which was not detected at Silt-Daly. At both sites the non-cancer hazard was less the one, below which health effects are not expected to occur.

It is important to note that 2005-2007 and 2008 studies were limited to determining only 128 possible air contaminants. Several other potential air contaminants, such as, ozone, and PAHs, were not measured[33] and therefore not included in the Human Health Risk Assessment or other Human Health Risk Assessment conducted by CDPHE in the past.

EnCana Oil and Gas (USA) Incorporated (EnCana) began conducting ozone measurements in 2007 at their mountain station in Garfield County. The mountain station is located at 8407 feet above sea level in a remote area with very little natural gas development and production. Ozone levels averaged over 8 hours ranged from 17 ppb to 74 ppb. While Encana's ozone data are from a rural area within Western Garfield County, it may not be a good estimate of ambient ozone levels in the Battlement Mesa PUD. This is because of the 3200 foot elevation difference between the two areas (the elevation of the PUD is approximately 5200 feet above sea level). Ground level ozone concentrations vary by elevation, with higher concentrations at higher elevations.

4.1.3 Antero Drilling Plans in Battlement Mesa and Air Quality

Garfield County's 2007 emission inventory indicates that the oil and gas industry (point and non-point sources combined) is the highest contributor to nitrogen dioxide, benzene, and sulfur dioxide emissions within Garfield County. For example, the oil and gas industry contributes five times more benzene to the inventory than any other emission source listed. The oil and gas industry also is a significant contributor to VOC, PM_{10}, and carbon monoxide emissions[32]. Therefore, it is expected that Antero's project will impact air quality in the PUD.

The VOC emissions from natural gas development and production have the potential to degrade the air quality within the PUD, if they are not adequately controlled. There is the potential for the production tank on each well pad to emit 37 tons per year (tpy) VOCs (including methane), based on Antero's estimate of 0.36 tpy benzene and the composition of the condensate at the Watson Ranch Well located on the south east border of the PUD (Antero Battlement Mesa Natural Gas Development Plan Meeting #7, October 7, 2009, Information provided by Antero). Antero has specified that they will use combustors to control VOC emissions from production tanks[7] to achieve a 95% VOC control efficiency in compliance with COGCC rule 805b[9]. Applying a 95% control efficiency to the potential VOCs emissions results in 18.6 tpy VOC emissions from the production tanks on all 10 proposed well pads combined. Production tanks are only one of a number of potential sources of VOCs emissions from natural gas production activities. Some sources, such as flow back operations, are likely to cause a higher emission rate of VOCs, while others may have VOC emissions similar to the production tanks. It is important to note that while combustors may decrease VOC emissions, they have the potential to increase carbon monoxide, carbon dioxide, and nitrogen oxides emissions.

COGCC Rule 324A requires operators to take precautions to prevent significant negative impacts to air; COGCC Rule 317 requires that any gas escaping during drilling must be directed a safe distance from the well and burned (flared); and COGCC Rule 805b requires that gas facilities and equipment shall be operated in such a manner that odors and dust do not constitute a nuisance or hazard to public welfare. However, natural gas development and production may have some impact on localized air quality at residences near the well pad, as evidenced by odor complaints to COGCC and the Garfield County Oil and Gas Department from Battlement Mesa residents in July 2010 (COGCC complaint reports)[9]. The odor complaints occurred during flow back operations at Antero's Watson Ranch Pad located on the southeast border of the PUD, within approximately ½ a mile from several residences, and resulted in COGCC issuing a notice of alleged violation (also known as NOAV) to Antero on 7/14/2010. In the 2005 to 2007 Garfield County Ambient Air study, air samples collected when residents noticed odors (thought to be from natural gas development and production), contained levels of benzene, ethylbenzene, toluene, and xylenes that were greater than EPA regional screening levels for residential ambient air[18]. EPA Regional Screening Levels are health-based levels above which health effects may occur.

Diesel exhaust from heavy trucks and generators has the potential to impact air quality within the PUD. The transportation and traffic assessment discusses the number of expected truck trips that were used to estimate the annual emissions from Antero's projected heavy truck activity as summarized in the following table.

Estimated Annual Emissions from Trucks

Contaminant	five year Well Development (Phases 1 through 3)	20 - 30 Years of Well Production and Operations
PM (tons/year)[1]	0.26 to 0.75	0.05 to 0.12
Nitrogen dioxide (tons/year)[2]	0.35 to 0.45	0.068
Carbonyls (tons/year)[3]	0.063 to 0.082	0.012
Alkanes (tons/year)[4]	0.05 to 0.064	0.0097
PAHs (tons/year)[5]	0.14 to 0.18	0.027

[1]assuming a PM emission rate of 0.64 to 1.4 grams per mile [35], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[2]assuming a nitrogen dioxide emission rate of 0.84 grams per mile[36], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[3]assuming a carbonyl emission rate of 0.15 grams per mile[36], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[4]assuming an alkane emission rate of 0.121 grams per mile[37], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[5]assuming a PAH emission rate of 0.0.338 grams per mile[37], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip

The estimated emissions are based on the period of time during which trucks are moving and do not include emissions created during idling and emissions from diesel powered generators. Each of the proposed truck routes is near at least one Battlement Mesa housing area[38].

With the following control measures in place, project dust from construction activities, well pads, and access roads is not expected to significantly impact Battlement Mesa air quality. COGCC rule 805b requires operators to employ practices for control of fugitive dust caused by their operations. Antero has specified the following dust control measures: (1) soiltac and/or liquid dust suppressants will be used; (2) all access roads and well pads will be graveled; (3) truck traffic will not exceed 20 miles per hour (mph); and (4) all contractors will be notified they must obey traffic laws and that they will be disciplined, up to removal from Antero's project, if they fail to comply[7].

Fugitive emissions from pipes, valves, pneumatic devices, and wellheads have the potential to impact Battlement Mesa air quality and can do so over the life of the well, estimated to be at least 20 years. In addition, VOCs may be vented during maintenance ("pigging") of pipes, occurring intermittently over 20 years. COGCC rules require that no bleed valves be used on pneumatic devices, where technically feasible. Appendix B discusses specific requirements for pipelines within the PUD, as agreed in the Surface Use Agreement. No centralized compressor stations will be located in the PUD[7].

Appendix D contains a Human Health Risk Assessment that was performed by the CSPH team to estimate the potential impacts to the public health from Antero's proposed project. The Human Health Risk Assessment was conducted using five years of data from the Bell-Melton Ranch monitoring station, the 2008 Air Toxics study, and the 2005-2007 air study. Three exposure scenarios were evaluated: (1) chronic exposure of all residents within the Battlement Mesa PUD; (2) chronic exposure of residents within the PUD living adjacent to a well pad; and (3) acute exposure of child residents living within the PUD living adjacent to a well pad. The Human Health Risk Assessment concludes that there is a potential for natural gas development and production within the Battlement Mesa PUD to adversely impact public health. The highest risk is projected for residents living adjacent to well pads through acute exposure to air contaminants emitted during well completion activities. Following is a summary of the conclusions of the Human Health Risk Assessment:

- These non-cancer hazards and cancer risks may be significantly underestimated because there is currently little or no information for many contaminants associated with natural gas operations. They may be even higher if information were available for polycyclic aromatic hydrocarbons (PAHs), chemicals in fracking fluids, ozone, $PM_{2.5,}$ PM_{10}, and contaminants without toxicity values. In addition, little information is available for soil and water.
- For Battlement Mesa residents living adjacent to a well pad, the estimated Hazard Index of 40 for acute non-cancer hazard and the estimated Hazard Index of 2 for the chronic

non-cancer both are greater than one, above which health effects may occur. Both of these hazard estimates are driven by trimethylbenzenes and benzene in ambient air.

- For chronic exposure of Battlement Mesa residents living adjacent to a well pad, the estimated lifetime excess cancer risk of 83 cancers per one million people, while within EPA's acceptable range of one to 100 cancers per one million people, exceeds EPA's goal of less than one cancer per million people and is near the high end of the acceptable range. This translates to a population attributable risk of less than one cancer for a population of 5,041. The contribution of benzene, methylene chloride, and ethylbenzene also exceed the contribution of these contaminants to the baseline cancer risks measured at the Silt-Daley and Silt-Cox monitoring stations.
- For chronic exposure of Battlement Mesa residents not living adjacent to well pads, the estimated Hazard Index of 0.6 for non-cancer hazards is less than one, below which health effects are not expected to occur.
- For Battlement Mesa residents not living adjacent to well pads, the estimated lifetime excess cancer risk of 71 cancers per one million people, while within EPA's acceptable range of one to 100 cancers per one million people, exceeds EPA's goal of less than one cancer per million people and is near the high end of the acceptable range. This translates to a population attributable risk of less than one cancer for a population of 5,041.

4.1.4 Characterization of the Air Quality on Health

The impact of air quality due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Air Quality	Negative(-)	Community wide	Yes	Long	Frequent	Likely	Moderate to High	-14.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated air contaminant exposures associated with the Antero development within the Battlement Mesa PUD, air quality will likely produce **undesirable health effects** in the areas both in near development areas and **community wide.** Much of the community will be near sources of air contamination and ambient air quality will affect the entire community. Children, older adults, and individuals with respiratory diseases may be more vulnerable to the air contaminants and are considered **vulnerable populations**. Air quality degradation may last for the duration of Antero's project, from well pad preparation through well abandonment, and therefore could be long in duration. The impacts to air quality are expected to be **frequent** and occur constantly and/or reoccur. It is **likely** that contaminant concentrations in residential ambient air may be high enough to cause short-term and long-term disease. Health effects may

include respiratory disease, neurological problems, and cancer. It is likely that medical attention will be necessary for some of these effects and that some of these effects will not be reversible. Therefore the impacts are rated as **moderate to high** magnitude. Using the numerical ranking scheme, air quality impacts are expected to produce a negative rank of -14.5 on a scale of ±6-15.

4.1.5 Findings and Recommendations from Air Quality Assessment

What we know: Air pollution is a hazard to the public health. GCPH and CDPHE ambient air studies, air toxics studies, and the broader scientific literature demonstrate that natural gas development and production contribute diminish air quality. These studies also show that the largest volume of emissions to air occur during well development. The Human Health Risk Assessment in this HIA, previous CDPHE risk assessments, and Saccomanno Study all conclude that there is likely to be an increased risk of cancer and other chronic and acute health effects from residential exposure to air emissions that can result from natural gas development and production. There have been several odor complaints associated with the Watson-Ranch well pad at the perimeter of the PUD filed with the COGCC. These odor complaints resulted in COGCC issuing a Notice of Alleged Violation.

What we do not know: The ambient air quality within the Battlement Mesa PUD is not known. The levels of air emissions during all stages of natural gas development and production are not known. Many types of possible emissions, such as PAHs and fracking chemicals, as well as the contribution of PM and ozone have not been assessed. It is not known if the set backs of wells from occupied buildings are adequate to protect public health.

Recommendations to Reduce Impacts to Public Health from Air Pollution

Based on these findings, the following are some of the suggested ways to reduce the potential impact of air emissions.

1. Require submission of a quality assurance project plan (also known as a QAPP) to GCPH for review and approval for all monitoring specified in these recommendations to assure monitoring information will be adequate for informing public health decisions.
2. Require Antero monitoring results conducted in response to CDPHE consultation (dated 4/12/2010) be made available to the public in a timely manner to provide accessible information and transparency.
3. Require corrective action when odor events occur, including notification of the GCPH and residents to reduce impacts.
4. Require adherence to COGCC 805b green completion practices, with no variances, and EPA natural gas STAR program to reduce VOC emissions to the lowest level technically possible.
5. Require use of electrically powered generators in place of diesel powered generators for well drilling and fracking operations to reduce VOC, PAH, and PM emissions.
6. Require a valid emissions permit from the CDPHE for each well pad, per COGCC rule 805b to establish inspection and monitoring requirements.

7. To reduce VOC emission, require pilot lights on production tank combustors remain lit through use of appropriate technology, such as spark igniters.
8. Require adherence to dust control measures and traffic measures specified in the Surface Use Agreement.
9. Require that Antero establish and implement a plan that ensures all trucks used for its plan within the PUD meet emission standards specified in the Clean Fuel Vehicles (heavy trucks) for the Clean Fuel Fleet Program (CFR Part 88.105-94) to reduce VOC, PAH, and PM emissions.
10. Require truck loads of dirt, sand, aggregate materials, drilling cuttings, and similar materials be covered to reduce dust and PM emissions.
11. Require pits at the water storage facility to be covered to reduce VOC emissions.
12. Require air monitoring of water storage facility for VOC/BTEX and report results to GCPH.

The recommendations to address information gaps are in Section 5.

4.2 Assessment of Water and Soil Quality on Health in Battlement Mesa

> "What will be the effect of chemicals on the water supply?"
> *June 15 stakeholder meeting*

The impact of natural gas development and production on water and soil quality and the water supply is a major concern to Battlement Mesa residents. Surface run-off, and infiltration from drilling cuttings and produced water stored in pits on well pads or off-site locations; well installation errors; and uncontrolled well development (kick backs, blow outs, and well fires) could result in emissions of contaminants to groundwater, subsurface soil, surface soil and surface water. Spills of fracking fluids, drilling muds, condensate, and diesel could result in contamination of surface soil. Run-off and infiltration then could result in subsequent contamination of surface waters and of groundwater and subsurface soil, respectively. Exhaust from diesel engines (through dry deposition of particulates) and wind erosion from drill cuttings could contaminate surface soils (through deposition of particulates). If the groundwater or subsurface soil is contaminated, VOCs could infiltrate and accumulate in the air of buildings. Sources of contaminants include the natural gas resource itself, chemicals used in well production activities, wastes from well production activities, and exhaust from machinery used in well production and maintenance.

4.2.1 Water and Soil Quality Impacts on Health

Natural gas development and production and the diesel engines used to support them have the potential to release hundreds of metals, salts, hydrocarbons, carbonyls, and other contaminants to groundwater, surface water, and soil. People can be exposed to these contaminants through ingestion of water, incidental ingestion of soil, dermal absorption from water, inhalation of soil particulates, inhalation of VOCs released from water during activities such as showering, and

inhalation of VOCs in building air. Some of these contaminants, such as benzene[39] and several of the PAHs, are human carcinogens. Others, such as the carbonyls, alkanes, and 1,2,4-trimethylbenzene, can act as irritants of the eyes and skin or cause neurologic effects[29]. Specific health effects of several potential contaminants are described in the Air Quality Assessment and in the Human Health Risk Assessment (Appendix D).

Significant contamination of water supplies with salts, such as those containing chloride, can make the water unsuitable for human consumption and stress water treatment facilities. The water requirements for natural gas development and production are large, with the potential to tax local water supplies, particularly in the event of a drought.

4.2.2 Current Conditions of Water and Soil Quality

The primary source of drinking and domestic water in Battlement Mesa is the Colorado River. The Battlement Mesa Water Treatment Plant draws water from two intakes located in the middle of the river for treatment. The available baseline groundwater and surface water data specific to Battlement is Mesa is limited to the annual testing of the surface water intake and back-up groundwater wells at the Battlement Mesa Water treatment facility. These results indicate that there is no VOC, herbicide, pesticide or carbamate contamination of either drinking water supply. In addition, a domestic well at the Historic Battlement Mesa Schoolhouse was sampled on May 17, 2010 in response to an anonymous request from a landowner in the vicinity of Antero's Watson Ranch Well. The COGCC concluded the laboratory analysis did not indicate any impacts to this domestic water well from natural gas production operation[40].

A baseline water quality study for the Piceance Basin was performed in 2006 [22]. Seventy groundwater samples were collected from water supply wells located north of the Colorado River and south of the upland "Hogback" between the communities of Rifle and Parachute. The inorganic results are not applicable to Battlement Mesa, because the water chemistry between these two areas could be quite different. However, the BTEX and methyl-tert-butyl-ether (also known as MTBE) results could be somewhat representative of Battlement Mesa, because they are not naturally occurring. No measureable concentrations of BTEX, methyl-tert-butyl ether, or methane were detected in any of the samples.

There is no baseline data for surface soil or subsurface soil within the PUD and current conditions are not known.

The Colorado Department of Labor & Employment's Oil and Public Safety Division has permitted ten underground storage tanks within the PUD, summarized in the following table.

Permit Holder	**Fuel**	**Tank Capacity (gallons)**
Battlement Mesa Service	Gasoline	1,000

Permit Holder	Fuel	Tank Capacity (gallons)
Battlement Mesa Service	Diesel	1,000
Battlement Mesa Golf Course	Gasoline	2,000
Battlement Mesa Golf Course	Diesel	1,000
Kum and Go, Stone Quarry Road	Gasoline	20,000
Kum and Go, Stone Quarry Road	Gasoline	12,000
Kum and Go, Stone Quarry Road	Diesel	12,000
Kum and Go, Tamarisk Trail	Gasoline	10,000
Kum and Go, Tamarisk Trail	Gasoline	10,000
Kum and Go, Tamarisk Trail	Gasoline	8,000

These underground storage tanks have the potential to leak and contaminant subsurface soil and groundwater with fuel contaminants, including benzene. The permit holder is required to perform weekly leak tests on the underground storage tanks and the Oil and Gas Public Safety Division performs an annual inspection of the underground storage tank. Review of the Oil and Gas Public Safety Division files on August 18, 2010 indicated no leaks or contamination of soil or groundwater associated with these underground storage tanks.

There also are natural gas productions operations occurring on the border of the PUD that could potentially impact the water and soil quality within the PUD, as well as the water supply. Other potential sources of contamination to groundwater and soil are the golf course and landscaping operations (e.g. application of fertilizers, herbicides and pesticides).

In the event that the Battlement Mesa Water Treatment Plant was shut down, drinking and domestic water for Battlement Mesa residents would be supplied from four groundwater wells along the south bank of the Colorado River. These wells are not supplied with water from the Colorado River and it is believed that the source of water in these wells is from an up-gradient aquifer. There could be a hydrologic connection between these wells and the aquifer on Battlement Mesa, allowing for a conduit of natural gas extraction activity contaminants to the secondary drinking water source, although this has not been verified.

4.2.3 Antero Drilling Plans in Battlement Mesa and Water and Soil Quality

The Mamm Creek field, located approximately 20 miles to the east of Battlement Mesa in Garfield County, has experienced extensive natural gas development and production, with over 1100 gas wells installed between 2000 and 2007. The two phase hydrogeologic study conducted between 2006 and 2007 on the Mamm Creek field [21-22] provides data that is useful in estimating potential impacts from natural gas development and production on water quality in Battlement Mesa. An increasing temporal trend of methane and chloride groundwater concentrations coincident with the increasing number of gas wells installed was observed in the hydrogeologic

study[21-22, 41]. The isotopic methane data indicate a thermogenic origin of methane, which may be attributed to the Williams Fork gas. The increasing chloride concentrations are attributed to Williams Fork production water.

In the Mamm Creek field hydrogeologic study, chloride concentrations did not exceed regulatory limits and there is no regulatory limit for methane. Benzene was only detected in groundwater and surface water samples collected in proximity to the West Divide Creek seep and the Amos well. Many of the benzene concentrations in these samples exceeded the 5 µg/L regulatory limit and the 0.41 µg/L EPA Regional Screening Level for tap water. At the West Divide Creek seep, a faulty cement job on the casing of the Schwartz well resulted in the migration of natural gas and BTEX over 2,000 feet southeast of the well and seepage into Divide Creek. At the Amos well, Williams Fork gas from poorly installed wells are believed to be responsible for the contamination.

Pavillion Wyoming, a community of approximately 166 residents located in Fremont County, also has experienced intensive natural gas development and production, with 211 active gas wells, 30 plugged and abandoned wells, 20 "shut-in" wells, and 37 production pits in an 8 square mile area. In response to complaints from Pavillion residents of odors and off-tastes in domestic water, EPA conducted sampling of both domestic and monitoring wells in the area between 2009 and 2010. The sampling results indicate that domestic wells are contaminated with low levels of petroleum hydrocarbons and thermogenic methane and that the shallow groundwater is heavily contaminated with petroleum hydrocarbons and BTEX. Natural gas development and production are the most likely source of the petroleum hydrocarbons and BTEX. Several inorganic compounds, such as sodium, sulfate, and nitrate, also were detected which could have sources other than natural gas development and production. The hydrologic connection between the drinking water aquifer and shallow groundwater is not well characterized. In their health consultation based on EPA's results, ATSDR found the quality of the drinking water in several of the domestic wells was not acceptable and concluded that exposure to some of the contaminants could result in health effects[42-43]. While the groundwater contamination that occurred in Pavillion is not directly comparable to Battlement Mesa because of differences in the natural gas resource and state regulations, it does indicate that natural gas development and production can adversely impact groundwater quality.

Review of water quality data in the USGS and COGCC databases indicate that groundwater and surface water contamination from natural gas development and production at levels with the potential to impact water quality and exceed regulatory levels results from incidents such as loss of well control during development, well installation errors, and spills from produced water pits, as described in the Accidents and -Malfunctions Assessment. Available routine monitoring data in these databases indicate routine natural gas development and production (i.e. without incidents) may not be a significant source of water contamination, however, routine monitoring is limited and may not be representative of all instances of gas development and production. It is noted, that samples are most often collected in response to a complaint or incident or as part of a remedial action. There is very little data for routine monitoring of impacts to water quality at gas

wells or exploration and production (also known as E&P) waste pits, with the exception of required monitoring in the 3-mile perimeter of Project Rulison. This small about of data limits the ability to make a true estimate of exposures from groundwater and surface water.

The Mamm Creek field hydrogeologic study results and USGS and COGCC databases indicate that routine natural gas development and production could impact water quality in Battlement Mesa, but not to an extent that causes exceedence of regulatory standards and triggers regulatory action. It is possible that increasing chloride concentrations could eventually affect the potable groundwater. Incidents resulting from well installation errors, uncontrolled well development, and spills could significantly affect the potable groundwater and water quality, as well as soil quality, in Battlement Mesa.

While there is no permanent surface water body in the PUD, there are intermittent drainages and creeks that could discharge to the Colorado River. Monument Creek, one of the major drainages off of Battlement Mesa discharges to the river downstream of domestic water intakes. It still is possible that surface run-off could introduce contaminants from upstream well pads into the river. However, the Colorado River has a high volume of water and it is most likely that any contamination would be diluted to non-harmful concentrations. The annual surface water quality results have not indicated any detectable levels of contamination from natural gas development and production at the intakes. In addition, natural gas operators must inform the Battlement Mesa Water Treatment Plant of upstream spills or incidents affecting the river (COGCC rule 317B) [9]. In the event of such a spill or incident, the intakes to the treatment plant can be shut down. The treatment plant routinely stores a week's supply of water allowing time for remediation of spills. The Battlement Mesa Metropolitan District is subject to the protections of COGCC Rule 317B, which regulates natural gas operations in surface water supply areas.

Antero is proposing to employ pitless drilling systems on the well pads within the PUD and to distribute and store production water at a centralized water storage facility, within the PUD. COGCC rule 904 requires liners for pits at centralized water storage facilities and has a provision[9], at the discretion of the director, for the installation of leak detection systems in sensitive areas such as the PUD. COGCC rule 908 requires that centralized water storage facilities be permitted[9]; the geologic and hydrogeologic characterization of site; control of public access; fire lanes; surface water diversion systems, waste characterization profiles; an operating plan; baseline groundwater sampling and analysis; groundwater and surface water monitoring (at the discretion of the COGCC director); and groundwater and soil sampling when a pit is closed and the site remediated. Adherence to these rules, including the discretionary leak detection and monitoring, will significantly reduce the potential for impacts to water and soil quality from produced water and other exploration and production waste stored in the centralized pit. However, leaking pipelines and spills from chemical and production water hauling trucks could still create the potential to impact surface water quality. COGCC rules do not specifically address water pipeline leaks.

Any spills that occur on the pads could potentially impact water and soil quality by surface run-off and infiltration during precipitation events. This potential is evidenced in a sample of snow melt collected from a project Rulison well pad contained levels of benzene greater than regulatory limits[44]. COGCC rule 603 specifies that in high density areas, such as the PUD, berms (or other secondary containment devices) capable of containing 150 percent of the fluid in the largest tank within the berm be constructed around produced water and condensate tanks[9]. However, this rule does not provide for containment of spills that may occur outside the berm perimeter, such as during transfer of chemicals and materials to and from trucks and at well heads.

Wind erosion and surface run-off from drill cuttings stored on Antero's pads could impact surface water and surface soil quality. The COGCC rules do not specifically address drill cutting stored on well pads[9].

At time of preparation of this HIA, it was not known if Antero is planning for deep injection of exploration and production wastewater within the PUD. COGCC rule requires written permission from the COGCC director prior to construction of an injection well. The HIA would need to be updated to include potential impacts to public health, if injections wells are proposed.

The Battlement Mesa Metropolitan District has a capacity of 6 million gallons of water per day. Currently, 3-3 ½ million gallons per day are used, allowing for the accommodation of Antero's water needs during well development operations. If water capacity were to significantly decrease, the needs of Battlement Mesa would take precedence to Antero's needs.

It is unlikely that Antero's proposed project will have a significant impact on the primary domestic water supply for Battlement Mesa. The potential for a significant impact to the secondary water supply may exist. If the potable groundwater is impaired, Battlement Mesa may not have a back up source of domestic water. In addition, there is the potential for the Antero's project to impact the water quality of intermittent streams, creeks, and puddles, as well as soil quality. Finally, it is possible that shallow aquifer contamination could cause VOC off gassing into Battlement Mesa homes, but since the hydrology of the area is not well understood, the likelihood of such an occurrence is not clear.

4.2.4 Characterization of the impact on Water and Soil Quality

The impact of water and soil quality due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Water and Soil Quality	Negative(-)	Community wide	Yes	Long	Infrequent	Unlikely	Moderate to High	-11.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated water and soil contaminant exposures associated with the Antero development within the Battlement Mesa PUD, water and soil quality may produce **negative health impacts** in the areas in close proximity to the development areas and community wide. If the domestic water supply were to be contaminated, the health effects would be **community wide**. Effects of wind erosion and surface run-off could be more localized, and could impact children more than adults. Children, older adults, and individuals with pre-existing disease may be more vulnerable to water and soil contaminants and are considered a **vulnerable population**. The duration of water quality degradation could be **long** and may last through the life of the Antero's project, from well pad preparation through well abandonment. The impacts to water quality are expected to be **infrequent**. It is, however, **unlikely** that contaminant concentrations in water and soil will be high enough to cause short-term and long-term disease because the current supply of domestic water is the Colorado River and the COGCC has extensive rules to protect this resource. If exposure were to occur, health impacts may include skin and eye irritation, neurological problems, and cancer. It is likely that medical attention would be necessary for some of these impacts and that some of these impacts will not be reversible. Therefore the health impacts, if exposure were to occur, are rated as **moderate to high** magnitude. . Using the numerical ranking scheme, water and soil quality impacts are expected to produce a negative rank of -11.5 on a scale of ±6-15.

4.2.5 Findings and Recommendations from Water and Soil Quality Assessment

What we know: Water pollution is hazardous to the public health. Garfield County Oil and Gas studies, EPA studies, and other studies demonstrate that natural gas development and production can release contaminants to domestic water supplies and compromise water quality. Individual circumstances can influence the potential contamination of water. In Garfield County, accidents and malfunctions have been the most common cause of water contamination from natural gas development and production. If a domestic water resource is contaminated, remediation is time and cost intensive and may not restore the water resource to a quality for domestic use.

What we do not know: The hydrogeology in Battlement Mesa has not been characterized and the relationship between groundwater, domestic water supplies, and the Colorado River in not well understood. The quality of groundwater in the Battlement Mesa PUD is not known and the extent of routine natural gas development and production on water quality is not known.

Recommendations to Reduce Impacts to Public Health from Water and Soil Pollution

Based on these findings, the following are some of the suggested ways to reduce the potential impact of water and soil pollution.

1. Require COGCC rules 317B, 603, 904, and 908, including those at the discretion of the director, be applied with no variances or exemptions, to prevent pollution of water and soil.
2. Require Antero to develop and implement plans to ensure removal of mud from vehicles leaving the well pads and access roads to prevent tracking of mud onto Battlement Mesa and Garfield County roads.
3. Require full disclosure of all chemicals, with their volumes, concentrations, and Material Safety Data Sheets (also known as MSDS), used in natural gas development process to GCPH and Battlement Mesa Residents.
4. Require continuation of all baseline and continuing monitoring requirements for groundwater, surface water, and soil and leak detection to prevent pollution of potential domestic water supplies.
5. Require the berming of the down gradient well pad perimeters, as well as surface water diversion ditches for each well pad to prevent pollution of water and soil.
6. Require monthly inspection of water and gas pipeline for leaks to prevent water and soil pollution.
7. Require immediate notification of GCPH (in addition to COGCC) in the event of a spill of five barrels to protect public health.
8. Require that drill cuttings be covered during storage on well pads to prevent wind transport and soil pollution.
9. Place an inlet protection system, similar to the system in place for Rifle and planned for Parachute, on the two intakes for the Battlement Mesa water treatment plant that would shut off the intakes if contaminants are detected to protect public health.

The recommendations to address information gaps are in Section 5.

4.3 Assessment of Transportation and Traffic on Health in Battlement Mesa

> Will there be motor vehicle accidents and related injury and death?
> *February 3, 2010 stakeholder meeting*

Increases in transportation and traffic can impact health and safety of a community by increasing the risk of motor vehicle accidents, release of hazardous pollutants, creation of road dust, and impediment of walking and biking routes. Development of natural gas wells can cause significant increases in a variety of traffic, especially large truck traffic. Workers driving at high speeds may place residents at risk for severe injury or death. Residents living in Battlement Mesa have expressed concerns that traffic associated with the Antero gas project will impact the health

and safety of those living in the community. This assessment will address traffic impacts to the safety of Battlement Mesa citizens. Air quality, noise, and quality of life impacts due to increased traffic are addressed in other sections.

4.3.1 Traffic and Safety

Vehicular traffic is a known hazard to safety. Increases in traffic are associated with increased risk of motor vehicle injury and death, due to vehicle-vehicle, vehicle-pedestrian, and vehicle-bicycle accidents. Motor vehicle accidents can be associated with speeding, poor traffic management at intersections, and heavy vehicle movement. Numbers of injuries/fatalities are directly related to vehicle volume and severity of injury is directly related to vehicle speed[45-46].

4.3.2 Current Traffic Conditions

Currently, large truck traffic within the PUD is mainly from delivery trucks supplying the local businesses, including gas stations and convenience and grocery stores. There are established county approved haul routes along the perimeter of the PUD, while most roads within the perimeter are limited to small vehicles. There are two entries into Battlement Mesa. The main entrance is just south of Exit 75 off of Interstate-70. A traffic analysis conducted by Schmueser/Gordon/Meyer, Inc. (SGM) for Antero in September 2009 [38] found that this entrance had the highest traffic count in Battlement Mesa with 8,662 vehicle trips per day (vt/d). The second entry into Battlement Mesa is from Exit 75 via US 6 west to County Road (CR) 300 (CR 300/Stone Quarry Road) on the southwest side of Battlement Mesa. Traffic counts at the US 6/CR 300 intersection were 2,300 vt/d, but were only 648 vt/d on CR 300 where it enters the PUD west of the recreational vehicle (RV) park. Other counts indicate that on West Battlement Mesa Parkway there were 5,340 vt/d and on CR 307 (River Bluff Road) there were 371 vt/d. Since there is no current industrial activity and very few retail stores, it is assumed that the large majority of these vehicle trips were passenger cars and light trucks, although this is not specifically stated in the traffic report. The report also projects an increase of 2.3% vehicle trips annually unrelated to the Antero drilling plan, based on average annual growth of Garfield County.

Motor vehicle accidents in Garfield County are handled by the county sheriff's office, local municipal law enforcement and the Colorado State Patrol. When looking at accidents handled by the state patrol, Garfield County had the 9th highest number of motor vehicle accidents in the state in 2008, with 1,091 accidents total (14 fatal crashes, 116 that resulted in injury and 961 that resulted in property damage)[47]. Data from the county sheriff's office and data specific to Battlement Mesa are not currently available.

Top 10 Colorado Counties **2008 Fatal, Injury, and Property Damage Crashes by County** **as Covered by the Colorado State Petrol (not all Colorado Crashes)**
http://csp.state.co.us/TS_CrashStat.html

County	Fatal	Injury	Property Damage	Grand Total
Jefferson	19	395	2,530	2,944
El Paso	20	278	1,953	2,251
Adams	13	233	1,773	2,019
Mesa	7	211	1,188	1,406
Larimer	14	275	1,080	1,369
Weld	28	258	1,065	1,351
Eagle	6	132	1,073	1,211
Douglas	10	145	1,032	1,187
Garfield	14	116	961	1,091
Boulder	14	182	860	1,056
Grand Total	**290**	**3,895**	**23,028**	**27,213**

Children attending school in Battlement Mesa arrive and leave via passenger car, school bus, walking, or bicycle. Underwood Elementary (grades 1-3), St. John Elementary (grades 4-5) and Grand Valley Middle School (grades 6-8) are in Battlement Mesa. The Early Childhood Center (PreK-Kindergarten) and Grand Valley High School are in Parachute. Some students are not offered bus service if they live within a "Walk" zone. Specifically, students attending Underwood Elementary and living in Saddleback Village, Tamarisk Village, Tamarack Meadows are not offered bus service; children attending St. John Elementary and living in Willow Ridge, Willow Park, Valley View, Monument Creek Village, Canyon View, and Stone Ridge are not offered bus service; and children attending Grand Valley Middle School and living in Mesa Ridge, Eagle's Point, Willow Ridge, Willow Park, and Valley View are not offered bus service. (Battlement Mesa early childhood students and high school students are all offered bus service and ride together.) School hours in Battlement Mesa schools are 8:40 am -3:40 pm at Underwood (early release at 2:10pm); 8:25am- 3:25pm at St. John (early release at 1:55pm); and 7:50am-7:15pm at Grand Valley Middle School (1:45pm early release). A map detailing Antero's planned haul routes and school bus stops will be included in the final report.

4.3.3 Antero Drilling Plans in Battlement Mesa and Traffic

Traffic associated with natural gas development is related to earth moving construction of well pads; movement of materials and waste to and from the well site; installation of pipelines; long term production; maintenance operations; final reclamation of the site after production is completed; and travel of workers to/from work. The most traffic intensive phases involve pad construction, drilling and well completion and pipeline construction.

Antero has described a three phase development plan for the Battlement Mesa project as described in the public meetings powerpoints. Phase 1 will develop the Stierberger Pad, Pad E,

Pad G, and the water storage facility (Pad F) on the south side of the PUD. Phase 2 will develop the Parks and Rec Pad, Pad A, Pad B, and Pad D on the north side of the PUD. The Parks and Rec pad replaces the Pad C originally planned. Phase 3 will develop the L and M pads on the northeast side of the PUD. Each phase will involve access road, pad and pipeline construction needed to develop the wells and tie them to the water movement system and the gas gathering lines at the eastern edge of the PUD.

The traffic analysis conducted by SGM used estimates from previous Antero development sites in the Mamm Creek area to project average and maximum trips per day, for the Battlement Mesa project. Trips per day range from 2 (production phase) to 280 or more (intensive construction phase). Drilling completion, light construction, and pipeline installation range from on average 16-31 vt/d and a maximum of 30-46 vt/d. The duration of the pad construction ranges from 10-30 days and the other phase durations *per well* are drilling (18 days); completion (30 days); pipe installation (60 days/ mile); duration of each phase per pad was not calculated but efficiencies associated with drilling multiple wells sequentially on a pad will reduce the time of each phase on a pad. Production is projected to last 20 years. Reclamation after production is expected to have 7-10 vt/d for 11 days per pad.

Although initial presentations to the public describe well development phases to last 3-4 years, more recent estimates in the traffic analysis indicate that well development is expected to occur for at least five years, maybe longer, depending on economic and regulatory conditions. Well development phases will overlap on different well pads so that while pad construction is occurring on one pad, drilling is accomplished on another and completion may be occurring on another pad. Therefore, traffic will be overlapping as well, with trucks associated with construction, drilling, pipeline and completion using the haul routes simultaneously. Trips per day for each of these phases are added to estimate the number of trips per day expected during the first five years when well development is occurring. The number of trips per day is estimated to be 90-120 vt/d when light construction is occurring. When more intense well pad construction is occurring (during the Phase 2 well pad construction) traffic is projected to be 340 vt/d for approximately 120 days. Some activities will occur 24 hours a day and the vehicle trips will be spread throughout the day and night. Antero has stated they will limit truck hauling to hours outside of school zone hours. The majority of these trips are expected to be heavy trucks.

Antero plans to use county haul routes for traffic. During all phases entrance and exit from Battlement Mesa will be via the US 6/ CR 300 route (Stone Quarry Road), on the southwest side of the PUD. Phase 1 also will utilize CR 303, CR 308 and CR 302. Phase 2 will utilize CR 303, CR 308, East Battlement Mesa Parkway, South Battlement Mesa Parkway, and CR 307 (River Bluff Road). Phase 3 will utilize CR 303, CR 308, East Battlement Mesa Parkway, North Battlement Mesa Parkway, and West Battlement Mesa Parkway. The county restricts hauling on CR302, CR 307, South Battlement Mesa Parkway, and West Battlement Mesa Parkway. It is assumed that Antero will be required to obtain special permits to use these roads.

School buses for all the schools use and cross Antero haul routes. Although all children in the PUD may be impacted by crossing the haul routes while going to and from school, middle school age children may be the most impacted since the middle school is near two haul routes and children this age are more likely than younger children to be walking or bicycling on their own. According to the traffic analysis plan, Antero has decided to avoid any heavy truck hauling during school zone hours. Children going to/from school outside of school zone hours will be crossing haul routes while truck traffic is occurring.

Antero has planned mitigations to decrease impacts of traffic on the Battlement Mesa Community. Of significance, Antero has committed to building a water management system comprised of water distribution pipes going from the well pads to the water storage site on the south side of the PUD. This water management system is intended to decrease movement of water by trucks and it is estimated that there will be fewer trips during the development phases because of this system.

In addition to heavy truck traffic, there will be workers coming into Battlement Mesa and traveling within Battlement Mesa in passenger cars and light trucks. It is estimated that there will be an average of 120-150 workers in Battlement Mesa during the five year development period. Antero intends to house some workers in Battlement Mesa to decrease worker movement into and out of the PUD. Workers exceeding speed limits can put other vehicles and pedestrians at risk for injury and fatality. . Antero management emphasizes safe driving but a formal safe driving program does not exist.

It is expected that the increase in heavy truck volume from negligible to tens or hundreds per day within the PUD may compromise road integrity and needs for increased road maintenance is anticipated. County funds will be needed to maintain haul routes as well as installation of road and pedestrian safety mitigations if needed. Utilization of county funds for roads and road safety may divert funds from other county programs, including health programs, there by potentially impacting public health infrastructure.

4.3.4 Characterization of Traffic Impacts on Safety

The following table summarizes the characterization of impacts from traffic.

Impact	Direction of health effects	Geographic extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Ranked
Traffic and Transportation	Negative (-)	Community-wide	Yes	Long	Frequent	Possible	Low to high	-13.0*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering public health to residents of Battlement Mesa, the increased traffic within the PUD is likely to create **negative** health effects due to increased safety risks. Because the haul routes include the entire circle of the Battlement Mesa Parkway as well as other roads within and on the perimeter of the PUD, the impact of the traffic is likely to be **community-wide**. There will be certain parts of the community that will be greater impacts for the duration of Antero's project (those homes next to CR300/Stone Quarry Road) while others will be impacted by very high volume traffic during the construction of the Phase 3 pads (those along River Bluff Road). Because children often walk and ride bicycles and are not as safety conscious, they are more **vulnerable** than most adults to the impacts of traffic within the PUD. Antero has committed to limit heavy truck traffic during school zone hours which will decrease risk to children traveling to and from school at those times. Children staying after school for sports and other activities may be at risk for traffic incidents related to truck traffic outside of those hours. Furthermore, truck traffic is likely to continue on weekends and holidays and children may be crossing haul routes at those times. The duration of exposure to increased traffic will be **long**, spanning the entire duration of the development of all three phases, at least five years. The traffic will be frequent, in some cases (River Bluff Road), several hundred trucks will be passing a day for several months. Along Stone Quarry road, there will be 45 to 113 trucks passing a day for approximately five years. Increased traffic is known to be associated with increased risk of traffic accidents and it is **possible** that there will be traffic related accident as a result of the Antero project. The magnitude will depend upon how well the traffic is controlled, how well mitigation efforts are adhered to, and to unrelated or perhaps chance factors. Traffic can cause minor to severe/fatal injuries and as such, the magnitude of the impacts will be **low to high**. Using the numerical ranking scheme, traffic impacts are expected to produce a negative rank of -13.0 on a scale of ±6-15.

4.3.5 Findings and Recommendations from Traffic and Transportation Assessment

What we know: An increase in traffic is associated with an increase in risk for motor vehicle accidents that can involve cars, pedestrians, and bicycles. The risk of severe injuries in motor vehicle accidents increases as the speed of traffic increases. Increased traffic also increases air pollution and noise levels.

What we do not know: We do not know if Battlement Mesa has dangerous traffic spots or the normal pedestrian/bicycle patterns.

Recommendations to Reduce Impacts to Public Health from Traffic and Transportation

Based on these findings, the following are some of the suggested ways to reduce the potential impact of traffic and transportation.

1. Require Antero to build water treatment facility and associated pipelines in advance of well development, to immediately remove water hauling traffic from PUD.
2. Require Antero to communicate and coordinate with local school district to develop plan for transportation and safety needs of all children going to and from school by car, bus, bicycle and walking during and outside of school zone hours to prevent injury to school children.
3. Reduce truck speed limits to 20 mph in areas where there is existing pedestrian traffic that is not buffered from haul routes to prevent accidents and to reduce the severity of injury should an accident occur.
4. Consider speed control measures on worker ingress and egress routes (ie decreased speed limits, signage, real time speed measurement signs, photo speed ticket vans, speed bumps or other measures) to prevent workers from speeding.
5. Mark pedestrian/bike high use routes and establish safe crossing zones where they intersect Battlement Mesa Parkway or other haul routes to alert drivers of potential pedestrians and bicyclers.
6. Install safety measures (ie, signaled cross walks, elevated side walks, green space buffers) for pedestrians/bikes where established waking/biking routes overlap/run along haul routes to prevent accidents.
7. Request that the Garfield County Sheriff's Department or other qualified entity to review Antero's Traffic Impact Analysis and request feedback on possible safety mitigations and traffic hot spots to ensure the plan has is protective of public health.
8. Require safe driver training for workers and implement penalty system for unsafe drivers, to encourage safe driving.
9. Require Antero to have a system to identify and remove unsafe drivers to prevent accidents and injuries.
10. Provide Sheriff's Auxiliary Unit with authority to log speeding and unsafe driving incidents and complaints within the PUD, which can be provided to Antero, subcontractors and the Sheriff's department so that problems can be resolved, to identify unsafe conditions.

The recommendations to address information gaps are in Section 5.

4.4 Assessment of Noise, Vibration, and Light Pollution on Health in Battlement Mesa

> "I am concerned that noise and vibration will affect my sleep. Will these be addressed?"
> *June 15 stakeholder meeting*

Increased noise, vibration, and light are common concerns for citizens near construction and industrial sites. At natural gas sites noise and vibration can occur in the construction phase, drilling and completion phases, and due to truck traffic. Light pollution can occur due to 24 hour lighting during development and production operations. Because of these sources, noise,

vibration, and light concerns have been expressed by Battlement Mesa residents at stakeholder meetings.

COGCC Rule 802[48], based upon the State of Colorado Noise Ordinance[49], states that pad construction operations are considered industrial sites and site noise may not exceed 80 decibels (dB) in the day and 75 dB at night. Residential noise must not exceed 55 dB in the day and 50 dB at night. COGCC Rule 803[50] states "site lighting shall be directed downward and internally so as to avoid glare on public roads and building units within seven (700) hundred feet." COGCC does not have a rule limiting ground vibration, but according to the US Department of Transportation ground vibration is generally not felt below 65 VdB and annoyance can be experienced at 70 VdB[51].

According to EPA research, construction equipment can produce noise ranging from 80-89 dB at a distance of 50 feet and 60-69 dB at 500 feet[52]. Heavy construction equipment can cause vibration of 85 VdB 50 feet from the source[51].

Because there is a potential for noise, light and vibration to exceed COGCC rules and background levels, a review of potential noise, vibration and light impacts is warranted.

4.4.1 Noise, Vibration, Light pollution and Health

Both acute loud noise and chronic lower level noise have been associated with a variety of negative health effects. Hearing loss and impairment are known to occur as a result of exposure to acute, high decibel noise (greater than 85 dB). The odds of hearing loss increase as the decibel level increases. A dose relationship between noise level and hearing loss exists[53].

Studies looking at the relationship between noise and cardiovascular disease, hypertension, psychological symptoms, and respiratory impairment are numerous. Reviews and meta-analysis of these studies conclude that noise has the potential to impact these health outcomes[54-57]. Cardiovascular risk factors have been shown to be impacted by noise levels in the range of 51-70 dB in persons with several years of exposure[58].

Noise annoyance can lead to stress related impacts on health such as feelings of displeasure, interference with thoughts, feelings, and activities and disturbed sleep and can have impacts on mood, performance, fatigue, and cognition[59]. Noise levels that produce these impacts can vary: annoyance can occur at 55dB; school performance can be impacted at 70 dB; and sleep can be impacted by as little as 35-60 dB. Ground vibration and low frequency noise may cause health impacts similar to those associated with noise annoyance.

Establishment of causal relationships between noise/ vibration and health impacts is complicated by the fact that noise annoyance in particular can vary with pitch, frequency, and duration. In addition, individual adaptation to noise can vary and complicates subjective reporting as well as expected outcomes.

Preliminary research suggests that light at night may affect health by disrupting normal circadian rhythms[60-61]. The International Agency for Research on Cancer has listed shift work a Class 2A (probable) carcinogen based on epidemiologic links to breast cancer. Mechanisms for the health effects of light at night are actively being studied and include altered melatonin and other hormone release[62].

4.4.2 Current Noise, Vibration, and Light Conditions

Residences in Battlement Mesa are located one mile or more from Interstate-70 and are not likely to have noise impacts from this source. As such, background noise is likely to be comparable to other non-industrial, rural/semi-rural communities. In 2002, La Plata County, Colorado conducted noise sampling in rural, residential, traffic corridors and light industrial areas[63]. Twenty-four hour residential subdivision noise ranged from 37-53 dB, with an average of 42-45 dB. Traffic corridors ranged from 55-65 dB, with an average of 57 on a state highway and 45 on a collector road. Battlement Mesa neighborhoods are likely to have noise levels similar to those measured in La Plata County. Likewise, night time light is likely to be similar to other residential areas, consisting of municipal street and outdoor home lighting. Baseline lighting measures for Battlement Mesa do not exist.

Some residences in Battlement Mesa, however, may already be proximate to natural gas production sites located outside the PUD and maybe experiencing or have experienced noise and light trespass elevated above background in relation to this development. There not currently any significant sources of vibration within the PUD.

4.4.3 Antero Drilling Plans in Battlement Mesa and Noise/Vibration/Light

Sources of noise will include: large truck traffic; road and well pad construction machinery; diesel engines used during drilling; fracking and completion stages; and drill rig brakes. Antero has stated that they will use electric engines for some drilling operations within the PUD but that diesel engines will be used for all completion activities. Antero indicates that well pads are expected to be at least 500 feet from residences and much well pad noise will be abated by distance. However, without ancillary noise abatement, it is likely that the Antero project will produce noise above background, and possibly above COGCC levels, during the construction and well development phases and during well maintenance (workovers). The topography of the land may play an important role in increasing or decreasing noise emanating from the well pad. Noise is expected to range from intermittent (traffic and drill rig brakes) to continuous (diesel engine use during drilling and fracking) for several weeks to months. Drilling and associated noise will also round the clock. Although specific distances from truck haul routes to schools is not available, rough estimates indicate that schools are roughly 1,000 feet or more from truck routes and may not experience significant noise impacts. Residents living less than 500 feet from truck routes, such as along CR 300 (Saddleback Village) or West Battlement Mesa Parkway (Willow Creek Village), are close enough to experience noise that could be between 65

and 85 dB when trucks are passing, at times 9- 12 times per hour or more. These areas could experience some associated intermittent vibration as well.

Because drilling operations occur round the clock, the well pad is lighted and may contribute to light at night at nearby residences. Elevated light levels would be expected to last throughout the drilling period for each pad. In addition, Antero may choose to light well pads for security reasons.

In community meetings, Antero has described possible noise and light abatement strategies. According to meetings documents and the Surface Use Agreement, Antero is not planning centralized compression (a significant noise source). Well head compression if utilized will be housed with noise suppression equipment. Other noise abatement strategies may include use of hay bale walls around the pad, noise blankets for diesel engines, and electric grid power for drilling. Antero documents also indicated possible use of drill rig placement strategies and sodium vapor lights to decrease light trespass. At this time, it is unclear which of these mitigations will be included in the Major Land Use Impact Review and Comprehensive Drilling Plan permit application. However, because Battlement Mesa currently enjoys very low ambient noise and light levels, the Antero project will likely produce noise and light above ambient levels during construction and well development/workover stages and along haul routes, and may at times exceed COGCC rules.

4.4.4 Characterization of Noise, Vibration and Light Impacts

The impact of noise due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable Populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Noise, Vibration, Light	Negative (-)	Local	No	Long	Frequent	Possible	Low-Medium	-10.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated noise, vibration, and light exposures associated with the Antero development within the Battlement Mesa PUD, noise, vibration and light may produce **negative** health effects. Of the three, noise is likely to be the significant health driver. Distance and light mitigations should decrease light at night to the point where there are not significant health impacts. Vibration may occur as a result of truck traffic but health effects are more likely to be due to noise annoyance in these situations. While all or most parts of the community may be proximate to noise sources at different times, it is not likely that the entire community will be

affected by noise during the development of an individual pad or by truck traffic. There are some residents close to haul routes that may experience elevated noise due to truck traffic for five years or more. Noise impacts will therefore be **local** to areas in close proximity to the development areas and areas close to truck traffic routes. There are **no vulnerable populations** in Battlement Mesa, although truck traffic passing by the St. John Elementary School and the Grand Valley Middle School may be disruptive during school hours. The elevated noise is expected to be associated with construction and development phases and with truck traffic on haul routes. The pad development phases will last several months, while nearby truck traffic may last several years for some residents, and so, duration of exposure is expected to be **long** depending on location. Significant noise levels are not expected during normal production phases in the years subsequent to well development. Should reworking of wells be conducted, noise levels are expected to increase, again for several months, during the reworking phase. When noise occurs is expected to occur **frequently** as it will be constant and/or frequently reoccurring. It is unlikely that residential noise will be loud enough to cause noise induced hearing loss or long enough in duration to impact cardiovascular disease. In general, health impacts are likely to result from annoyance due to noise above background and may cause sleep disturbance, displeasure, fatigue, etc. It is not likely that medical attention will be necessary for most people, although some may seek medical assistance. Therefore the health effects are rated as **low-medium magnitude**. It is possible that in some individuals, noise levels will produce significant annoyance and may produce larger health effects. Using the numerical ranking scheme, noise/vibration/light impacts are expected to produce a negative rank of -10.5 on a scale of ±6-15.

4.4.5 Findings and Recommendations from Noise, Vibration, and Light Assessment

What we know: Noise can have negative effects on public health that can vary at the individual level. Background noise levels in Battlement Mesa are low.

What we do not know: The potential noise levels at COGCC and Antero's proposed set backs and along truck haul routes are not known.

Recommendations to Reduce Impacts to Public Health from Noise, Vibration, and Light

Based on these findings, the following are some of the suggested ways to reduce the potential impact of noise, vibration, and light pollution.

1. Reduce speed limits for trucks within the PUD to 20 miles per hour to reduce noise and vibration levels.
2. Require best available noise reduction technology for heavy equipment, including trucks and truck brakes, to reduce noise levels.
3. Require Antero to alert residents of anticipated noise, including time, duration, decibel levels, and machinery to be used to protect public health.

4. Require Antero, in cooperation with Battlement Mesa residents and GCPH, to develop and implement a plan that includes a variety of noise control strategies to address the Battlement Mesa resident's noise concerns to protect public health and to prevent long-term nuisance noise levels.
5. Provide residents the option of requiring Antero to install permanent/semi-permanent noise mitigation structures (sound walls) along haul routes CR300 and other routes where trucks are anticipated to be passing throughout the development period to reduce noise levels.
6. Consider installation of traffic noise barriers near the St. John Elementary School and Grand Valley Middle School to reduce noise levels at schools.

The recommendations to address information gaps are in Section 5.

4.5 Assessment of Impacts on Community Wellness

> Will the development have impacts on education? What will be the mental health impacts? Will there be more or less services in the community?
> *February 3, 2010 stakeholder meeting*

Residents of Battlement Mesa are concerned that the Antero project may affect the well-being of their social and community environment. Current epidemiologic literature cites a myriad of challenges in understanding the specific effects of the community and social environment on individual physical and psychological health. Largely, this is due to the difficulty in analyzing the separate and complex processes through which community and individual factors work together to influence health[64-65]. As such, it is difficult to identify and measure community factors which may influence health and well-being independent of individual level risk factors. Never the less, it is widely accepted that societal factors contribute to the health status of individuals through either the promotion or hindering of healthy choices and behaviors, and it is the collective health of individuals which contribute to the broader sense of community well-being among residents[66-67].

While there is no single determinant or definition of a healthy community, the CSPH team assessed current community wellness conditions through societal-based factors which were expressed as concerns by Battlement Mesa citizens. School enrollment, crime rates, prevalence of substance abuse, prevalence of sexually transmitted infection, and social service availability were assessed as surrogate measures of community health. Other measures of quality of life, such as the availability of and participation in recreational activities and the depth and breadth of active social networks, may also speak to the health status of a community, but these are more difficult to codify with data.

4.5.1 Current Community Wellness Conditions

Primary data on several baseline community health characteristics were collected and are cited and described in detail in Appendix C, including data on school enrollment, criminal activity, mental health and substance abuse, and sexually transmitted infections. The years 2005-2008 appear to be a period of increase for several of the measures observed. During this time, school enrollment in Garfield County's District 16 increased by 37.4%. There was a substantive change in the racial/ethnic distribution of students enrolled during this time, demonstrated by the decrease in the proportion of Caucasian/non-Hispanic students accompanied by a rise in the percentage of Hispanic children. Criminal activity was elevated during 2005-08, with a calculated average of over 300 arrests per year during that time. Chlamydia and gonorrhea counts in Garfield County steadily increased during the 2005-2008 time period. However, counts for Battlement Mesa varied, with a larger number of cases occurring in 2007 and 2008. For the purposes of community health monitoring, is important to review these data prospectively to evaluate future changes and trends.

Longitudinal data on mental health, substance abuse and suicide were not available for similar analysis. Results from a 2006 public health survey conducted by the Garfield GCPH found that upwards of 17% of residents were burdened by at least one of these conditions. Further, in many cases, when respondents reported experiencing mental health problems (defined as experiencing depression or stress), they also reported difficulties coping with substance abuse issues and engaging in physical activity[68]. A 2006 study of hospital discharge data for Garfield County regional hospitals found that 275 persons had been hospitalized for alcohol/substance abuse or suicidal behavior during the period 2003-05. Of those 275, 47 (17.1%) had an alcohol/drug abuse diagnosis and 228 (82.9%) had a diagnosis of suicidal behavior [69].

To meet area community health needs, Garfield County operates a comprehensive Public Health Department (the GCPH) with locations in Rifle and Glenwood Springs[70]. Battlement Mesa residents are eligible for all services provided by the GCPH. Some services relevant to the community health measures discussed include:

- General health education and screenings
- Communicable disease surveillance
- STD/HIV screening
- Crisis support hotlines for domestic violence, suicide and mental health
- Tobacco prevention
- Emergency service and assistance
- Adult education programs
- Human services, including employment, food and housing assistance programs
- Services of a designated environmental health department, including the C.A.R.E.S. project for responding to community concern about environmental health issues

4.5.2 Antero Drilling Plans in Battlement Mesa and Community Wellness

While numerous case studies and assessments have been done around boomtown and industrial effects on psychosocial and community health, very little peer-reviewed research has looked at the relationship between natural gas development and production exposure and social-based health effects, and the existing literature appears to be mixed. While there are several studies providing evidence that exposure to natural gas development and production can have negative psycho-social health implications, there are also studies that find positive effects[71, 72-75]. Additionally, there are a few studies that find no association at all between natural gas development and production and social and psychological health[17, 76]. Based on the current state of this literature, it is difficult to estimate social and community health effects related to natural gas development and production.

There is some literature available which discusses the relationship of "boomtown" economies and community health. According to information provided by Antero, the workforce for Antero's project is likely to average 120-150 workers. The impact of the Antero workforce may produce some "boomtown" effects, but the magnitude of these effects will depend a great deal upon the makeup of the workforce (number of single men, number of families, living in or out of Battlement Mesa, etc.). Some commonly recognized social impacts of boomtown economies, many of which can be attributed to rapid increases in population and changes in the economic base, are: stresses on local government support and planning agencies; shortages of permanent housing units; and changing employment and business trends, both positive and negative[77]. The social problems of mental health, criminal activity, divorce, suicide and alcoholism are said to occur at disproportionate rates in boomtown economies compared to non-impacted communities[77]. Boomtown literature also describes disruptions in social cohesion due to population influx and the likely opposition that arises between the "new comers" (both temporary and permanent new residents) and the "old timers"[77]. However, both groups are vulnerable to combination of positive and negative community impacts.

Due to limited availability of readily accessible data measures, only the following topics were assessed to address uncertainty and community concern for community impacts of Antero's project.

***Education*:** Inherent with changes in population come changes to school enrollment; increased population generally leads to an increase in the class size, which may dictate an increase in the ratio of students-to-teachers. Larger class sizes also put a strain on the physical aspects of educational facilities with increased wear-and-tear on furniture, books and equipment and need for more physical space. Influx of a semi-permanent or long-term work force coupled with a booming local economy could increase local school enrollments beyond capacity and expected annual growth rates. Increase school enrollment may also have positive effects in that the schools may qualify for increased funds to improve educational services and options.

***Crime*:** Several research studies have correlated increased crime rates with communities involved in natural gas development and production, including crimes such as domestic violence,

rape, prostitution, assault, child abuse, and homicide[72-75]. Because jobs in natural gas development and production usually attract a transient workforce, residents in affected communities often attribute increasing crime rates to the industry workers. On the other hand, there has also been some literature reporting lower crime rates after the commencement of natural gas development and production [71] and some research arguing that there is no association at all between natural gas development and production and social and psychological health outcomes[17, 76]. Due to the uncertainty and potential for high impact on community residents, it is important to examine and monitor the available crime data for Battlement Mesa.

***Substance Abuse*:** Several studies have reported an increased burden of substance abuse behaviors in communities involved in natural gas development and production, with primary emphasis being that substance abuse is prevalent among workers in the oil natural gas development and production [71, 75, 78]. In some cases, increased illegal substance activity has been associated with seasonal increases in natural gas development and production [79]. At the local level, a 2006 survey of EnCana subcontractors working in Colorado, conducted by White River Counseling, reported that 66.3% of subcontractors were concerned about methamphetamine use among their employees, and 68.9% were concerned about heavy drinking. Concern was rated primarily with respect to productivity and workplace safety, however questions about community impact were also assessed. Notably, the respondents who reported higher levels of concern about the potential impact of employee substance abuse affecting the local community also had stronger feelings about being proactive to prevent alcohol and drug abuse[80]. While not a conclusive study, this indicates that workers may be receptive to substance abuse prevention and intervention efforts presented as part of a community health initiative. For these reasons, it is important to monitor whether drug and alcohol use among community residents shifts with the introduction of gas drilling.

***Mental Health and Suicide*:** Treatment for mental health conditions and suicidal tendencies is conducted predominantly in the outpatient setting. As such, hospital discharge data for these and related conditions generally do not reflect the true burden of these issues in any given community. Additionally, due to their highly sensitive nature, outpatient data for these issues at the local community level is not publicly available. Studies of the community impacts of boomtown industries do not offer clear evidence for direct impacts to mental health, other than to suggest that changes in other measures may add or subtract from the levels stress, worry, and satisfaction experienced by individuals in the community[77, 79].

***Sexually Transmitted Infection*:** In any population, sexually transmitted infections are an important public health prevention priority. Undetected and untreated infection with certain sexually transmitted infections can cause long term health problems. As described by the National Institute of Allergy and Infectious Diseases, some of the health complications that arise from sexually transmitted infections include pelvic inflammatory disease, infertility, tubal or ectopic pregnancy, cervical cancer, and perinatal or congenital infections in infants born to infected mothers[81]. In addition, syphilis and HIV/AIDS cause substantial health problems in all those infected. In addition to long-term health effects of acquired sexually transmitted

infection's, there are the daily consequences of pain, discomfort, and often embarrassment. Loss of worker productivity is also a concern with sexually transmitted infection, due to time required away from work to access testing, and received results and treatment, a process which may involve two days off work depending on travel distance to the nearest confidential testing/treatment center[82-83].

Increases in the community burden of sexually transmitted infection have been identified as a health effect of extraction industries in many low- and middle-income countries [82-83]. The same association has not been causally established by research conducted in relation to North American energy-extraction; however, it stands to reason that this is an area which should be monitored. Key factors perceived to increase the spread of sexually transmitted infection with the influx of extraction-industries include the transient nature of the in-migrant worker population who are away from social controls of their home community, the long and difficult work days possibly fostering desire for drug and alcohol binges during time off, and high salaries and disposable income in a young work-force[82-83]. These contributing factors are concerning given the difficulties often experienced in providing sexually transmitted infection prevention and treatment for an itinerant natural gas development and production workforce. In addition to the inherent stigmas often associated with sexually transmitted infection testing/treatment, workers cite lack of access to sexually transmitted infection services due to geographic isolation from sexually transmitted infection services, lack of available walk-in testing and sexually transmitted infection clinic hours overlapping with their own working hours[82-83].

***Lifestyle/Recreation*:** Many residents of Battlement Mesa seek the enjoyment of outdoor recreational activities, and thus expressed concern over potential impediments to participating in activities such as hiking, biking, fishing, hunting, and golfing. Negative effects to community engagement in these activities would likely be due to changes in the surrounding wilderness and public lands that may be caused by natural gas development and production. We were unable to assess whether public access to recreational activities would be altered by this project, and the extent of potential environmental effects are not known at this time. In addition to outdoor recreation, Battlement Mesa offers residents a 53,000 square-foot indoor recreation facility. An increase in local population may raise membership at the activity center, however this is not expected to supersede capacity as the facility was designed and built as part of the planned community of Battlement Mesa[11].

***Social Capital/Social Cohesion*:** Perhaps the biggest contributor to the social cohesion of Battlement Mesa is its status as a "planned community", where business, schools, and facilities and access for recreation are cohesively integrated with residential living[11]. Well-planned combinations of built and natural environments promote social interaction and pride in community living, which are in turn determinants of mental health and well-being[66]. Strong social support and community networks have generally positive effects on physical and mental health of individuals[84]. As such, effects on the social cohesion of Battlement Mesa residents may be determined and intertwined with physical effects to the community itself, such as damaged or neglected roads, neighboring homes and businesses, public lands and parks. There is limited

data available to directly assess the functioning level of social capital and cohesion in any community, yet surrogate measures can be monitored. These include many of the issues already discussed, as well as monitoring access and use of public health and social services. As population of an area changes or grows, it is expected that the infrastructure of services rendered to that community may need to adapt to meet increasing or changing demands

4.5.3 Characterization of Community Wellness Impacts

As described above, community wellness is characterized by a compilation of factors such as school enrollment, rates of sexually transmitted infection, incidence of criminal activity, burden of substance abuse, and other immeasurable factors such as quality of life, social cohesion, and social capital. For the purposes of this project, the impact due to the Antero project in Battlement Mesa on the community wellness of local residents was calculated as a single factor as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Community Wellness	Mixed (±)	Community Wide	Yes	Long	Infrequent	Possible	Low to Medium	±11.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

Community health effects are expected to be **mixed**, both positive and negative. Positive effects might include less stress over finances if increased demand for local business trickles down through the local economy, and increased access to social resources, services and infrastructure expanded to support a growing and changing population[77]. Negative effects that may be experienced include stresses associated with perceived or real increased threat of crime, heavier industrial traffic and visible impacts to natural environment and recreation areas. Community impacts would be expected to be **community-wide,** affecting the entire geographic extent of the Battlement Mesa PUD equivalently. It is possible that the elderly or youth of the community are more **vulnerable** to impacts of community well-being. Elderly may be more vulnerable to crimes of theft or burglary, and are the likely group most affected by changes in social service availability and accessibility. Children would be most affected by changes in school enrollment and class size. They may also be affected by changes in outdoor areas used for play, which may overlap with areas prone to more industrial activity or along roadsides used more frequently for hauling drilling materials. We expect the community impacts to continue for the duration of Antero's project (five years), and therefore be **long**. Because the Antero project is relatively small, it is expected that exposure to altered community wellness will actually be **infrequent**. The overall magnitude of health effects is **low to medium**. This assessment is made based on

the nature of community impacts, which do not often present through acute mechanisms. Given adequate coverage and support offered by social infrastructure, we expect the residents of Battlement Mesa will be able to successfully tolerate and adjust to community well-being impacts. Using the numerical ranking scheme, community wellness impacts are expected to produce a negative rank of -11.5 on a scale of ±6-15.

4.5.4 Findings and Recommendations Related to Community Wellness

What we know: A variety of physical and social factors impact the health of a community. The little information available on these physical and social factors for Battlement Mesa show the community is in good health, as compared to the population of Colorado.

What we do not know: We do not know the actual population count, demographics, physical and social health specific to the Battlement Mesa PUD because information has not been collected at this level. In addition, several physical and social health measurements are not routinely monitored.

Recommendations to Reduce Impacts to Community Wellness

Based on these findings, the following are some of the suggested ways to reduce the potential impact to Community Wellness.

1. Establish a mechanism to facilitate on-going community engagement between Antero, GCPH officials and residents of Battlement Mesa for early identification of impacts to community wellness.
2. Review sexually transmitted infection clinic access, outreach and education, with particular attention to in-migrant workforce to reduce spread of sexually transmitted infections within the community.
3. Identify employers that have implemented drug and alcohol free work-place programs and encourage other employers to do so to reduce drug and alcohol abuse. Provide education to employers regarding benefits of such programs.

The recommendations to address information gaps are in Section 5.

4.6 Assessment of Economic and Employment Impacts on Health in Battlement Mesa

> ***Will a boom and bust cycle occur? We are now in a bust and the food banks drying up.***
> *February 3, 2010 stakeholder meeting*

Economic conditions of a region can have significant impact on the health of the population. Employment status can impact individual health and well being and economic uncertainty can impact health by increasing stress. Economic development of poor and rural areas is often credited with bringing resources that support health; however "boom town" growth related to natural gas development in Garfield County and other parts of the West have had mixed economic impacts. Residents of Battlement Mesa have expressed concerns that sudden economic growth within their community may negatively impact the community by causing housing and goods inflation, and impacting services. Others in the community are concerned that gas industry development will decrease the appeal of the community and cause a decrease in home values. A review of economic and employment impacts of the Antero gas project in Battlement Mesa is warranted.

4.6.1 Economy, employment, and health

Income and employment influence many central determinants of health and wellbeing, including quality of housing, education, diet, lifestyle, access to health services, etc. Income sufficient to support these basics is strongly related to life expectancy: internationally, annual per capita income above $5,000- $10,000 translates into decades of increased longitivity for the population[85]. For individuals, employment is directly related to positive health outcomes[86] and stress related to job loss, unemployment, and job instability is strongly correlated with self-report of poor health[87]. In addition, in the Untied States, health insurance access is directly related to employment for those under the age of 65. Loss of insurance can lead to decreased health care access and poorer health.

Increased economic activity of a region can increase tax revenues which in turn can be used to support public services, thereby enhancing community wellness. However, if an economy grows too fast, it can create excessive demands on public services and community wellness can suffer. In addition, housing prices and property taxes can rise in response to growing local economies and stress finances of local residents, particularly those on fixed incomes. Increased wages and growing populations associated with new industry can increase demand for all goods, can also create price inflation, which in turn can impact residents' ability to maintain health.

Furthermore, if economic booms are followed by economic busts, loss of resources and jobs can devastate community and individual wellbeing. Repeated boom/bust cycles, where jobs, wages, and services are recurrently out of balance, can lead to significant community stress.

4.6.2 Current Economic and Employment Conditions

Housing prices in Battlement Mesa have been rising steadily over the last decade and have increased faster than average income. In 2008, the estimated median value for a house or condominium was $201,116, nearly 150% higher than estimated values in 2000 ($136,100). Meanwhile, the estimated median household income in 2008 was $42,882—up 17% from the median income in 2000 ($36,680), but still lower than the estimated 2008 state average

($56,993)[88]. Housing price inflation was for the most part due to the regional natural gas boom. The decline of natural gas development in 2008-09 has relieved some pressure on housing prices and availability.

In 2008, Battlement Mesa had a lower poverty rate than Colorado (6.0% vs 9.3%). Primary industries for males is construction, mining, natural gas development and production, and accommodations, and for females health care, education, and food and beverage stores[88].

Residents in Garfield County generally rate themselves to be in good health. In 2008, the Saccommano Institute conducted a survey of Garfield County residents. The results found that 85% of residents surveyed perceived themselves to be in excellent or good health, and that about 76% of those surveyed reported feeling about the same or better level of health than one year prior. Similar results were recorded for the Battlement Mesa/Parachute zip code, with approximately 83% excellent or good health[23].

4.6.3 Antero Drilling Plans in Battlement Mesa and Economics and Employment

Natural gas development has created boom economies in Wyoming, Colorado and other regions of the West over the last decade, with mixed economic impacts to local residents and workers. Examination of natural gas boomtown economics in three towns in Wyoming, related to approximately 40-60 operating rigs in the county, revealed that itinerant workers in the natural natural gas development and production benefited the most from high industry wages, while local residents and workers experienced negative economic impacts associated with inflation, increased property taxes and decreased services[89-90]. This boomtown model predicts changes for other communities involved in the natural gas development and production. Some local businesses may benefit from an increase in commerce, but some may not be able to expand to meet demand and quality of service declines. Increased commerce may bring "box" stores and other new businesses, putting more strain on longtime local business, and some may end up closing. Local residents not earning high industry wages may not be able to keep up with rising cost of living, housing prices, property taxes, and other signs of inflation. Such a change in the economy can cause psychological stress to local workers and residents, resulting in possible mood disturbance, disturbance of thought, sleep disturbance, and immune system effects[91]. Because the gas well development phase is very labor intensive, boom economics associated with worker population influx predictably cycles to bust economics when the development phase for the area is over and development moves on to other regions.

The number of workers involved in well development can vary widely according to pad site topography and geology, number of wells per pad, characteristics of the gas, etc. Most workers are employees of companies subcontracted to perform very specific development jobs and remain on a given pad only as long as needed, sometimes only days, weeks or a few months. Antero plans to use two rigs to develop approximately 200 wells in the PUD over the course of five years. This kind of serial operation may keep many of the workers working within the PUD for much of that time, moving from one site to the next as development progresses. Influx of

workers associated with all stages of development during this period is likely to have the most significant economic impact to the area. Once all the wells in the PUD are developed, the workforce needed to maintain the wells over the 20 years of production is relatively very small.

When comparing the economics of the two rig operation in Battlement Mesa to the 40-60 rig boomtown economics of Wyoming and Colorado it becomes apparent that the Antero project is relatively small and the economic benefits and detriments are expected to be small as well. Furthermore, these impacts are not expected to be restricted to Battlement Mesa, but are more likely to be absorbed into the general Garfield County economy. Some workers may live in Battlement Mesa, thereby creating demand for housing, but many may live outside of the Battlement Mesa community as well. Tax revenues from the Antero project will be realized at a county level. By itself, this operation is not likely to create a significant boom economy

Antero estimates of number of workers needed for well development to be an average of 60-75 workers per rig operation .This number is necessarily an average and an estimate and actual numbers of workers are likely to vary significantly from day to day, and well pad to well pad. Once in production, only a small number of workers are needed for routine maintenance of wells.

Economic benefits of higher wages will be primarily realized by industry itinerant workers. The presence of 120-150 workers in the PUD will provide economic benefits to some local businesses, however, these businesses will also be negatively impacted when the development stages are over and the workers leave. Local residents not employed by the industry or supporting businesses may not benefit from economic growth but may be at risk for negative impacts of housing and goods price inflation, rising property taxes and potentially compromised services.

4.6.4 Characterization of the Economy and Employment Impacts on Health

The impact on the economy and employment due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographic Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Employment and economy	Mixed (±)	Community wide	Yes	Long	Infrequent or constant	Unlikely	Low	±10.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

Based upon estimates of 100-200 workers for a 2 rig operation over five years, the health effects of the Antero project on Battlement Mesa citizens is likely to be **mixed** with positive effects of

higher wages for some residents and higher inflation and no wage increase for others. Economic impacts are likely to be experienced **community-wide** and those on fixed incomes are more **vulnerable** to the negative effects of inflation. The impacts of increased economic activity are likely to be **long**, lasting at least five years, and the frequency of having a health impact (stress, sleep disturbance) as a result of the economic activity is likely to be either **infrequent or constant**, depending upon the individual circumstances. Given the small economic size of Antero's plan and the probability that the economic impacts will be absorbed into the county, it is **unlikely** that there will be health impacts due to changing economic conditions and the magnitude of any health impacts will be **low**. Using the numerical ranking scheme, economic and employment impacts are expected to produce a mixed rank of ± 10.5 on a scale of ±6-15.

4.6.5 Findings and Recommendations from Economic and Employment Assessment

What we know: Boom and bust industries, such as natural gas development and production, can affect public health through rises and falls in the local economy and employment. However, Antero's project within the PUD is too small to initiate a boom and bust cycle.

What we do not know: We do not know the affect Antero's plan will have on housing prices within the PUD.

Recommendations to Reduce Impacts from Boom and Bust Cycles

Based on these findings, the following are some of the suggested ways to reduce the potential negative aspects and maximize potential positive aspects from economic and employment impacts.

1. Review local tax structure to ensure that revenue from natural gas development and production are used to mitigate impacts in areas most affected by the industry development in order for the community to realize the economic benefits.
2. Continue to consider public health as a high level priority when judging uses of local government revenues derived from the natural gas development and production to maximize protection of public health.
3. Engage in long term planning to maintain affordable housing, education, and public services to protect residents from sudden industry downturns (e.g. the bust).
4. Consider mechanisms for providing property tax relief for residents on fixed income should home values rise rapidly to reduce negative economic impacts.
5. Engage local educational institutions to provide industry related training so that local residents can be employed by the industry.
6. Engage local educational institutions to provide retraining for residents employed by the industry so that they can find future employment when industry development is complete and development jobs are no long available locally to reduce impacts from sudden industry downturns.

The recommendations to address information gaps are in Section 5.

4.7 Assessment of Impacts to Health Infrastructure in Battlement Mesa

> "What will be the impacts to health care in Battlement Mesa?
> *February 3 stakeholder meeting*

Health infrastructure can include private and public medical services, hospitals, and emergency transport services. Availability, access and quality of local clinical and public health services can be limited in small communities, due to small populations, low rates of insured patients, and limited public resources. New industry can lead to positive and /or negative impacts on the health care infrastructure. Industrialization of a rural community can increase the insured population and local revenues, which may provide resources for expansion of local clinical and public health care services. On the other hand, without substantial investment in health infrastructure, population and employment changes may increase both clinical and public health care utilization, stretching already limited resources. The citizens in the rural community of Battlement Mesa have expressed concerns that development of natural gas resources in their community may negatively impact available medical resources. Because the Battlement Mesa health infrastructure may be exposed to utilization changes, a review of potential health impacts is needed.

4.7.1 Private and Public Health Services and Health

Availability, access and quality of medical health services can have direct impacts on individual physical health. Research demonstrates that residents of rural communities often have decreased clinical health care services available to them, negatively impacting health [92-95]. Limited availability can be due to a combination of small population and low health insurance coverage, both of which limit the financial viability of both clinical and public services. As a result, residents of rural communities may need to travel long distances for care.

Increased economic activity in a community may bring more patients and insurance coverage which can support increased and diversified clinical medical services. On the other hand, a rapid increase in population, particularly uninsured population, can increase utilization of services beyond capacity and may strain the finances of small medical facilities and decrease incentive to increase services[77].

Public health programs provide services to the general community and can fill some gaps for the un-insured[96-97]. Vaccination programs, health screenings, and communicable disease clinics provide limited clinical health care to uninsured populations. Public health programs that focus on food safety programs and health education programs benefit the community at large. When the local population increases, particularly an uninsured population, local public health services

may experience increased utilization while capacity may lag or never catch up. Cyclical economic conditions may also cause intermittent strain on public health programs while making it difficult to adjust capacity to need. On the other hand, local revenues may be able to increase public health services, should tax and royalty structures and community priorities permit it. In some cases, severance taxes from extractive industries are sent to state agencies, with little benefit to the localities where the industrial activity is occurring[77].

4.7.2 Current Health Infrastructure Conditions

Currently, primary clinical health services in Battlement Mesa include a primary care clinic administered by the Grand River Hospital District, staffed five days a week by family medicine providers and visiting specialists. The clinic also provides physical therapy services three days a week. There is also separate chiropractic, orthopedic, and dental services in Battlement Mesa. There are four hospitals within 60 minutes of Battlement Mesa. The closest hospital is Grand River Medical Center in Rifle, 20 minutes away. This is a 12-bed hospital with an emergency room, surgical, acute care facilities, and outpatient clinics. Grand River Medical Center is a Level 4 trauma center; it does not provide have obstetric (baby delivery) services. Valley View Hospital in Glenwood Springs, 46 miles away, has 80 beds, a 24 hour emergency department, and obstetric services. Community Hospital in Grand Junction, 48 mile away, has 78 beds and does not provide obstetric services. St. Mary's Hospital in Grand Junction, 49 miles away, is a Level 2 trauma center and has obstetric services. The closest Level 1 trauma center is 4 hours away in Denver. Patients needing such services may be airlifted. Emergency response and transport is provided by the Grand Valley Fire Protection District. There is an occupational health clinic operated by Grand River Hospital District in Battlement Mesa that sees work related injuries five days a week.

There is a 40 room assisted living facility in Battlement Mesa. The closest skilled nursing facility is in Rifle and there are other nursing facilities in the county. Meals on Wheels is offered in Battlement Mesa and a senior center in Parachute offers lunch daily.

Public Health services for Battlement Mesa citizens are offered by GCPH. Services include vaccination clinics, communicable disease surveillance, health education programs, safety programs, health screening for Medicaid patients, and programs for underinsured children and low income families. The Environmental Health Program serves the public by evaluation and education regarding environmental health risks related to air and water quality, sewage treatment, mosquito control, and environmental sustainability. The GCPH offices are located in Rifle and Glenwood Springs.

Insurance coverage rates for Battlement Mesa residents are not available. According to the Colorado Household survey conducted in 2008-9 by the Colorado Department of Health Care Policy and Financing[98], 14% of Colorado residents were uninsured and in the five county region that included Garfield County, 21% of the population was uninsured (the highest in the state). In

Colorado, 15% of employed adults were uninsured. Insurance status for natural gas industry workers is unavailable.

4.7.3 Antero Drilling Plans in Battlement Mesa and Healthcare Infrastructure

The development of natural gas wells requires several labor intensive phases, which can last several years for large natural gas projects. Most health infrastructure impacts relate to the expanded workforce during the well development phase. Antero estimates an average of 120-150 workers will be working in Battlement Mesa.

Workers associated with natural gas development and production projects can increase utilization of emergency services due to increased work related and transportation related accidents associated with the injury[77]. Insured natural gas workers utilizing the health care system could provide positive support to the system as long as the utilization does not exceed capacity. Should utilization exceed capacity, then the availability of services may be negatively impacted. Uninsured workers strain the health care system. Public health programs may see an increase of utilization as a result of an increase the insured and uninsured population. On the other hand, pubic health programs may benefit from increased local revenues, as long as utilization does not exceed capacity. Should this happen without increased supporting revenue dedicated to public health, then services may be compromised. The cyclical nature of the natural gas development and production, which is dependent upon market influences, technological advances and regulatory forces, can make both clinical and public health infrastructure planning difficult and lead to a mismatch between needs and services.

Workers and their families are expected to utilize clinical and public health services in Battlement Mesa and other local services. According to Antero representatives, Antero workers are offered health insurance; however, information regarding health insurance coverage for subcontracted workers (the majority) is not available. Some clinical services may see a disproportional increase in utilization, including emergency, urgent care and trauma services and services related to pediatric care for young families. Depending on the insurance status of the workers, these services may or may not be directly supported by the industry. Clinical and emergency providers may be negatively impacted by uncompensated care, and public health services may see an increase in local needs without increased funding. Utilization of health services by insured gas workers will support the health system. Revenues to Garfield County could be used to support public health services, depending upon prioritization of needs.

4.7.4 Characterization of Healthcare Infrastructure Impacts

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Health Infrastructure	Mixed (±)	Community-wide	Yes	Long	Infrequent	Unlikely	Low	±10*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated impacts to local health infrastructure associated with the Antero development within the Battlement Mesa PUD, the increase in workforce and the associated potential health care utilization could have **mixed** health effects in Battlement Mesa community; however, impacts to the health care system are anticipated to be small given Antero's project only involves 120 to 150 workers, spread into a community of approximately 5,000 in Battlement Mesa and 55,000 in Garfield county. There is a potential for increased utilization of the health care services to strain existing services, however, the extent of such a strain may be small enough that it is unlikely to lead to decreased availability and quality of services. Likewise, insured workers will support local health services but the extent of such support may not be sufficient to lead to increased availability and quality of services. Local tax revenues from the Antero project will contribute to the overall county fund are not likely to be large enough to directly impact public health services in Battlement Mesa. Impacts of uninsured workers are likely to be noted by providers, but it is unclear that this would reach a level that would negatively impact either clinical or public health services. Should health services be impacted in Battlement Mesa, the impacts would affect the **entire community**, although those that utilize health care services most frequently such as the elderly, young children and disabled may be more **vulnerable** to negative impacts such as decreased availability. Likewise, those groups may benefit from expanded health care services. Should health service impacts occur, they are likely to be noted in the first few **years** of Antero's project as the health infrastructure adjusts to new needs. Impacts to the health care infrastructure are not anticipated to last the entire duration of Antero's project. The frequency of both positive and negative on impacts the health care system and therefore on the community are likely to be **sporadic**, given that the relatively small number of workers and families associated with the Antero project. It is possible that large financial strain to local providers, particularly emergency care providers, could occur should expensive emergent care become necessary for an uninsured worker, but this is anticipated to be an infrequent event. Potential impact to vulnerable groups, the community at large and the multiple years of potential exposure drive a high summary statistic, however, it is **unlikely** that Battlement Mesa citizens will experience positive or negative health impacts as a result of changes to the health care infrastructure related to the Antero project. The overall magnitude of health effects due to health infrastructure impacts are expected to be **low**. Using the numerical ranking scheme, healthcare infrastructure impacts are expected to produce a mixed rank of ±10.0 on a scale of ±6-15.

4.7.5 Findings and Recommendations Related to Health Care Infrastructure

What we know: The availability of healthcare facilities and professionals affects public health. The level of health insurance in an area affects health care infrastructure.

What we do not know: The level of health insurance in natural gas development and production is not known.

Recommendations to Prepare for Impacts to Health Care Infrastructure

Based on these findings, the following are some of the suggested ways to prepare for the potential impact to the Health Care infrastructure.

1. Monitor which companies, including Antero and subcontracting companies, provide health insurance to employees to determine direction of impact.
2. Review county tax structure for adequacy of revenues necessary to meet increased county services, including public health services.

The recommendations to address information gaps are in Section 5.

4.8 Assessment of Accidents and Malfunctions Impacts on Health

> Is there a plan to prevent pipeline leaks and explosions?
> *February3, 2010 stakeholders meeting*

Accidents and malfunctions can occur as a result of a variety of causes, including equipment failure, human error, and environmental hazards. Identification of potential sources of accidents and malfunctions can lead to effective prevention efforts, while recognition of potential health, community, and environmental effects can direct response strategies which can decrease impacts should an incident occur. COGCC addresses accident prevention (fire, explosion, hazardous materials release, pipeline maintenance) throughout the Rules Document[9]. The 600 series rules address safety regulations. For example, setbacks for pad locations are 150 feet in low population density areas, 350 feet in high population areas and 1000 feet for other facilities such as schools, hospitals, etc. Rule 906 specifies reporting, prevention and clean up requirements for spills and releases. Pipeline regulations are found in Rules 1101-1103, however, there is not a designated setback for pipelines in the COGCC rules.

According to the Denver Post, there were over 1,000 spills statewide and over 230 in Garfield County reported to the COGCC between January 2008 and June 2010[99]. There were 21 fires, loss of well control (including gas kicks), and explosions in Garfield County that were reported to the COGCC from January 1997 to August 2010 (COGCC database). The Battlement Mesa citizens have expressed concerns regarding the potential for accidents and spills and the potential

for related health and safety impacts. Because incidents of this nature happen with low, but predictable, regularity, an assessment of potential health impacts is warranted.

4.8.1 Accidents, Malfunctions and Health

Accidents and malfunctions can occur as a result of well installation errors, material failure, construction and operations accidents, equipment accidents and failures, third party activities, and environmental episodes. Incidents can manifest as fires, explosions, hazardous material losses, and/or spills. Fires and explosions may result from well blowouts, gas kicks, pipeline leak or rupture, ignition of flammable materials during storage, transportation or transfer. Hazardous materials spills/loss may be due to transportation accidents or equipment failure, during material transfer, leaking valves, fittings, etc in storage equipment, well blowouts, and improper disposal of hazardous materials. Environmental conditions such as wildfires, tornados, lighting, blizzards, and extreme heat and cold may cause or exacerbate incidents.

These incidents may result in release of contaminants into surface water, ground water, soil, and air. Releases associated with significant accidents and malfunctions are likely to be acute, high level emissions. Releases of produced water into soil and water sources contain salts, metals, VOC/BTEX, drilling fluids, muds and fracking chemicals. Spills of drilling and fracking materials could include a variety of chemicals such as diesel fuel and other hydrocarbons, BTEX, acids, glutaraldehyde, and other proprietary chemicals. Releases of natural gas into water or air contain VOC/BTEX. Combustion products of hydrocarbons released during fires contain PAHs, including naphthalene, sulfur oxides, nitrogen oxides, PM and other chemicals.

Examples of potential health effects of chemicals given sufficient exposure:

Chemical	**Acute health effect**
VOC	Irritant, neurological
Benzene	Neurological, anemia
Naphthalene	Anemia
Combustion Products	Respiratory, cardiovascular, irritants
Hydrochloric acid	Irritant
Glutaraldehyde	Irritant, allergic reactions

In addition to chemical exposures, accidents and malfunctions can expose nearby persons to injury or death. Although outcomes are potentially severe, these exposures are generally short-term, very rare and only those in close vicinity at the time of the accident are at risk. Employees on the well pad during a fire or explosion are at most risk for injury. Although the likelihood of an explosion involving a pipeline occur is very small, persons in the community may be at risk for injury should such an incident occur. An explosion occurred in a rural area of Johnson County Texas on July 7, 2010 when crews installing a communications pole hit a 36-inch gas transmission line. Newspaper reports indicated that one worker was killed, and seven injured.

The fire was reported to be 400-600 feet in circumference and intense heat was felt 900 feet away. The gas line valves were shut off 1.5 hours after the explosion, and the fire stopped. A more recent explosion of a 30 inch gas distribution line in San Bruno, California on September 9, 2010, destroyed 150 homes and killed four people. The cause of this explosion is still unknown. Other accounts of explosions related to natural gas development, production, and distribution can be found in newspaper accounts throughout the country.

4.8.2 Current Conditions for Accidents and Malfunctions

According to the Denver Post, 236 spills in Garfield County were reported to the COGCC between January 1, 2008 and June 15 2010, involving 66,386 barrels of fluids (primarily drilling liquids and produced water)[99]. During that time, Antero submitted approximately 5 percent of the gas permits in Garfield County, reported 15 spills to the COGCC (6 percent of the spills). Antero's contribution of 1707 barrels of fluids to the total barrels spilled in Garfield is small (2.6 percent). Five of Antero's 15 spills have required remedial action and one resulted in a notice of alleged violation (also known as NOAV) because of failure to report the spill to COGCC per the oil and gas rules.

Antero has received three other Notice of Alleged Violations since January 1, 2008. The latest, on July 14, 2010, was in response to several odor complaints filed during flow back operations on the Watson Ranch well pad. Another Notice of Alleged Violation issued on January 04, 2010, resulted from lack of secondary containment of condensate from fracking tanks and observation of condensate lying on the ground around fracking tanks and separation units. COGCC issued a third Notice of Alleged Violation because Antero spudded a well prior to permit approval in June 2009[100].

Local newspapers and COGCC databases have recorded incidents of well fires, blowouts, tanker spills, condensate tank emissions and pit discharges in Garfield County. These incidents have resulted in contamination of surface and ground water with BTEX, and other chemicals. Residents have reported a variety of health effects, including acute and long term neurological complaints, upper respiratory issues, headaches and fatigue, and nausea. There have been no reported fatal injuries related to accidents or malfunctions in Garfield County reported to COGCC.

4.8.3 Antero Drilling Plans in Battlement Mesa and Accidents and Malfunctions

Applying Antero's spill rate of 15 spills per 252 permit applications (6 percent) and rate of 5 remediations per 15 spills to the 200 wells proposed for Battlement Mesa it is estimated that approximately 12 spills of 5 gallons or more may be expected in Battlement Mesa. It can be expected that at least four of these spills may have some impact to soil, groundwater, or surface water requiring remediation and have the potential to impact public health.

As discussed in the Water and Soil Quality Assessment, Battlement Mesa residents use a municipal water system that draws water from the Colorado River. Secondary water supplies include four shallow ground water wells which were used prior to the establishment of the water treatment plant. These wells are monitored once a year for quality.

The Surface Use Agreement between Antero and The BMC specifies a temporary 50 foot easement for pipeline construction and a permanent 25 foot easement for gas gathering lines. Antero also plans to build a wastewater pipeline system along the same easements. The Surface Use Agreement states that the gas gathering lines will be 48 inches below the surface. The gas gathering lines in Battlement Mesa will be 12 inches in diameter. According to maps provided at community meetings, the pipelines primarily follow haul routes, however, a pipeline there is one pipeline that will cross an open space in a residential area between Valley View Village and Fairways Village. It is unclear from available maps how far this pipeline, or any other pipeline on the map, is from residences, schools and other buildings.

Although the COGCC rules allow for 350 foot well pad setbacks in densely populated areas, the Antero well pads in Battlement Mesa are all at least 500 feet from the nearest residence.

4.8.4 Characterization of the Impact from Accidents and Malfunctions

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects	Magnitude of health effects	Rank
Accidents and malfunctions	Negative (-)	Local or Community wide	Yes	Short	Infrequent	Possible	Low to high	-10*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering the possible health impacts due to an accident or malfunction of Antero gas operations in Battlement Mesa, the health effects are likely to be **negative**. Depending upon the size and nature of the incident, health and safety impacts may be felt only in close proximity (**local**) or throughout the PUD (**community-wide**). Again, depending upon the nature of the incident, certain populations may be more **vulnerable** to health impacts. For instance, elderly or frail and those living in the assisted living facility, may have difficulty evacuating an area quickly. Children in school may also be slower to evacuate. Those with underlying medical conditions such as pulmonary or cardiovascular disease, may have negative health effects to fires or air emissions at levels that are may not have significant impact to others. Accidents and malfunctions are likely to be **short in duration** and **infrequent.** Given the 6% rate of incidents in the industry and within Antero's other operations in Garfield County, incidents are likely to occur and it is **possible** that health impacts will occur. The health effects will be **low to high** in magnitude, potentially ranging from minor irritation to more severe exacerbation of underlying health conditions to severe injury or death. Using the numerical ranking scheme, accidents and malfunction impacts are expected to produce a negative rank of -10.0 on a scale of ±6-15.

4.8.5 Findings and Recommendations from Assessment of Accidents and Malfunctions

What we know: A small number of accidents and malfunctions occur on a regular basis in natural gas development and production. These accidents and malfunctions can have minor to catastrophic consequences and can impact air, water, and soil quality. Lack of adherence to rules and regulations, as well as regulatory oversight and enforcement can result in accidents and malfunctions.

What we do not know: We do not know if the current setbacks and placements of pads, pipes, and maintenance stations are sufficient to protect residents from catastrophic malfunctions. We also do not know if there are emergency plans in place that address catastrophic malfunctions.

Recommendations to Reduce Impacts from Accidents and Malfunctions

Based on these findings, the following are some of the suggested ways to reduce the potential public health impact from accidents and malfunctions.

1. Require review of evacuation, shelter in place and air intake plans for all locations with high concentrations of persons, such as the schools, the assisted living facility, and recreation center to protect the public health and reduce injury. Allow these entities an opportunity to comment on Antero and community emergency response plans.
2. Require emergency responders to review evacuation and shelter in place plans for Battlement Mesa community and Antero emergency response plans to protect public health and reduce injury.
3. Periodically test emergency communications systems. Consider siren, reverse 911, or other system of other mass alert to protect the public health and reduce injury.
4. Require periodic maintenance review of water and gas gathering lines to highest industry standards to reduce accidents and malfunctions.
5. Institute mechanism for reporting safety concerns, near-misses, etc to the appropriate designated county agency or department to reduce accidents and malfunctions. Ensure timely follow up of all concerns.
6. Review procedures for utility permissions to dig near line location to reduce accidents and malfunctions.
7. Require permanent gas line markers in the field, and other standard practice safety procedures to reduce accidents and malfunctions.
8. Review pipeline system for routes that avoid proximity to homes, schools or other areas used by residents to protect the public health and reduce injury.

The recommendations to address information gaps are in Section 5.

4.9 Summary of Assessments on Health in Battlement Mesa

The following table summarizes the characterization of stressors and the numerical ranking of impacts on the health in Battlement Mesa. By ranking the stressors we are able to conclude that air quality impacts are likely to produce important negative health impacts to residents throughout the community. Other stressors that may produce relatively important health impacts include traffic, and noise. Compromise of water supplies could produce important effects to health but are not likely to occur. Some stressors may produce both positive and negative impacts (mixed) but health impacts will be of low to medium magnitude. These include stressors to community wellness, the economy and health infrastructure. The driving force for those impacts is primarily the workforce associated with the five year development phase. Accidents and malfunctions may impact health but incidents of this nature are difficult to predict. Recent events demonstrate, that although accidents and malfunctions are infrequent, on rare occasions they can be devastating and significant care should be taken to prevent them.

Assessment	**Direction of health effects**	**Geographical Extent of exposure**	**Vulnerable populations**	**Duration of exposure**	**Frequency of exposure**	**Likelihood of health effects as a result of Project**	**Magnitude of health effects**	**Rank**
Air Quality	Negative (-)	Community-wide	Yes	Long	Frequent	Likely	Moderate to High	-14.5
Water and Soil Quality	Negative (-)	Community-wide	Yes	Long	Infrequent	Unlikely	Moderate to High	-11.5
Traffic	Negative (-)	Community-wide	Yes	Long	Frequent	Possible	Low to high	-13
Noise, Vibration, Light	Negative (-)	Local	No	Long	Frequent	Possible	Low-Medium	-10.5
Community Wellness	Mixed (±)	Community-wide	Yes	Long	Infrequent	Possible	Low to Medium	± 11.5
Employment and economy	Mixed (±)	Community-wide	Yes	Long	Frequent	Unlikely	Low	±10.5
Health Infrastructure	Mixed (±)	Community-wide	Yes	Long	Infrequent	Unlikely	Low	±-10
Accidents and malfunctions	Negative (-)	Local or Community-wide	Yes	Short	Infrequent	Possible	Low to high	-10

5 Next Steps

This HIA used the compiled baseline health characteristics of Battlement Mesa, current ambient environmental conditions in Garfield County and Antero's proposed gas development and production plans to evaluate probable and possible health impacts of Antero's project to the residents of Battlement Mesa. Through this process the CSPH has attempted to address the concerns of the citizens outlined in the BCC petition.

At the end of each assessment recommendations aimed at decreasing potential negative health impacts are provided. However, CSPH identified numerous gaps in information that limited this evaluation and may limit future evaluations of health in Battlement Mesa.

In order to fill the information gaps identified in this HIA, investigation is needed in the following areas. The immediate next step will be development of an environmental and health monitoring study (EHMS) that addresses some but not all, of these issues.

AIR

1. Conduct baseline measurement of ambient air concentrations for air toxics within the Battlement Mesa PUD. Continue ambient air monitoring through out the development of Antero's natural gas project. Detection limits should be at or below EPA Regional Screening Levels and air quality standards, when available and technically possible.
2. Conduct air sampling at COGCC setbacks (150 feet, 300 feet), Antero setback (500 feet) and set back requested by citizens (1000 feet) during well installation, completion, and production operations and at the proposed water storage facility.
3. Further characterize constituents of odors during odor events.
4. Determine how to enhance public health response should emission levels exceed health based standards.

WATER

1. Establish hydrogeological characterisics of the four back up groundwater wells and the well pads, the proposed central water storage facility in Battlement Mesa and in other areas of gas development in Garfield County.
2. Develop estimates of environmental fate and transport of chemicals used in natural gas development

TRAFFIC

1. Use Geographical Information System technology to overlay proposed truck routes on a map of Battlement Mesa with location of schools, school zones, school bus routes, bike and walking paths to determine if alternative truck routes will improve community safety.
2. Conduct baseline pedestrian/bike route survey to establish current use and to identify where these routes overlap with haul routes. Monitor use through out the five year development phase.
3. Identify existing traffic "hot spots" within the PUD and along the haul routes that will be susceptible to increased traffic.

NOISE

1. Conduct background noise monitoring for Battlement Mesa residential areas, schools, and along main traffic routes.
2. Conduct noise monitoring at COGCC setbacks (150 feet, 300 feet), Antero setback (500 feet), and set back requested by citizens(1000 feet) during well installation, completion, and production operations and at the proposed water storage facility.

COMMUNITY WELLNESS

1. Determine number of workers needed for various development operations, including operator and subcontractor employees.
2. Establish methods to monitor measures of community well-being (i.e., mental health, suicide, substance abuse, crime, educational opportunities) specific to Battlement Mesa/Garfield County.
3. Monitor access and use of public health and social services.

ECONOMY

1. Monitor economic effects of natural gas development in Battlement Mesa/Garfield County.

HEALTH CARE INFRASTRUCTURE

1. Convene county level health care forum with private and public health providers to assess health care services and anticipated needs related to the natural gas development and production.

ACCIDENTS AND MALFUNCTIONS

1. Use Geographical Information System technology to overlay pipelines, pigging stations, well locations within Battlement Mesa community to determine relationship to residences, schools, assisted living facility, etc.

2. Determine if standards of practice for gas line placement within residential communities exists.

The Antero project described in this HIA involves approximately 200 wells, which is only a fraction of the natural gas development that is occurring in Garfield County. Furthermore, natural gas development is and will continue to grow in other parts of the region and state, as well as other parts of the country. The results of the EHMS will likely have application beyond the study area and will contribute to filling some of the knowledge gaps about natural gas development and production and health.

6 Conclusions

In May, 2010, the Garfield County BOCC engaged the CSPH to perform a HIA to respond to citizen concerns about natural gas drilling in Battlement Mesa, Colorado. The CSPH has worked closely with the GCPH to ensure the scope of the HIA addressed the concerns outlined by the citizens in their letter to the BOCC as well as those voiced in citizen meetings. Along with the GCPH, the CSPH also met with the COGCC, the CDPHE, Antero, and the Colorado Hospital Association to ensure that all stakeholders with pertinent data and information had an opportunity to be involved in the HIA process.

To provide a scientific basis for the HIA we conducted a longitudinal review of multiple Garfield County air and water monitoring studies as well as COGCC reports of water contamination in the county. This information was used to conduct a Human Health Risk Assessment. We also obtained demographic, physical and social health outcome data and used it in a comprehensive review described in the Battlement Mesa Baseline Health Profile. We also reviewed all publicly available information on Antero's plans to drill in Battlement Mesa, as well information made available to us by request from Antero.

With this data we determined that natural gas development and production has the potential to create a variety of stressors that can impact health. Using the medical and social health literature, we reviewed the links between these stressors and health and then applied current conditions and Antero's natural gas development and production plans to assess the potential future impacts of these physical, psychological and social stressors. The HIA considers the mitigations that Antero has disclosed to decrease impacts, so the HIA is based on anticipated effects to current and future residents. These stressors include air emissions, water and soil contamination, traffic, noise/vibration/light, community wellness, economic/employment changes, health infrastructure stress, and industrial accidents/malfunctions.

Using this scientifically based, methodological approach we found that air emissions are likely to occur at levels that can cause human health impacts, especially to vulnerable populations. Increased traffic, particularly increased truck traffic, will be a safety risk to Battlement Mesa residents and contribute to increased air and noise pollution. Increased noise may annoy some residents, but at current and anticipated future levels it is not likely to cause health impacts. Should water contamination and industrial accidents/malfunctions occur they could also cause important health impacts to Battlement Mesa residents, but these events are not likely to occur.

Some stressors may have positive as well as negative social impacts. The Antero project may provide jobs for some Battlement Mesa residents and may provide increased economic activity for some local businesses, including health clinics. As long as these businesses are able to maintain services in the face of increased business, this increased economic activity can be positive for the community. If the quality of services, including medical services, diminishes,

then negative physical and/or social health impacts could occur. Other aspects of community wellness may be negatively impacted, and increased levels of substance abuse, crime, and sexually transmitted infections may occur, while opportunities for recreation and social cohesion could decrease. Both the positive and the negative effects of changing economics/employment, health care infrastructure, and community wellness will likely be small given the relatively small size of the Antero project and the likelihood that these affects will be generally absorbed into the County as a whole rather than affecting Battlement Mesa alone.

At the end of each assessment and Section 5, the CSPH investigators have provided several recommendations aimed at decreasing negative impacts or improving positive impacts. Central to decreasing the primary health stressor, air pollution, is continued efforts to decrease all possible emission sources. To bring emissions to the lowest possible level, it is important that the best available current technology be utilized, and new technologies be developed and adopted. To provide an adequate margin of safety, current COGCC emissions rules need to be strictly enforced. Ambient and well pad monitoring should be conducted to characterize emissions and their impacts on local air sheds and determine if further regulation is needed to protect public health. Likewise, because of the potential for important health impacts due to water contamination from accidents and/or malfunctions, effort should be focused on prevention of such events, the best available technologies required, new technologies adapted, and strict monitoring maintained. Traffic mitigation should also be a priority in order to reduce the inherent safety risk associated with large truck traffic in residential areas. Noise associated with Antero's project should be monitored and efforts to decrease noise due to drilling activities as well as truck traffic undertaken. Finally, efforts should be made to use economic benefits from Antero's project to mitigate the potential negative impacts of change in social structure. Planning should take place to provide services needed for increased population, as well as planning for the loss of the economic activity in five years when the development phase ends.

The CSPH investigators and the BOCC recognize that implementation of recommended impact mitigations may be insufficient to protect public health. To that end, the BOCC has provided funding to CSPH to design a long term EHMS in Battlement Mesa and/or Garfield County to address some of these issues. This long term study will: 1) further characterize air emissions associated with natural gas production; 2) characterize air emission exposure levels for persons living in close proximity to natural gas production; 3) further characterize emission sources during development and production phases; 4) develop methods to characterize surface and ground drinking water contamination; 5) conduct health surveillance of residents in areas impacted by natural gas and in similar comparison populations not affected by natural gas development and production; 6) conduct social and community health surveillance of areas impacted by natural gas development and production.

Because there are natural gas plays in other parts of the United States undergoing similar development as that occurring in the Piceance Basin, this HIA and future studies are likely to be broadly applicable. Communities in Texas and Wyoming have reported health and social impacts associated with natural gas development and production, while communities in

Pennsylvania, New York and other places are trying to anticipate and forestall impacts before drilling occurs. Use of this or other HIAs as a tool to summarize potential impacts can help communities prioritize mitigations and local resources. Local environmental and health monitoring can provide communities with information necessary to protect public health. This information can also contribute to the growing body of knowledge on chemical and psychosocial stressors and health impacts associated with natural gas development and production.

In Colorado, recent legislation will compel Front Range coal fired electrical plants to switch to cleaner fuels and alternative energies, thus enhancing the natural gas market. In Grand Junction, two fueling stations for natural gas vehicles are slated to be built in the next few years. These and other market enhancing projects and policies will mean Colorado natural gas development and production projects will continue to grow. The recently updated COGCC rules included provisions to protect health and environment. These rules should undergo regular review and update in order to reflect new understanding and technologies as they emerge.

Because development of domestic natural gas resource is part of the national policy to increase domestic energy production and reduce greenhouse gas emissions, a high level discussion of the health implications of this policy needs to take place. While municipal, county and state governments have begun to respond to citizen concerns, a national discussion of the benefits and risks associated with this policy is due. As outlined in this HIA, local economic benefits of energy development may not outweigh the negative local impacts to physical and social health of the community. Without understanding public health implications in the context of national priorities for domestic energy production, continued disagreements about the impact of drilling and its effects on local health are bound to continue.

7 References

1. Centers for Disease Control and Prevention (CDC). Health Impact Assessment. Available at: http://www.cdc.gov/healthyplaces/hia.htm. Accessed September 1st 2010.
2. Pachauri RK, Reisinger A. IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: IPCC; 2008:104.
3. Miller CM, Blevins A. Battlement Mesa: a case study of community evolution. *The Social Science Journal* 2005;42(1):1-12.
4. United States Census. American FactFinder. In; 2000.
5. Burnett J. Health Issues Follow Natural Gas Drilling in Texas. In: Radio NP, ed. *Morning Edition*; 2009.
6. Williams DO. Battlement Mesa residents ask for health study in advance of drilling agreement. In: *The Colorado Independent*: The American Independent News Network; 2009.
7. Battlement Mesa Partners L, Antero Resources Corporation. Battlement Mesa Natural Gas Development Plan: Surface Use Agreement. In; 2009.
8. Colorado Oil and Gas Conservation Commission (COGCC). Comprehensive Drilling Plans Under COGCC's Amended Rules. In: Resources DoN, ed. Denver, CO; 2008:2.
9. Colorado Oil and Gas Conservation Commission (COGCC). Final Amended Rules. In. Website; 2009.
10. Garfield County Energy Advisory Board (EAB). Energy Advisory Board. Available at: http://www.garfield-county.com/Index.aspx?page=768. Accessed September 10th 2010.
11. Battlement Mesa Service Association (BMSA). Battlement Mesa - The Colorado Dream Documents. Available at: http://www.battlementmesacolorado.com/documents.aspx. Accessed September 10th 2010.
12. Wichmann HE. Diesel exhaust particles. *Inhal Toxicol* 2007;19 Suppl 1:241-4.
13. Ballester F, Rodriguez P, Iniguez C, et al. Air pollution and cardiovascular admissions association in Spain: results within the EMECAS project. *J Epidemiol Community Health* 2006;60(4):328-36.
14. Lin CA, Pereira LA, Nishioka DC, Conceicao GM, Braga AL, Saldiva PH. Air pollution and neonatal deaths in Sao Paulo, Brazil. *Braz J Med Biol Res* 2004;37(5):765-70.
15. Lin CM, Li CY, Mao IF. Increased risks of term low-birth-weight infants in a petrochemical industrial city with high air pollution levels. *Arch Environ Health* 2004;59(12):663-8.
16. Lin M, Chen Y, Burnett RT, Villeneuve PJ, Krewski D. Effect of short-term exposure to gaseous pollution on asthma hospitalisation in children: a bi-directional case-crossover analysis. *J Epidemiol Community Health* 2003;57(1):50-5.
17. Seydlitz R, Laska S, Spain D, Triche EW, Bishop KL. Development and Social Problems: The Impact of the Offshore Oil Industry on Suicide and Homicide Rates. *Rural Sociology* 1993;58(1):93-110.

18. Garfield County Public Health Department - GCPH, Colorado Department of Public Health and Environment (CDPHE). Garfield County Ambient Air Quality Monitoring Study. In: Health P, ed.; 2007:63.
19. Colorado Department of Public Health and Environment (CDPHE) - Air Pollution Control Division. Colorado Air Quality Data Report. In. Denver, CO: CDPHE; 2008:89.
20. Thyne G. Summary of PI and PII Hydrogeologic Characterization Studies - Mamm Creek Area, Gafield County, Colorado. In: Science Based Solutions; 2008.
21. URS. Phase I Hydrogeologic Characterization of the Mamm Creek Field Area in Garfield County. In. Denver, CO; 2006:149.
22. S.S. Papadopulos & Associates I. Phase II Hydrogeologic Characterization of the Mamm Creek Field Area, Garfield County, Colorado. In. Boulder, CO; 2008:58.
23. Coons T, Walker R. Community Health Risk Assessment: An Assessment of Risk Related to the Natural Gas Industry in Garfield County. In: Saccommano Institute; 2008.
24. Garfield County Public Health Department - GCPH. Garfield County CARES. Available at: http://www.garfield-county.com/Index.aspx?page=1304. Accessed September 10th, 2010 2010.
25. Health Impact Project (HIP), Pew Charitable Trusts, Robert Wood Johnson Foundation. About Health Impact Assessment. Available at: http://www.healthimpactproject.org/hia#Process. Accessed September 10th 2010.
26. Scott-Samuel A, Birley M, Ardern K. The Merseyside Guidelines for Health Impact Assessment. In. Second Edition ed; 2001:22.
27. Witter R, Stinson K, Sackett H, et al. Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2006). In. Denver, CO: Colorado School of Public Health
University of Colorado Denver; 2008:32.
28. Witter R, Stinson K, Sackett H, et al. Potential Exposure-Related Human Health Effects of Oil and Gas Development: Literature Review Appendices. In. Denver, CO: Colorado School of Public Health
University of Colorado Denver; 2008:68.
29. United States Environmental Protection Agency (EPA) Office of Pollution Prevention and Toxics. Chemicals in the Environment: 1,2,4-Trimethylbenzene (C.A.S. No. 95-63-6). In: EPA, ed.; 1994.
30. United States Environmental Protection Agency (EPA). Air Quality Criteria for Ozone and Related Photochemical Oxidants (2006 Final). In: Agency USEP, ed. Washington, DC; 2006.
31. United States Environmental Protection Agency (EPA). Integrated Science Assessment for Particulate Matter (Final Report). In: Agency USEP, ed. Washington, DC; 2009.
32. Colorado Department of Public Health and Environment (CDPHE). Garfield County Emissions Inventory. In: Health P, Division APC, eds.; 2009.
33. Colorado Department of Public Health and Environment (CDPHE). Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment. In: Division DCaEE, ed. Denver, CO: CDPHE; 2010.

34. Colorado Department of Public Health and Environment (CDPHE) - Air Pollution Control Division. Analysis of Data Obtained for the Garfield County Air Toxics Study Summer 2008, October. In: Health P, ed.; 2009a.
35. Canagaratna MR, Jayne JT, Ghertner DA, et al. Chase studies of particulate emissions from in-use New York City vehicles. *Aerosol Science and Technology* 2004;38(6):555-573.
36. Ban-Weiss GA, McLaughlin JP, Harley RA, Kean AJ, Grosjean E, Grosjean D. Carbonyl and nitrogen dioxide emissions from gasoline- and diesel-powered motor vehicles. *Environ Sci Technol* 2008;42(11):3944-50.
37. Shah SD, Ogunyoku TA, Miller JW, Cocker DR, 3rd. On-road emission rates of PAH and n-alkane compounds from heavy-duty diesel vehicles. *Environ Sci Technol* 2005;39(14):5276-84.
38. Antero Resources I. Traffic Impact Analysis: Update Antero Drill Sites - Battlement Mesa PUD. In; 2010.
39. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Benzene. In: Services USDoHaH, ed. Benzene ed. Atlanta, GA: ATSDR; 2007:438.
40. COGCC COaGCC-. On-line Database Available at: http://cogcc.state.co.us/. Accessed 2010.
41. Thyne G. Review of Phase II Hydrogeologic Study. In; 2008:26.
42. EPA RM-U, ATSDR VA-. Press Release: EPA releases results of Pavillion, Wyo. water well testing. In: Agency USEP, ed.; 2010.
43. Agency for Toxic Substances and Disease Registry (ATSDR). Health Consultation: Evaluation of Contaminants in Private Residential Well Water Pavillion, Fremont County, Wyoming. In: Services USDoHaH, ed.; 2010:46.
44. URS. Second Quarter 2008 Report Operational and Environmental Monitoring Within a Three-mile Radius of Project Rulison. In; 2008.
45. Nilsson G. Traffic safety dimension and the power model to describe the effect on speed safety. In. Lund: Lund Institute of Technology and Society; 2004.
46. World Health Organization (WHO). Global status report on road safety: time for action. In. Geneva: World Health Organization; 2009:301.
47. Colorado State Patrol (CSP). Traffic Safety: Crash Trends. Available at: http://csp.state.co.us/TS_CrashStat.html. Accessed September, 11 2010.
48. Colorado Oil and Gas Conservation Commission (COGCC). Aesthetic and Noise Control Regulations: Noise Abatement. In: COGCC, ed.; 2009.
49. Colorado State Legislature. Noise Abatement: Maximum permissible noise levels. In: Legislature CS, ed.; 2004.
50. Colorado Oil and Gas Conservation Commission (COGCC). Aesthetic and Noise Control Regulations: Lighting. In: COGCC, ed.; 2009.
51. Hanson CE, Towers DA, Meister LD. Transit Noise and Vibration Impact Assessment. In: Transportation USDo, Administration FT, Enviroment OoPa, eds.; 2006:274.
52. Crocker MJ, Kessler FM. Noise and Noise Control: CRC Press; 1982.

53. National Institute for Occupational Safety and Health (NIOSH). Noise and Hearing Loss Prevention. Available at: http://www.cdc.gov/niosh/topics/noise/. Accessed September 11th 2010.
54. van Kempen EE, Kruize H, Boshuizen HC, Ameling CB, Staatsen BA, de Hollander AE. The association between noise exposure and blood pressure and ischemic heart disease: a meta-analysis. *Environ Health Perspect* 2002;110(3):307-17.
55. Stansfeld SA, Haines MM, Burr M, Berry B, Lercher P. A Review of Environmental Noise and Mental Health. *Noise Health* 2000;2(8):1-8.
56. Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. *Br Med Bull* 2003;68:243-57.
57. Berglund B, Hassmen P, Job RF. Sources and effects of low-frequency noise. *J Acoust Soc Am* 1996;99(5):2985-3002.
58. Babisch W, Ising H, Gallacher JE, Sharp DS, Baker IA. Traffic noise and cardiovascular risk: the Speedwell study, first phase. Outdoor noise levels and risk factors. *Arch Environ Health* 1993;48(6):401-5.
59. Passchier-Vermeer W, Passchier WF. Noise exposure and public health. *Environ Health Perspect* 2000;108 Suppl 1:123-31.
60. Pauley SM. Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue. *Med Hypotheses* 2004;63(4):588-96.
61. Davis S, Mirick DK. Circadian disruption, shift work and the risk of cancer: a summary of the evidence and studies in Seattle. *Cancer Causes Control* 2006;17(4):539-45.
62. Stevens RG. Light-at-night, circadian disruption and breast cancer: assessment of existing evidence. *Int J Epidemiol* 2009;38(4):963-70.
63. La Plata County. La Plata County Impact Report. In; 2002:Section 3.5 pp.3.98-101.
64. Diez Roux AV. Investigating neighborhood and area effects on health. *Am J Public Health* 2001;91(11):1783-9.
65. Lantz P, Pritchard A, . Socioeconomic indicators that matter for population health. *Prev Chronic Dis* 2010;7(4).
66. Abbott A, Bindee J. Health Impact Assessment: Flinders Street Redevelopment. In: Tropical Population Health Services
Population Health Queensland; 2008.
67. Yen I, Syme S, . The social environment and health: A discussion of the epidemiologic Literature. *Annu Rev Public Health* 1999;20:287-308.
68. Garfield County Public Health Department - GCPH. Community Themes and Strengths Assessment: A Report of the 2006 Garfield County Public Health Community Resident Needs Assessment. In. Glenwood Springs, CO: Garfield County Public Health; 2006.
69. Garfield County Public Health Department (GCPH) -Colorado Prevention Partners. Local Needs Assessment: Regional Hospital Admissions Data for 2003-2005 - Alcohol/Drug Abuse and Suicidal Behavior Diagnoses. In; 2006.
70. Garfield County Public Health - GCPH. Garfield County Public Health. Available at: http://www.garfield-county.com/Index.aspx?page=569. Accessed September 11th 2010.

71. Forsyth CJ, Luthra AD, W.B. B. Framing perceptions of oil development and social disruption. *Social Science Journal* 2007;44(2):pp. 287-299.
72. Bhatia R. Protecting health using an environmental impact assessment: a case study of San Francisco land use decisionmaking. *Am J Public Health* 2007;97(3):406-13.
73. Srinivasan S, O'Fallon LR, Dearry A. Creating healthy communities, healthy homes, healthy people: initiating a research agenda on the built environment and public health. *Am J Public Health* 2003;93(9):1446-50.
74. Bhatia R, Wernham A. Integrating Human Health into Environmental Impact Assessment: An Unrealized Opportunity for Environmental Health and Justice. *Environ Health Perspect* 2008;116(8).
75. Wernham A. Inupiat Health and Proposed Alaskan Oil Development: Results of the First Integrated Health Impact Assessment/Environmental Impact Statement for Proposed Oil Development on Alaska's North Slope. *EcoHealth* 2007;4(4):500-513.
76. Luthra AD, Bankston WB, al. e. Economic fluctuation and crime: A time-series analysis of the effects of oil development in the coastal regions of Lousiana. *Deviant Behavior* 2007;28(2):pp. 113-130.
77. Jacquet J. Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities. In: *NERCRD Rural Development*. University Park, PA: The Northeast Regional Center for Rural Development; 2009:63.
78. Kettl P. Alaska native suicide: lessons for elder suicide. *Int Psychogeriatr* 1998;10(2):205-11.
79. Bush K. Population Health and Oil and Gas Activities: A Preliminary Assessment of the Situation in North Eastern BC. In: The Board of Northern Health; 2007:77.
80. White River Counseling. Company Management to Prevent Employee Alcohol and Drug Abuse. In; 2006.
81. National Institute of Allergy and Infectious Diseases (NIAID). Sexually Transmitted Infections. Available at: http://www.niaid.nih.gov/topics/sti/Pages/default.aspx. Accessed September 11th 2010.
82. Goldenberg S. Sexually transmitted infections (STIs) and the oil and gas industries: Recommendations for sexually transmitted infection testing and prevention interventions. In: Prepared for the Habitat Health Impact Consulting Corp.; 2008.
83. Goldenberg SM, Shoveller JA, Ostry AC, Koehoorn M. Sexually transmitted infection (STI) testing among young oil and gas workers: the need for innovative, place-based approaches to STI control. *Can J Public Health* 2008;99(4):350-4.
84. Birley. A Prospective Rapid Health Impact Assessment of the Energy from Waste Facility in the States of Jersey: Stage 2. In: *International Health Impact Assessment Consortium*; 2008.
85. Bezruchka S. The effect of economic recession on population health. *CMAJ* 2009;181(5):281-5.
86. Abdel-Aziz MI, Radford J, McCabe J. Health Impact Assessment, Finningley Airport. In. Doncaster, England: Doncaster Health Authority; 2000:47.
87. Strully KW. Job Loss and Health in the Us Labor Market. *Demography* 2009;46(2):221-246.

88. City Data. Battlement Mesa Colorado. Available at: http://www.city-data.com/city/Battlement-Mesa-Colorado.html. Accessed September 11th 2010.
89. Jacquet J. Social & Economic Impacts to Sublette County, WY from Natural Gas Development: A General Summary from Winter 2007. In: Sublette County W, ed.; 2009.
90. Jacquet J. Sublette County: Wage and Employment Study. In: The Sublette County Socioeconomic Analysis Advisory Committee; 2006.
91. Jacquet J. Marcellus Chale: Community and Economic Considerations. In: Cornell University Department of Natural Resources; 2010.
92. Rosenthal TC, Fox C. Access to health care for the rural elderly. *JAMA* 2000;284(16):2034-6.
93. Nesbitt TS, Connell FA, Hart LG, Rosenblatt RA. Access to obstetric care in rural areas: effect on birth outcomes. *Am J Public Health* 1990;80(7):814-8.
94. Chan L, Hart LG, Goodman DC. Geographic access to health care for rural Medicare beneficiaries. *J Rural Health* 2006;22(2):140-6.
95. Arcury TA, Gesler WM, Preisser JS, Sherman J, Spencer J, Perin J. The effects of geography and spatial behavior on health care utilization among the residents of a rural region. *Health Serv Res* 2005;40(1):135-55.
96. Gamm L, Hutchison L. Rural health priorities in America: where you stand depends on where you sit. *J Rural Health* 2003;19(3):209-13.
97. Berkowitz B. Rural public health service delivery: promising new directions. *Am J Public Health* 2004;94(10):1678-81.
98. Colorado Department of Health Care Policy and Financing (CDHCPF). Colorado Household Survey 2008-2009. In: Financing HCPa, ed.; 2009.
99. Hubbard B. Millions of gallons spilled in Colo. over 2 1/2 year period. In: *Denver Post*. Denver, CO; 2010.
100. Colorado Oil and Gas Conservation Commission (COGCC). On-line Database. Available at: http://cogcc.state.co.us/. Accessed 2010.
101. Garfield County Energy Advisory Board (EAB). Community Guide: Understanding Natural Gas Development. In: Garfield County EAB, ed.; 2007.
102. National Institute for Occupational Safety and Health (NIOSH). Comprehensive Safety Recommendations for Land-Based Oil and Gas Well Drilling. In: NIOSH; 1983.
103. Halliburton. Drilling Fluid Additives. Available at: http://www.halliburton.com/ps/default.aspx?navid=1074&pageid=64&prodgrpid=MSE%3a%3aIQU4J8JSZ. Accessed September 12 2010.
104. Kirschbaum MA. National Assessment of Oil and Gas Fact Sheet: Assessment of Undiscovered Oil and Gas Resources of the Uinta-Piceance Province of Colorado and Utah, 2002. In: Survey USG, ed.: USGS; 2002.
105. Spencer CW. Uinta-Piceance Basin Province. In: Gautier DL, Dolton GL, Takahashi KI, Varnes KL, eds. *National Assessment of United States oil and gas resources--Results, methodology, and supporting data*: United States Geological Survey; 1995.
106. United States Geological Survey (USGS) Names Committee. Divisions of Geologic Time - Major Chronostratigraphic and Geochronologic Units. In: *Website*; 2007.

107. Hettinger RD, Kirschbaum MA. STRATIGRAPHY OF THE UPPER CRETACEOUS MANCOS SHALE (UPPER PART) AND MESAVERDE GROUP IN THE SOUTHERN PART OF THE UINTA AND PICEANCE BASINS, UTAH AND COLORADO. In: Interior, ed.; 2002.
108. Scamehorn L. High Altitude Energy: A History of Fossil Fuels in Colorado. Boulder, Colorado: University Press of Colorado; 2002.
109. Olinger D. Battlement Mesa: Once intended as a company town for workers who would squeeze oil from rock, Battlement Mesa now is home to a new breed of retirees. . In: *The Denver Post*. SUN1 ed. Denver, CO; 1998:D-04.
110. Dreyer E, Castle M. Governor Ritter Signs Historic Clean Air-Clean Jobs Act: Bipartisan measure will cut air pollution, create jobs & boost Colorado natural gas sector. In: Office of Governor Bill Ritter J, ed. Denver; 2010.
111. Webb D. COGCC reforms clear Senate: Bill would increase the board's size from seven to nine. In: *Glenwood Springs Post Independent*. Glenwood Springs, CO; 2007.
112. Anderson RN, Minino AM, L HD, Rosenberg. National Vital Statistics Reports: Comparability of Cause of Death Between ICD-9 and ICD-10: Preliminary Estimates. In: Services DoHaH, ed. Atlanta, GA: Centers for Disease Control and Prevention; 2001:32.
113. Garfield County School District No. 16. Garfield County School District No. 16. Available at: http://admin.garcoschools.org/. Accessed September 12 2010.
114. Colorado Bureau of Investigations (CBI). Crime in Colorado. In. Denver. CO; 2010.
115. Colorado West Regional Mental Health (CWRMH). Colorado West Regional Mental Health, Inc. Available at: http://www.cwrmhc.org/. Accessed.
116. Community Health Initiatives (CHI). Community Health Initiatives. Available at: http://www.chi-colorado.org/. Accessed.

Part Two: Supporting Documentation

TABLES

Table 1: Identified Stakeholders

Stakeholder	Acronym	Stakeholder Role
Antero Resources Corporation	Antero	Natural gas operator, proposes development within the planned urban development of Battlement Mesa
Battlement Mesa Concerned Citizens	BMCC	Grassroots citizen group formed in response to the Antero gas project.
Battlement Mesa Company	BMC	Owner of mineral and surface rights in Battlement Mesa.
Battlement Mesa Service Association	BMSA	Home owners association for Battlement Mesa residential communities.
Colorado Department of Public Health and Environment	CDPHE	State health department; has consultative responsibility to the state permitting agency for comment health and environmental concerns, but has no regulatory responsibilities.
Colorado Oil and Gas Conservation Commission	COGCC	Colorado regulatory and permitting agency. Maintains databases for water quality, spills, and well locations Databases include federal and tribal lease owners as well as state lease owners. Provides permitting for state lease owners only.
Garfield County Board of County Commissioners	BOCC	Requested county environmental health to develop proposals to respond to citizens health concerns. Have indicated that HIA and health study proposals will satisfy this request.
Garfield County Oil and Gas Department	GCOG	County office that oversees county relationships with oil and gas operators.
Garfield County Oil and Gas Operators	GCOGO	Natural gas companies operating in Garfield County but not involved in the development within the Battlement Mesa PUD (Encana, Williams, Bill Barrett, Noble).
Garfield County Public Health	GCPH	County health agency with environmental health program. Environmental health program directed to respond to citizen concerns and has strong ties to all stakeholder groups. Environmental health program considered a regional leader in health and gas exploration and production.
Grand River Hospital District	GRHD	Primary hospital and Emergency department provider in Rifle, Colorado (28 miles east of Battlement Mesa) and operator of a primary care clinic in Battlement Mesa.
Grand Valley Citizens Alliance	GVCA	Grassroots community group, loosely tied to the Battlement Concerned Citizens.

Table 2: Stakeholder Meetings		
Date	**Location**	**Groups represented**
January 13, 2010	CDPHE, Denver	CDPHE
January 27, 2010	COGCC, Denver	COGCC
February 3, 2010	GCPH, Rifle	BMCC, BMC, BMSA, BOCC, CDPHE, COGCC, GCPH, GVCA, Encana Corporation, Williams Corporation
February 16, 2010	GC Board Chambers, Glenwood Springs	BOCC
April 22, 2010	Antero Field Office, Rifle	Antero Resources
June 15, 2010	Battlement Mesa Fire Station, Battlement Mesa	BMCC, BMC, BMSA, BOCC, CDPHE, COGCC, GCPH, GVCA, Antero Resources, EnCana Corp., Williams Corp
June 24, 2010	CDPHE, Denver	CDPHE

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
Air Pollution/Quality	
February 3, 2010	Will PM10, VOC monitoring be included?
February 3, 2010	Parachute= Battlement Mesa when it comes to air monitoring?
February 3, 2010	Is PM2.5 a greater hazard?
February 3, 2010	Will the air quality assessment include all processes of the well development?
February 3, 2010	Do hydrocarbons evaporate from produced water ponds?
February 3, 2010	Are there BTEX emissions from trucks?
February 3, 2010	Will gathering pipelines with leaks be accounted for?
June 15, 2010	Is there enough water and air baseline data for Battlement Mesa?
June 15, 2010	Have air quality exposures in the summer when swamp coolers are being used? Will air pollution be concentrated indoors?
Water Quality	
February 3, 2010	Is there adequate monitoring of water?
February 3, 2010	How will impacts to the water supply (CO river, surface and spring) be assessed?
February 3, 2010	What if domestic supply is ½ mile from well pad, is it safe?
February 3, 2010	Will emergency wells within the PUD be impacted, are the pads close to the emergency wells?
February 3, 2010	Should the intake on the CO river have gates (like Rifle)?
February 3, 2010	Should real time monitoring instead of 3 month turn around for sampling results be implemented?
February 3, 2010	Can there be a quicker response to water issues?
February 3, 2010	Is there enough water for all needs, including fires?
February 3, 2010	Should there be a drill for potential water shut-down?
June 15, 2010	Will the effect of chemicals on the water supply be included in the study?
June 15, 2010	Will possible contamination of the Colorado River from upstream contamination be considered?
June 15, 2010	Is there enough water and air baseline data for Battlement Mesa?
Drilling and Fracking Chemicals	
June 15, 2010	Will fracking chemicals be considered?
June 15, 2010	How will chemical spills be considered?
June 15, 2010	Why can't Colorado require public release of fracking chemicals like Wyoming?
June 15, 2010	Will you be working with physicians and Grand River Hospital to obtain local data?
Pipeline Safety	
February 3, 2010	Is there a plan to prevent pipeline leaks/ explosions?
February 3, 2010	Does pipeline proximity to buried high voltage power lines pose a risk?
Occupational Hazards	
February 3, 2010	How will the development have social impacts: will it increase domestic abuse? Will workers have health insurance?

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
Occupational Hazards Continued	
February 3, 2010	How does worker schedules impact families?
February 3, 2010	Will the health of workers on rigs be included?
February 3, 2010	What are the mental health impacts?
February 3, 2010	If economic security is tied to gas jobs, will fear of loosing a job prevent workers from speaking up about health problems? Grand Valley Citizens Alliance gets input from workers that wish to remain anonymous.
Concerns of Industry	
February 3, 2010	There is misinformation that drives fear. The health study will relieve the misinformation.
February 3, 2010	The industry will partner with local fire department.
February 3, 2010	Industry hopes to make Battlement Mesa to be a better place.
Concerns about Research and the HIA	
February 3, 2010	Hope that HIA will not be "inconclusive"
February 3, 2010	What is the difference between probability vs. predictability: What does probability mean?
February 3, 2010	How are acute vs. chronic diseases defined? This needs to be communicated.
February 3, 2010	Will the HIA include information on healthy individuals? Balanced picture of the community
June 15, 2010	Is there a formula that will tell us that the hazards are too high?
June 15, 2010	Will analysis be comparing results to other areas in Colorado such as Denver and Grand Junction?
June 15, 2010	Will illnesses be captured even if a resident goes to a hospital outside of Garfield County?
June 15, 2010	How will gaps in health outcomes be addressed?
June 15, 2010	Will there be another public meeting prior to the release of the draft report?
June 15, 2010	Be aware that the population has been trending to younger age groups during the 2000-2010 time period.
Community Concerns	
February 3, 2010	What will the impacts on county services be? Will there be more or less services? services Will there be an increase in STD's and other "social" diseases
February 3, 2010	Will the development impacts on education? Will class size be affected?

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
February 3, 2010	Will there be adequate affordable housing? Sometimes there is not enough, sometimes too much.
Additional Exposures/Impacts	
February 3, 2010	Will decreased property value be included in the assessment?
Additional Exposures/Impacts Continued	
February 3, 2010	Will decreased aesthetics of the community be included?
February 3, 2010	Are set backs adequate to protect health?
February 3, 2010	Will other stressors including light, noise, traffic be considered?
February 3, 2010	Will concern include skin, respiratory, vertigo?
February 3, 2010	Will there be motor vehicle accidents and related injury and death?
February 3, 2010	What kind of impacts will fracking have?
February 3, 2010	Will remote frac'ing with high pressure pipelines be dangerous?
February 3, 2010	How will changing landscape and changing resident demographics be included?
February 3, 2010	Will a boom and bust cycle occur? We are now in a bust and the food banks drying up.
February 3, 2010	What are the impacts to health services and other community services in BM?
February 3, 2010	How will post drilling, post spill reclamation be handled?
February 3, 2010	What will be done with cuttings? Will they be buried onsite?
February 3, 2010	Will the sites be contaminated and be unsuitable for future use?
June 15, 2010	Will vibration be considered along with noise?
June 15, 2010	Have exposures to herbicides and dust been considered?
June 15, 2010	Will fires on the well pad be considered?
June 15, 2010	Will you consider all O&G activity in close proximity to the PUD? The project should expand beyond the PUD.
June 15, 2010	Mental health and social issues are important impacts.
Outside Agencies	
June 15, 2010	Does EPA have any interest in the work being done? What other studies have been done or are being conducted?
June 15, 2010	What role does Pew Charitable Trust play in the HIA?

APPENDICES

APPENDIX A: SUMMARY OF THE NATURAL GAS DRILLING PROCESS

APPENDIX B: NATURAL GAS DEVELOPMENT IN THE PICEANCE BASIN

APPENDIX C: BATTLEMENT MESA BASELINE HEALTH PROFILE

APPENDIX D: HUMAN HEALTH RISK ASSESSMENT

APPENDIX E: GENERAL RECOMMENDATIONS

APPENDIX A: SUMMARY OF THE NATURAL GAS DRILLING PROCESS

To transport natural gas that is diffusely embedded in sediment thousands of feet below the earth's surface to a commercial gas pipeline and into a household's gas stove is a complex process involving many different operations. While the description included in this HIA is far from complete, to understand the HIA and its recommendations requires some familiarity with natural gas drilling. For additional reading about the natural gas drilling process, please refer to the following documents:

- *Community Guide to Understanding Natural Gas Development*, written by the Garfield County Energy Advisory Board[101] and
- *Comprehensive Safety Recommendations for Land-Based Oil and Gas Well Drilling*[102]

Natural gas drilling involves the following processes.

Site Selection

A geological survey team collects information on the geology of potential sites to drill. The geological survey team and business managers discuss the benefits and risks of each potential site. Eventually, the business managers and geologists select a site or a group of sites to develop into well pads.

Site Preparation

Before drilling can begin, an operator must prepare the site. The operator typically contracts this task to earth moving companies that create a level surface on which to work. In addition to creating a level platform for drilling activities, site preparation companies often dig and dike any required reservoirs and excavate the cellar. The cellar is, essentially, a pit that collects fluids and accommodates the **blowout preventer** and other equipment. During the site preparation, contractors often transport heavy machinery to the site for earth moving operations and gravel/soil to create a level well pad. Site preparation also may include building roads to access the well pad and installation of pipes to transport natural gas and water.

Drilling

A subcontractor delivers and erects a load-bearing structure to support the weight of the **drill**, the **drill string** and other relevant equipment. Historically, contractors used a structure called a **derrick**. While many contractors still use derricks, contractors also use a different type of structure called a **mast**. Whereas derricks must be constructed on site, masts do not require as much assembly once they are delivered to the site. Masts are simply hoisted and secured into place.

When the load-bearing structure is secure, the drill creates an initial hole by a process commonly called "**spudding in**". As soon as "spudding in" is complete, the contractor inserts a section of metal pipe, called **conductor casing**, into the hole to prevent blowouts and ensure the well's integrity. The contractor secures the conductor casing into place by injecting cement between the sediment and the casing.

Once the conductor casing is securely cemented into place, the drill bores to a depth of approximately 900 feet below ground surface (bgs). This "surface hole" is also lined with casing (called **surface casing**), which like the conductor casing is cemented into place. Surface casing is the barrier between the well bore and groundwater reserves.

After surface casing is securely in place, the contractor continues to drill, meanwhile installing the subsequent layer of casing, called **production casing**. Production casing, like other forms of casing, is manufactured, transported and installed in thirty-foot sections. Eventually, the production casing runs thousands of feet deep to reach the hydrocarbon formations – as much as 10,000 feet bgs but in the Piceance Basin, more likely around 6,000 feet bgs. The production casing, as with the other sections of casing, is cemented into place.

During the drilling process, contractors transport the drill rig, casing, materials for drilling mud, water and other equipment to the well pad. After the production casing is securely in place, the drill rig is disassembled and the well completion process begins.

A couple of additional terms to be aware of include (but are not limited to):

Drilling Mud – Drilling contractors use drilling mud to lubricate the drill bit, carry cuttings (i.e. sediment) to the surface, and provide downward pressure in the well bore. Drilling mud is usually a complex mixture of liquids, reactive solids and inert solids. Mud often includes bentonite, a heavy clay material. The liquid might be comprised of freshwater, diesel oil, crude oil and/or "conditioners." The category of "conditioners" actually includes a wide variety of chemical compounds that serve various purposes in the drilling process[103]. Some conditioners stabilize the geologic formation as the operator drills deeper. Other conditioners lubricate the drill. Some conditioners make the drilling mud thicker. Others make the mud thinner. Characterizing the precise chemical composition of all of the conditioners available for Antero's use is beyond the scope of this HIA.

Directional Drilling – Drilling contractors now have the ability to drill at angles other than directly downward. The angle of the well bore relative to the surface can change during the drilling process. Sometimes, wells are started at an angle and drill practically horizontally. Other times, contractors drill straight down and change the angle of the well bore after the production casing is in place.

Well Stimulation

At the depth of the hydrocarbon formation, the production casing is pierced with explosive charges or bullets. Perforating the production casing itself and the surrounding layer of cement creates channels through which natural gas can pass. Well perforation is not the same as hydraulic fracturing, although it is a necessary precursor.

Natural gas contractors use **well stimulation** methods to increase the rate at which natural gas flows to the surface. One prominent stimulation method is **hydraulic fracturing**, whereby a contractor injects liquids under high pressure to create fissures in the sediment surrounding the well bore. By creating fissures in the sediment, hydraulic fracturing releases natural gas that was embedded in the tightly packed sediment. The gas enters the well bore through the perforated production casing and flows up to the surface. The liquids used in the hydraulic fracturing process are composed of water and various chemicals – some of which may be protected by trade secrets. Hydraulic fracturing fluids also may be called fracking or frac'ing fluid or water.

Well Completion

The pressure of the geologic formation and its heterogeneous contents necessitate the process called **well completion**. After a formation is hydraulically fractured, the natural gas operator must collect water, hydraulic fracturing fluids, sediment, condensate, oil and natural gas that is generated in the process. Well completion is a process by which the channels of the well are cleared so that natural gas can pass freely to the surface. The contents are typically collected into tanks and shipped off-site.

Well Production

After the well has been completed, the well pad shifts into production mode, whereby the recently-drilled well releases natural gas into the commercial line. However, to ensure the safety and the quality of the gas, the well production phase requires additional technologies. For instance, tanks collect water and additional condensate that the well may produce.

Reclamation

After a well is no longer producing gas, it is plugged and abandoned. According to the Colorado Oil and Gas Conservation Commission's regulations pertaining to well reclamation, the land surrounding the wellhead must be restored as closely as possible to its original condition. If the well pad is on cropland, the operator has three months to begin the reclamation process. Operators have 12 months to begin reclamation on non-crop land. To reclaim the well-pad, the operator needs to remove all of the equipment and waste from the site. They need to re-fill the hole in which the wellhead was located. Land needs to be re-graded and re-vegetated to its original condition, as do access roads. Prior to deeming the land "reclaimed" a COGCC inspector must investigate the land to ensure it has been properly re-graded and re-vegetated and that all of the waste and debris have been cleared.

APPENDIX B: NATURAL GAS DEVELOPMENT IN THE PICEANCE BASIN

B1 Geology

This brief summary of the area's geology provides additional context for understanding the potential drilling plan, in particular how the geology of the region relates to proposed drilling methods.

The Battlement Mesa PUD rests on top of a geologic formation known as the Piceance Basin. The Piceance Basin stretches underneath seven Colorado counties, including Garfield County, where Battlement Mesa is located. The Piceance Basin is a part of the larger Uinta-Piceance Province, which is 40,000 square miles in area. Of the larger Uinta-Piceance Province, the Piceance Basin is approximately 100 miles long and 40-50 miles wide. The Axial Uplift forms the Piceance's northeastern border and the White River Uplift forms the eastern border. The Douglas Creek Arch forms the Piceance Basin's western border. The southern border is roughly parallel with and north of the Uncompahgre Uplift axis.

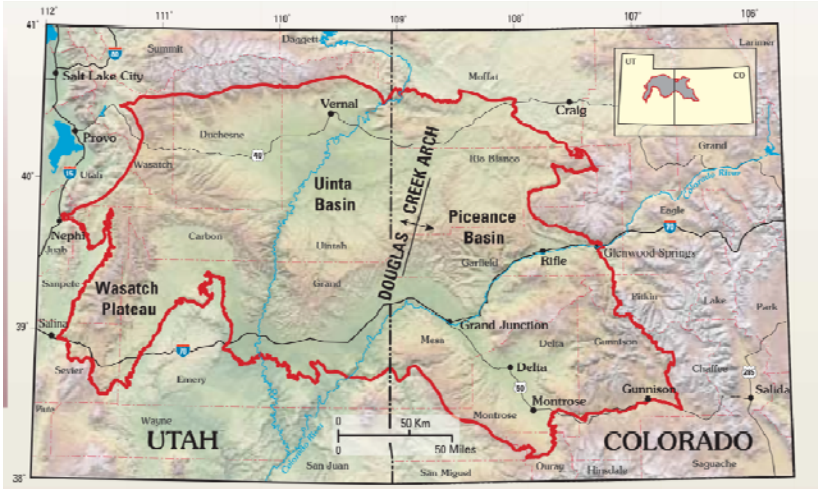

Figure 1. Uinta-Piceance Province located in northwestern Colorado and northeastern Utah. The Douglas Creek arch separates Piceance Basin from Uinta Basin. The Wasatch Plateau is included in this province.

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The Piceance Basin, however, is not simply an area of land, the Piceance Basin refers to the geology underlying the area previously described. Therefore, it is useful to consider the Basin as

being "deep" as well as "wide." At its deepest section, the Phanerozoic sedimentary rock* of the Piceance Basin extends 20,000 feet below the Earth's surface.

The Piceance Basin was formed during a period geologists call the Tertiary Period[105] – which ranges from approximately 65 million years ago to 1.8 million years ago[106]. The layers of rock and sediment that comprise the Piceance Basin include significant deposits of petroleum, much of which geologists term "unconventional" petroleum. As opposed to "conventional" reserves of hydrocarbons, that can be accessed using oil well technology from the 1800's, unconventional reserves such as tight sands, shale gas, coal bed methane and oil shale require more technologically advanced extraction methods. While all of the types of unconventional reserves previously listed are embedded in the Piceance Basin[105], the type of unconventional reserve that relates most directly to Antero's proposed drilling plan in Battlement Mesa are tight sands.

Tight Sands

Tight sands are deposits of compacted sediment or hard rock that are saturated with natural gas (also known as methane or methane gas). Operators require advanced technologies - particularly hydraulic fracturing and/or acidizing – to access the methane gas permeating tight sand formations.

According to a United States Geological Survey (USGS) assessment of the Uinta-Piceance Province, "Major resources of tight gas are present in the province."[105] The same USGS assessment highlights two notable tight gas plays in the Piceance Basin. Both tight sands plays are in the Mesaverde Group, and the USGS differentiates them from each other by the quality of the reservoirs, their respective depths and other geological characteristics (i.e. stratigraphy).

Williams Fork Play
Rivers and streams deposited the sediment in the Williams Fork Play. The play's thickness ranges between 1,500 feet and 4,500 feet. To access methane gas embedded in the Williams Fork Play, natural gas companies need to drill anywhere from 5,500 feet to more than 9,800 feet. The average drill depth for the Williams Fork Play in the Piceance Basin is 7,500 feet.

At the time the USGS assessment was performed, geologists from USGS and industry were "attempting to determine why water is being recovered from horizontal wells; whereas, vertical wells in the same areas do not produce significant amounts of water." The author hypothesized that the water was from open natural fractures. One implication of the recovered water, noted the assessment's author, is that "operators may need to attempt to dewater the wells through sustained production." Although Antero has indicated that their natural gas drilling within the PUD will primarily involve the Williams Fork Play they have also indicated that they are also going to explore the Mancos shale beneath the Williams Fork.

* I.e. sedimentary rock from the Phanerozoic Eon – the current eon of the geologic timescale – which covers the previous 542 million years

Iles Play
The Iles Play lies directly beneath the Williams Fork Play. Sediment in the Iles Play is marine and marginal marine (i.e. deposits from oceans, as opposed to rivers and streams). The Iles Play is approximately 500-1,500 feet thick. To access the Iles Play, natural gas companies would need to drill between 5,800 feet, in excess of 10,000 feet. On average, the drill depth in the Iles Play is 7,700 feet.

Mancos Shale[107]
In addition to the Williams Fork Play and the Iles Play, it's important to mention a shale formation commonly called the "Mancos Shale" formation. The Mancos Shale is comprised of mudrock (i.e. hardened mud) that was deposited by the Cretaceous Interior seaway between 90 and 85 million years ago. The Mancos Shale is interconnected with the Williams Fork Play and the Iles Play.

B2 Energy Development in the Piceance Basin: Past

The 1973 Organization of the Petroleum Exporting Countries (OPEC) oil embargo and subsequent fluctuations in the price of crude oil created strong financial incentives for the United States to reconsider its dependence on foreign oil. The United States' Government invested in programs, such as the Synthetic Fuels Corporation, to support research and development of alternative fuel sources (such as oil shale and coal gasification)[108]. Private energy companies also invested in what seemed to be a growing market for domestically produced fuels. In 1980, the Exxon Corporation announced its Colony Oil Shale Project, which involved developing the oil shale resource within Garfield County. They began building the Battlement Mesa Planned Urban Development (PUD) shortly thereafter. The Battlement Mesa PUD was originally created as a company town for Colony Project workers[3]. However, when crude oil prices dropped in the early 1980's, the economic viability of oil shale collapsed. On May 2, 1982, the Colony Project was shut down, thereby eliminating 2,200 jobs[3]. Following the oil shale bust and subsequent exodus of oil shale workers, Exxon marketed the Battlement Mesa PUD as a retirement community until December 1989 when it sold the PUD's surface rights and mineral rights to the Battlement Mesa Company (BMC)[3]. Though the BMC continues to operate rental properties (primarily town homes and mobile homes) for local workers and their families, the BMC continued to market Battlement Mesa as a retirement community. By 1998, more than two-thirds of Battlement Mesa's residents were retirees[109].

B3 Energy Development in the Piceance Basin: Present

The United States' dependence on fossil fuels has re-emerged as in issue of national political significance. As in the 1970's, policymakers in Federal and State agencies have been considering incentives to promote "alternative" sources of energy (i.e. energy sources that are neither conventional petroleum reserves nor coal reserves). One such energy source, which is

abundantly infused into the geology of Western Colorado's Piceance Basin[105], is methane – commonly referred to as "natural gas."

In April, 2010, Colorado House Bill 1365, referred to as the "Clean Air – Clean Jobs" initiative, became law. The new law is to provide resources to reduce emissions of air pollutants through retiring, retrofitting, or reprocessing Front Range coal-fired power plants by replacing them with facilities fueled by natural gas or other lower or non-emission sources. This action "will jumpstart our natural gas sector the same way we are driving Colorado's solar and wind industries, according to Governor Bill Ritter,"[110].The Governor went on to say that the "Clean Air-Clean Jobs" law will bring "economic, energy and environmental benefits together in one package."[110] Even before House Bill 1365 was signed into law, though, Colorado's natural gas industry had been expanding rapidly, in Garfield County, as well as other parts of the state. High oil prices and technological advances such as hydraulic fracturing and directional drilling were making Colorado's vast "unconventional" natural gas reserves increasingly viable economically. In Garfield County, Colorado, the increased demand for extraction of natural gas was most apparent between 2003 and 2008. As a rapid influx of new workers arrived in Garfield County, some of them bringing families, hotels and motels filled quickly. Temporary housing facilities, commonly referred to as "man camps" were established. The pace of development stressed local infrastructure, creating concerns at the local and state levels of government. In 2009, the Colorado State Legislature implemented revised regulations governing oil and gas development, in part, to minimize development's impact on public health and the environment[111]. Continued, and possibly accelerated expansion of the natural gas industry within Garfield County is expected with the passage of House Bill 1365.

B4 Antero's Plan in Battlement Mesa

This section of Appendix B gives a brief overview of what information Antero has shared with the community as to it Plan to drill for natural gas in the PUD. A review of the natural gas drilling process is presented in Appendix A.

In the Spring of 2009, Antero announced plans to purchase surface rights and mineral rights from the BMC. Along with this, Antero indicated its intent to drill for natural gas within the Battlement Mesa PUD. It is important to keep in mind that Antero's drilling plans have not and will not be determined entirely by Antero. In addition to the federal, state and local regulations, drilling activities in the PUD are subject to three separate Surface Use Agreements (which are legally binding agreements for the parties entering into them). This section briefly summarizes the Surface Use Agreements determining how and where drilling activities will occur in the PUD:

<u>Surface Use Agreement #1: Exxon and BMC – December 12, 1989</u>
This Surface Use Agreement will always be effective as a condition of BMC's purchase of the PUD. It requires that before mineral resources within the PUD are developed, a formal Surface

Use Agreement must be executed. This initial Surface Use Agreement also established "general" locations for 16 well pads – 15 of which are within the PUD. BMC agreed to accommodate necessary changes to the locations. This Surface Use Agreement also required that in the event that surface development and mineral resource development were in conflict, there needed to be alternate locations for the drill sites.

Surface Use Agreement #2: Barrett Resources and BMC – August 6, 1990
This Surface Use Agreement is only binding for the natural gas operator Williams (which is Barrett Resources' successor in the Surface Use Agreement). Various restrictive provisions exist within the Surface Use Agreement to dictate how Williams can develop resources in the PUD. Among them is a provision that wells be set back at least two hundred feet from existing structures.

Surface Use Agreement #3: Antero Resources and BMC
According to the Surface Use Agreement (Surface Use Agreement) entered into between Antero and the BMC, the Battlement Mesa PUD development project will utilize horizontal drilling techniques and hydraulic fracturing stimulation to develop approximately 200 gas wells on 10 pads distributed throughout the residential community. The full Surface Use Agreement is included in [Attachment 2].

While the Surface Use Agreement is a worthwhile basis for understanding Antero's plans, it is not a legally binding agreement with BOCC. Only the Major Land Use Impact Review will represent a contract between BOCC and Antero. The Surface Use Agreement includes provisions (in addition to compliance with existing regulations) that are intended to reduce any potential impacts on the Battlement Mesa community's health and quality of life.

This is a summary of some, but not all, provisions in the Surface Use Agreement # 3 between Antero and the BMC[7]:

Wellsite Locations
The Surface Use Agreement identifies ten locations where Antero will erect drilling rigs and one site where Antero will build a covered water handling facility.

Access Roads
Access roads Antero builds to and from its well pads must be 20 feet wide and gated. Antero agreed to keep the access roads clean and suppress dust generated on the access roads.

Pipelines
The pipelines that gather gas must be at least 48 inches deep except where BMC and Antero agree that the pipelines need to accommodate existing infrastructure (in particular, gravity-dependent facilities including but not limited to sewer lines). Antero was granted 25 foot easements to install, operate maintain and repair permanent pipelines. They were also granted 50 foot easements for pipelines during construction.

Power/Telephone/Transformers
The only situation in which power lines, transformers and data transmission lines can be installed at a pre-identified well location is when they are necessary for the operation of production equipment.

Hours of Operation
BMC does not restrict the times of day when Antero can be engaged in drilling, completing, re-completing, well workover or reservoir stimulation operations. For routine maintenance, development and production, the Surface Use Agreement requires Antero to work between 7 AM and 8 PM, except in the event of an emergency.

Noise Abatement
Antero needs to be in compliance with COGCC standards that relate to noise (e.g. COGCC Series 802 Noise Abatement Rule[48]). There will be no centralized compression stations, which could be sources of constant noise, in the PUD. Hospital-grade mufflers will be installed on high noise output machinery.

Lighting Abatement
Rigs will be oriented to direct light away from closest homes. Antero "shall use appropriate technology to minimize light pollution emanating from the Property, including, but not limited to, utilization of low density sodium vapor lighting."

Air Emissions and Odor Abatement
Antero will use mats, soil tack and/or liquid dust suppressants as necessary to suppress dust. Antero can not flare wells within 2,000 feet of an occupied dwelling, unless they take the measures specified in the COGCC rules to contain the flare or unless there is an emergency. Antero will comply with Colorado Department of Public Health and Environment (CDPHE)Air Quality Control Commission Regulations. At the "F" pad, there will be a centralized water handling facility that will be lined and covered.

Noxious Weed Management
Antero will implement a noxious weed management plan in accordance with Garfield County and COGCC requirements. While it is expected the weed management plan will be similar to weed management plans currently in place within the PUD, the plan was not available for review at the time of this HIA report.

Visual Impact Mitigation and Reclamation of Wellsite Locations
Antero will construct well pads that mitigate the visual impact using berms and trees to shield the pad from view. Some drill rigs will be shrouded.

Environment and Safety

Antero will comply with all applicable COGCC, CDPHE, United States Environmental Protection Agency (EPA), Comprehensive Environmental Response Compensation and Liability Act (also known as CERCLA), Resource Conservation and Recovery Act (also known as RCRA), Oil Pollution Act, and Clean Water Act regulations. These include, but are not limited to, stipulations pertaining to sanitary facilities; refuse, trash and solid waste disposal; hazardous materials; spills of oil, gas and other hazardous chemicals; spill prevention and control plans; employee training; and employee housing.

Emergency Communications
Antero will comply with local, state and federal reporting requirements in all emergency situations.

Operator's Sole Risk: Insurance
Antero assumes all risk and liability of "any natural incident to, occasioned by or resulting in any manner, directly or indirectly, from (Antero's) operations hereunder."

Owners' Utilities
If Antero requires any utility lines to service any of the well site locations, Antero will pay to locate the lines underground.

The Surface Use Agreement does not address environmental monitoring.

Antero has described a three-phase development plan for the Battlement Mesa project. (Battlement Mesa Website)

- Phase 1 will develop the Stierberger Pad, Pad E, Pad G and the water storage facility (Pad F) on the south side of the PUD.
- Phase 2 will develop the Parks and Rec Pad, Pad A, Pad B and Pad D on the north side of the PUD.
- Phase 3 will develop the L and M pads on the northeast side of the PUD.

Each phase will involve access road, pad and pipeline construction needed to develop the wells and tie them to the water movement system and the gas gathering lines at the eastern edge of the PUD. At this time, Antero anticipates that all three phases will be completed in five years. A slower development scenario is possible and could depend upon the natural gas economy, internal Antero priorities, regulatory impacts, etc. This HIA is based upon the five-year development concept currently favored by Antero.

APPENDIX C: BATTLEMENT MESA BASELINE HEALTH PROFILE

C1 Physical Determinants of Health

In order to describe the baseline of physical health for the residents of Battlement Mesa, the CSPH team obtained information regarding cancer, inpatient hospital diagnoses, mortality and births. By comparing Battlement Mesa data to the same data for Colorado, we were able to provide a relative picture of health for the time period 1998-2008.

C1.1 Methods

Public health practitioners often compare the number of observed events (i.e. disease, death, hospitalizations) to the number of expected events. This allows practitioners to determine if a certain group of people is experiencing an increased (or decreased) amount of disease. A Standardized Incidence Ratio is one method used to measure excess or decreased amount of disease, or when mortality is examined, a Standardized Mortality Ratio (SMR). These methods were used to describe disease incidence and deaths in the Battlement Mesa/Parachute zip codes (81635, 81636).

C1.1.1 Cancer Data Methods

The Colorado Central Cancer Registry at the Colorado Department of Public Health and Environment is mandated by state statute to collect all diagnosed cancers among state residents. This registry provided the CSPH HIA team with aggregated counts of cancer for residents living within the two zip codes and age adjusted standardized incidence ratios for selected cancers diagnosed during the time period of 1998-2008.

Standardized incidence ratios were calculated using the numbers of cancers diagnosed in the Battlement Mesa/Parachute zip code compared to an expected number of cancer cases based on statewide Colorado cancer rates. Colorado rates were obtained from the Colorado Central Cancer Registry for men and women of comparable race and age and were used to calculate expected number of cancers for the Battlement Mesa/Parachute zip code. Adjusting for age, sex, and race/ethnicity assures that any difference found is not due to differences in demographics. The state of Colorado was used as a comparison to provide a large population base to generate stable, reliable rates.

Cancers studied included those based on known association between a specific type or types of cancer and the exposures of concern, common cancers, and those for which community members voiced concerns. Cancers selected for these analyses included:

- Hodgkin Lymphoma

- Non-Hodgkin Lymphomas
- Multiple Myeloma
- Leukemias
- Melanoma
- Breast cancer
- Prostate cancer
- Bladder cancer
- Colorectal cancer
- Cancer of the adrenal gland

When the number of events is less than 3 the data are not reported to preserve confidentiality, this is a policy of the Health Statistics and Vital Record Division at CDPHE. Leukemias were originally requested by type: acute lymphoblastic leukemia, acute myeloid leukemia, chronic lymphocytic leukemia, and chronic myelogenous leukemia., Because fewer than 3 cases of each type of leukemia were diagnosed over the 10 year period, the Leukemias were grouped together for the analysis.

When interpreting an standardized incidence ratio/SMR, size and stability need to be taken into consideration. Standardized incidence ratios based on greater numbers of events produce estimates that are more stable, meaning that there is greater confidence in the conclusions being drawn from the information. Because the population of Battlement Mesa/Parachute is small and the number of diseases is small, determining the *statistical significance* is extremely important. Confidence intervals (CIs) were calculated, in order to determine if the number of observed cases is significantly different from the number of expected cases or whether the difference may be due to chance alone. For these analyses, a 95% confidence interval (CI) was calculated for each standardized incidence ratio.

The following table describes how the standardized incidence ratio/SMRs are interpreted and deemed statistically significant or statistically insignificant.

Interpretation of Statistical Measures

Ratio (SIR/SMR)	Interpretation	95% Confidence Interval	Significance
< 1.00	The number of events observed is less than expected	The lower and upper limits of the interval are < 1.00	Ratio is considered statistically significant.
		The upper limit of the interval is > 1.00	Ratio is not considered statistically significant.
= 1.00	The number of events observed is equal to the number of events expected for the population.		
> 1.00	The number of events observed is greater than expected	The lower limit of the interval is < 1.00	Ratio is not considered statistically significant.
		The lower limit of the interval is > 1.00	Ratio is considered statistically significant.

C1.1.2 Inpatient Hospital Diagnoses Data Methods

Inpatient hospitalization diagnoses data from the Colorado Hospital Association were analyzed by the Health Statistics Section at the Colorado Department of Public Health and Environment and provided to the CSPH. The Colorado Department of Public Health and Environment provided aggregated inpatient hospitalization counts and standardized incidence ratios of select diagnoses using the International Classification of Diseases, ninth revision or ICD-9 codes for the time period of 1998-2008. The ICD-9 is the official system in the United States of assigning codes to diagnoses and procedures associated with hospital admissions during the 1998-2008 time period.

The Colorado Hospital Association collects discharge data for inpatient hospitalizations from participating hospitals throughout the state of Colorado. Each hospital discharge record collected can contain up to 15 diagnoses. For purposes of this analysis, the total hospitalizations were counted by including ICD-9 codes listed in any of the 15 diagnoses fields.

The Colorado Department of Public Health and Environment provided the CSPH team with aggregated numbers of hospitalizations by major category as well as standardized incidence ratios computed using indirect adjustment of age based on the 2000 Census populations for the zip codes 81635 and 81636.

Major categories of ICD-9 codes included those based on known association between disease and the exposures of concern, and those for which community members voiced concerns of elevated occurrence of disease. Major diagnosis categories analyzed included:

- Depression
- Nervous system

- Ear nose and throat (ENT)
- Vascular system
- Pulmonary

Similar to the cancer analyses, a 95% CI was calculated for each standardized incidence ratio to determine statistical significance and data are suppressed when less than 3 cases were recorded for the time period.

C1.1.3 Mortality Data Methods

Mortality data were analyzed by the Health Statistics Section at the Colorado Department of Public Health and Environment and provided to the CSPH.

The Colorado Department of Public Health and Environment provided aggregated mortality counts and standardized ratios of select underlying causes using the International Classification of Disease, tenth revision or ICD-10 codes for determining diagnoses. Mortality data were provided for the time period of 1999-2008. Data for the year 1998 were not included due to a switch from ICD-9 codes in 1998 to ICD-10 codes in 1999.

Mortality data were presented as number of deaths by primary underlying cause as well as SMRs computed using indirect adjustment of age based on the 2000 Census populations for the zip codes 81635 and 81636.

Major categories of ICD-10 codes were chosen based on diseases of interest. Major mortality categories included seven major categories:

- Suicide
- Nervous system diseases
- Major cardiovascular diseases
- Chronic lower respiratory diseases
- SIDS
- Cancers
- Leukemias

Similar to the cancer and inpatient hospitalization analyses described above, a 95% CI was calculated for each SMR to determine statistical significance. Also, data are suppressed when less than 3 deaths were recorded for the time period.

C1.1.4 Birth Outcomes Data Methods

The Colorado Department of Public Health and Environment provided CSPH data from the Colorado Birth Registry for the analyses of birth outcomes.

CSPH analyzed data from 1998 to 2008 for incidences of negative birth outcomes in zip codes 81635 and 81636 based on total births. Incidences of negative birth outcomes in the remainder of Colorado were used to determine expected incidences.

Birth outcome data are presented as the number of observed and expected birth outcomes, as well as standardized incidence ratios adjusted for maternal age and race.

Two negative birth outcomes were analyzed:

- Preterm birth (Gestational age less than 37 weeks)
- Low Birth weight (Gestational age 37 weeks or greater and birth weight less than 5.51 pounds)

Birth defects were not analyzed because the birth registry may not accurately reflect the number of birth defects. Birth detects will be evaluated at the later date using data from the Colorado birth defects registry, given that more than three events exist for the recorded time period.

Similar to the cancer and inpatient hospitalization analyses, a 95% CI was calculated for each standardized incidence ratio to determine statistical significance. Data suppression was not necessary because greater than three events were recorded for the time period.

C1.2 Population/Demographics

For all analyses listed within the physical health outcomes section, the population of Battlement Mesa Planned Urban Development (PUD) was defined as the population living within one of two zip codes: 81635 and 81636. The zip code 81635 denotes physical addresses in both the Battlement Mesa PUD and the town of Parachute, which is just north of the Battlement Mesa PUD. The zip code 81636 is used for Post Office (PO) boxes and therefore the 81635 zip code was used for population counts. Because the town of Parachute shares zip codes with Battlement Mesa, we included the Parachute population in our analyses.

The 2000 U.S. census was used to obtain the most accurate population counts as well as information on age, gender, and racial composition for the Battlement Mesa/Parachute zip code. According to the 2000 U.S. census estimates, 49.3 percent of the Battlement Mesa/Parachute population was female and 50.7 percent male. The median age was 37.5 years. Twenty-six percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. For people reporting race in Battlement Mesa/Parachute, 98.0 percent reported a single race: 93.4 percent identified as White, 0.5 percent as Black or African American, 0.9 percent as American Indian and Alaska Native, 0.2 percent as Asian, 0.2 percent as Native Hawaiian and Other Pacific Islanders and 2.8 percent as another race. Two percent of the population reported two or more races and 9.7 percent of the population identified as Hispanic or Latino (of any race). (Table 1) The most dramatic difference between the population for the 81635 zip code and the state of Colorado as a whole is in the over 65 age group. In Colorado in 2000, 9.7 percent of the population was 65 years and over compared to 19.8 percent of the population in the Battlement Mesa/Parachute zip code. Demographic/Population information for the zip code 81635 is provided in the table below.

Demographic/Population information for the zip code 81635

Subject	Number	Percent
Total population	**5,041**	**100**
SEX		
Male	2,487	49.3
Female	2,554	50.7
AGE		
Under 5 years	361	7.2
5 to 9 years	407	8.1
10 to 14 years	347	6.9
15 to 19 years	310	6.1
20 to 24 years	252	5
25 to 34 years	661	13.1
35 to 44 years	690	13.7
45 to 54 years	510	10.1
55 to 59 years	245	4.9
60 to 64 years	258	5.1
65 to 74 years	613	12.2
75 to 84 years	333	6.6
85 years and over	54	1.1
Median age (years)	37.5	(X)
18 years and over	3,730	74
Male	1,833	36.4
Female	1,897	37.6
65 years and over	1,000	19.8
Male	479	9.5
Female	521	10.3
RACE		
One race	4,939	98
White	4,709	93.4
Black or African American	23	0.5
American Indian and Alaska Native	43	0.9
Asian	11	0.2
Asian Indian	0	0
Chinese	1	0

Subject	Number	Percent
Filipino	2	0
Japanese	8	0.2
Korean	0	0
Vietnamese	0	0
Other Asian	0	0
Native Hawaiian and Other Pacific Islander	11	0.2
Some other race	142	2.8
Two or more races	102	2
Race alone or in combination with one or more other races		
White	4,808	95.4
Black or African American	37	0.7
American Indian and Alaska Native	94	1.9
Asian	18	0.4
Native Hawaiian and Other Pacific Islander	13	0.3
Some other race	181	3.6
HISPANIC OR LATINO AND RACE		
Total population	**5,041**	**100**
Hispanic or Latino (of any race)	488	9.7
Mexican	372	7.4
Puerto Rican	17	0.3
Cuban	4	0.1
Other Hispanic or Latino	95	1.9
Not Hispanic or Latino	4,553	90.3
White alone	4,413	87.5

Source: U.S. Census Data, 2000.

C1.3 Vulnerable populations

It is important to note that within a population there are individuals and groups of individuals which are at increased risk or more Vulnerable to disease. Increased Vulnerability is dependent upon a number of factors that can be categorized as demographic factors, genetic factors, and acquired factors.

Demographic factors include age, sex, race and ethnicity. Age is an important factor in determining Vulnerability. As noted in the population/demographics section, the U.S. Census data for the 81635 zip code indicate that greater than 45% of the population, in the year 2000, may be considered to be more Vulnerable to certain exposures, based on age (26 % under the age of 18 and 19.8 % over the age of 65).

Acquired factors (pre-existing disease, and behaviors such as smoking history, alcohol use, pregnancy, and nutrition) and genetic factors require a more in-depth analysis of individual history, including detailed information such as lifestyle behaviors, occupation, and residential history. Although these factors can contribute significantly to a person's Vulnerability to disease, such information is not available to the HIA team.

C1.4 Cancer, Death, Birth, Hospital Inpatient Data

Data for Cancer, Inpatient Hospital Diagnoses, Mortality and Birth data are reported below.

C1.4.1 Cancer Data

The counts listed in the tables below provide a summary of disease frequency. The incidence analyses determine whether a certain number of diagnosed cancers is greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any cancer.

Tables 2-4 display the number of diagnosed cancers (types) in the Battlement Mesa/Parachute zip codes, the expected number of cases based on the population of male and female residents, stratified by race and age, and the calculated standardized incidence ratios with 95% CIs.

Male/Female Cancers Combined- As displayed in Table 2, the five most common cancers diagnosed in the Battlement Mesa/Parachute zip code during the 1998-2008 time period were prostate, breast, lung, colorectal, and melanoma. (Table 2) The only statistically significant difference between the number of diagnosed cancers and the number of expected cancers was shown for prostate cancer. Over the 10-year period, 79 cases of prostate cancer were diagnosed, compared to the calculated 61.897 expected cases, which yielded a ratio of 1.28 and a confidence interval of 1.01-1.59. However, caution should be exercised when interpreting standardized incidence ratios based on a small number of cases. In this case, if 2 fewer cases of prostate cancer were diagnosed over the 10-year period, the standardized incidence ratio would not have been significant. In addition, when multiple independent tests are compared, there is a statistical chance that 5 % of the tests will be abnormal by chance alone.

Table 2- Number of Males and Females Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.880	NC	NC
Non-Hodgkin Lymphoma	8	7.645	1.05	0.45-2.06
Multiple Myeloma	5	2.442	2.05	0.66-4.79
Leukemia	5	6.017	0.83	0.27-1.94
Lung	29	23.958	1.21	0.81-1.74
Melanoma	17	14.190	1.20	0.70-1.92
Prostate	79	61.897	1.28*	1.01-1.59
Bladder	13	13.200	0.99	0.52-1.68
Colorectal	20	19.954	1.00	0.61-1.55
Adrenal Gland	+	0.120	NC	NC
Hodgkin Lymphoma	+	0.880	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

Cancers (Male Group) – As displayed in Table 3, the five most common cancers diagnosed in **males** Battlement Mesa/Parachute zip code during the 1998-2008 time period were prostate, lung, colorectal, melanoma, and bladder. The only statistically significant difference between the number of diagnosed cancers and the number of expected cancers when adjusted for age, and race was calculated for prostate cancer.

Table 3 – Number of Males Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.880	NC	NC
Non-Hodgkin Lymphoma	8	7.645	1.05	0.45-2.06
Multiple Myeloma	5	2.442	2.05	0.66-4.79
Leukemia	5	6.017	0.83	0.27-1.94
Lung	29	23.958	1.21	0.81-1.74
Melanoma	17	14.190	1.20	0.70-1.92
Prostate	79	61.897	1.28*	1.01-1.59
Bladder	13	13.200	0.99	0.52-1.68
Colorectal	20	19.954	1.00	0.61-1.55
Adrenal Gland	+	0.120	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

Cancers (Female Group) - As displayed in Table 4, the five most common cancers diagnosed in **females** Battlement Mesa/Parachute zip code during the 1998-2008 time period were breast, lung, colorectal, melanoma, and bladder. No statistically significant differences were observed between the number of diagnosed cancers and the number of expected cancers when adjusted for age and race.

Table 4 - Number of Females Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.693	NC	NC
Non-Hodgkin Lymphoma	4	6.215	0.64	0.18-1.65
Multiple Myeloma	+	1.562	NC	NC
Leukemia	+	3.773	NC	NC
Lung	19	18.656	1.02	0.61-1.59
Melanoma	7	9.218	0.76	0.31-1.57
Breast	56	56.452	0.99	0.75-1.29
Bladder	6	3.663	1.64	0.60-3.57
Colorectal	14	16.335	0.86	0.47-1.44
Adrenal Gland	+	0.088	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

C1.4.2 Inpatient Hospital Diagnoses Data

The counts listed in the tables below provide a summary of inpatient hospital diagnoses data. The results provide a summary of diagnoses given patients while in the hospital. The results determine whether diagnoses are greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any hospital diagnoses.

Tables 5-7 display the number of diagnoses in the Battlement Mesa/Parachute zip code, the expected number of diagnoses per category based on the population of male and female

residents, stratified by race and age, and the calculated standardized incidence ratios with 95% CIs

Inpatient Hospital Diagnoses (Male/Female Group) - As displayed in Table 5, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 5 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Depression
- Nervous system
  - brain and CNS
  - dizziness
  - vertigo
- Ear, nose, and throat (ENT)
- Vascular (blood vessel related)
  - cardiovascular
  - cardiac dysrhythmia (abnormal heart rhythm)
  - heart failure
  - hypertension (high blood pressure)
  - stroke
- Pulmonary
  - bronchospasm-airway obstruction
  - asthma
  - other diseases with symptoms of the lung

Table 5- Inpatient Hospital Diagnoses (male/female combine group) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	491	569.16	0.86	0.79-0.94
Nervous system	377	427.229	0.88	0.8-0.98
Brain and Central Nervous System (CNS)	44	60.189	0.73	0.53-0.98
Peripheral Nervous System (PNS)	99	101.571	0.97	0.79-1.19
Headaches	47	49.115	0.96	0.7-1.27
Seizure, epilepsy	167	184.211	0.91	0.77-1.05
Dizziness, vertigo	40	60.106	0.67	0.48-0.91
Ear, Nose and Throat (ENT)	224	272.762	0.82	0.72-0.94
Vascular	2,454	2,897.65	0.85	0.81-0.88
Cardiovascular disease	891	1,120.45	0.8	0.74-0.85
Cardiac dysrhythmia	669	846.962	0.79	0.73-0.85
Heart failure	539	723.47	0.75	0.68-0.81
Hypertension	1,688	1,914.51	0.88	0.84-0.92
Stroke	202	234.681	0.86	0.75-0.99
Arterial disease	90	85.952	1.05	0.84-1.29
Pulmonary	1,184	1,402.48	0.84	0.8-0.89
Bronchospasm, airway obstruction	894	1,068.22	0.84	0.78-0.89
Chronic bronchitis	172	191.802	0.9	0.77-1.04
Asthma	307	348.671	0.88	0.78-0.98
Reactions to external agents	+	0.941	NC	NC
Other diseases, symptoms of the lung	384	494.032	0.78	0.7-0.86

+= Data are not reported when the value for the time period is fewer than 3.

NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Inpatient Hospital Diagnoses (Male Group) - As displayed in Table 6, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 6 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Depression
- Vascular disease
  - cardiovascular
  - heart failure
  - hypertension (high blood pressure)
- Pulmonary
  - bronchospasm-airway obstruction
  - chronic bronchitis
  - asthma
  - other diseases with symptoms of the lung

Table 6- Inpatient Hospital Diagnoses (male) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	146	199.205	0.73	0.62-0.86
Nervous system	178	192.663	0.92	0.79-1.07
Brain and CNS	19	29.116	0.65	0.39-1.02
PNS	55	48.653	1.13	0.85-1.47
Headaches	13	9.316	1.4	0.74-2.39
Seizure, epilepsy	86	95.26	0.9	0.72-1.11
Dizziness, vertigo	15	22.243	0.67	0.38-1.11
ENT	112	123.6	0.91	0.75-1.09
Vascular	1,112	1,456.82	0.76	0.72-0.81
Cardiovascular disease	531	710.133	0.75	0.69-0.81
Cardiac dysrhythmia	336	466.968	0.72	0.64-0.8
Heart failure	233	368.404	0.63	0.55-0.72
Hypertension	696	867.24	0.8	0.74-0.86
Stroke	112	118.67	0.94	0.78-1.14
Arterial disease	47	50.935	0.92	0.68-1.23
Pulmonary	527	700.505	0.75	0.69-0.82
Bronchospasm, airway obstruction	376	536.028	0.7	0.63-0.78
Chronic bronchitis	72	104.377	0.69	0.54-0.87
Asthma	97	122.566	0.79	0.64-0.97
Reactions to external agents	+	0.541	NC	NC
Other diseases, symptoms of the lung	178	247.538	0.72	0.62-0.83

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population

Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Inpatient Hospital Diagnoses (Female Group) - As displayed in Table 7, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 7 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Nervous system diseases
- ENT
- Vascular disease
    - cardiovascular disease
    - cardiac dysrhythmia
    - heart failure
    - stroke

- Pulmonary disease

Table 7- Inpatient Hospital Diagnoses (female) compared to expected number, in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	345	365.566	0.94	0.85-1.05
Nervous system	199	235.072	0.85	0.73-0.97
Brain and CNS	25	31.015	0.81	0.52-1.19
PNS	44	52.968	0.83	0.6-1.12
Headaches	34	40.1	0.85	0.59-1.18
Seizure, epilepsy	81	90.114	0.9	0.71-1.12
Dizziness, vertigo	25	36.953	0.68	0.44-1
Ear, Nose, and Throat (ENT)	112	149.617	0.75	0.62-0.9
Vascular	1,342	1,448.91	0.93	0.88-0.98
Cardiovascular disease	360	436.398	0.82	0.74-0.91
Cardiac dysrhythmia	333	390.491	0.85	0.76-0.95
Heart failure	306	358.627	0.85	0.76-0.95
Hypertension	992	1,033.64	0.96	0.9-1.02
Stroke	90	117.158	0.77	0.62-0.94
Arterial disease	43	36.563	1.18	0.85-1.58
Pulmonary	657	717.134	0.92	0.85-0.99
Bronchospasm, airway obstruction	518	547.509	0.95	0.87-1.03
Chronic bronchitis	100	91.099	1.1	0.89-1.34
Asthma	210	225.193	0.93	0.81-1.07
Reactions to external agents	+	0.409	NC	NC
Other diseases, symptoms of the lung	206	248.615	0.83	0.72-0.95

+= Data are not reported when the value for the time period is fewer than 3.
NC: Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population

Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C1.4.3 Mortality Data

The counts listed in the tables below provide a summary of mortality data. The results determine whether deaths categorized by underlying disease are greater or less than expected, and whether that difference is statistical significant. The results do not allow conclusions to be made about causal relationships between exposure and any cancer.

Tables 8-10 display the number of deaths by underlying disease in the Battlement Mesa/Parachute zip code, the expected number of deaths based on the population of male and female residents, stratified by race and age, and the calculated SMRs with 95% CIs.

Mortality (Male/Female group combined) - As displayed in Table 5, there are no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. However, Table 5 does show two categories of underlying disease where there were fewer deaths than expected. The following categories were less than expected (statistically significant):

- Nervous system diseases
- Major cardiovascular disease

Table 8- Deaths (Males/Females) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2009.

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	381	499.799	0.76	0.69-0.84
Suicide	11	7.81	1.41	0.7-2.52
Nervous system diseases	18	30.724	0.59	0.35-0.93
Major cardiovascular diseases	114	162.546	0.7	0.58-0.84
Chronic lower respiratory diseases	27	37.062	0.73	0.48-1.06
Sudden Infant Death Syndrome (SIDS)	+	0.501	NC	NC
Cancers				
Breast	7	7.843	0.89	0.36-1.84
Prostate	7	7.12	0.98	0.4-2.03
Lung and bronchus	30	28.094	1.07	0.72-1.52
Colon/rectum	7	11.359	0.62	0.25-1.27
Melanoma	3	1.943	1.54	0.32-4/51
Bladder	+	2.712	NC	NC
Adrenal gland	+	0.1	NC	NC
Non-Hodgkin's lymphoma	4	4.654	0.86	0.23-2.2
Hodgkin's lymphoma	+	0.255	NC	NC
Multiple myeloma	3	2.446	1.23	0.25-3.58
Leukemia	4	4.68	0.85	0.23-2.19
Acute lymphocytic leukemia	0	0.261	NC	NC
Chronic lymphocytic leukemia	3	1.024	2.93	0.6-8.56
Acute myeloid leukemia	+	1.846	0.54	0.01-3.02
Chronic myeloid leukemia	+	0.277	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.

Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Mortality (Male Group) - As displayed in Table 9, there were no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. There were also no groups of underlying disease in which the SMR was <1.00 and statistically significant.

Table 9- Deaths (Males) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2008

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	223	272.783	0.82	0.71-0.93
Suicide	9	6.295	1.43	0.65-2.71
Nervous system diseases	9	14.17	0.64	0.29-1.21
Major cardiovascular diseases	71	86.902	0.82	0.64-1.03
Chronic lower respiratory diseases	13	21.324	0.61	0.32-1.04
Sudden Infant Death Syndrome (SIDS)	+	NC	NC	NC
Cancers				
Breast	+	NC	NC	NC
Prostate	7	8.377	0.84	0.34-1.72
Lung and bronchus	21	16.728	1.26	0.78-1.92
Colon/rectum	4	6.355	0.63	0.17-1.61
Melanoma	+	1.373	NC	NC
Bladder	+	2.187	NC	NC
Adrenal gland	+	0.051	NC	NC
Non-Hodgkin's lymphoma	3	2.8	1.07	0.22-3.13
Hodgkin's lymphoma	+	0.165	NC	NC
Multiple myeloma	3	1.479	2.03	0.42-5.93
Leukemia	+	2.997	NC	NC
Acute lymphocytic leukemia	+	0.159	NC	NC
Chronic lymphocytic leukemia	+	NC	1.47	NC
Acute myeloid leukemia	+	NC	0.87	NC
Chronic myeloid leukemia	+	0.173	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.

Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Mortality (Female Group) - As displayed in Table 10, there are no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. Table 10 shows that there were fewer total deaths and deaths due to cardiovascular disease than expected and this was statistically significant.

Table 10- Deaths (Female) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2008

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	158	231.569	0.68	0.58-0.8
Suicide	+	1.642	NC	NC
Nervous system diseases	9	16.36	0.55	0.25-1.04
Major cardiovascular diseases	43	76.496	0.56	0.41-0.76
Chronic lower respiratory diseases	14	16.667	0.84	0.46-1.41
Sudden Infant Death Syndrome (SIDS)	+	0.189	NC	NC
Cancers				
Breast	7	7.329	0.96	0.38-1.97
Prostate	+	0	NC	NC
Lung and bronchus	9	12.083	0.74	0.34-1.41
Colon/rectum	3	5.139	0.58	0.12-1.71
Melanoma	+	0.636	NC	NC
Bladder	+	0.73	NC	NC
Adrenal gland	+	0.049	NC	NC
Non-Hodgkin's lymphoma	+	1.97	NC	NC
Hodgkin's lymphoma	+	0.096	NC	NC
Multiple myeloma	+	1.03	NC	NC
Leukemia	+	1.857	NC	NC
Acute lymphocytic leukemia	+	0.113	NC	NC
Chronic lymphocytic leukemia	+	0.38	NC	NC
Acute myeloid leukemia	+	0.759	NC	NC
Chronic myeloid leukemia	+	0.112	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.

NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C1.1.4 Birth Outcome Data

The counts listed in the tables below provide a summary of birth outcome data. The results determine whether birth outcomes are greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any birth outcome.

Table 11 presents a comparison of maternal age and race between the Battlement Mesa/Parachute zip code and the rest of Colorado.

Table 11- Maternal demographics in Battlement Mesa/Parachute zip codes 81635 and 81636 compared to Colorado, 1998-2008.

Race	Battlement Mesa/Parachute	Colorado
Hispanic	240 (23.98)	213842 (28.84)
White	727 (72.63)	455285 (61.41)
Other Race	34 (3.4)	72245 (9.74)
< 20 years	154 (15.38)	77679 (10.48)
20-40 years	833 (83.22)	643619 (86.81)
> 40 years	14 (1.4)	20074 (2.71)

Table 12 displays the number of a particular birth outcome observed in the Battlement Mesa/Parachute zip code, the expected number of birth outcomes, based on the number of total births in the Battlement Mesa/Parachute zip code, stratified by maternal race and age, and the calculated standardized incidence ratios with 95% CIs

As displayed in Table 12, there are no birth outcomes for which the standardized incidence ratio is >1.00 or <1.00 and statistically significant. There is no statistical difference between the number of negative birth outcomes observed and the number expected.

Table 12- Negative birth outcomes compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 to Colorado residents, 1998-2008.

Outcome	Observed	Expected	SIR	95% CI
Preterm Birth	92	93	0.99	0.68 – 1.4
Low Birth Weight	30	34	0.88	0.43-1.6

Note: Expected counts computed by applying age-and race-specific statewide incidence rates to births in zip codes 81635 and 81636 between 1998 and 2008
Note: standardized incidence ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Source: Data from Colorado Birth Registry provided by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C.1.5 Health Data Gaps/Limitations

In determining baseline health for the Battlement Mesa/parachute area, it was not possible to obtain some important information regarding physical health. This missing information is referred to as *Data Gaps.*

Some medical conditions are routinely treated on an outpatient basis, with rare hospital admissions. Asthma, hypertension, diabetes, mental health disorders and other conditions are such examples. While the CSPH team made several attempts to obtain outpatient and emergency department information, it was not possible to do so in the time frame of this report. Therefore, this information is not included in the baseline health assessment. In addition, the CSPH team was unable to include injury information in the baseline health assessment. Injury information is best found in emergency room data, outpatient and occupational health clinics.

All data sets have important limitations. It is important to understand the limitations of the data that was used for this baseline health assessment. Understanding the limitations helps researchers and readers interpret the data correctly.

C1.5.1 Cancer data

Cancers may sometimes be associated with residential history, lifestyle behaviors, occupation, or genetics. Cancers are typically diseases of long latency, often years to decades, therefore current incidence is not necessarily indicative of current exposure. We did not have information regarding individual residential history, lifestyle behaviors, occupation, or genetics.

C1.5.2 Inpatient hospitalization data

Hospital discharge records do not capture information about personal risk factors, such as weight, smoking, family medical history, which are all important in considerations when assessing health. Hospital discharge records often contain detailed information for each patient discharge record, such as demographic information, however, the CSPH team did not have access to hospital discharge records, and therefore no demographic information was obtained.

Some diseases may take years to be actively reflected hospital diagnoses numbers. As mentioned above these diseases may be treated primarily on an outpatient basis and are therefore not captured by hospital diagnoses. In addition, like cancer, some diseases have long latency and are not captured in hospital discharge records until years after pertinent exposures.

Medical practice patterns and payment mechanisms may affect decisions by healthcare providers to hospitalize patients, to correctly diagnose disease, and/or to list the condition as a discharge diagnoses.

The ICD-9 codes abstracted from the discharge records include all diagnoses made during that particular hospital stay. As a consequence of this method, the sum of the diagnoses across a series of diagnosis subcategories (i.e. stroke, cardiovascular disease) may be greater than the total count for a parent category (i.e. vascular disease) because a single hospitalization record may have provided more than one subcategory when containing multiple diagnoses. It should also be noted, that it is possible that a patient was admitted more than once during our time frame and therefore the diagnoses associated with that patient would have been counted more than once. Diagnoses, therefore, may be higher than prevalence of disease.

C1.5.3 Mortality Data

Mortality data provide information on fatal illness only, not on current rate of disease. In addition, there are often multiple causes that act synergistically to cause death, or the cause of death is not clear. For this analysis, only the primary cause of death was considered.

C1.5.4 Birth Data

Birth data provide information from birth certificate, which may not have been verified and are not always consistently recorded. They do reflect the current rate of disease. In addition, there are often multiple causes that act synergistically to cause negative birth outcome.

C1.6 Conclusions for Physical Health

In order to provide the residents of Battlement Mesa with a baseline picture of physical health, the CSPH obtained analyzed data from state and hospital databases, as well as birth outcomes data, from CDPHE.

For the time period of 1998-2008 the Battlement Mesa/Parachute residents were found to be in better health than people of similar age, race and gender elsewhere in the state of Colorado. The slightly higher than expected rate of prostate cancer is felt to be a chance occurrence. The residents of Battlement Mesa had the same number or fewer as expected of other common cancers and leukemia; the same number or fewer than expected hospital discharge diagnoses related to depression, nervous system conditions, ear/nose/throat conditions, vascular conditions, and pulmonary conditions. These residents also had the same as expected or fewer than expected total deaths and deaths related to suicide, nervous system diseases, cardiovascular diseases, chronic lower respiratory diseases, and sudden infant death syndrome, as well as common cancers. Finally, the negative birth outcomes preterm birth, low birth weight, and congenital malformations all occurred at rates no higher or lower than those elsewhere in Colorado.

Data gaps and limitations make this baseline profile incomplete. Future investigations should focus on establishing data sharing agreements with local hospitals to obtain emergency room and outpatient data. Furthermore, collection of primary data, through surveys, medical record review and reanalysis of existing databases would also yield a more complete picture of physical health in Battlement Mesa.

C2 Social Determinants of Health

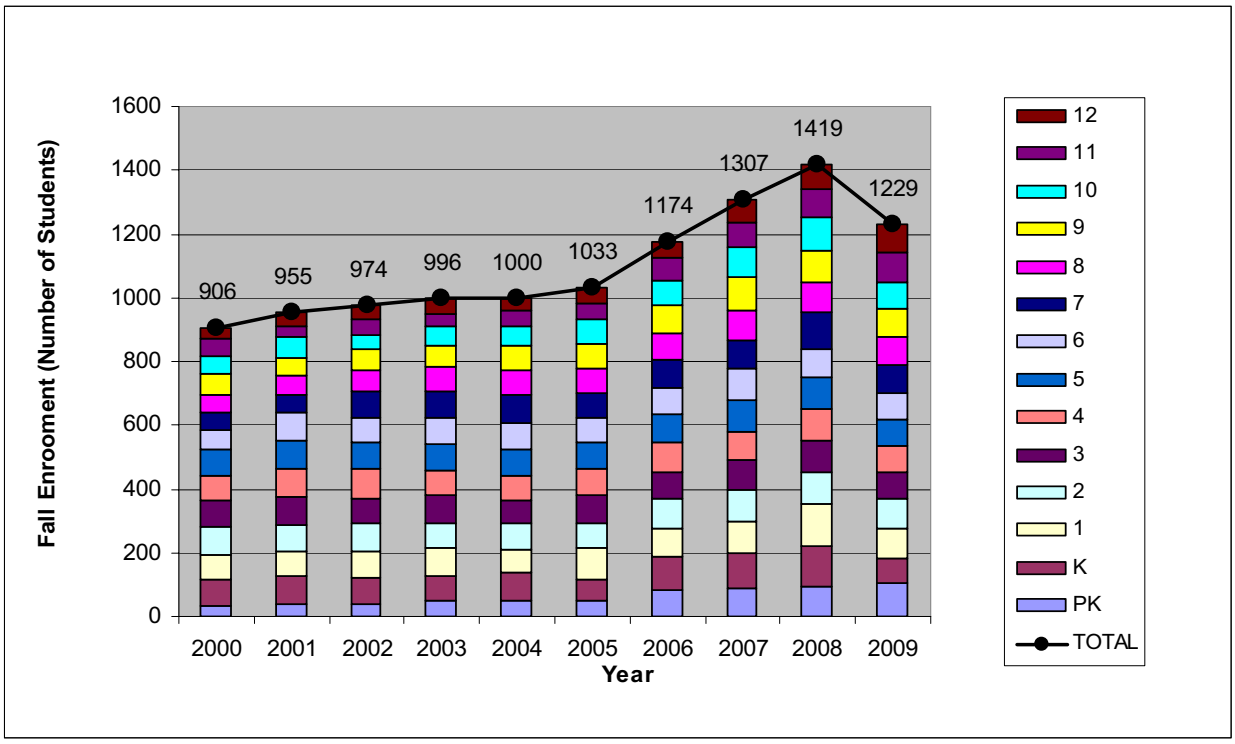
The following sections summarize key data evaluations conducted as part of the Community Wellness Assessment.

C2.1 Education/School Enrollment

Education for children in the towns of Battlement Mesa and Parachute is provided by Garfield County School District 16. Currently, the district is comprised of four schools, Grand Valley High School (9^{th}-12^{th}), Grand Valley Middle School (6^{th}-8^{th}), St. John Elementary School (4^{th}-5^{th}), and Bea Underwood Elementary School (1^{st}-3^{rd}). Additionally, the Grand Valley Center for Family Learning hosts the districts Head Start, Pre-Kindergarten and Kindergarten programs[113].

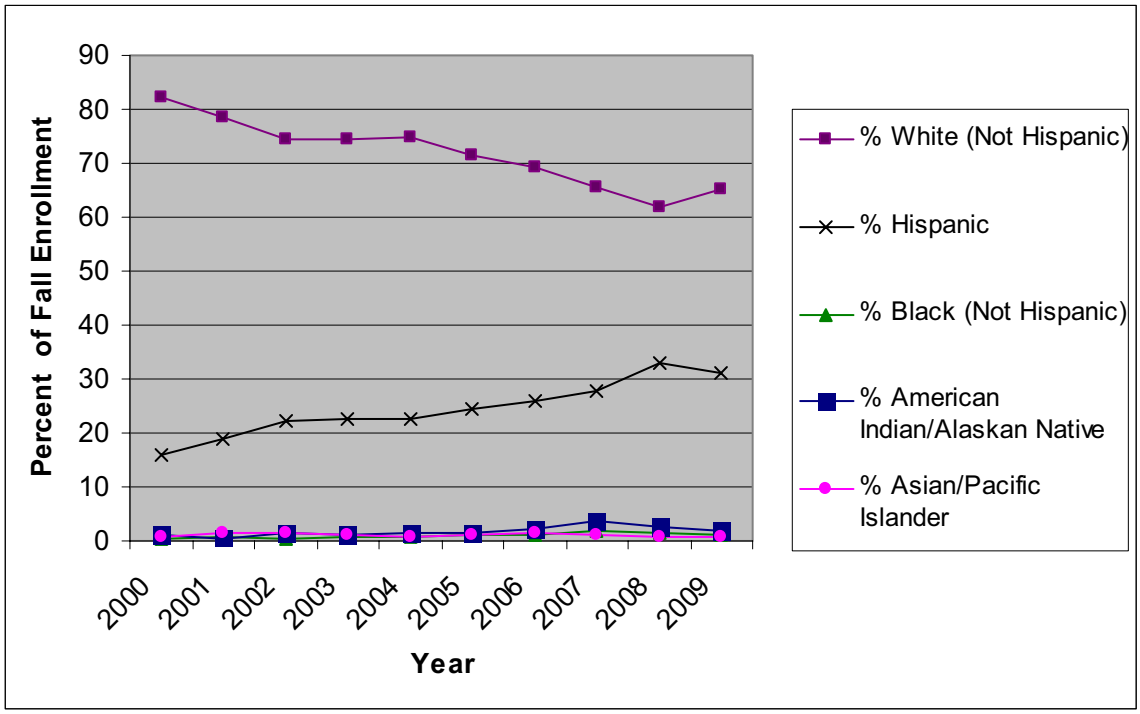
Data on school enrollment was collected from the Colorado Department of Education (http://www.cde.state.co.us/ index_stats.htm). In 2009, there were 1,229 students enrolled in the district, an increase of 19.0% since 2005 and 35.7% since 2000. Figure 1 displays annual district enrollment stratified by grade. While total enrollment has increased significantly, with an increase of nearly 400 students during the period 2005-2008, proportional enrollment by grade appears to have remained relatively stable.

Figure 1: Garfield County District 16, School Enrollment by Grade 2000-2009



Since 2000, there has been a change in the racial and ethnic profile of students enrolled in the district schools (Figure 2). The percentage of Hispanic children has doubled from approximately 15% in 2000 to 30% in 2009. At the same time, the percentage of White children has decreased from 82% to 65%. Proportions of African American, American Indian, and Asian children have remained relatively stable.

Figure 2: Garfield County School District 16, Enrollment by Race/Ethnicity 2000-2009



C2.2 Crime

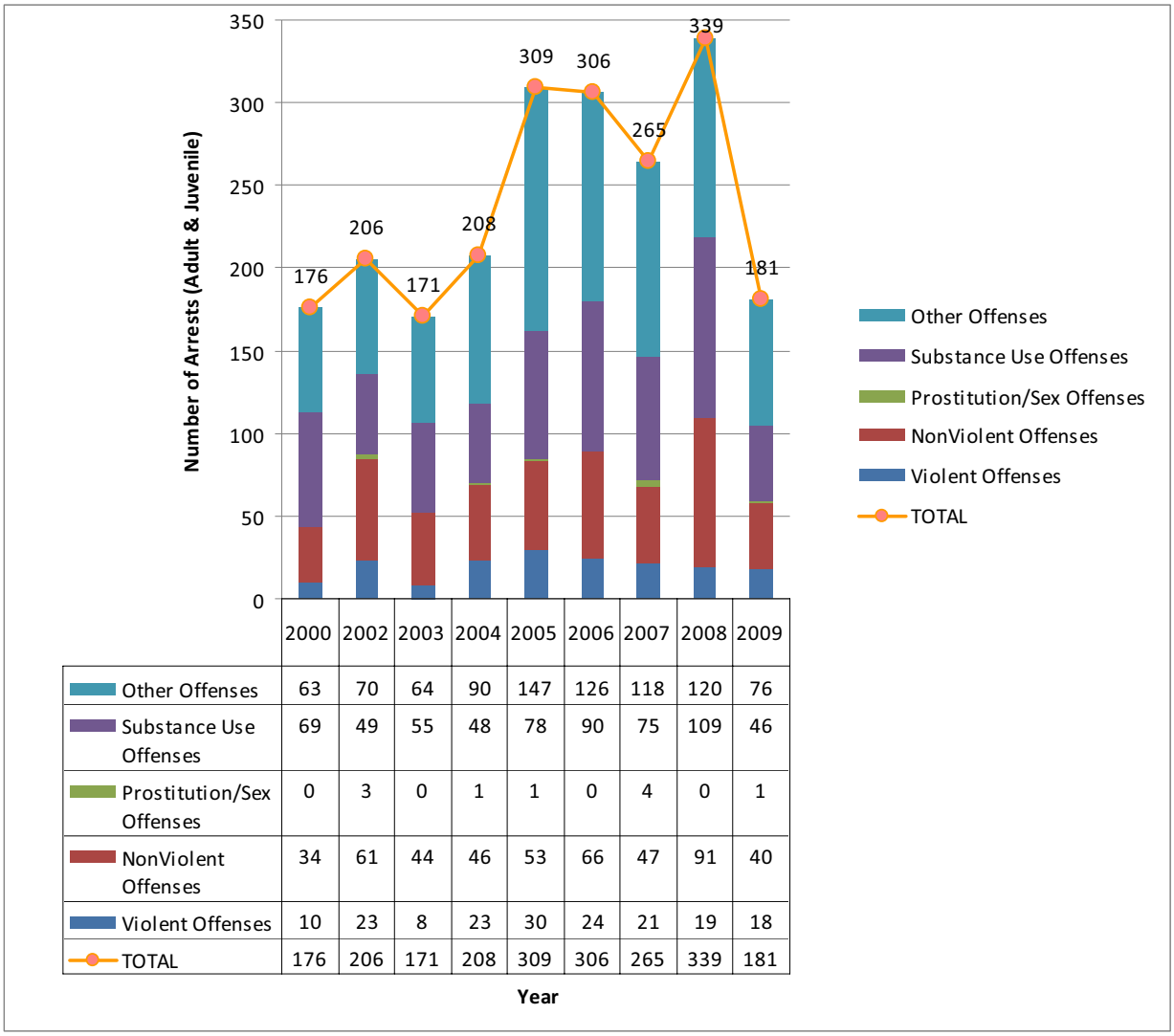
Data on criminal activity is publically available through the Colorado Bureau of Investigation (CBI) in the annual Crime in Colorado report. All Colorado law enforcement agencies are required to submit crime and arrest data to the CBI through the federally mandated Uniform Crime Reporting (UCR) Program. Incident data follow the national UCR Summary Hierarchy Rules and the National Incident-Based Reporting System (NIBRS) reporting and counting guidelines, broadly interpreted to mean the arrest for the most serious charge is counted[114].

Due to its unincorporated status and lack of a designated police force, criminal investigation for events in the Battlement Mesa PUD is under the jurisdiction of the Garfield County Sheriff's Office (GCSO). Statistics for crimes occurring in Battlement Mesa are reported to CBI by the GCSO and thus become part of the larger pool of data reported to the NIBRS database by that agency. For this HIA report, the GCSO was contacted and agreed to attempt retrieval of crime statistics specific to Battlement Mesa. These attempts were not successful due to recent changes in their internal electronic systems and also restrictions on mechanisms for agencies to retrieve data from the NIBRS system. The neighboring town of Parachute, which shares a zip-code with Battlement Mesa, operates a stand-alone police department and maintains NIBRS reporting separate from the GCSO. Due to its close proximity and similar community composition, CBI data from the Parachute PD was analyzed as a surrogate for criminal activity in Battlement Mesa. These data may also include crime occurring in Battlement Mesa which the Parachute Police force responded to and resolved. Adult and juvenile arrests were included.

In Figure 3 below, violent arrests consisted of crimes such as assault and forcible rape, nonviolent arrests included crimes like burglary, theft and vandalism, substance use offenses

included DUI and drug violations. The category of other arrests was not well-characterized in the source data, but includes various and numerous other crimes such as weapons offenses, fraud and forgery. There is no consistent trend apparent across the entire period of 2000-2009; however crime rates appear somewhat elevated during the period 2005-2008, then decreased to baseline frequency in 2009. This includes clear increases in the categories of substance abuse and other offences. While these data are not sufficient to establish a causal relationship between the boom of drilling activity in 2003 and crime rates, the higher crime numbers over the 2005-2008 period suggest additional monitoring in this area is warranted during times of high industry activity and in-migration of workers and other population shifts. Though not possible to do with publically available data, evaluation of crime rates by season or month may facilitate better understanding of whether criminal activity is correlated with increased drilling activity and workforce numbers.

Figure 3: Arrests Recorded by the Parachute Police Department, 2000-2009*



	2000	2002	2003	2004	2005	2006	2007	2008	2009
Other Offenses	63	70	64	90	147	126	118	120	76
Substance Use Offenses	69	49	55	48	78	90	75	109	46
Prostitution/Sex Offenses	0	3	0	1	1	0	4	0	1
NonViolent Offenses	34	61	44	46	53	66	47	91	40
Violent Offenses	10	23	8	23	30	24	21	19	18
TOTAL	176	206	171	208	309	306	265	339	181

*2001 data not available

C2.3 Mental Health, Substance Abuse and Suicide:

Significant efforts were made to obtain data on mental health, substance abuse and suicide specific to residents of Battlement Mesa. We identified the Colorado West Regional Mental Health, Inc. as a potential source of this information due to their wide-reach in the region with numerous local outpatient clinics, including Rifle and Glenwood Springs[115]. Outpatient services offered by Colorado West include key treatment approaches for mental health such as, emergency and critical incident consultation, counseling for families, children & adults, psychiatric evaluation and medication management, as well as being a major provider of Employee Assistance Programs. While data on clinical usage and outpatient visits is maintained centrally across all clinics in the Colorado West system, they were unable to provide data for analysis requested for this project due to recent changes in their electronic system rendering retrospective data inaccessible in the time-frame required for this report. Colorado West and the authors of this report are also aware of the highly sensitive nature of data on mental health measures, and were prepared to implement information sharing agreements as necessary to safe-guard any identifying protected health information.

As primary data from Colorado West was not available, nor does Colorado West track visit data specific to substance abuse, Community Health Initiative (CHI) was identified as a potential source of baseline data on this topic[116]. CHI is a public service organization with locations in Glenwood Springs and Carbondale. Working with partners from area agencies and organizations, such as Garfield County's Public Health Department and School District, its primary mission involves reducing substance abuse by sponsoring workplace and community prevention programs and providing outpatient treatment services for youth. While primary data were not available from CHI, several reports are publically available which detail recent projects in community prevention and provide summary statistics for measures pertaining to these issues.

One of these reports is the Garfield County Public Health Department's 2006 assessment on community needs[68]. Through their Health and Quality of Life Survey, conducted during the period of September-October 2005, the GCPH identified four types of health/quality-of-life problems most common to survey respondents. One of these common issues was the challenge associated with mental health and substance abuse. This topic was identified to be widespread across households of Garfield County, affecting a greater number of households than issues pertaining to medical/dental service access or environmental risk. Further, the survey found that when respondents reported mental health problems (defined as experiencing depression or stress), they also reported issues with substance abuse in the home and difficulties/restrictions to engaging in physical activity. Within the mental health and substance abuse domains, depression, anxiety and stress along with tobacco smoking and alcohol abuse were the top indicators of the burden of these conditions (Table 13).

Table 13: Data from the Garfield County Public Health Department 2006 Community Needs Survey

Health/Quality of Life Domain Assessed	Three Most Prevalent Conditions Reported	% All Respondents (n=740)
Household with member(s) affected by mental health issues	a) Depression/anxiety	17.2%
	b) Stress	15.4%
	c) Eating disorders	3.0%
Household with member(s) affected by substances abuse issues	a) Smoking using tobacco	10.4%
	b) Alcohol abuse	6.9%
	c) Drug abuse	1.5%

It is important to note that the survey respondents were self-selected through survey distribution at libraries, city halls, community centers, health clinics, and mailings to some randomly selected homes. Thus, the respondents did not represent a statistically chosen sample of Garfield County, however the authors noted that response came from a wide-range of individuals and were probably the "most valid information available on residents' health and quality-of-life experiences."

Another study available through CHI provides an analysis of discharge data from four Garfield County regional hospitals during the period 2003-2005 for persons whose diagnoses included either alcohol/drug abuse or suicidal behavior[69]. This study showed that of the 275 persons attributed to these discharge diagnoses during this period, 47 (17.1%) had an alcohol/drug abuse diagnosis and 228 (82.9%) had a diagnosis of suicidal behavior. (Table 14) This study only looked at count data of hospital admissions, so we cannot assess trends or compare rates of these conditions to expected rates or rates of other discharge diagnoses. While these data cannot be attributed directly to residents of Battlement Mesa, they suggest that substance abuse and suicidal ideation exist in the surrounding community. As such, they should be monitored and prevention measures should be implemented where possible.

Table 14: Data from the Garfield County Colorado Prevention Partners 2006 Local Needs Assessment Report on Alcohol./Drug Abuse and Suicidal Behavior

Hospital	Diagnostic Group		Total
	Alcohol/Drug Abuse	Suicidal Behavior	
Aspen Valley Hospital	12	32	44
Grand River Medical Center	0	8	8
Vail Valley Medical Center	17	133	150
Valley View Hospital	18	55	73
Total	**47** (17.1%)	**228** (82.9%)	**275**

Further analysis in this report showed fewer admissions for alcohol/substance abuse and suicidal behavior treatment during the summer months, with the highest numbers occurring in December and the late winter months. Also seen in this data were that significantly more men were treated for substance abuse and significantly more women for suicidal behavior; the mean ages of the two diagnoses groups were 41 and 39 respectively.

C2.4 Sexually Transmitted Infections

In Colorado, several sexually transmitted infections (STIs) are reportable to the state health department, including Chlamydia, Gonorrhea, Syphilis and HIV. De-identified sexually transmitted infection data were available by request from the Colorado Department of Public Health and Environment (CDPHE). Incident sexually transmitted infection cases were obtained for the years 2005-2009 for all zip codes in Garfield County.

Table 15 displays frequency of cases for the two sexually transmitted infection's of greatest prevalence in Battlement Mesa and Garfield County. Due to small numbers, it is difficult to draw conclusions about proportion or distribution of cases among Battlement Mesa residents, or make valid comparisons to a larger cohort such as Garfield County. However, these data show that Chlamydia is more prevalent in the female population, with between 70-85% of the Garfield County cases and 60-100% of the Battlement Mesa cases occurring in females. During the period 2005-2007, between 46-60% of Gonorrhea case occurred in Garfield County females, yet that proportion has decreased to around 20% in recent years. A similar assessment of Battlement Mesa cases cannot be made due to low numbers.

Table 15: Chlamydia and Gonorrhea Cases by Gender, Garfield County and Battlement Mesa, 2005-2009

sexually transmitted infection	Year	Garfield County N (% of Total)			Battlement Mesa N (% of Total)		
		Male	Female	Total N	Male	Female	Total N
Chlamydia	2005	13 (25.0)	39 (75.0)	52	2 (33.3)	4 (66.7)	6
	2006	12 (16.7)	60 (83.3)	72	0 (0.0)	6 (100.0)	6
	2007	25 (28.1)	64 (71.9)	89	7 (36.8)	12 (63.2)	19
	2008	27 (22.5)	93 (77.5)	120	0 (0.0)	10 (100.0)	10
	2009	21 (29.2)	51 (70.8)	72	1 (10.0)	9 (90.0)	10
Gonorrhea	2005	2 (50.0)	2 (50.0)	4	1 (100)	0 (0)	1
	2006	4 (40.0)	6 (60.0)	10	0 (0)	1 (100)	1
	2007	7 (53.9)	6 (46.1)	13	0 (n/a)	0 (n/a)	0
	2008	4 (80.0)	1 (20.0)	5	0 (n/a)	0 (n/a)	0
	2009	3 (75.0)	1 (25.0)	4	1 (100)	0 (0)	1

Using epidemiologic methods described below, we calculated rates of sexually transmitted infection for Battlement Mesa residents (defined as zip codes 81635 and 81636) as well rates for all residents of Garfield County combined.

Rather than assess only a count of the number of cases, evaluating a rate provides perspective on the measure of the frequency with which a disease occurs in a population over a specified period of time. Population incidence rates can be calculated using the number of new cases observed in the numerator and the mid-year population as the denominator. Using this method, sexually transmitted infection rates for Garfield County were calculated using population estimates from the U.S. Census Bureau, which produces annual mid-year estimates of total population for states, counties and other sub-county units (Table 16) [4]. For the period 2005-2009, these population estimates were derived from 2000 U.S. Census base data.

Within the Garfield County sexually transmitted infection dataset, Battlement Mesas cases were defined as occurring for residents of zip codes 81635 and 81636. Zip code 81635 denotes physical addresses in both the Battlement Mesa and the town of Parachute, while 81636 is used solely for Post Office (PO) boxes. Because the town of Parachute shares a zip code with Battlement Mesa, we were not able to exclude the population from these analyses. Because U.S. Census Bureau mid-year population estimates are not available for unincorporated places, such as the Battlement Mesa PUD, the population for 2005-2009 was calculated using the equivalent percentage changes as provided for Garfield County, described above and in Table 16.

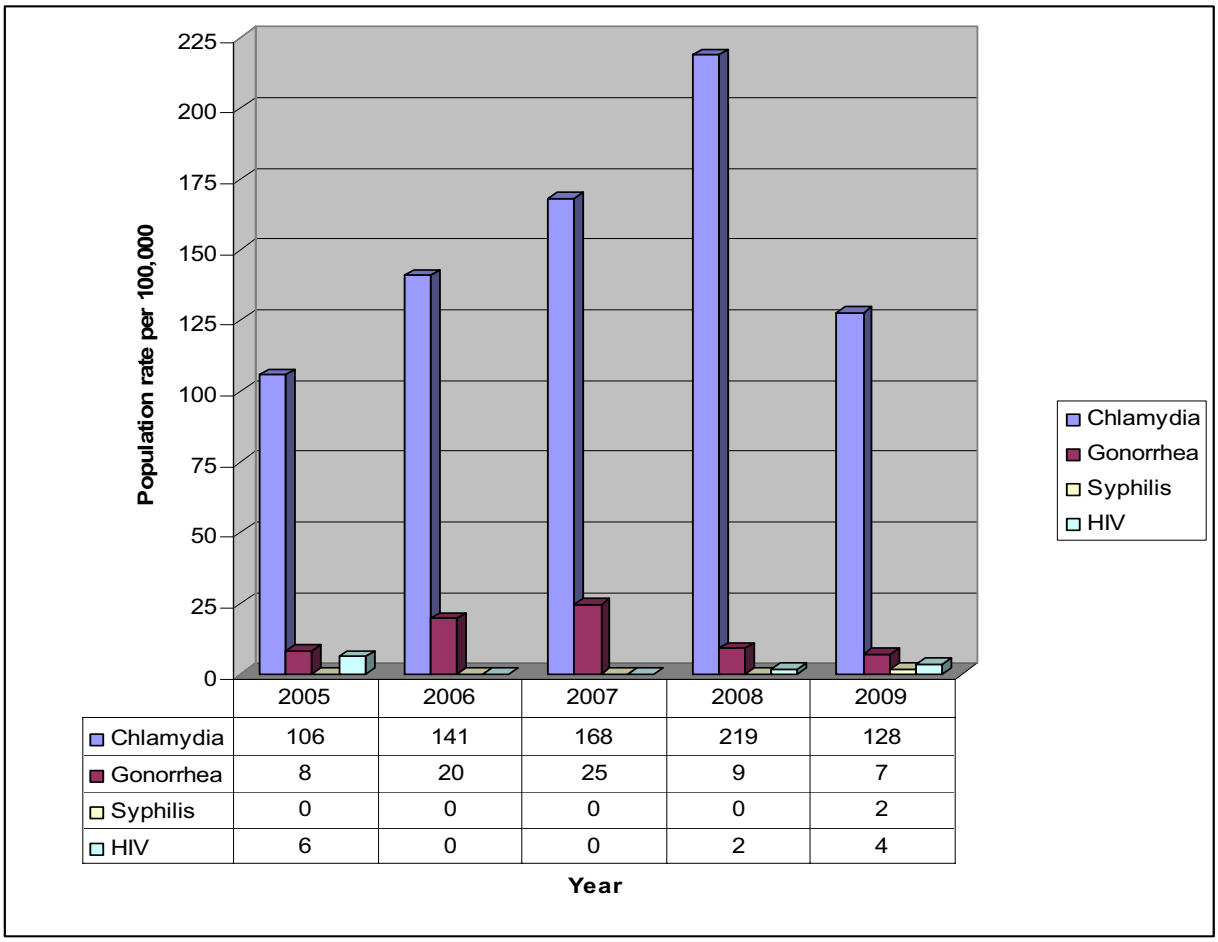
Table 4: Population Estimates for Garfield County and the Battlement Mesa PUD, 2005-2009

	2000 U.S. Census Population Estimate	2005	2006	2007	2008	2009
Garfield County Population Est. Provided by the US Census	43,791	49,177	51,111	52,965	54,838	56,298
Percent Change in Garfield County Population, Calculated & Applied to Battlement Mesa	(Baseline)	12.3 %	3.93 %	3.63 %	3.54 %	2.66 %
Battlement Mesa PUD Population Est.	5,041	5,661	5,884	6,097	6,313	6,481

Because the oil & gas industry boom occurred in 2003, in-migrant populations who have since remained in Garfield County and Battlement Mesas were not counted in the 2000 Census data. As such, these mid-year population estimates may be underestimate of the true population levels and may potentially inflate the observed the rates. Additionally, these population estimates for are not age adjusted. Never-the-less, this method represents the most accurate estimate available to assess trends in sexually transmitted infection incidence rates over time.

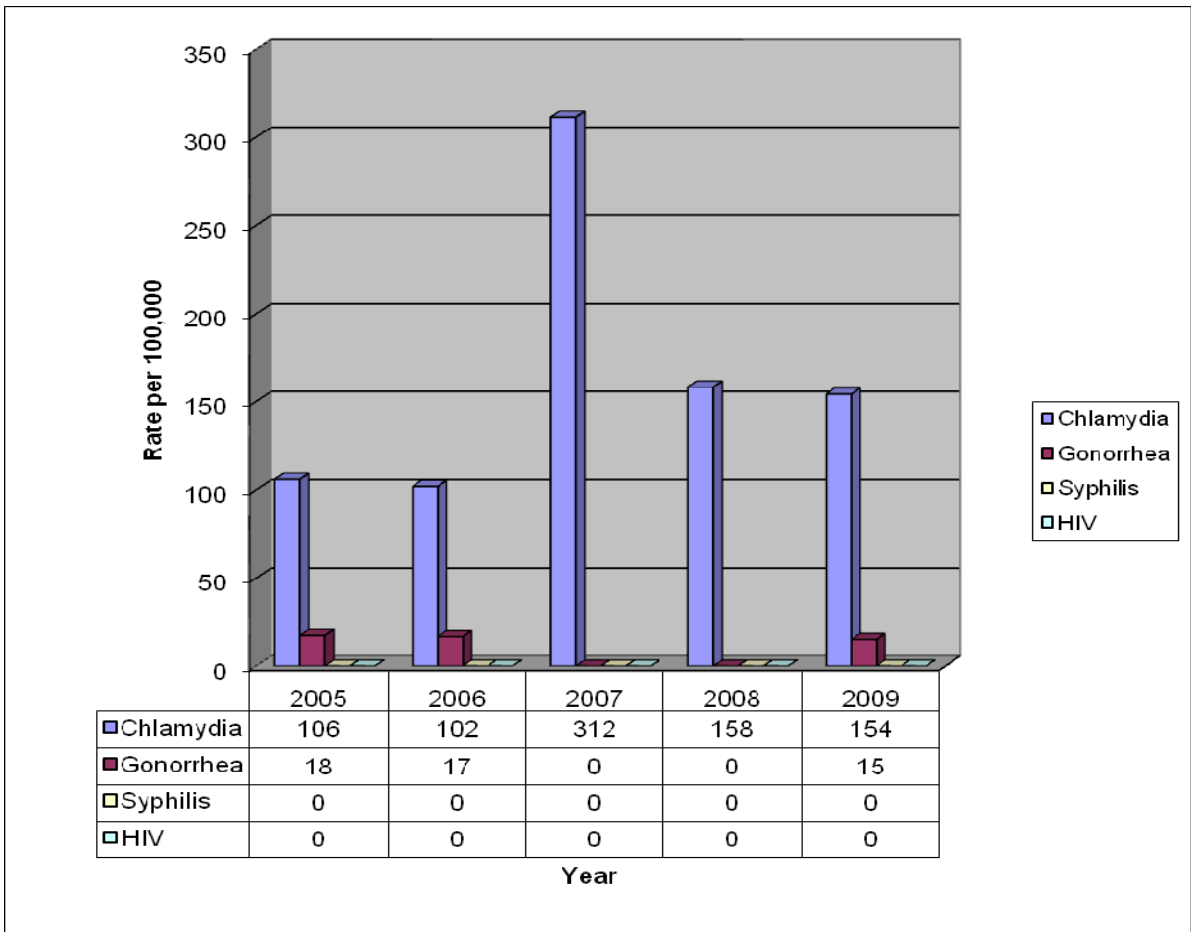
Garfield County experienced a steady increase in Chlamydia rates for the period 2005-2008, yet there was a noticeable decline in incidence in 2009. (Figure 4) In comparison, Battlement Mesa residents experienced stable rates of Chlamydia in 2005-06, yet saw a sharp increase in the case rate in 2007, which then decreased and remained stable in 2008-09. (Figure 5) In tandem with the increase of Chlamydia, rates of new Gonorrhea also increased significantly in Garfield County from 8 cases/100,00 population in 2005 to 25 cases/100,000 population in 2007, but declined and have remained stable since 2008. (Figure 4) The Gonorrhea case rate for Battlement Mesa did not experience the same trend, and has not increased over 18 cases per 100,000 population since 2005, the equivalent of < 1 case per 5,000 people. (Figure 5) It is worth noting that the numbers of cases for Battlement Mesa are very small, making it difficult to assess population trends and comparison with the larger cohort of Garfield County. Rates of Syphilis and HIV are extremely low for both Garfield County and Battlement Mesa. In fact, there were no cases of either recorded for residents of Battlement Mesa during this evaluation period.

Figure 4: Rates of Sexually Transmitted Infection, Garfield County, 2005-2009



	2005	2006	2007	2008	2009
Chlamydia	106	141	168	219	128
Gonorrhea	8	20	25	9	7
Syphilis	0	0	0	0	2
HIV	6	0	0	2	4

Figure 5: Rates of Sexually Transmitted Infection, Battlement Mesa Zip Codes 81635 & 81636, 2005-2009



	2005	2006	2007	2008	2009
Chlamydia	106	102	312	158	154
Gonorrhea	18	17	0	0	15
Syphilis	0	0	0	0	0
HIV	0	0	0	0	0

C2.5 Limitations of Social Determinants of Health

Data on measures of community well-being are rife with limitations, with the repeating theme being lack of primary data available for systematic review and analysis, especially at the level of a small community such as Battlement Mesa. For many key-indicators of community health, aggregate data may very well be available at the county, state or national level, yet these may not be representative of the local community due to local customs, culture and social structure in place in microcosms of a bigger community. In this case report, data sources were mostly limited to Garfield County and we were unable to locate data specific to the residents and the localized area of the Battlement Mesa PUD. Some additional limitations are as follows:

- U.S. Census and other types of nationally complied statistics are not available to the level of unincorporated areas, such as the Battlement Mesa PUD. Incorporating the Battlement Mesa PUD may increase access to health statistics collected and disseminated by the federal government.

- Data on student-teacher ratios for the local school district are not publically available beyond 2004, and so are not included as part of this baseline assessment. This information is crucial in order to fully characterize impact of the project on the local education system.

- While crime statistics from the Parachute Police Department represent a reasonable surrogate for the Battlement Mesa PUD, it is not possible to assess data only on crimes specifically occurring in Battlement Mesa. With publically available data, it is also not possible to evaluate criminal conduct on the basis of residence location or length of residence.

- Community level data on outpatient treatment for mental health, substance abuse and suicide are not readily available for public access. Analysis of hospital discharge data (in-patient) may provide additional perspective on the burden of these conditions.

- While local data on sexually transmitted infections was available, incidence rates were calculated using population estimates, which may not accurately reflect the true population at any given time. It is also difficult to assess statistical significance of the sexually transmitted infection data due to very low numbers.

C2.6 Summary and Conclusions for Social Determinants of Health

Of all the potential indicators of community health, only certain data were publically available and readily accessible in the time frame of this project to evaluate the health of resident of the Battlement Mesa PUD. As such, we were able to analyze data on education, criminal activity and sexually transmitted infections, obtained through web-based reports or by request of local agencies. The years 2005-2008 appear to be a period of increase for all three of these indicators, with apparent rises in local school enrollment as well as criminal activity. Incidence rates of sexually transmitted infection in Garfield County (Chlamydia and Gonorrhea) also increased during this period, accompanied by a noteworthy increase in the rate of Chlamydia observed in the Battlement Mesa population in 2007. Numbers in all categories appear to decrease in 2009. The mechanisms for obtaining and reviewing the community health indicators of education, crime and sexually transmitted infection are adequate for timely and prospective monitoring. Comparative review of these data should continue in a similar fashion to evaluate any changes and trends. Future analysis should focus on potential causal associations correlated with shifts in population or community environment that may be brought about by nearby industrial development.

Longitudinal source data for mental health, substance abuse and suicide were not available for analysis, however the 2006 survey data indicates upwards of 17% of residents were burdened by one of these conditions. Additional efforts to evaluate these issues should focus on pursuit of a relevant data source for outpatient visits or investigation of another source for surrogate data that are representative of these measures.

APPENDIX D: HUMAN HEALTH RISK ASSESSMENT

Attachments

Attachment 1: BCC letter
Attachment 2: Surface Use Agreement

Human Health Risk Assessment for Battlement Mesa Health Impact Assessment

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Disclaimer

The research team that performed this work has no conflicts of interest to report, financial or otherwise. The statements made in the Health Impact Assessment and Human Health Risk Assessment are the work product of the authors and do not represent the position of any university, private company, government agency, community group or any other organization.

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ACRONYMS

AI air intake
AIQ Air Quality Standard
Antero Antero Resources Corporation
APCD Air Pollution Control Division
AT averaging time
ATSDR Agency for Toxic Substances and Disease Registry
bgs below ground surface
BMC Battlement Mesa Company
BTEX benzene, toluene, ethylbenzene, and xylene
BTV background threshold value
BW body weight
CDPHE Colorado Department of Public Health and Environment
cm^2 square centimeters
COGCC Colorado Oil and Gas Conservation Commission
COPC contaminant of potential concern
CSM conceptual site model
DNPH 2,4-dinitrophenylhydrazine
ED exposure duration
EF exposure frequency
ET exposure time
EPA United States Environmental Protection Agency
EPC exposure point concentration
ERG Eastern Research Group
GCPHD Garfield County Public Health Department
HHRA Human Health Risk Assessment
HI hazard index
HIA Health Impact Assessement
HQ hazard quotient
IRIS Integrated Risk Information System
kg kilogram
IUR inhalation unit risk
L liter
MEI maximum exposed individual
MRL method reporting limit
NIOSH
PAH polycyclic aromatic hydrocarbon
PAR population attributable risk
PM particulate matter
$PM_{2.5}$ particulate matter of 2.5 microns or less
PM_{10} particulate matter of ten microns or less
ppb parts per billion
ppm parts per million
PPRTVs Provisional Peer-Reviewed Toxicity Values
PRG preliminary remediation goal

PUD Planned urban development
RAGs EPA Risk Assessment Guidance for Superfund
RfC reference concentration
RfD reference dose
RSL regional screening level
SNMOC speciated non-methane organic compound
TWA time weighted average
UCL upper confidence limit
VOC volatile organic compound
$\mu g/m^3$ micrograms per cubic meter

1 Introduction

This human health risk assessment (HHRA) was conducted in support of the Battlement Mesa health impact assessment (HIA). The HIA seeks to evaluate the potential health impacts of Antero Resources Corporation's (Antero) proposed natural gas production operations within the Battlement Mesa planned urban development (PUD). This HHRA specifically addresses potential impacts to the health of Battlement Mesa residents that may be exposed to chemicals released from natural gas production operations to ambient air, surface water, groundwater, and soil. The resident receptor refers to both an adults and children. The child resident receptor refers to children. Three exposure scenarios were evaluated:

(1) A long-term chronic exposure scenario for all Battlement Mesa residents
(2) A long-term chronic exposure scenario for Battlement Mesa residents living adjacent to a well pad.
(3) An acute exposure scenario for Battlement Mesa child residents living adjacent to a well pad

The risk assessment was conducted according to standard United States Environmental Protection Agency (EPA) methodology, including:

(1) EPA Risk Assessment Guidance for Superfund (RAGS) Part Volume 1 Human Health Evaluation Manual (Part A) Interim Final (EPA 1989)
(2) Residual Risk Report to Congress and the EPA Risk Assessment Reference Library (EPA 2004)
(3) ProUCL Version 4.00.05 Technical Guide (Draft). EPA/600/R-07/041 (EPA 2010).

This HHRA is organized as follows:

- Introduction
- Chemical Data Evaluation and Selection of contaminants of potential concern (COPCs)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis
- Summary and Conclusion
- Data Gaps
- References

1.1 Site Description

The Battlement Mesa Planned Urban Development (PUD) is a 3,200-acre unincorporated jurisdiction divided into several neighborhoods, the names of which are:

- The Reserve
- Battlement Creek Village
- Willow Creek Village
- Willow Ridge Apartments
- Willow Park Apartments
- Eagles Point
- Valley View Village
- Fairway Villas
- Stone Ridge Village
- Monument Creek Village
- Canyon View Village
- Mesa Ridge
- Mesa Vista
- Tamarisk Village
- Tamarisk Meadows
- Saddleback Village

The community sits on a 500 foot mesa approximately to the south of Colorado River and mesas continue to rise above the community for another 500-1000 feet.

1.1.1 Geology

Appendix B of the HIA provides a description of the sites geology.

1.1.2 Population

The most reliable estimates of Battlement Mesa PUD residents' demographic characteristics come from the 2000 US Census. It is important to keep in mind that the demographics of the PUD have likely changed since 2000, though without the most-recent census data it is difficult to tell how or by how much the community makeup has changed.

The 2000 United States census was used to obtain the most accurate population counts as well as information on age, gender, and racial composition for the Battlement Mesa/Parachute zip code 81635 (Zip code 81636 is used for post office boxes and there fore is not included in the demographic data). According to the 2000 United States census estimates, there total population of the Battlement Mesa/Parachute zip code was 5,041; 49.3 percent of the Battlement Mesa/Parachute population was female and 50.7 percent male. The median age was 37.5 years. 26.0 percent of the population were under 18 years of age, 7.2 percent under 5 years, and 19.8 percent were 65 years and older. For people reporting race in Battlement Mesa/Parachute, 93.4 percent identified as White, 0.5

percent as Black or African American; 9.7 percent of the population identified as Hispanic or Latino (of any race).

The Battlement Mesa PUD is often described as a "retirement community" (Miller et al. 2005). While it is difficult to precisely define what is and what is not a "retirement community," several objective measures reflect characteristics of Battlement Mesa's population. In Colorado in 2000, 9.7 percent of the population was 65 years and over compared to 19.8 percent of the population in the Battlement Mesa/Parachute zip code. Furthermore, whereas 63.9% of the United States population (16 and over) was participating in the labor force, only 48.9% of Battlement Mesa residents were either working or looking for work in 2000. There is a 40-unit nursing home in the Battlement Mesa PUD serving seniors of low to moderate income (Miller et al. 2005).

While the lower labor force participation rate of Battlement Mesa residents and the higher proportion of people 65 and over are likely indicators of a high retiree population in the PUD, almost half of the PUD residents 16 and over were either working or looking for work. More than a quarter of the family households in Battlement Mesa had children under the age of 18 (27.2%). While the Battlement Mesa PUD is home to higher proportions of people 65 and over than the US as a whole, the community is not homogeneously "retired."

1.1.3 Economy

Currently, the Battlement Mesa community is entirely residential. The only businesses in the PUD support the local residents. While there has been extensive natural gas drilling in the area surrounding the PUD, there is currently no industrial activity within the PUD itself. Several natural gas operators operate wells in the area surrounding Battlement Mesa. The businesses with in the PUD include:

- A grocery store
- Gas stations
- Several medical facilities
- A public golf course
- Banks
- A café
- A recreation center (paid for by homeowner association dues)
- A local newspaper

In addition to the local businesses, the PUD is home to two churches and two schools – Underwood Elementary (grades K-5) and St. John Middle School (grades 6-8). Battlement Mesa students attend Grand Valley High School in Parachute for grades 9-12.

1.1.4 Antero's Proposed Plan

In the Fall of 2009, Antero announced plans to purchase surface rights and mineral rights from the BMC. Along with this, Antero indicated their intent to drill for natural gas

within the Battlement Mesa PUD. Antero plans to drill approximately 200 natural gas wells on ten well pads (approximately 20 wells per pad) in three phases spanning a total of 5 years. Each well is currently estimated to produce natural gas for 20 to 30 years, after which the well would be abandoned. The possibility exists for some wells to be re-developed.

1.2 Previous Risk Assessments

Four risk assessments have been conducted in Garfield County over the past 8 years to determine if air borne emissions from natural gas production operations have an impact on public health. As described in the following sections, each of these risk assessments evaluated one specific set of data. This HHRA incorporated several of the data sets used in previous risk assessments to provide a more comprehensive evaluation of the potential risks to human health from natural gas production operations.

1.2.1 2002 Community-based Short-term Ambient Air Screening Study in Garfield County for Oil and Gas Related Activities (CDPHE 2002)

The Colorado Department of Public Health and Environment (CDPHE) first conducted a limited screening level risk assessment using ambient air data from 20 samples collected in 2002 by the EPA in response to a request of the Grand Valley Citizen's Alliance. Samples were collected over 24- and 8-hour intervals at wells and residences located in the Parachute valley. The samples were analyzed for 42 volatile organic compounds (VOCs) by EPA method TO-14. Maximum concentrations of acetone, methyl ethyl ketone, benzene, toluene, and xylenes (the only contaminants detected in the samples) were compared to EPA region 9 preliminary remediation goals (PRGs) for residential ambient air. PRGs are protective risk-based levels below which chronic health effects are not expected to occur. Benzene, a known human carcinogen, was the only contaminant, at a concentration of 6.5 $\mu g/m^3$, that exceeded its PRG of 0.23 $\mu g/m^3$. None of the non-carcinogenic VOCs were detected at concentrations that would pose a significant health risk to area residents. While the cancer risk from benzene was within EPA's generally acceptable range of 1E-06 to 1E-04, it was greater than the 1E-06 (l cancer in a million). The report concluded benzene may warrant further review pertaining to exposure scenario assumptions and typical exposure concentrations.

1.2.2 2005-2007 Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment (CDPHE 2007)

CDPHE conducted a second more rigorous screening level HHRA in accordance with Tier-1 of EPA's Air Toxic Risk Assessment Library (EPA, 2004) in 2007. The data for risk assessment was collected from 14 fixed air monitoring sites for 24-hour intervals on a once per month or once per quarter basis. The 14 sites were divided into three categories: Oil and Gas Development (eight sites); Urban (four sites); and Rural

Background (two sites). In addition, grab samples were also collected at 27 locations based on odor complaints. All samples were analyzed for VOCs by EPA method TO-14a/15.

This HHRA concluded that, the non-cancer hazards on either a chronic or short-term basis do not exceed the acceptable health based standard and the cancer risk estimates are at, or slightly above, the upper-end of EPA's acceptable risk range (1 to 100 excess cancers per 1 million individuals). However, the HHRA identified the need for continued air monitoring and source apportionment and strongly supported the need to manage the risk posed by potential exposure of residents of the Garfield County to air toxics as a result of the dramatic increase in oil and gas development for the following reasons:

(1) The estimated cancer risks and the non-cancer hazards across the rural background areas were significantly lower than those across the oil and gas development and urban areas.
(2) Although total cancer risks were slightly higher in the urban areas than those in the oil and gas areas, the major contributors of cancer risk were different between the two areas. Benzene, a known human carcinogen, was the major contributor of risk across the oil and gas development areas, while trichloroethene and 1,4-dichlorobenzene were the major contributors in the urban areas.
(3) The cancer risk estimates for benzene across the oil and gas development areas were significantly higher than those across the urban and rural background areas.
(4) The high-end, short-term, non-cancer hazard estimates across the oil and gas development area exceed an acceptable value of one for benzene (e.g., Hazard Quotient [HQs] of 2 or 3) showing the potential for adverse health effects in areas of oil and gas development.
(5) The high-end acute non-cancer hazard estimates for benzene across the oil and gas development area, as represented by several grab sampling sites collected during observed odor events, exceed an acceptable value of one (e.g., HQs of 2 to 6) showing the potential for adverse health effects associated with odor events.
(6) Exposures may be underestimated because increases in air concentrations of VOCs over time were not evaluated and several important air toxics, such as polycyclic aromatic hydrocarbons (PAHs) were not evaluated.

1.2.3 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado (Coons and Walker, 2008)

The Saccomanno Research Institute sought to evaluate the risk associated air, water, and soil contaminants associated with natural gas operations. A lack of data on pollutant concentrations in water and soil limited the quantitative evaluation to contaminants in air. Air concentrations were estimated with a Gaussian plume model, based on meteorological conditions specific to Garfield County (measured at the Rifle Airport) and "typical" emission rates of benzene, toluene, and m&p-xylene from natural gas and condensate to predict air contaminant concentrations that may occur during natural gas operations. It should be noted that these concentrations were not based on actual data

collected in Garfield County. Contaminant concentrations for five specific natural gas operations were modeled: flow back with no recovery of natural gas, flow back with 93% recovery of natural gas, wellhead glycol dehydration, uncontrolled emissions from condensate tanks, and condensate emissions controlled by a combustion device. Risks to human health were calculated from the modeled air concentrations according to EPA's RAGS Volume 1 (EPA 1989).

The results of the risk assessment indicate that the cancer risk from benzene for 70 years of exposure in air exceeds EPA's generally accepted range of 1E-06 to 1E-04 for flow back with no gas recovery for distances up to 500 meters (1640 feet) downwind of the well; flow back with 93% gas recovery for distances up to 75 meters (246 feet) downwind of the well; wellhead glycol dehydration for distances up to 50 meters (164 feet) downwind of the well; and uncontrolled condensate emissions for distances up to 100 meters (328 feet) downwind of the tank.

The results of the risk assessment also indicated that acute (1-<14 day exposure) reference concentrations (RfCs) for non-cancer hazards from benzene and m&p-xylene may be exceeded for flow back with no gas recovery for distances up to 250 meters (820 feet) downwind of the well and uncontrolled condensate emissions for distances, up to 55 meters (180 feet) downwind of the tank.

The risk assessment concluded that benzene emissions during uncontrolled flow back present the greatest threat of cancer risk and non-cancer hazard and that these effects may occur in people who spend one or more days within 250 meters (820 feet) downwind of the natural gas well during flow back operations with no gas recovery. This observation has been sited as a rationale for moving Antero's proposed set back from 500 feet to 1000 feet. Whether or not this finding would apply to Antero's proposed wells, depends on the extent to which Antero intends to control flow back emissions. In addition, the exposure concentrations in this risk assessment were modeled using "typical" emission rates rather than site specific emission rates and meteorological data from the Rifle airport. Actual emission rates and meteorological conditions in the PUD could be different than those used in the model. Therefore, the modeled exposure concentrations may not be applicable to Antero's natural gas production operations within the PUD.

1.2.4 2010 Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment Inhalation of Volatile Organic Compounds Measured in 2008 Air Quality Monitoring Study (CDPHE 2010).

CDPHE conducted a rigorous screening level HHRA in accordance with Tier-1 of EPA's Air Toxic Risk Assessment Library (EPA, 2004) using data for speciated non-methane organic compounds (SNMOCs) and carbonyls collected by the Garfield County Public Health Department (GCPHD) during the 2008 air quality monitoring study. GCPHD collected 24-hour air samples from four fixed monitoring sites on a weekly (SNMOCs) or bi-weekly (carbonyls) basis over the course of 12 months. The four monitoring sites,

Bell-Melton Ranch, Brock, Parachute, and Rifle, were located in close proximity (<1.5 mile) to oil and gas production operations in the rural and urban oil and gas development areas.

The HHRA concluded that there is a potential for public health impacts across the oil and gas development areas in Garfield County for the following reasons.

- The estimated cumulative lifetime cancer risks for the crotonaldehyde, benzene, formaldehyde, ethylbenzene, 1,3-butadiene, and acetylaldehyde are at or slightly above the high-end of EPA's acceptable cancer risk range of 1 to 100 excess cancers in a million (1E-06 to 1E-04) across all monitoring sites.
- Each of the 20 individual air toxics assessed at any monitoring site have a chronic non-cancer hazard estimate well below an acceptable value of one. However, when accounting for the cumulative chronic non-cancer hazards for all of these 20 air toxics the chronic non-cancer hazard estimate is just below the acceptable level of one and the non-cancer hazards are most likely underestimated because non-cancer toxicity values were not available for 65 contaminants. The major contributing chemicals to the cumulative hazard estimate are acetaldehyde, formaldehyde, trimethylbenzenes, and benzene.
- The cumulative health impacts of 86 detected ambient air toxics cannot be determined due to the absence of EPA-reviewed toxicity values for 65 air toxics.

2 Data Evaluation and Selection of COPCs

2.1 Sources of data

Several sources of data collected in Garfield County between 2005 and 2010 were used for this HHRA.

2.1.1 2005 to 2007 Garfield County Ambient Air Quality Study

Garfield County contracted Colorado Mountain College (CMC) to collect ambient air samples from June 2005 through May 2007 for analyses of VOCs and particulate matter of ten microns or less (PM_{10}). The samples for VOC analyses were collected over 24-hours interval into Summa-polished stainless steel canisters (Summa canisters) either monthly or quarterly from 14 monitoring stations. In addition, 28 15-second grab samples were collected into Summa canisters by residents when they observed odors. Columbia Analytical Services analyzed the samples for 43 VOCs by EPA Method TO-14/15a. CDPHE provided some support for equipment and installations as well as data processing and analysis support. CDPHE performed a screening level risk assessment for ambient air with this data (CDPHE 2007).

The VOC data from 29 samples collected from the rural oil and gas impacted Bell-Melton Ranch monitoring station, and 18 samples collected from the rural Silt-Daley and Silt-Cox monitoring stations were employed in this HHRA. The PM_{10} data is discussed in the Uncertainty Section.

2.1.2 2008 Garfield County Air Toxics Study

The GCPHD, in conjunction with the CPDHE's Air Pollution Control Division (APCD), and the aid of a Regional Geographic Initiatives Grant administered by the EPA conducted a study of air toxics associated with natural gas production operations in the summer of 2008. Ambient air samples were collected over 24-hour intervals into Summa canisters and sent to Eastern Research Group (ERG) for analyses of 78 SNMOCs by EPA method TO-12. The samples were collected at each cardinal direction from the perimeter of eight well pads during drilling and well completion activities (four locations for each activity). In addition, one background sample was collected for each location. The well completion and background data was employed in this HHRA.

Data also was collected for particulate matter of 2.5 microns or less ($PM_{2.5}$), real time VOCs, and meteorology during the 2008 air toxics study. This data is discussed in Uncertainty Section.

2.1.3 2008 to 2010 Garfield County Ambient Air Study

The GCPHD collected ambient air samples from five monitoring stations over 24-hour intervals and shipped the samples to ERG for analyses of 78 SNMOCs by EPA method TO-12 and 11 carbonyls by EPA method TO-11a. Samples for SNMOC analysis were collected into Summa canisters every 6 days. Samples for carbonyl analysis were collected onto pre-treated 2,4-dinitrophenylhydrazine (DNPH) cartridges every 12 days. CDPHE performed an annual screening level risk assessment for ambient air with the data collected in 2008 (CDPHE 2010)

The data from 188 samples collected from the Bell-Melton Ranch monitoring station from January 2008 through March 2010 were employed in this HHRA. Ozone, PM_{10}, and $PM_{2.5}$ data collected at the Rifle and Parachute monitoring stations will be discussed in the Uncertainty Section.

2.1.4 2010 annual groundwater quality results – Battlement Mesa Water treatment plant

The Battlement Water Treatment Plant collected one groundwater sample from one of the back-up groundwater wells in July 2010 and submitted the sample to Accutest Laboratories in Wheat Ridge Colorado for analysis of VOCs by EPA method 524.2, endothall by EPA method 548.1, 1,2-dibromo-3-chloropropane and 1,2-dibromoethane by EPA method 504.1, herbicides by EPA method 515.4, carbamates by EPA method 531.1, and pesticides by EPA method 508. This data was used to evaluate baseline groundwater conditions.

2.2 Sample Quantitation Limit Evaluation

Method reporting limits (MRLs) were adjusted for sample characteristics, sample preparation, and analytical adjustments. Therefore, the MRL are equivalent to the sample quantitation limit. Chemicals reported as not detected are considered to have a concentration less than the MRL for the purposes of the HHRA.

The MRLs were compared to EPA regional screening levels (RSLs) (EPA 2010) to determine if they were adequate for the purposes of the HHRA. RSLs are protective health-based levels below which chronic health effects are not expected to occur. If the RSL is greater than the MRL, the MRL is adequate for determining the chemical is not present at a concentration that may impact health. If the RSL is less than the MRL, the MRL is not adequate to determine whether the chemical is present at a concentration which may impact health.

2.2.1 2005 to 2007 VOC data

Table 2-1 summarizes the MRLs for chemicals with a detection frequency less than five percent for the VOC data collected between 2005 and 2007. For the following 15 VOCs with a detection frequency of less than five percent, the EPA RSL was less than the minimum MRL:

- 1,2-Dibromoethane
- 1,1,2,2-tetrachloroethane
- Bromodichloromethane
- 1,2-Dichloroethane
- Chloroform
- 1,1,2-Trichloroethane
- Vinyl Chloride
- 1,4-Dichlorobenzene
- 1,2-Dichloropropane
- Carbon Tetrachloride
- Tetrachloroethene
- cis-1,3-Dichloropropene
- Trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane

The data for these chemicals is not adequate to determine if the chemical is present at a concentration that may impact health, which contributes to the uncertainty of the HHRA, as discussed in Section 6.1.1.

2.2.2 2008 to 2010 data

Table 2-2 summarizes MRLs for chemicals with a detection frequency less than five percent for the SNOMC and carbonyl data collected between 2008 and 2010. EPA RSLs are not available for the six chemicals with detection frequencies less than five percent and the MRLs were not further evaluated.

2.2.3 Groundwater data

No contaminants were detected in the groundwater sampled by the Battlement Mesa Water Treatment Plant. Table 2-3 compares the MRLs to EPA RSLs for tap water. Out of 98 contaminants, 29 MRLs were greater than the EPA RSL. The data for these contaminants is not adequate to determine if the contaminant is present at a concentration that may impact health, which contributes to the uncertainty of the HHRA, as discussed in Section 6.1.1.

2.3 Data Reduction, Summary Statistics

The data was modified (reduced) as described in this section, for use in the HHRA. The section also discusses the summary statistics that were generated from the reduced data.

2.3.1 Duplicate Analyses

Duplicate analyses were reduced as follows:

1. For duplicate pairs, for which each sample had detectable quantities of a contaminant in question, the higher of the two concentrations was used in the HHRA, per RAGS (EPA 1989).
2. For duplicate pairs, for which neither sample had detectable quantities of a contaminant, the lower of the two MRLs was used in the HHRA.
3. For duplicate pairs, for which one sample contained a detectable quantity of contaminant in question and the other sample does not, the detectable quantity was used in the HHRA.

2.3.2 Summary Statistics of Sample Data

Data from samples collected at the Bell-Melton Ranch monitoring station from 2005 to 2007 was combined with data from samples collected at the Bell-Melton Ranch monitoring station from 2008 through March 2010 for evaluation of the long-term chronic exposure scenario for all Battlement Mesa residents. Table 2-4 contains summary statistics (number of samples, detection frequency, maximum detected concentrations, and mean) for the Bell-Melton Ranch monitoring station.

Table 2-5 contains summary statistics for the data from samples collected from the well completion sites, during the 2008 Air Toxics Study. This data was used with the Bell-Melton Ranch data described in the preceding paragraph to calculate a time-weighted average for residents living adjacent to a well pad and to evaluate acute exposures for the child resident living adjacent to a well pad.

Table 2-6 contains summary statistics for data from the grab samples collected during odor events in the 2005 to 2007 air monitoring study. This data was used to evaluate potential acute exposures for the child resident living adjacent to a well pad.

No contaminants were detected in the groundwater and summary statistics were not performed.

2.4 Background

The VOC data from the samples collected at the rural Silt-Daley and Silt-Cox monitoring sites during the 2005 to 2007 air monitoring study was combined with the SNMOC data from the samples collected during the 2008 air toxics study to compile a background

dataset. Samples have not been collected for carbonyls from background locations. Table 2-7 summarizes summary statistics for the background data set.

Table 2-7 also presents background threshold values (BTVs) computed per EPA guidance (EPA 2010). BTVs are background contaminant concentrations computed based upon the sampled data collected from the site- specific background locations. Site observations can be compared to BTVs. A site observation exceeding a BTV can be viewed as coming from a contaminated area of the site under study. For most of the SNMOCs, only seven samples were available for the background dataset. EPA recommends that the background data set contain greater than 8-10 observations for statistical computation of the BTV (EPA 2010). Therefore, the maximum detected concentration was selected as the BTV for chemicals with seven samples in the background dataset. EPA also recommends that the background data set contain at least 4-6 detected concentrations for statistical computation of the BTV (EPA 2010). Therefore, for chemicals with 18 or 25 samples but less than 4 detected concentrations in the background data set, the maximum detected concentration was assigned as the BTV. The maximum MRL was assigned as the BTV for chemicals that were not detected in the background dataset. For the remaining chemicals, BTVs were calculated using EPA's proUCL version 4.00.05 statistical software (EPA 2010).

These BTVs were not used in the selection of COPCs for the HHRA. Rather, they were used in the qualitative assessments and uncertainty assessment to evaluate COPCs without toxicity values and to add prospective for the calculated risk for COPCs with toxicity values.

2.5 Selection of Contaminants of Potential Concern and Exposure Point Concentrations

The EPA RSL is the level at which health effects are not expected to occur for a given contaminant and exposure route. To account for possible additive effects of multiple contaminants and exposure routes, the maximum detected concentration of each contaminant detected in each of the data sets described in Section 2.3.2 was compared to 1/10 EPA's RSL. If the maximum detected concentration exceeded 1/10 EPA's RSL, the contaminant was retained as a COPC in the HHRA. If the maximum concentration of the contaminant did not exceed 1/10 EPA RSL, the contaminant was not considered further in the HHRA. If EPA did not have an RSL for a contaminant, the contaminant was retained as COPC if its detection frequency was five percent or greater. Contaminants without an EPA RSL and with a detection frequency of less than five percent were not considered further in the HHRA.

2.5.1 Bell-Melton Ranch Monitoring Station

Table 2-4 summarizes the selection of COPCs from samples collected at the Bell-Melton Ranch monitoring station for the all Battlement Mesa residential chronic exposure scenario described in Section 3. 74 out of 126 chemicals were selected as COPCs. The

following nine chemicals were retained as COPCs because the maximum detected concentration exceeded 1/10 the EPA RSL:

- Acetaldehyde
- Formaldehyde
- 1,2,4-Trimethylbenzene
- 1,4-Dichlorobenzene
- Methylene chloride
- Benzene
- Ethylbenzene
- 1,3-Butadiene
- 2-Hexanone

There was no EPA RSL for the remaining 65 COPCs. They were retained because they were detected in 5 percent or more of the samples.

The EPA recommends that the 95 percent upper confidence limit (UCL) of the arithmetic mean concentration be used as the Exposure Point Concentration (EPC) in calculating exposure and risk for contaminants with 10 or more detections. The 95 percent UCL was calculated for COPCs with 10 or more detections using the EPA ProUCL version 4.00.05 software (EPA 2010). Per current EPA guidance, all non-detect sample results were assigned a value at the MRL (EPA 2010). If the 95 percent UCL was greater than the maximum detected concentration, the maximum detected concentration was assigned as the EPC. For COPCs with less than 10 detections, the maximum detected concentration was assigned as the EPC. The EPC values for COPCs from the Bell-Melton monitoring station are summarized in Table 2-8. Also included in Table 2-8 are 95% UCLs and EPCs from the Bell-Melton Ranch Monitoring stations that were identified as COPCs in the well completion data.

2.5.2 Contaminants of Potential Concern Well Completion

Table 2-5 summarizes the selection of COPCs from samples collected in the 2008 air toxics study during well completion activities. In addition, COPCs identified from the Bell-Melton Ranch data set that were not measured in the 2008 air toxics study were identified as COPCs. 73 contaminants were selected as COPCs. The following 13 contaminants were retained as COPCs because the maximum detected concentration exceeded 1/10 the EPA RSL or they were identified as COPCs in the Bell-Melton Ranch data set.

- 1,2,4-Trimethylbenzene
- 1,3-Butadiene
- Benzene
- Ethylbenzene
- m&p-Xylene

- n-Hexane
- n-Nonane
- n-Pentane
- Acetaldehyde
- Formaldehyde
- 1,4-Dichlorobenzene
- Methylene chloride
- 2-Hexanone

There was no EPA RSL for the remaining 61 COPCs, which were retained because their detection frequency was 5 percent or greater.

The maximum detected concentrations were observed in the sample collected downwind of an Antero well during flow back operations. Because flow back is one of the operations with the greatest potential for emissions of contaminants, this maximum concentration assigned as the EPC. In addition, samples were collected over a 24-hour interval which may have diluted out peak emissions during flow back operations.

2.5.3 Chemicals of Potential Concern Odor events

Table 2-6 summarizes the selection of COPCs from grab samples collected when odors were observed in the 2005 -2007 ambient air monitoring study. In addition, COPCs identified from the Bell-Melton Ranch data set or 2008 air toxics study that were not measured in the 2005-2007 study were identified as COPCs. The following 14 contaminants were selected as COPCs because the maximum detected concentration exceeded 1/10 the EPA RSL or they were identified as COPCs in the Bell-Melton Ranch or well completion data set.

- Benzene
- Ethylbenzene
- m&p-Xylene
- o-Xylene
- Toluene
- Chloroform
- 1,2,4-Trimethylbenzene
- 1,3-Butadiene
- n-Hexane
- 2-Hexanone
- n-Nonane
- n-Pentane
- Acetaldehyde
- Formaldehyde

The maximum concentration assigned as the EPC because the maximum possible exposure was desirable in the evaluation of acute exposure for the maximum exposed individual (MEI).

2.6 Observed Trends for Select COPCs

Temporal trends were evaluated for select COPCs from the five year of data that have been collected in Garfield County.

Figure 2-1 illustrates temporal trends for BTEX at the Bell-Melton Ranch monitoring station from 2005 to 2010. There is a consistent seasonal pattern for BTEX with higher concentrations in the winter than the summer, with the exception of one high concentration measured in August 2008. Overall, it does not appear that BTEX concentrations are increasing at the Bell-Melton Ranch monitoring site.

Figure 2-2 illustrates temporal trends for formaldehyde, crotonaldehyde, and acetylaldehyde at the Bell Melton Ranch monitoring station from 2008 to 2010. A consistent seasonal pattern for crotonaldehyde is apparent, with the highest concentrations observed in the summer months. The seasonal pattern is not as apparent for formaldehyde or acetylaldehyde. Overall, it does not appear that carbonyl concentrations are increasing at the Bell-Melton Ranch monitoring site.

Figure 2-2 also show a formaldehyde outlier in the sample collected in January 2009. The 95% UCL for formaldehyde was calculated with and without the outlier. The outlier was retained and not treated separately because the difference between the two 95% UCLs was less than 10 percent.

3 Exposure Assessment

This section presents and discusses potentially exposed populations; the conceptual site model (CSM); exposure assumptions; and estimated intakes of COPCs potentially resulting from natural gas production operations in the Battlement Mesa PUD.

3.1 Potentially Exposed Populations

Current land use within the PUD at Battlement Mesa is primarily residential. It is likely that Battlement Mesa will remain residential in the future. Three populations of residents were evaluated as potential receptors for COPCs resulting from natural gas production operations within the Battlement Mesa PUD. The first population is residents living within the PUD at residence not adjacent to a well pad. The second population is residents living within the PUD at a residence adjacent to a well pad. The third population is child residents aged 3 to 6 living at a residence adjacent to a well pad. The third population represents the MEI.

3.2 Conceptual Site Model

The CSM for human exposure to COPCs resulting from natural gas production operations is shown in Figure 3-1. A CSM is a schematic representation of the chemical sources and release mechanisms, environmental transport media, potential exposure routes, and potential receptors. The purpose of the CSM is to represent chemical sources and exposure pathways that may result in human health risks.

Only potentially complete exposure pathways were evaluated in the risk assessment. A complete exposure pathway includes all of the following elements:

- A source and mechanism of contaminant release
- A transport or contact medium (e.g., air or water)
- An exposure point where receptors can contact the contaminated medium
- An exposure (intake) route such as inhalation or ingestion

The absence of any of these elements results in an incomplete exposure pathway. Where there is no potential exposure, there is no potential risk. The CSM shows (1) incomplete pathways – no evaluation necessary (represented by an “I”); (2) pathways that may be or complete, but for which risk is likely low and only qualitative evaluation is needed (“P”); (3) pathways that are complete and may be significant – quantitative evaluation was performed if there was environmental data available. (“C”). The sources and exposure pathways for each scenario are described in the following sections. Surface soil is defined as 0 to 2 feet below ground surface (bgs) and subsurface soil is defined as greater than 2 feet bgs.

3.3 Sources of potential contamination

The extraction of the natural gas resource from tight sands includes several processes, including transporting materials to and from well pads (trucking), well pad preparation, well drilling, well completion (plug pull out, fracturing, and flow back), collection of salable gas from producing well, maintenance of wells, installation and maintenance of well pads, and abandonment of wells. There is the potential for the release of contaminants during all these processes. Sources of contaminants include the natural gas resource itself, chemicals used in well production activities, wastes from well production activities, and exhaust from machinery used in well production and maintenance.

Well completion activities, trucking, well installation errors, and uncontrolled well development (kick backs, blow outs, and well fires) can result in emissions of contaminants to ambient air, groundwater, subsurface soil, surface soil and surface water. Spills of fracturing fluids, drilling muds, condensate, and diesel can result in contamination of surface soil and ambient air. Run-off and infiltration then can result in subsequent contamination of surface waters and of groundwater and subsurface soil, respectively. Wind erosion, run-off, and infiltration from drilling cuttings and produced water stored on well pads or off-site locations can result in contamination of ambient air, surface soil, surface water, groundwater, and subsurface soil. Exhaust from diesel engines can contaminate ambient air and surface soils (through deposition). Fugitive emission of natural gas through pneumatic pumps and devices, pipe lines, and values and venting of condensers and glycol dehydrators can result in emissions of contaminants to ambient air.

VOC contaminants released to the subsurface (groundwater and soil) have the potential to contaminate air inside buildings (indoor air) through infiltration.

3.4 Exposure Pathways

This section discusses exposure pathways that are quantified, evaluated qualitatively, and those than are not evaluated in the HHRA.

3.4.1. Complete Pathways

Complete pathways for residents to contaminants from natural gas production operations include:

- Inhalation of ambient air
- Incidental ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of particulates from surface soil.
- Dermal contact with surface water

Of these, the inhalation of ambient air pathway and surface water pathways were quantitatively evaluated. Surface soil pathways were not evaluated because no surface soil data is available.

3.4.2 Potentially Complete Pathways

Potentially complete pathways for residents to contaminants from natural gas production operations include:

- Ingestion of surface water
- Ingestion of groundwater
- Dermal contact with groundwater
- Inhalation of VOCs from groundwater
- Inhalation of indoor air

The primary source of drinking and domestic water in Battlement Mesa is the Colorado River. The Battlement Mesa Water Treatment Plant draws water from two intakes located in the middle of the river for treatment, as shown in Figure 3-2. Moument Creek, one of the major drainages off of Battlement Mesa discharges to the river downstream of these intakes. It still is possible that surface run-off could introduce contaminants from upstream well pads into the river. However, the Colorado River has a high volume of water and it is most likely that any contamination would be diluted to non-harmful concentrations. The annual surface water quality results have not indicated any detectable levels of contamination from natural gas production operations at the intakes. In addition, natural gas operators must inform the Battlement Mesa Water Treatment Plant of upstream spills or incidents affecting the river per COGCC rules. In the event of such a spill or incident the intakes to the treatment plant can be shut down. The treatment plant routinely stores a week's supply of water allowing time for remediation of spills. Therefore, while the ingestion of surface water is a potentially complete pathway, its contribution to human health risk is considered to be minimal. This pathway was not considered further in the HHRA.

In the event that the Battlement Mesa Water Treatment Plant was shut down, drinking and domestic water for Battlement Mesa residents would be supplied from four groundwater wells along the south bank of the Colorado River (Figure 3-2). These wells are not supplied with water from the Colorado River and it is believed that the source of water in these wells is from an up-gradient aquifer. There could be a hydrologic connection between these wells and the aquifer on Battlement Mesa, allowing for a conduit of natural gas extraction activity contaminants to the secondary drinking water source. However, the hydrologic connection has not been studied and is currently theoretical. The annual water quality results from these wells have not indicated any detectable levels of contamination. For these reasons, the ingestion of, dermal contact with, and inhalation pathway for contaminants in groundwater is considered to be minimal under current conditions. These pathways were not considered further in the HHRA.

Air inside of an occupied building (indoor air) could become contaminated with VOCs through infiltration if shallow subsurface soil or shallow groundwater in close proximity

to the building were contaminated with VOCs. EPA recommends considering this pathway if groundwater or soil within 100 feet (laterally or vertically) of an occupied building is contaminated with VOCs (EPA 2002). This pathway is considered to be minimal because the wells in Battlement Mesa will be set back at least 500 feet from any buildings (Antero Plan), and fracturing occurs at depths much greater than 100 feet bgs. This pathway was not considered further in the HHRA.

3.4.3 Incomplete Pathways

Incomplete pathways for residents include:

- Incidental ingestion of subsurface soil
- Dermal contact with subsurface soil
- Inhalation of subsurface soil particulates

These pathways are incomplete because direct contact with subsurface soil (i.e. greater than 2 feet bgs) involves significant digging or excavation activities unlikely under the residential scenario.

3.5 Exposure Assumptions and Intake Equations

This section presents assumptions for chronic exposures of all residents and residents living adjacent to well pads to contaminants from natural gas production operations within the Battlement Mesa PUD. Assumptions for child residents living adjacent to well pads also are presented.

3.5.1 All Resident Chronic Exposure Assumptions and Intake Equations

Only ambient air was quantitatively evaluated for the residential chronic exposure scenario because data on which to estimate for surface soil EPCs is not available and exposure to surface water run-off from pads is expected to be of short duration. The chronic exposure area for contaminants in ambient air is the entire Battlement Mesa PUD.

Chronic EPCs for ambient air were estimated from ambient air samples collected from 2005 through March 2010 at the Bell-Melton Ranch Monitoring Station (CDPHE 2007, Garfield County 2008, Garfield County 2009, Garfield County, 2010). Of the three ambient air monitoring stations within Garfield County where data has been regularly collected in this time period, Bell-Melton Ranch was considered to most closely represent the impacts of the nature gas production operations that may occur within the Battlement Mesa PUD. The other two monitoring locations, Rifle and Parachute, have greater traffic density, are in closer proximity to a major Interstate (I-70), and have more influence from other industries than Battlement Mesa. The Bell-Melton Ranch monitoring is located

south of Silt Colorado within the midst of natural gas production operations and rural home sites and ranches, as shown in Figure 3-3.

The following assumptions are used in this HHRA based on the EPA methodology regarding chronic exposure and Antero's proposed plan:

- The duration of Antero's project, from preparation of the first well pads to abandonment of the last well will be 30 years.
- A resident lives, works, and otherwise stays within the Battlement Mesa PUD for 24 hours per day, 350 days per year, for a 30-year time period.
- The air a resident breathes, both while indoors and outdoors, contains the same concentration of contaminants measured in the Bell-Melton Ranch ambient air samples.
- Air quality, as reflected by the Bell-Melton Ranch ambient air results, will remain relatively constant over the entire 30-year duration of Antero's proposed project.
- The lifetime of a resident is 70 years.

Table 3-1 summarizes intake rates for ambient air. The intake equation for the chronic exposure scenario follows.

$AI = (EPC_c \times EF_c \times ED_c \times ET \times 1\ day/24\ hours)/AT$

AI = Air Intake ($\mu g/m^3$)
EPC_c = Chronic exposure point concentration ($\mu g/m^3$)
EF_c = Chronic exposure frequency = 350 days/year
ED_c = Chronic exposure duration = 30 years
ET = Exposure time = 24 hours/day
Non-cancer AT = averaging time = 10950 days
Cancer AT = 25550

3.5.2 Residents Living Adjacent to Well Pads Exposure Assumptions and Intake Equations

Only the ambient air exposure pathway was quantitatively evaluated for the residents living adjacent to well pads because data on which to estimate surface soil EPCs is not available and exposure to surface water run-off from pads is of short duration. The exposure area for contaminants in ambient air is homes and yards adjacent to well pads.

Based on Garfield County's 2008 Air Toxic's Study, the highest concentrations of SNMOCs in ambient air were observed during well completion activities (Garfield County 2008). Therefore, intermediate EPCs for ambient air were estimated from ambient air samples collected at four separate well completion sites in Garfield County's 2008 air toxics study. Four ambient air samples (one from each cardinal direction) were collected at distances ranging from 130 to 430 feet from the well pad center at each site (Paul Reaser, personal communication 7/6/2010).

The EPC for chronic exposure was estimated by calculating a time weighted average (TWA) from the intermediate EPCs described in the preceding paragraph and chronic EPCs described in Section 3.5.1.

The following assumptions regarding the chronic scenario for residents living adjacent to a well pad are used in this HHRA based on the EPA methodology and Antero's proposed plan:

- The duration of Antero's project, from preparation of the first well pads to abandonment of the last well will be 30 years.
- A resident lives, works, and otherwise stays within the Battlement Mesa PUD for 24 hours per day, 350 days per year, for a 30-year time period.
- The resident's home is adjacent to well pad.
- Well completion activities, including plug pull outs, hydraulic fracturing, and flow back occur over two weeks for each well on the well pad. This assumes some overlap between activities and wells.
- For a 20 well pad, well completion activities (flow back and hydraulic fracturing) will occur over 10 months.
- The resident lives, works, or otherwise stays at the home during the duration of well completion activities.
- The air that the resident breathes, both while indoors and outdoors, contains the same concentrations of contaminants measured in the Air Toxics Study during the duration of the well completion activities.
- The air a resident breathes, both while indoors and outdoors, after the well completion activities contains the same concentration of contaminants measured in the Bell-Melton Ranch ambient air samples.
- Air contaminant concentrations will remain constant over the 10-month period of well completion.
- Air quality, as reflected by the Bell-Melton Ranch ambient air results, will remain relatively constant over the entire 30-year duration of Antero's proposed project.
- The lifetime of a resident is 70 years.

Table 3-1 summarizes intake rates for ambient air, which were calculated by the intake equations presented in Section 3.5.1. TWA EPCs for residents living adjacent to well pads were calculated as follows:

$EPC_{I+c} = (EPC_c \times ED_c/ED) + (EPC_I \times ED_I/ED)$

EPC_c = Chronic exposure point concentration ($\mu g/m^3$)
ED_c = Chronic exposure duration = 350 months
EPC_I = Intermediate exposure point concentration ($\mu g/m^3$)
ED_I = Intermediate exposure duration = 10 months
ED = Total exposure duration = 360 months

3.5.3 Child Resident Acute Exposure Assumptions and Intake Equations

Only ambient air and surface water pathways were quantitatively evaluated for the child acute exposure scenario because data on which to estimate for surface soil EPCs is not available. The acute exposure area for contaminants in ambient air is homes and yards located adjacent to a well pad. The acute exposure areas for contaminants in surface water are puddles in the yards of homes adjacent to well pads resulting from well pad run-off during precipitation events. A child resident was evaluated as the receptor for this exposure scenario because a child is more likely to play in a puddle and is a more sensitive receptor than an adult. The acute risk calculated for the ambient air pathway is applicable to both the child and adult resident living adjacent to a well pad.

The EPC for ambient air was estimated from concentrations of contaminants observed during odor events in CPDHE's 2005-2007 ambient air study. If a contaminant was not measured in the 2005-2007 and was identified as the COPC in the 2008 Air Toxics study, the maximum concentration observed in the 2008 Air Toxics study was used as the EPC. If a contaminant was not measured in either of these studies and was identified as a COPC from 2008-2010 ambient air study data, the maximum concentration observed in the 2008-2010 ambient air study was used as the EPC. The EPC for a puddle of surface water run-off was estimated from contaminants observed in snow-melt run-off collected from a well pad within the three-mile radius of the former Project Rulison near Rulison, Colorado (URS 2008).

The following assumptions for acute exposure of a child resident to contaminants in surface water puddles are used in this HHRA based on EPA methodology.

- A child lives, plays, and otherwise stays at the home for 24 hours per day for 7 days.
- The child is 3-6 years old.
- The air the child breathes, both while indoors and outdoors, contains the same concentration of contaminants measured during odor events in the 2005-2007 ambient air study.
- The concentration of contaminants in ambient air will stay constant over the 7-day period.
- The surface water puddle will exist for 7 days before it evaporates or is absorbed into the ground
- The child will have a 70 year lifetime (EPA 1989).
- A child will play for 2 hours per day in the puddle (EPA 2009 and professional judgment).
- The child has a body mass of 18.6 kg (EPA 2009)
- The child will have an exposed skin surface area (arms, hands, legs, and feet) of 5190 cm^2 (EPA 2009).
- The child does not ingest the water.

Table 3-2 summarizes intake rates for surface water. The following equations were used to calculate the intake rates for surface water.

SWI = [(EPC x ET x EF x ED x CF)/(BW x AT)] x [(PC x SA)]

SWI = Surface Water Intake (mg/kg-day)
EPC = Exposure Point Concentration (mg/L for surface water, µg/m^3 for air)
ET = Exposure Time = 2 hours/day
EF = Exposure Frequency = 7 days per year
ED = Exposure Duration = 1 year
BW = Body Weight = 18.6 kg
AT = Averaging time = 365 days
PC = chemical-specific dermal permeability constant (cm/hour)
SA = exposed skin surface area = 5190 cm^2
CF = conversion factor = 1 L/1000 cm^3

4 Toxicity Assessment

This section presents the toxicity assessment. The purpose of the toxicity assessment is to evaluate available evidence regarding the potential for a particular contaminant to cause adverse health effects in exposed individuals and how the appearance and severity of these adverse effects depends on the dose of the contaminant. In addition, the toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal), the duration of exposure (acute, intermediate, chronic or lifetime), age, sex, diet, family traits, lifestyle, and state of health.

4.1 Selection of Toxicity Values

The following hierarchy was used to compile a list of inhalation toxicity values for the HHRA. For COPCs identified in ambient air, inhalation values established specifically by the State of Colorado were given priority over all other sources of toxicity values, followed by EPA's Air Toxics Website (http://www.epa.gov/ttn/atw/toxsource/summary.html). The State of Colorado has not established toxicity values for the COPCs identified in this HHRA. If values were not available the Air Toxics Website, toxicity values were filled (in order of preference) EPA's Integrated Risk Information System (IRIS), EPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs), and other applicable secondary sources (e.g., California EPA; ATSDR). Inhalation toxicity values were available for 19 out of 82 COPCs as presented in Table 4-1. Inhalation toxicity values were not available for the remaining 63 COPCs presented in Table 4-2. These COPCs were omitted altogether from the quantitative inhalation risk estimation.

A list of oral toxicity values was complied for the HHRA (in order of preference) from EPA's IRIS and the Agency for Toxic Substances and Disease Registry (ATSDR). Oral toxicity values were available for all the surface water COPC presented in Table 4-3. Dermal toxicity values can be extrapolated from oral toxicity values by adjusting the oral RfD by its oral absorption factor, per EPA guidance (EPA 1989). The oral absorption factor for all the COPCs identified in surface water was 100 percent. Therefore, the dermal RfD is equivalent to the oral RfD.

4.1.1 Cancer Toxicity Values

Potential carcinogens are grouped according to the likelihood that the chemical is human carcinogen, depending on the quality and quantity of carcinogenic potency data for a given chemical.

Group A – Human Carcinogen (sufficient evidence of carcinogenicity in humans)

Group B – Probable Human Carcinogen (B1 – limited evidence of carcinogenicity in humans; B2- sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans).

Group C – Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans)

Group D – Not Classifiable as to human carcinogenicity (inadequate or no evidence)

Group E – Evidence of non-carcinogenicity (no evidence of carcinogenicity in adequate studies).

Weight of evidence classifications for COPCs are provided in Section 4-2.

Cancer risks are expressed as a probability of suffering an adverse effect (cancer) during a lifetime. They estimate risks to individuals in a population and not to a particular individual.

For carcinogens, inhalation toxicity measurements are generally expressed as a risk per unit concentration (e.g., an inhalation unit risk (IUR) in units of risk per $\mu g/m^3$). The IUR is based on an upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of $1\mu g/m^3$ in air.

4.1.2 Non-Cancer Toxicity Values

Non-cancer hazards are expressed, semi-quantitatively, in terms of the HQ, defined as the ratio between an individual's estimated exposure and the toxicity value. HQs are not an estimate of the likelihood that an effect will occur, but rather an indication of whether there is potential cause for concern for adverse health effects. Like cancer risks, HQs estimate risks to individuals in a population and not to a particular individual (i.e., personal risk).

For non-carcinogens, inhalation toxicity measurements are generally expressed as a concentration in air (e.g., an RfC in units of $\mu g/m^3$ air). The RfC is an exposure that is believed to be without significant risk of adverse non-cancer health effects in a chronically exposed population, including sensitive individuals.

For non-carcinogens, oral toxicity measurements are generally expressed as a reference dose (RfD). The RfD is an estimate of a daily chemical intake per unit body weight for the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime.

Chronic RfDs and RfCs are developed to evaluate long-term exposures of 7 years to a lifetime (70 years), intermediate RfDs and RfCs are developed to evaluate exposures of >14 to 364 days, and acute RfDs and RfCs are developed to evaluate exposures of 1 to 14 days. Chronic RfCs were used for the chronic all resident and resident adjacent to a well pad scenarios. Acute RfDs and RfCs were used for the acute child resident adjacent to a well pad scenario. If an acute value was not available, the intermediate toxicity value

was used. If an intermediate value was not available, the chronic toxicity value was used, per EPA guidance (EPA 1989).

4.2 Summary of Health Effects of COPCs

This section summarizes the adverse of effects for the COPCs with toxicity values (Tables 4-1 and 4-3).

4.2.1 Acetylaldehyde

EPA has classified acetylaldehyde as probable human carcinogen (Class B2). There is inadequate evidence of carcinogenicity in humans, but adequate evidence of carcinogenicity in animals. An increased incidence of nasal and laryngeal tumors has been observed in animals after inhalation exposure (EPA IRIS 2010).

Short term inhalation exposure of rats to high concentrations of actylaldehyde was observed to result in degradation of the olfactory epithelium (EPA IRIS 2010, 1991 revision).

4.2.2 Benzene

Benzene is classified as a "known" human carcinogen (Category A) for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies. Exposure to benzene can cause acute nonlymphocytic leukemia, acute myeloid leukemia, and also may cause chronic nonlymphocytic and chronic lymphocytic leukemia. (ATSDR, 2007, IRIS 2010).

Benzene's non-cancer toxicity is observed by all routes of administration. The following is ATSDR's summary of non-cancer health effects. "Brief exposure (5–10 minutes) to very high levels of benzene in air (10,000–20,000 ppm) can result in death. Lower levels (700–3,000 ppm) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when they are no longer exposed and begin to breathe fresh air. Eating foods or drinking liquids containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death. If you spill benzene on your skin, it may cause redness and sores. Benzene in your eyes may cause general irritation and damage to your cornea. Benzene causes problems in the blood. People who breathe benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. A decrease in red blood cells can lead to anemia. Reduction in other components in the blood can cause excessive bleeding. Blood production may return to normal after exposure to benzene stops. Excessive exposure to benzene can be

harmful to the immune system, increasing the chance for infection and perhaps lowering the body's defense against cancer (ATSDR 2007a)".

4.2.3 1,3-Butadiene

EPA has classified 1,3-butadiene as a known human carcinogen (Class A). Occupational studies suggest exposure to 1,3 butadiene in ambient air results in an increased risk for cancers of the stomach, blood, respiratory system, and lymphatic system (ATSDR 2009).

Very high exposures to 1,3-butadiene vapors in humans (>10,000 ppm) may result in narcosis and death from respiratory paralysis. Short term exposure to lower levels in ambient air may cause nausea, dry mouth and nose, headache, and decreased blood pressure and heart rate (ATSDR 2009).

4.2.4 Chloroform

EPA has determined that chloroform is a probable carcinogen (Class B2) based on sufficient animal evidence. Cancer of the liver and kidneys was observed in rats and mice that ingested chloroform (ATSDR 1997). "Chloroform is *likely to be carcinogenic to humans by all routes of exposure* under high-exposure conditions that lead to cytotoxicity and regenerative hyperplasia in susceptible tissues. Chloroform is *not likely to be carcinogenic to humans by any route of exposure* under exposure conditions that do not cause cytotoxicity and cell regeneration" (IRIS 2001).

Short term exposure to high concentrations of chloroform in ambient air causes fatigue, dizziness and headache. Long term exposure in ambient air, food, or water may cause liver and kidney damage (ATSDR 1997).

4.2.5 Crotonaldehyde

Crotonaldehyde is classified as a possible human carcinogen (Category C) based on limited animal evidence. An increased incidence of hepatic neoplastic nodules and hepatocellular carcinomas were observed in animal carcinogenicity study that was limited by only one sex of one species (IARC 1995).

Crotonaldehyde is a potent eye, respiratory and skin irritant and brief exposures to moderate concentrations in ambient air can irritate the nose and upper respiratory tract, with lachrymation (IARC 1995). However, no RfC is available for crotonaldehyde.

4.2.6 1,4-Dichlorobenzene

EPA has determined 1,4-dichlorobenzene is likely to be a human carcinogen based on limited animal studies (Class C). Increased risk in kidney and liver tumors have been observed in rats after ingestion of 1,4-dichlorobenzene. An increased incidence of lung adenomas in males and of liver adenomas in females was observed in an inhalation study on mice (IRAC 2000).

Short term exposure to high concentrations of 1,4-dichlorobenzene in ambient may cause eye, nose, and eye irritation and burning, coughing, breathing difficulties, and upset stomach. Long term exposures to high concentrations may case decreased lung function, dizziness, headache, liver problems, skin blotches, and anemia.

4.2.7 Ethylbenzene

EPA has determined ethylbenzene is not classifiable as human carcinogen (Class D). The International Agency for Research on Cancer (IARC) has classified ethylbenzene as possibly carcinogenic to humans, based on sufficient evidence in animal studies (IARC 2000). An increased incidence of lung adenomas in males and of liver adenomas in females was observed in an inhalation study on mice (IRAC 2000).

Short term exposure to high levels of ethylbenzene in ambient air can cause eye and throat irritation, vertigo, and dizziness. Evidence of long-term exposure effects in humans is lacking. Animal studies indicate long-term exposure to low levels of ethylbenzene in ambient air may result in irreversible damage to the inner ear and hearing, as well as kidney damage. Rats ingesting large amounts of ethylbenzene had severe damage to the inner ear. Dermal exposure has caused eye damage and skin irritation in rabbits (ATSDR 2007b).

4.2.8 Formaldehyde

EPA has determined formaldehyde is probable human carcinogen with limited evidence of carcinogenicity in humans and sufficient evidence in animals (Class B1). Exposure to formaldehyde in ambient air may result in an increased risk for nasal and throat cancers (ATSDR 1999a).

NIOSH states that exposure to formaldehyde in ambient air is immediately dangerous to life and health at 20,000 ppb. Lower short-term exposures to lower concentrations can irritate the eyes, nose, and throat (ATSDR 1999a).

4.2.9 n-Hexane

EPA has determined n-hexane is not classifiable as human carcinogen (Class D) (ATSDR 1999b).

Workers exposed to greater than 500,000 ppb of n-hexane in ambient air for over 6 months have experienced numbness in their feet and hands followed by muscle weakness in their feet and lower legs. With continuing exposure, peripheral neuropathy can result in paralysis of the arms and legs developed (ATSDR 1999b).

4.2.10 2-Hexanone

EPA has determined 2-hexanone is not classifiable as human carcinogen (Class D) (EPA IRIS 2010/2009).

Workers exposed to 2-hexanone for almost a year experienced harmful effects to the nervous system. Symptoms included weakness, numbness, and tingling in the skin of the hands and feet (ATSDR 1992).

4.2.11 Methylcyclohexane

EPA has not determined a cancer classification for methylcyclohexane.

Evidence on human exposure to methylcyclohexane is lacking. Decreased body weight has been observed in animal studies on hamsters and male rats, as well as progressive renal nephropathy in male rats, after inhalation of methylcyclohexane (Kinkead et al. 1985)

4.2.12 Methylene Chloride

EPA has classified methylene chloride as a probable human carcinogen (Class B2) based on sufficient evidence in animal studies. Increased incidence of hepatocellular neoplasms, alveolar/bronchiolar neoplasms, mammary tumors, salivary gland sarcomas, and leukemia have been observed in studies on rats (EPA IRIS 1995/2010).

Inhalation of very high concentrations of methylene chloride can cause death. Inhalation of lower concentrations can cause dizziness, nausea, tingling or numbness of fingers and toes, and drunkenness. Symptoms usually disappear shortly after the exposure ends. Methylene chloride vapors also may cause eye irritation. (ATSDR 2000).

4.2.13 n-Nonane

EPA has not determined a cancer classification for n-nonane.

Evidence on human exposure to n-nonane is lacking. Central nervous system or peripheral nervous system abnormalities (tremors, convulsions, coordination loss, and limb paralysis) and irritation, as well as liver and lung lesions have been observed in rats exposed to n-nonane vapor (Carpenter et al. 1978; Nilsen et al. 1988).

4.2.14 n-Pentane

EPA has not determined a cancer classification for n-pentane.

Breathing very high concentrations of n-pentane can cause drowsiness and anesthetic effects. At even higher concentrations, n-pentane can act as an asphyxiant (Galvin and Marashi 1999).

4.2.15 Toluene

Toluene can not be classified as a carcinogen because of inadequate evidence (Class D) (EPA Toxicological Review of Toluene, September 2005, EPA/635/R-05/004).

Human occupational studies have reported experienced altered color vision, dizziness, fatigue, headache, and decreased performance in neurobehavioral tests in humans exposed to toluene via inhalation. Children of mothers who inhaled very high levels of toluene during pregnancy exhibited a number of physical (small mid face, deep-set eyes, micrognathia, and blunting of the fingertips) and clinical (microcephaly, CNS dysfunction, attention deficits, and developmental delay/mental deficiency) changes which were attributed to toluene. Histopathologic lesions, damage to the tubular epithelia of the kidney, decreased antibody body response, and increases in brain neurotransmitter levels have been observed in animals following oral exposure to toluene. (EPA Toxicological Review of Toluene, September 2005, EPA/635/R-05/004).

4.2.16 Trimethylbenzenes

EPA has not classified the trimethylbenzenes for carcinogenicity.

Breathing high levels of 1,2,4-trimethylbenzene for short periods of time adversely affects the human nervous system. Effects range from headaches to fatigue and drowsiness. TMB vapor irritates the nose and the throat. Prolonged contact with liquid TMB irritates the skin (EPA 1994). Health effects and toxicity of 1,3,5-trimethylbenzene and 1,2,3-trimethylbenzene may be similar to those of 1,2,4-trimethylbenzene. Therefore, the RfC for 1,2,4-trimethylbenzene was used as a surrogate for 1,3,5-trimethylbenzene and 1,2,3-trimethylbenzene.

4.2.17 Xylenes

Xylenes have not been classified as carcinogens because of inadequate evidence (Class D) (ATSDR 2007c).

The three forms of xylene (m-xylene, p-xylene, and o-xylene) have very similar effects on human health. Exposure to very high levels of xylene can cause death. Short-term exposure of people to high levels of xylene can cause irritation of the skin, eyes, nose, and throat; difficulty in breathing; impaired function of the lungs; delayed response to a visual stimulus; impaired memory; stomach discomfort; and possible changes in the liver and kidneys. Both short- and long-term exposure to high concentrations of xylene can also cause a number of effects on the nervous system, such as headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance (ATSDR 2007c).

5 Risk Characterization

Risk characterization integrates the information from the data, exposure and toxicity assessments to provide an estimate of the magnitude of potential risk. Both cancer and non-cancer health effects are evaluated in this HHRA. This section presents an estimation of the baseline risk within the Battlement Mesa PUD and an estimation of excess risk that may be introduced within the Battlement Mesa PUD as a result of Antero's drilling plan.

5.1 Risk Estimations

The methods for estimating cancer, non-cancer, and multiple contaminant risk follow.

5.1.1 Cancer Risk Estimation

The lifetime cancer risk for each COPC for which there is a toxicity value is derived by multiplying the intake values in presented in Table 3-1 for the chronic exposure scenarios and Table 3-2 for the acute exposure scenario by the respective IUR value, as shown in the following equation.

$$Risk_x = Intake_x * IUR_x$$

Where:
$Risk_x$ = the risk of the X^{th} COPC at a monitor;
$Intake_x$ = the intake concentration of the substance or the maximum detected value;

Estimates of cancer risk are expressed as a probability, represented in scientific notation as a negative exponent of 10. For example, an additional lifetime risk of contracting cancer of 1 chance in 1,000,000 (or one additional person in 1,000,000) is written as 1E-06.

The level of cancer risk that is of concern is a matter of individual, community, and regulatory judgment. However, the EPA typically considers risks below 1E-06 to be so small as to be negligible (USEPA 1991). Therefore, the EPA uses a cancer risk of one in a million (1E-06) as a regulatory goal, which means that regulatory programs are generally designed to try to reduce risk to this level. When it is not feasible to meet this regulatory goal, the EPA may consider cancer risks lower than 1 in 10,000 (1E-04) to be acceptable.

5.1.2 Non-Cancer Hazard Estimation

In contrast to cancer risks, non-cancer hazards are not expressed as a probability of an individual suffering an adverse effect. Instead, the non-cancer hazard to individuals is expressed in terms of the HQ. For a given contaminant, exposures below the reference

concentration (HQ less than one) are not likely to be associated with an appreciable risk of adverse health effects. With exposures increasingly greater than the reference concentration, the potential for adverse effects increases. HQs are calculated as follows:

$$HQ_x = Intake_x/RfC_x$$
$$HQ_x = Intake_x/RfD_x$$

Where:

HQ_x = the hazard quotient of the X^{th} COPC at a monitor;
$Intake_x$ = the intake concentration of the substance (i.e., most stringent of the 95% UCL or maximum air concentration); and
RfC_x = the reference concentration of the substance.
RfD_x = the reference dose of the substance

When used in the assessment of non-cancer risks, the HQ is commonly reported to one significant figure (USEPA, 1989). For example, a HQ of 0.13 is rounded to 0.1, and a HQ of 1.6 is rounded to 2.

5.1.3 Cumulative Risks for Multiple Chemicals

As noted in the 2008 risk assessment, emissions from natural gas development activities represent a complex mixture of hundreds of contaminants that can include aliphatic, aromatic, and polycyclic aromatic hydrocarbons, and carbonyls. Exposures to these contaminants may occur acutely or chronically, and commonly occur concurrently with exposure to other contaminants and stressors. The toxicity of contaminants in complex mixtures may differ greatly from that of a single compound. Therefore, estimating cancer risks or non-cancer hazard potential by considering one contaminant at a time might significantly underestimate the risks associated with simultaneous exposures to several contaminants. The consequences of the multiple exposures can be quantified, within some limitations, based on EPA's default assumption of additivity.

For cancer risk, the individual contaminant risks are added to estimate the total risk for the site. This summation is based upon the principle that the addition of each risk produces a combined total cancer risk estimate.

For non-carcinogenic contaminants, the HQs for each exposure pathway can be summed to develop a HI for that exposure pathway. For screening purposes, it is acceptable to sum all HQ values in order to derive an HI value. If the resulting HI is less than one, no further evaluation is necessary and it can be concluded that no unacceptable risks are present. If the HI is greater than one as a consequence of summing several HQs of similar value, it would be appropriate to segregate the contaminants by effect and by mechanism of action and to derive separate HIs for each group.

5.2 Baseline Risk

Baseline risks were estimated for ambient air, groundwater, and surface water. There is no data available for the estimation of a baseline risk for surface or subsurface soil.

5.2.1 Ambient Air Baseline Risk

The baseline risks determined for the Silt-Daley and Silt-Cox monitoring sites in the risk assessment performed with the 2005-2007 ambient air study data were employed as an estimate of the baseline risk within the Battlement Mesa PUD (CDPHE 2007). The Silt-Daley and Silt-Cox monitoring sites are described as rural sites without natural gas production operations.

COPCs for cancer risk across the two rural background monitoring sites are limited to benzene at Silt-Daley and 1,4-dichlorobenzene at Silt-Cox. The cancer risk estimates ranged from 1.5E-05 for benzene (15 excess cancers per 1 million individuals) to 5.1E-05 for 1,4-dichlorobenzene (51 excess cancers per 1 million individuals). These risks were based on a 70-year exposure duration and a 365 day/year exposure frequency. Adjusting these risks for a 30-year exposure duration and a 350 day/year, results in baseline cancer risks ranging from 6.2 E-06 to 2.1E-05 (6.2 to 21 excess cancers per 1 million individuals).

None of the individual chemicals that were assessed at any monitoring location were found to have an HQ exceeding a value of one for chronic as well as short-term (average) exposure durations. None of the HIs exceeded a value of one for either exposure duration.

It is important to note that the following 11 out of 19 COPCs with toxicity values identified in this HHRA were not determined in the 2005-2007 study.

1,3-Butadiene
Acetylaldehyde
Crotonaldehye
Formaldehyde
Methylcyclohexane
n-Hexane
n-Nonane
n-Pentane
1,2,3-Trimethylbenzene
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene

Seven background results for the trimethylbenzenes, 1,3-butadiene, methylcyclohexane, n-hexane, n-nonane, and n-pentane are available from the 2008 air toxics study. As shown in table 2-10, 1,3-butadiene was not detected in any of the background samples. The trimethylbenzenes, n-hexane, n-nonane, and n-pentane were detected in 100 percent of these background samples, but their maximum detected values did not exceed the EPA

RSL for residential ambient air. Methylcyclohexane also was detected in 100 percent these background samples. However, the maximum detected concentration for methylcyclohexane was much less than the RfC listed in Table 4-1. For these reasons, it is unlikely that the trimethylbenzenes, 1,3-butadiene, methylcyclohexane, n-hexane, n-nonane, and n-pentane contribute significantly to the baseline risk in the Battlement Mesa PUD.

There are no background results available for acetylaldehyde, formaldehyde, and crotonaldehyde. Therefore, it is not possible to estimate the contribution of these chemicals to the baseline risk.

5.3 Risk After Implementation of Natural Gas Production operations

The risk for each of the three populations discussed in Section 3 was quantitatively evaluated for COPCs with toxicity values. Risk for COPCs without toxicity values was addressed qualitatively.

5.3.1 All Battlement Mesa Residents Chronic Risk

Cancer Risk Estimates

The sum of the cancer risk to all Battlement Mesa residents (i.e., not living adjacent to a well pad is estimated at 7.1E-05 (71 cancers per 1,000,000 individuals), as shown in Table 5-1. This cancer risk is within EPA's acceptable range of 1E-06 to 1E-04. Crotonaldehyde, a possible human carcinogen, is the major contributor to the cancer risk (4.5E-05), followed by 1,4-dichlorobenzene, a possible human carcinogen, (1.0E-05), formaldehyde, a probable human carcinogen, (6.7E-06), benzene, a known human carcinogen, (5.4E-06), and 1,3-butadiene, a known human carcinogen (1.9E-06). Acetylaldehyde, a probable human carcinogen, methylene chloride, a probable human carcinogen, and ethylbenzene, a possible human carcinogen, also contribute to the cancer risk at levels less than 1E-06.

As noted in Section 5-2, data for crotonaldehyde, acetylaldehyde, and formaldehyde were not available for the baseline risk assessment. Therefore, it is not appropriate to directly compare the 7.1E-05 cancer risk to the baseline risk. It is possible to compare contribution of benzene, 1,4-dichlorobenzene, 1,3-butadiene, methylene chloride, and ethylbenzene to cancer risk to the baseline risk. These contaminants contribute 1.9E-05 of the cancer risk, which is within the baseline cancer risk range of 6.2E-06 to 2.1E-05.

The cancer risk of 7.1E-05 is less than the 1.2E-4 cancer risk reported in the 2008 risk assessment for the Bell-Melton Ranch monitoring station (CDPHE 2010). Adjusting the 1.2E-04 cancer risk reported in the 2008 risk assessment for Bell-Melton Ranch for a 30-year exposure duration and a 350 day/year exposure frequency results in a cancer risk of 4.9 E-05, which is less than the 7.1E-05 cancer risk for the resident not living adjacent to a well pad. The main reasons for this difference is because of the inclusion of 1,4-

dichlorobenzene results from the 2005-2007 air study that were not considered in the 2008 risk assessment and differences in EPCs. EPCs were different because this HHRA included results from 2009 and 2010.

Non-Cancer Risk Estimates

No COPC had an HQ greater than one, as shown in Table 5-1. The HI for non-cancer hazard is 0.6, which is less than EPA's level of one below which health effects are not expected to occur.

The HI of 0.6 is higher than the 0.4 HI (0.2 adjusted for a 30-year exposure duration) reported in the 2008 risk assessment for the Bell-Melton monitoring station (CDPHE 2010). Differences between the two estimates are mainly because this HHRA included chemicals not measured in the 2005-2007 study.

Qualitative Risk Evaluation

Of the COPCs identified from the 2005 to 2010 data set used to evaluate the risk for residents not living near a well pad, 61 did not have toxicity values. However, background information is available for 55 of these COPCs. As shown in Table 5-2, the EPC for 42 of these COPCs did not exceed the BTV, indicating they would not contribute more to risk than already contributed by the baseline. The remaining 13 COPCs are alkenes and alkanes that may contribute to the risk over baseline.

At low concentrations, the toxicity of alkanes and alkenes is generally considered to be minimal (Sandmeyer, 1981). For example, the RfCs for the three alkanes with toxicity values, n-hexane, n-pentane, and n-nonane, range from 200 to 1000 $\mu g/m^3$. None of the EPCs for the alkenes and alkanes listed in table 5-2 exceed $100 \mu g/m^3$.

Six of the COPCs for which there are no toxicity values or background/baseline data are aldehydes, which generally act as irritants of the eyes, skin, and respiratory tract. Some aldehydes have also been shown to be mutagenic and/or carcinogenic. The variation in toxicity among the individual aldehydes is large. Investigations are needed to further characterize the health effects of the common aldehydes.

Overall, based on the qualitative evaluation of health risks, it appears that exposure to 55 COPCs identified in Table 5-2 individually is not likely to result in significant cancer and non-cancer effects. Any of the six carbonyls without toxicity values could potentially have a significant contribution to the cancer and/or non-cancer effects. In addition, the cumulative health effects of these 61 COPCs cannot be estimated. It should be noted that the current state of the science is unable to assess exposures to complex mixtures of air toxics, especially, synergistic and antagonistic interactions at low levels.

5.3.2 Residents Living Adjacent to a Well Pad

Cancer Risk Estimates

The sum of the cancer risk to Battlement Mesa residents living adjacent to a well pad is estimated at 8.3 E-05 (83 cancers per 1,000,000 individuals), as shown in Table 5-3. This cancer risk is within EPA's acceptable range of 1E-06 to 1E-04. Crotonaldehyde, a possible human carcinogen, is the major contributor to the cancer risk (4.5E-05), followed by benzene, a known human carcinogen (1.13E-5), 1,4-dichlorobenzene, a possible human carcinogen, (1.0E-05), ethylbenzene, a possible human carcinogen (6.9E-06), formaldehyde, a probable human carcinogen, (6.7E-06), and 1,3-butadiene, a known human carcinogen (1.9 E-06). Acetylaldehyde, a probable human carcinogen, and methylene chloride, a probable human carcinogen, also contribute to the cancer risk at levels less than 1E-06.

As noted in Section 5-2, data for crotonaldehyde, acetylaldehyde, and formaldehyde were not available for the baseline risk assessment. Therefore, it is not appropriate to directly compare the 9.4E-05 cancer risk to the baseline risk. It is possible to compare contribution of benzene, 1,4-dichlorobenzene, 1,3-butadiene, methylene chloride, and ethylbenzene to cancer risk to the baseline risk. These contaminants contribute 3.1E-05 of the cancer risk, which is greater than the baseline cancer risk range of 6.2E-06 to 2.1E-05.

The cancer risk of 8.3E-05 for the resident living adjacent to a well pad is higher than the 7.1E-05 estimated cancer risk for the resident not living adjacent to a well pad. The increase is due the increase in cancer risk from benzene and ethylbenzene. It is important to note that intakes for crotonaldehyde, acetylaldehyde, formaldehyde, methylene chloride, and 1,4-dichlorobenzene were the same as the chronic intakes for the residents not living near a well pad because data for these chemical was not available from the 2008 air toxics study. If concentrations of these compounds in ambient air are higher during well completion activities, the actual cancer risks for residents living adjacent to a well pad may be higher.

Non-Cancer Risk Estimates

While no individual contaminant had an HQ greater than one, the HI for the non-cancer hazard is 2, as shown in Table 5-3. The HI is greater than EPA's level of one above which health effects may occur. It also is greater than the baseline non-cancer hazard. It is important to note that if concentrations of acetylaldehyde, formaldehyde, methylene chloride, and 1,4-dichlorobenzene in ambient air are higher during well completion activities, the actual non-cancer hazards for residents living adjacent to a well pad may be even greater.

Qualitative Risk Evaluation

Of the COPCs identified from the 2008 well completion data sets used to evaluate the risk for residents living near a well pad, 64 did not have toxicity values. However, background information is available for 57 of these COPCs. As shown in Table 5-2, the

maximum detected concentration for six of these COPCs did not exceed the BTV, indicating they would not contribute more to risk than already contributed by the baseline. The remaining 51 COPCs are alkenes, alkanes, and aromatic hydrocarbons that may contribute to the risk over baseline.

At low concentrations, the toxicity of alkanes and alkenes is generally considered to be minimal (Sandmeyer, 1981). For example, the RfCs for the three alkanes with toxicity values, n-hexane, n-pentane, and n-nonane, range from 200 to 1000 $\mu g/m^3$. The maximum concentrations for 15 alkanes listed in Table 5-2 exceed $100\mu g/m^3$. Ethane, propane, n-butane, and iso-butane concentrations exceed $1000\mu g/m^3$. At high concentrations, health effects that are associated with alkanes include acting as anesthetics and subsequently asphyxiants, showing narcotic or other central nervous system depression effects, and dermal and pulmonary irritation. Some alkanes (propane, butane and isobutane) may be weak cardiac sensitizers in humans following inhalation exposures to high concentrations (greater than 5 percent for isobutane and greater than 10 percent for propane).

Five of the COPCs which exceed BTVs and for which there are no toxicity values are aromatic hydrocarbons. The toxicity of aromatic hydrocarbons has is varied and some, such as benzene and ethylbenzene have been shown to carcinogenic. Investigations are needed to further characterize the health effects of these aromatic hydrocarbons.

Six of the COPCs for which there are no toxicity values or background/baseline data are aldehydes, which generally act as irritants of the eyes, skin, and respiratory tract. Some aldehydes have also been shown to be mutagenic and/or carcinogenic. The variation in toxicity among the individual aldehydes is large. Investigations are needed to further characterize the health effects of the common aldehydes.

Overall, based on the qualitative evaluation of health risks, it appears that exposure to several of the alkanes, and aromatic hydrocarbons identified in Table 5-2 that exceed BTVs could potentially make a significant contribution to cancer and/or non-cancer effects for residents living adjacent to well pads. Any of the six carbonyls without toxicity values also could potentially have a significant contribution to the cancer and/or non-cancer effects. In addition, the cumulative health effects of these 63 COPCs cannot be estimated. It should be noted that the current state of the science is unable to assess exposures to complex mixtures of air toxics, especially, synergistic and antagonistic interactions at low levels.

5.3.3 Acute Risk - Child Living Adjacent to a Well Pad

Non-Cancer Risk Estimates Ambient Air

Ambient air HQs for 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, and n-nonane all exceed EPA's level of one above which

health effects may occur, as shown in Table 5-4. The HI for the ambient air pathway is 30.

It is important to note that acetylaldehyde, formaldehyde, the trimethylbenzenes, 1,3-butadiene, methycyclohexane, n-hexane, n-pentane, and n-nonane were not measured for odor complaints in the 2005 to 2007 air study. If concentrations of these chemicals are higher for odor complaints, the actual acute non-cancer hazards for the child resident living adjacent to a well pad may be even greater.

This acute non-cancer hazard in ambient air is greater than the acute non-cancer hazard estimated (HI 2-6) in CDPHE's 2007 HHRA. The difference is due the inclusion of the trimethylbenzenes in this estimate. The data for the trimethylbenzenes had not been collected at the time of the 2007 HHRA.

Non-Cancer Risk Estimates Surface Water

For the surface water pathway, no individual COPC has an HQ greater than one, as shown in Table 5-4. The HI for non-cancer risks is 0.6, which is less than EPA's level of one below which health effects are not expected to occur.

Non-Cancer Risk Estimates Combined Ambient Air and Surface Water

The overall HI of 40 for the acute exposure of a resident child living adjacent to a well pad is 40, which is much greater than EPA's acceptable level of one at which health effects may occur. The trimethylbenzenes, benzene, and n-nonane in ambient air are the primary contributors to the overall HI.

Qualitative Risk Evaluation

The qualitative risk evaluation performed for the resident living near a well pad also applies to the acute risk for a child resident living near a well pad. Overall, based on the qualitative evaluation of health risks, it appears that exposure to several of the alkanes, and aromatic hydrocarbons identified in Table 5-2 that exceed BTVs could make a significant contribution to acute non-cancer effects for child residents living adjacent to well pads. Any of the six carbonyls without toxicity values also could potentially have a significant contribution to the acute non-cancer effects. In addition, the cumulative health effects cannot be estimated. It should be noted that the current state of the science is unable to assess exposures to complex mixtures of air toxics, especially, synergistic and antagonistic interactions at low levels.

6 Uncertainty in Risk Assessment

Uncertainties and limitations are inherent in the risk assessment process. The level of uncertainty associated with the conclusions of a risk assessment is conditional upon data quality and models used to estimate exposure concentrations, assumptions in estimating exposure, and methods used to develop toxicity factors. Uncertainties in the risk assessment process could result in an underestimation or overestimation of risk. However, it is standard in risk assessment (per EPA guidance) to use health protective assumptions when uncertainty in quantifying risks exist, so as not to underestimate potential risk. While, the risk assessment process is generally skewed towards overestimating rather than underestimating risk, the risk estimated is this HHRA is most likely underestimated because of lack of data for the surface soil and water pathways, lack of toxicity data for most of the COPCs, lack of data for many potential COPCs, ozone and PM are not included in the quantitative risk assessment, and the chemicals reactions between the hundreds of chemicals in ambient air are not evaluated.

6.1 Uncertainties in Chemical Data

Section 2 discusses the evaluation and usability of the chemical data used in the HHRA in detail.

6.1.1 Bell-Melton Ranch Monitoring Station Data

Sample Frequency

Twenty-nine ambient air samples for VOCs were collected from the Bell-Melton monitoring station once per month for 29 months, followed by the collection of 128 samples for SNMOCs and 60 samples for carbonyls over the next 27 months. There is a low to moderate uncertainty that this dataset reflects the 30-year exposure assumed in this HHRA as changes in meteorology and chemical emissions could lead to lower or higher concentrations in air from year to year. However, the temporal trends illustrated in Figures 2-1 and 2-2 indicate no overall increase or decrease in ambient air concentrations over the past five years. To reduce this uncertainty would require monitoring over several years or modeling based on observed changes in meteorology and chemical emissions.

The 29 ambient air samples collected for VOCs were analyzed for 43 chemicals. Thirty-six of these chemicals were not included in the SNMOC or carbonyl analysis. Therefore, for 36 chemicals evaluated in this HHRA, there are only 29 results for a 29 month period. There is more uncertainty that this sub-dataset reflects the 30-year exposure assumed in the HHRA, than the overall dataset.

Method Reporting Limits

For the 15 VOCs listed in Section 2.2.1 with a detection frequency of less than five percent, the RSL was less than the MRL. It is uncertain if these chemicals are present at a concentration that may impact human health. The presence of any of these chemicals in ambient at concentrations that could impact human health would contribute to an underestimation of the risks calculated in this HHRA. The contribution to the uncertainty would be expected be low because these chemicals are mostly chlorinated solvents which have not been associated with natural gas production operations. To reduce this uncertainty would require collection of ambient air samples for VOCs for analysis by a method with MRLs below EPA RSLs for ambient air.

6.1.2 Well Completion Data

Sixteen ambient air samples for SNMOCs were collected from the perimeter of four different well pads undergoing well completion activities. At each well pad, one sample was collected from each of the four cardinal directions (four total samples). There is high level of uncertainty that this dataset reflects the 10-month exposure assumed for well completion in this HHRA as changes in meteorology and chemical emissions could lead to lower or higher concentrations in air from month to month. In addition, it is uncertain whether this dataset reflects all stages of well completion as different stages of well completion can lead to lower or higher concentrations in ambient air. To reduce this uncertainty would require daily monitoring over all stages of well completion or modeling based on observed changes in meteorology and chemical emissions.

6.1.3 Data Collected with Observed Odors at Residences

Sample Collection

Grab samples rather than 24-hour integrated samples were collected during odor events. There is a high level of uncertainty that a grab sample reflects the 24 hour per day exposure time assumed in this HHRA as changes in meteorology and chemical emissions could lead to lower or higher concentrations in air from minute to minute.

Sample Frequency

Twenty-eight samples for VOCs were collected during the 2005-2007 Garfield County Air Quality Study by residents when they observed odors. There is a high level of uncertainty that this dataset reflects the 7 day acute exposure scenario in this HHRA as changes in meteorology and chemical emissions could lead to lower or higher concentrations in air from day to day. In addition, it is uncertain whether this dataset reflects all stages of well completion as different stages of well completion can lead to lower or higher concentrations of chemicals in ambient air. To reduce this uncertainty would require sample collection over many odor events associated with different stages of well completion or modeling based on observed changes in meteorology and chemical emissions.

Method Reporting Limits

For the 15 VOCs listed in Section 2.2.1 with a detection frequency of less than five percent, the RSL was less than the MRL. It is uncertain if these chemicals are present at a concentration that may impact human health. The presence of any of these chemicals in ambient at concentrations that could impact human health would contribute to an underestimation of the risks calculated in this HHRA. The contribution to the uncertainty would be expected be low because these chemicals are mostly chlorinated solvents which have not been associated with natural gas production operations. To reduce this uncertainty would require collection of ambient air samples for VOCs for analysis by a method with MRLs below EPA RSLs for ambient air.

6.1.4 Surface Water Run-off Data

One sample of snow melt from one well pad was collected and analyzed for BTEX. There is a high level of uncertainty that this sample represents concentrations in surface water run-off from other well pads and during various stages of well drilling and completion. Potential surface water run off from the well pads proposed for Battlement Mesa could have lower or higher concentrations of chemicals. To reduce this uncertainty would require sample collection of surface water run off from many well pads over the stages of well completion.

6.1.5 Background Data for Ambient Air

BTVs determined for 72 out of the 115 chemicals listed in Table 2-7 were determined from seven background samples collected during the 2008 Air Toxics study. For the remaining 43 chemicals, only 5 had 8 or more detected observations. EPA recommends that BTVs be determined from data sets containing at least 8 to 10 samples with detectable observations (EPA 2010). It is moderately uncertain that the datasets with only 7 samples or less than 8 detected observations truly reflect background conditions. Actual background concentrations may be higher or lower. To reduce this uncertainty would require collection of additional background samples.

6.1.6 Groundwater Data

Out of 98 contaminants measured in groundwater, 29 had MRLs greater than the EPA RSL for tapwater. Because the groundwater exposure pathway is currently incomplete, this has minimal impact on this HHRA.

6.2 Uncertainty in Exposure Assessment

There are uncertainties in the exposure assessment related to potentially complete pathways that were not evaluated, use of ambient air stations to represent residential exposure, use of Bell-Melton Ranch monitoring station to represent Battlement Mesa, using well completion data from the 2008 perimeter study to estimate exposure during well completion, using default exposure factor values, and estimating exposure point concentrations.

6.2.1 Potentially Complete Exposure Pathways Not Evaluated

As discussed in Section 3, complete pathways involving surface soil were not evaluated in this HHRA because data was not available. Excluding the surface soil pathway could moderately affect the results of the HHRA and lead to an underestimation of the risk.

Several potentially complete pathways were not evaluated in this HHRA because data was not available or potential for exposure is low. Excluding these pathways would not be expected to significantly affect the results of this HHRA and may lead to a low underestimation of the risk. It is important to note that if the groundwater became contaminated as a result of natural gas production operations and was used as a source of drinking water, the risk calculated in this HHRA could be significantly underestimated.

6.2.2 Use of Bell-Melton Ranch Monitoring Station

There is a moderate level of uncertainty that the Bell-Melton Ranch monitoring station is representative of air concentrations to which a resident is exposed in the breathing zone 24 hours a day over 30 years. Actual concentrations may be higher or lower. Additionally, actual risk to residents living near sources of high concentrations of contaminant emissions may be underestimated.

There also is moderate level of uncertainty that the concentrations of contaminants measured at the Bell-Melton Ranch monitoring station are representative of what may be expected within the Battlement Mesa PUD. The Bell-Melton Ranch Monitoring Station is located in the Mamm Creek natural gas field. The natural gas produced from this field contains 83.1 to 84.3 molar percent methane and 13.5 to 16.2 molar percent heavier hydrocarbons (S.S. Papadopulos, 2008). Measurements of natural gas produced from Antero's Watson Ranch well pad (which is on the border of the PUD and within the same natural gas field as the PUD) indicate the produced gas is 91.1 molar percent methane and 6.4 molar percent heavier hydrocarbons (Antero personnel communication). However, the natural gas from the Watson Ranch pad contains 0.45 molar percent of hydrocarbons with 6 or more carbon atoms, which is a larger fraction than the 0.155 to 0.369 molar percent of hydrocarbons with 6 or more carbon atoms measured at Mamm Creek. Of the hydrocarbons identified as COPCs in this HHRA, all but one (n-pentane) have 6 or more carbon atoms. Therefore the uncertainty associated with the difference in the natural gas resources my result in an underestimation of the estimated risk for the Battlement Mesa PUD.

Other differences between the Bell-Melton Ranch monitoring station and Battlement Mesa include:

- Population density - Battlement Mesa is more densely populated which could result in greater emissions of contaminants in ambient air, leading to an underestimation of the risk calculated in the HHRA.
- Well Emission Controls – Not all of the wells in the vicinity of Bell-Melton Ranch flare vented gas, whereas Antero has indicated flares will be installed on all wells within the Battlement Mesa PUD. This could result in an overestimation of the risk calculated in the HHRA

Overall, using data from the Bell Melton Ranch monitoring station to estimate risk to Battlement Mesa residents introduces a low to moderate level of uncertainty to the risk estimates. Actual risks may be lower or higher.

6.2.3 Use of Well Completion Samples

As with the samples collected at the Bell-Melton Ranch monitoring station, there is a moderate level of uncertainty that the samples collected at the perimeter of the well pads represent air concentrations to which a resident is exposed in the breathing zone for 24 hours a day over 10 months. Actual concentrations may be higher or lower. Additionally, samples were collected at distances nearer the well head than the 500 foot set back proposed by Antero. This may result in a low overestimation in the calculated risk.

A large uncertainty stems from inability to monitor intermittent peak exposure. The nature of oil and gas operations is such that emissions vary strongly with time. To reduce this uncertainty, short-term air monitoring is needed.

6.2.4 Use of EPA Default Exposure Factor Values

EPA recommends the use of site-specific exposure factor values for HHRAs when available. When site-specific information is not available, such as was the case for exposure frequencies and the surface water exposure factor values, EPA standard default values are recommended. In general, there is a higher uncertainty and protectiveness of health involved in using default values instead of site-specific values. Therefore default values used for exposure frequency and the surface water exposure factor values may have contributed to a low to moderate overestimation of risk.

6.2.5 Exposure Point Concentrations

The EPCs for 1,4-dichlorobenzene, 2-hexanone, and methylene chloride are based on one detected result out of 29 samples. Actual concentrations of 1,4-dichlorbenzene, 2-

hexanone, and methylene chloride may be lower and risks from these contaminants may be overestimated.

The maximum detected concentration was used from the well completion data was used to calculate the TWA for the EPC used to estimate the exposure of a resident living adjacent to a well pad. The maximum concentration was observed in the sample collected at 200 feet from the well head at an Antero well pad. The proposed set back for the wells in the Battlement Mesa PUD is 500 feet. Using the maximum concentration collected from a sample collected at a distance closer to a well head than the proposed set back may contribute moderately to an overestimation of the risk calculated in this HHRA. To reduce this uncertainty would require collection of samples at the proposed set back distance.

The maximum detected concentration for the data collected during odor events was used as the EPC to estimate an acute exposure of a child resident living adjacent to a well pad. Using the maximum concentration may contribute moderately to an overestimation of the risk calculated in this HHRA. However, the intention of the acute exposure scenario was to evaluate the MEI.

6.2.6 Exposures for children

The uncertainty noted for children in the 2007 risk assessment also applies to this HHRA (CDPHE 2007). Children generally are expected to have some exposures that differ (higher or lower) from those of adults because of differences in size, physiology, and behavior. For example, children exposed to the same concentration of a chemical in air as adults may receive a higher dose because of greater lung surface area-to-body weight ratios and higher ventilation rate per kilogram of body weight. EPA has recently concluded that cancer risks of mutagenic carcinogens generally are higher from early-life exposures than from similar exposure durations later in life. It is, however, important to note that when exposures are fairly uniform over a lifetime exposure of 70 years, the effect of child adjustments on the estimated lifetime cancer risk is relatively small. These adjustments are more important when estimating the cancer risks from less than 70 years of exposure duration, such as the 30-year exposure duration used in this HHRA. In addition, children are more at risk because of the availability of a longer latency period for the development of cancer.

6.3 Uncertainty in the Toxicity Assessment

There are uncertainties in the toxicity assessment related to the toxicity values, COPCs without toxicity data, the lack of data on potential COPCs for which there is no data, interactions resulting from exposures to multiple chemicals, and the effect of other pollutants such as ozone and particulate matter on toxicity.

6.3.1 Toxicity Values

The RfC and RfD values used to evaluate non-cancer risk and the IUR values used to quantify cancer are often derived from limited toxicity databases. This can result in substantial qualitative and quantitative uncertainty. To account for this uncertainty, EPA derives RfCs, RfDs, and IURs in a way that is intentionally conservative (protective of human health). Risk estimates based on the RfCs, RfDs, and IURs are likely to overestimate risk.

The 2008 risk assessment notes that the EPA has calculated a range of IURs for benzene between 2.2×10^{-6} and 7.8×10^{-6} per $\mu g/m^3$. The upper-bound value was used in this HHRA, as was done in the 2008 risk assessment, in accordance with the EPA Air Toxic guidance, which may slightly overestimate risk (up to 3-fold). The set of risk estimates falling within this interval reflects both the inherent uncertainties in the risk assessment of benzene and the limitations of the epidemiologic studies in determining dose-response and exposure data (CDPHE 2010).

Also noted in the 2008 risk assessment, the IUR for crotonaldehyde is particularly uncertain (CDPHE 2010). An IUR is not reported in EPA's IRIS for crotonaldehyde. The toxicity of crotonaldehyde was evaluated using a cancer toxicity value derived in the EPA Health Effects Assessment Summary Tables (HEAST) from oral exposure studies. Although conversion of oral dose-response information to inhalation exposure is not optimal risk assessment practice, the alternative would be to omit this substance altogether from any quantitative evaluation. Crotonaldehyde is classified as a possible human carcinogen (Category C). The classification was assigned based on one animal study in which an increase in the incidence of hepatic neoplastic nodules and hepatocellular carcinomas was observed in only one sex of one species. There is insufficient evidence that inhalation is a route that results in crotonaldehyde- induced liver lesions or neoplastia.

The IUR for 1,4-dichlorobenzene also is particularly uncertain. An IUR is not reported in EPA's IRIS for 1,4-dichlorobenzene. The toxicity of 1,4-dichlorobenzene was evaluated using a cancer toxicity derived by CALEPA from oral exposure studies. 1,4-dichlorobenzene is classified as a possible human carcinogen (Category C). The classification was assigned based on two animal studies in which an increase in the incidence of hepatocellular adenomas and carcinomas was observed in male rats and both sexes of mice.

The RfC for 1,2,4-trichlorobenzene was used as a surrogate toxicity value for 1,2,3-trichlorobenzene and 1,3,5-trichlorobenzene. This may have resulted in an underestimation or overestimation of the contribution of these two contaminants to the risk.

The RfD for chronic benzene exposure was used for the acute benzene exposure in surface water. This may have contributed to an overestimation of the risk from surface

water. However, the HI from the acute surface water exposure was less than one and the overall effect on the risk estimate is minimal.

The RfC for intermediate ethylbenzene exposure was used for the acute ethylbenzene exposure in surface water. This may have contributed to an overestimation of the risk from surface water. However, the HI from the acute surface water exposure was less than one and the overall effect on the risk estimate is minimal.

RfDs for dermal exposure were extrapolated from oral RfDs for the evaluation of acute exposure from surface water. This may have contributed to an overestimation of the risk from surface water. However, the HI from the acute surface water exposure was less than one and the overall effect on the risk estimate is minimal.

6.3.2 COPCs without toxicity values

One of the largest sources of uncertainty in the toxicity assessment is unavailability of toxicity values for 63 out of 82 COPCs in ambient air. Therefore, cancer risks and non-cancer hazards are likely to be underestimated for ambient air.

6.3.3 Potential COPCs Not Measured

Another one of the largest sources of uncertainty in the HHRA is lack of data for many chemicals in ambient air and surface water run-off that could be associated with natural gas production operations. These include chemicals in hydraulic fracturing fluid and drilling mud, polycyclic aromatic hydrocarbons (PAHs), and metals. Of the contaminants detected in samples collected at observed odor events between 2005 and 2007, only m&p-xylene exceeded Texas Commission on Environmental Quality's acute odor based effects screening level (ESL) (Table 2-6). The ESL is the level at which 50 percent of people can smell a contaminant and is not necessarily associated with health effects (TCEQ 2006). Health effects are possible for some contaminants, such as benzene, at levels below the odor threshold. The fact that only m&p-xylene exceeded the odor threshold indicates that there may be other ambient air contaminants associated in with natural gas production operations that have not been measured.

Table 6-1 lists 234 chemicals complied from Antero's material safety data sheets (MSDS) for natural gas production operations that have not been measured in ambient air or surface water samples. These include chemicals in hydraulic fracturing fluids and drilling mud. The list includes carcinogenic PAHs, metals, irritants, and odorous compounds, such as glutaraldehyde. Cancer risks and non-cancer hazards may be significantly underestimated without data for these chemicals.

Several of the PAHs are probable human carcinogens, including benzo (a) pyrene, dibenz(a,h)anthracene, benz(a)anthracene, benzo(b)fluoranthene, and indeno(c,d)pyrene (EPA IRIS). Others, such as naphthalene, are possible human carcinogens (EPA IRIS).

PAHs are associated with emissions from diesel engines. Once emitted to the air, the PAHs can contaminate surface soil and water via dry deposition. The trucks and generators used during natural gas production operations are powered by diesel engines. The truck traffic within the Battlement Mesa PUD is expected to be extensive with as many as 280 truck trips per day during peak well pad construction activities (Antero, 2010). Generator use is expected to be extensive during hydraulic fracturing operations. Naphthalene also is one of the chemicals listed on the MSDS sheets for hydraulic fracturing fluids, as well as being one of the components of the natural gas resource. Cancer risks may be significantly underestimated without PAH data for both ambient air and surface soil.

6.4 Uncertainty in Risk Estimation Due to Ozone and Particulate Matter

Ozone, PM_{10} and $PM_{2.5}$ were not evaluated in the HHRA because they are regulated by federal Air Quality Standards (AQS). The purpose of the AQSs is to protect human health. However, there has been much debate over whether the 75 ppb (147 $\mu g/m^3$) (averaged over 8 hours) AQS for ozone is protective and EPA is proposing a lower AQS of 60 ppb (118 $\mu g/m^3$). In addition, applying these standards on an individual basis does not account for potential additive affects in multiple chemical mixtures, as occurs in ambient air. A qualitative evaluation of the effects of these air pollutants on the risk estimates follows.

Ozone

There is not any conclusive evidence that ozone is a human carcinogen (EPA 2006, EPA 2009a).

Short-term exposure to ground level ozone through inhalation can cause reversible decrements to lung function, airway inflammation, coughing, chest pain, wheezing, and airway hyperactivity. These symptoms may be more long-lasting and pronounced in sensitive populations, such as people with asthma, children, and adults over 65 years of age. Acute ozone exposure also is associated with increased cardiovascular morbidity and non-accidental and cardiovascular mortality. There is some evidence long term exposure to ozone may cause decreased pulmonary function, but it is inconclusive (EPA 2006, EPA 2009a).

High concentrations of ozone precursors (VOCs and nitrogen oxides) have been observed in areas with high natural gas production operations in Garfield County (CDPHE 2009b). CDPHE ranked Garfield County as 5th out of 64 Colorado counties in levels of these ozone precursors in 2009, while Garfield ranked only 14th in population (CDPHE 2009c). In 2009, the 8-hr average ozone concentrations measured at the Rifle monitoring station did not exceed the 75 ppb AQS. However, 8-hour average ozone concentrations did exceed the proposed 60 ppb AQS on five days in March and April 2009, with a maximum concentration of 64 ppb (Garfield County 2010). For days on which the proposed 8-hour ozone AQS is exceeded, the acute non-cancer hazard calculated in this HHRA may be underestimated.

Particulate Matter

There is suggestive evidence indicating $PM_{2.5}$ may be associated with increased mortality from lung cancer (EPA 2009b).

Short-term exposure to $PM_{2.5}$ through inhalation is associated with increased emergency room visits and hospitalizations for ischemic heart disease, congestive heart failure chronic obstructive pulmonary disease (COPD), respiratory infections. Increases in all-cause, cardiovascular, and respiratory mortality are associated with short exposure to $PM_{2.5}$. Long-term exposure to $PM_{2.5}$ has been associated with cardiovascular mortality, decrements in lung function, and development of asthma (EPA 2009b). There is suggestive evidence that short-term and long term exposure to PM_{10} may cause health effects similar to those of $PM_{2.5.}$ Sensitive populations, such as children, older adults, and people with cardiopulmonary disease are more susceptible to these health effects.

Increased truck traffic can result in increased levels of $PM_{2.5}$ and PM_{10} through diesel emissions and stirring up road dust, respectively. The AQSs for $PM_{2.5}$ are 35 $\mu g/m^3$ (24-hour, 98^{th} percentile averaged over 3 years) and 15 $\mu g/m^3$ (annual, mean averaged over 3 years). The AQS for PM_{10} is 150 $\mu g/m^3$ (24-hour, not to be exceeded more than once per year on a 3-year average). Neither $PM_{2.5}$ or PM_{10} concentrations measured at the Rifle monitoring station nor PM_{10} concentrations measured at the Parachute monitoring station exceeded any of these AQSs. However, several 24-hour $PM_{2.5}$ concentrations exceeded 35 $\mu g/m^3$ in 2009. The highest observed concentration was 41$\mu g/m^3$ (Garfield County 2010). $PM_{2.5}$ concentrations measured during the 2008 Air Toxics Study were all less than the 24-hour AQS ranging from 4.9 to 20.5 $\mu g/m^3$ (Garfield County 2009). For days on which the 24-hour $PM_{2.5}$ AQS is exceeded, the acute non-cancer hazard calculated in this HHRA may be underestimated.

6.5 Uncertainty in Risk Estimation Due to Chemical Mixtures

Interactions among components within ambient air, such as hydrocarbons, carbonyls, ozone, and ozone, are not well understood. Natural gas production operations and the diesel engines used to support them have the potential to release hundreds of hydrocarbons, including alkanes, alkenes, aromatics, and PAHs, and chemicals used in operations, such as hydraulic fracturing into the air, soil, and water. The diesel engines also release $PM_{2.5}$ and nitrogen oxides. Hydrocarbons, carbonyls, and nitrogen oxides serve as precursors for ground level ozone formation. The number of possible interactions this complex mixture of hydrocarbons, carbonyls, ozone, particulate matter, and other chemicals is very large. The effects of these complex interactions on human health are not well understood, but there is some indication that these complex mixtures can act additively or synergistically to increase effects on human health.

As previously stated, diesel engine exhaust is a complex mixture of hydrocarbons, $PM_{2.5}$ and nitrogen oxides. EPA has classified diesel engine exhaust as *likely to be carcinogenic to humans* based on: (1) strong, but less than sufficient evidence for a causal association

between diesel engine exhaust exposure and increased lung cancer risk among workers in occupational studies; (2) extensive supporting data including the demonstrated mutagenic and/or chromosomal effects of diesel engine exhaust and its organic constituents, and knowledge of the known mutagenic and/or carcinogenic activity of a number of individual organic compounds that adhere to the particles and are present in the diesel engine gases; (3) evidence of carcinogenicity of diesel particulate matter and the associated organic compounds in rats and mice by other routes of exposure (dermal, intratracheal, and subcutaneous and intraperitoneal injection); and (4) suggestive evidence for the bioavailability of organic compounds from diesel engine exhaust in humans and animals. Non-cancer health effects of exposure to diesel engine exhaust include pulmonary inflammation and histopathology (IRIS 2003/2010).

Studies on air pollution indicate that continuous exposure of healthy human adults to sulfur dioxide or nitrogen dioxide increases ozone absorption, suggesting that co-exposure to other gaseous pollutants in the ambient air may enhance ozone absorption. Studies that evaluated response to allergens in asthmatics (allergic and dust-mite sensitive) suggest that ozone enhances response to allergen challenge. Other studies have reported increased response (lung tissue injury, inflammatory and phagocytosis) to the mixture of PM and ozone compared to either PM or ozone alone (EPA 2006).

There also is the potential that some interactions may have an antagonistic effect on human health, resulting in the over- estimation of risk. However, it is more likely that the risk calculated in this HHRA is underestimated by not accounting for interactions of the complex mixture of chemicals in ambient air.

7 Summary and Conclusions

7.1 Summary

COPCs for ambient air were selected from data collected in three major Garfield County air studies between 2005 and 2010 by comparing the maximum detected concentration for each contaminant determined in the study to 1/10 EPA's RSL for that contaminant in residential ambient air. If an EPA RSL was not available for a contaminant it was retained as a COPC if it had a detection frequency greater than 5 percent. The following 20 COPCs for which toxicity values are available were evaluated quantitatively.

- Acetaldehyde
- Crotonaldehyde
- Formaldehyde
- 1,2,3-Trimethylbenzene
- 1,2,4-Trimethylbenzene
- 1,3,5-Trimethylbenzene
- 1,4-Dichlorobenzene
- 2-Hexanone
- Benzene
- Ethylbenzene
- 1,3-Butadiene
- m&p-Xylene
- methylcyclohexane
- n-Hexane
- n-Octane
- n-Nonane
- n-Pentane
- Chloroform
- o-Xylene
- Toluene

There are no toxicity values for the 62 COPCs listed in Table 4-2. These COPCs are primarly alkanes, alkenes, aromatic hydrocarbons, and carbonyls. They were addressed qualitatively in the HHRA.

The following COPCs were selected for surface water run-off.

- Benzene
- Ethylbenzene
- m&p-Xylene
- o-Xylene
- Toluene

Three exposure scenarios were evaluated:

(1) A long-term (30-year) chronic exposure scenario for all Battlement Mesa residents
(2) A long-term (30-year) chronic exposure scenario for Battlement Mesa residents living adjacent to a well pad.
(3) An acute (7-day) exposure scenario for Battlement Mesa child residents living adjacent to a well pad

Table 7-1 summarizes the cancer risk and non-cancer HI for each of these exposure scenarios.

7.2 Conclusions

The data evaluated in this HHRA suggest that there is a potential for natural gas production operations within the Battlement Mesa PUD to negatively impact public health, particularly through acute ambient air exposures during well completion activities, for the following reasons:

- The estimated HI of 40 for acute non-cancer hazard to a child resident living adjacent to a well pad is much greater than one. Benzene, the trimethylbenzenes, and n-nonane in ambient air are the primary contributors to this HI. The surface water exposure pathway contribution to this HI is less than one. Potential COPCs, such as PAHs and chemicals in hydraulic fracturing, that were not measured, ozone, $PM_{2.5,}$ PM_{10}, and COPCs without toxicity values could have significant contributions to the acute non-cancer hazard. These potential unmeasured contributions could increase the acute non-cancer hazard via inhalation for Battlement Mesa child residents living adjacent to well pads. This acute non-cancer hazard also applies to adult residents living adjacent to well pads.
- The estimated cancer risk of 83 cancers per one million people (8.3E-05) for Battlement Mesa residents living adjacent to a well pad, while within EPA's acceptable range of 1 to 100 cancers per million people, exceeds EPA's goal of less than 1 in a million and is near the high end of the acceptable range. It also exceeds the baseline cancer risk of 1 per million. This cancer risk translates to a population attributable risk (PAR) of less than 1 cancer in a population of 5,041 residents. The estimated HI of 2 for non-cancer hazards exceeds one, above which health effects may occur. The qualitative evaluation of the COPCs without toxicity values concluded the cancer risk and non-cancer hazard may be significant underestimates. In addition potential COPCs, such as PAHs and chemicals in hydraulic fracturing, that were not measured, could have contributions to the cancer risk and non-cancer hazard. These potential unmeasured contributions could increase the cancer risk or non-cancer hazard for Battlement Mesa residents living adjacent to well pads.
- The estimated cancer risk of 71 cancers per one million people (7.1 E-05) for all Battlement Mesa residents, while within EPA's acceptable range of 1 to 100

cancers per million people exceeds EPA's goal of less than 1 in a million and is near the high end of the acceptable range. This cancer risk translates to a PAR of less than 1 cancer in a population of 5,041 residents. The estimated HI of 0.6 for non-cancer hazards is less than one, below which health effects are not expected to occur. The qualitative evaluation of the COPCs without toxicity values concluded the cancer risk and non-cancer hazard are underestimates. In addition potential COPCs, such as PAHs and chemicals in hydraulic fracturing, that were not measured contribute to the cancer risk and non-cancer hazard. These potential unmeasured contributions could increase the cancer risk or non-cancer hazard for Battlement Mesa residents.

8 Key Data Gaps

To address the uncertainties in this HHRA, the following data is needed.

- Baseline air data for SNMOCs, carbonyls, PAHs, ozone, $PM_{2.5}$, and chemicals associated with well installation collected within the Battlement Mesa PUD.
- 24-hour air monitoring data for SNMOCs, carbonyls, PAHs, ozone, $PM_{2.5}$, and chemicals associated with well installation collected at 500 foot set backs from well heads at all stages of well installation and completion
- Short-term acute air monitoring data for SNMOCs, carbonyls, PAHs, $PM_{2.5}$, and chemicals associated with well installation collected at 500 foot set backs from well heads at all stages of well completion and when odors are observed.
- 24-hour air monitoring data for SNMOCs, carbonyls, PAHs, ozone, $PM_{2.5}$, and chemicals associated with well installation collected at a centralized monitoring station within Battlement Mesa.
- Direct measurements of air concentrations for toxics in the breathing zone.
- Toxicity values for 62 air toxics.
- Baseline surface soil data for PAHs.

9 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. Toxicological Profile for 2-Hexanone. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 1997. Toxicological Profile for Chloroform. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 1999a. Toxicological Profile for Formaldehyde. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 1999b. Draft Toxicological Profile for Hexane. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2000. Draft Toxicological Profile for Methylene Chloride. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2006. Draft Toxicological Profile for Dichlorobenzenes. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2007a. Toxicological Profile for Benzene. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2007b. Draft Toxicological Profile for Ethylbenzene. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2007c. Toxicological Profile for Xylene. U.S Department of Health and Human Services, Public Health Service.

ATSDR. 2009a. Minimal Risk Levels for Hazardous Substances. http://www.atsdr.cdc.gov/mrls/index.html.

ATSDR. 2009b. Draft Toxicological Profile for 1,3-Butadiene. U.S Department of Health and Human Services, Public Health Service.

Antero Resources Inc.. 2010. Traffic Impact Analysis Update Antero Drill Sites – Battlement Mesa PUD. Memorandum April 20.

California Environmental Protection Agency (CAL EPA) Office of Environmental Health Hazard Assessment Toxicity Criteria Database. http://www.oehha.ca.gov/risk/ChemicalDB/index.asp. Accessed July 2010.

Carpenter, C.P., Geary, D.L., Myers, R.C., Nachreiner, D.J., Sullivan, L.J., and King, J.M. 1978. Petroleum Hydrocarbons Toxicity Studies XVII. Animal Responses to n-Nonane Vapor. Toxicol. Appl. Pharmacol. 44:53-61.

Colorado Department of Public Health and Environment (CDPHE). Air Pollution Control Division. 2002. A Community-based Short-term Ambient Air Screening Study in Garfield County for Oil and Gas Related Activities - Results and Discussion-. October.

CDPHE . Environmental Epidemiology Division. 2007. Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment Inhalation Of Volatile Organic Compounds Measured In Rural, Urban, and Oil &Gas Areas In Air Monitoring Study (June 2005 – May 2007). December.

CDPHE Air Pollution Control Division. 2009a. Analysis of Data Obtained for the Garfield County Air Toxics Study Summer 2008, October.

CDPHE Air Pollution Control Division. 2009a. Garfield County Emissions Inventory, October.

CDPHE Air Pollution Control Division 2009c. State of Colorado Technical Support Document For Recommended 8-hour Ozone designations, March.

Coons, T and Walker, R. 2008. 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado. Saccomanno Research Institute.

Galvin, J. B. and Marashi, F. 1999. n-Pentane, Journal of Toxicology and Environmental Health, Part A, 58: 1, 35 — 56

International Agency for Research on Cancer (IARC). 1995. Monographs on the Evaluation of Carcinogenic Risks to Humans: Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals. Volume 63.

IARC. 2000. Monographs on the Evaluation of Carcinogenic Risks to Humans: Some Industrial Chemicals. Volume 77.

Kinkead, E. R., Haun, C. C., Schneider, M. G., Vernot, E. H., and MacEwen, J. D. 1985. Chronic Inhalation Exposure of Experimental Animals to Methylcyclohexane. Defense Technical Information System.

Miller, C.M., Blevins, A. 2005. Battlement Mesa: a case study of community evolution. The Social Science Journal. Volume 42. pages 1-12

Nilsen, O.G., Haugen, O.A., Zahisen, K., Halgunset, J., Helseth, A., Aarset, A., and Eide, I. 1988. Toxicity of n-C9 to n-C13 alkanes in the rat on short term inhalation. Pharmacol. Toxicol. 62: 259-266.

Sandmeyer, E.E. 1981. Aliphatic Hydrocarbons, P. 3175-3220. In: Patty's Industrial Hygeine and Toxicology, Third Edition, Volume IIB, John Wiley, New York.

S.S. Papadopulos & Associates, Inc. 2008. Phase II Hydrogeologic Characterization of the Mamm Creek Field Area, Garfield County, Colorado.

Rothman N, Smith MT, Hayes RB, et al. 1997. Benzene poisoning, a risk factor for hematological malignancy, is associated with the NQ01 609C-T mutation and rapid fractional excretion of chlozoxazone. Cancer Res 57(14):2839-2842.

URS. 2008. Second Quarter 2008 Report Operational and Environmental Monitoring Within a Three-mile Radius of Project Rulison. Prepared for Noble Energy Inc. EnCana Oil & Gas (USA) Inc., Williams Production RMT Inc.

United States Environmental Protection Agency (EPA). 1989. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part A). EPA Document EPA/540/1-89/002.

EPA. 1994. Chemical Fact Sheet: EPA 749-F-94-022: Chemicals in the Environment: 1,2,4-Trimethylbenzene (CAS No. 95-63-6) prepared by the Office of Pollution Prevention and Toxics.

EPA. 1997. Office of Research and Development. Health Effects Assessment Summary Tables. July.

EPA 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA 530-D-02-004. November.

EPA 2004. U.S. Environmental Protection Agency, The OAQPS Air Toxic Risk Assessment Library. Available at EPA's fate, exposure, and risk analysis (FERA) website: http://www.epa.gov/ttn/fera/risk_atra_main.html

EPA 2006. Air Quality Criteria for Ozone and Related Photochemical Oxidants. EPA 600/R-05/004aF. National Center for Environmental Assessment Office of Research and Development. February.

EPA. 2009a. Provisional Assessment of Recent Studies on Health and Ecological Effects of Ozone Exposure. EPA/600/R-09/101. National Center for Environmental Assessment Office of Research and Development. September.

EPA. 2009b. Integrated Science Assessment for Particulate Matter. EPA/600/R-08/139F. National Center for Environmental Assessment Office of Research and Development. December.

EPA. 2010. ProUCL Version 4.00.05 Technical Guide (Draft). EPA/600/R-07/041 May.

EPA. Integrated Risk Information System. http://www.epa.gov/IRIS/. Assessed August 2010.

Texas Commission on Environmental Quality (TCEQ). 2006. Guidelines to Develop EffectsScreening Levels, ReferenceValues, and Unit Risk Factors.

USGS Google Pitkin, Gunnison, Delta, Garfield, Mesa, Rio Blanco and Moffat counties.

Table 2-1
Comparison of MRLs for 2005 - 2007 Data to EPA RSLs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	EPA RSL[1] (µg/m3)	EPA RSL greater than Maximum MRL?	EPA RSL greater than minimum MRL?
1,1,2,2-Tetrachloroethane	**0**	**1.50E+00**	**2.20E+00**	**4.20E-02**	**no**	**no**
1,1,2-Trichloroethane	**0**	**1.50E+00**	**2.20E+00**	**1.50E-01**	**no**	**no**
1,1-Dichloroethane	**0**	**1.50E+00**	**2.20E+00**	**1.50E+00**	**no**	**no**
1,2-Dibromoethane	0	1.50E+00	2.20E+00	4.10E-03	no	yes
1,2-Dichloroethane	**0**	**1.50E+00**	**2.20E+00**	**9.40E-02**	**no**	**no**
1,2-Dichloropropane	**0**	**1.50E+00**	**2.20E+00**	**2.40E-01**	**no**	**no**
1,4-Dichlorobenzene	**3**	**1.50E+00**	**2.20E+00**	**2.20E-01**	**no**	**no**
Bromodichloromethane	**0**	**1.50E+00**	**2.20E+00**	**6.60E-02**	**no**	**no**
Bromoform	0	1.50E+00	2.20E+00	2.20E+00	yes	yes
Carbon Tetrachloride	**0**	**1.50E+00**	**2.20E+00**	**4.10E-01**	**no**	**no**
Chloroform	**0**	**1.50E+00**	**2.20E+00**	**1.10E-01**	**no**	**no**
cis-1,3-Dichloropropene	**0**	**1.50E+00**	**2.20E+00**	**6.10E-01**	**no**	**no**
Dibromochloromethane	**0**	**1.50E+00**	**2.20E+00**	**9.00E-02**	**no**	**no**
Tetrachloroethene	**0**	**1.50E+00**	**2.20E+00**	**4.10E-01**	**no**	**no**
trans-1,3-Dichloropropene	**0**	**1.50E+00**	**2.20E+00**	**6.10E-01**	**no**	**no**
Trichloroethene	**0**	**1.50E+00**	**2.20E+00**	**1.20E+00**	**no**	**no**
Vinyl Chloride	**0**	**1.50E+00**	**2.20E+00**	**1.60E-01**	**no**	**no**
1,1,1-Trichloroethane	0	1.50E+00	2.20E+00	5.20E+03	yes	yes
1,1-Dichloroethene	0	1.50E+00	2.20E+00	2.10E+02	yes	yes
1,2-Dichlorobenzene	0	1.50E+00	2.20E+00	2.10E+02	yes	yes
1,3-Dichlorobenzene	0	1.50E+00	2.20E+00	NA	yes	yes
2-Hexanone	3	1.50E+00	2.20E+00	3.10E+01	yes	yes
4-Methyl-2-pentanone	0	1.50E+00	2.20E+00	3.10E+03	yes	yes
Bromomethane	0	1.50E+00	2.20E+00	5.20E+00	yes	yes
Carbon Disulfide	0	1.50E+00	2.20E+00	7.30E+02	yes	yes
Chlorobenzene	0	1.50E+00	2.20E+00	5.20E+01	yes	yes
Chloroethane	0	1.50E+00	2.20E+00	1.00E+04	yes	yes
Chloromethane	0	1.50E+00	2.20E+00	9.40E+01	yes	yes
cis-1,2-Dichloroethene	0	1.50E+00	2.20E+00	NA	-	-
Methyl tert-Butyl Ether	0	1.50E+00	2.20E+00	9.40E+00	yes	yes
Methylene chloride	3	1.50E+00	2.20E+00	5.20E+00	yes	yes
Styrene	0	1.50E+00	2.20E+00	1.00E+03	yes	yes
trans-1,2-Dichloroethene	0	1.50E+00	2.20E+00	6.30E+01	yes	yes
Trichlorofluoromethane	0	1.50E+00	2.20E+00	7.30E+02	yes	yes
Trichlorotrifluoroethane	0	1.50E+00	2.20E+00	3.10E+04	yes	yes

Notes:

Bold text indicates the EPA RSL is lower than the MRL. The MRL is not adequate for a HHRA.

[1]EPA Regional Screening values for residential ambient air May 2010. Based on exposure of 24 hours per day for 350 days per year for 30 years: http://www.epa.gov/region9/superfund/prg/index.html

RSL = regional screening values: Health effects are not expected to occur at or below this level.

MRL = method reporting limit: Results less than this level were reported as not detected.

NA = not available

µg/m^3 = micrograms per cubic meter

% = percent

Table 2-2
Comparison of MRLs from 2008 to 2010 Data to EPA RSLs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	EPA RSL[1] (µg/m3)	EPA RSL greater than Maximum MRL?	EPA RSL greater than minimum MRL?
1-Decene	0	1.15E-01	1.43E-01	NA	-	-
2,5-Dimethylbenzaldehyde	0	2.20E-03	1.10E-02	NA	-	-
2-Ethyl-1-butene	1	1.49E-01	2.47E-01	NA	-	-
Propyne	1	9.83E-02	1.09E-01	NA	-	-
trans-2-Hexene	1	1.49E-01	2.47E-01	NA	-	-
2-Methyl-1-pentene	2	1.49E-01	2.47E-01	NA	-	-

[1]EPA Regional Screening values for residential ambient air May 2010. Based on exposure of 24 hours per day for 350 days per year for 30 years: http://www.epa.gov/region9/superfund/prg/index.html
RSL = regional screening values: Health effects are not expected to occur at or below this level.
MRL = method reporting limit: Results less than this level were reported as not detected.
NA = not available
µg/m^3 = micrograms per cubic meter
% = percent

Table 2-3
Comparison of MRLs for 2010 Groundwater Data to EPA RSLs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Detection frequency (%)	MRL (µg/L)	EPA RSL[1] (µg/L)	EPA RSL greater than MRL?
1,1,1,2-Tetrachloroethane	0	5.00E-01	5.10E-01	yes
1,1,1-Trichloroethane	0	5.00E-01	9.10E+03	yes
1,1,2,2-Tetrachloroethane	**0**	**5.00E-01**	**6.70E-02**	**no**
1,1,2-Trichloroethane	**0**	**5.00E-01**	**2.40E-01**	**no**
1,1-Dichloroethane	0	5.00E-01	2.40E+00	yes
1,1-Dichloroethylene	0	5.00E-01	3.40E+02	yes
1,1-Dichloropropylene	0	5.00E-01	NA	-
1,2,3-Trichlorobenzene	0	5.00E-01	2.90E+01	yes
1,2,3-Trichloropropane	**0**	**5.00E-01**	**7.20E-04**	**no**
1,2,4-Trichlorobenzene	0	5.00E-01	2.30E+00	yes
1,2,4-Trimethylbenzene	0	5.00E-01	1.50E+01	yes
1,2-Dibromo-3-chloropropane	**0**	**2.00E-02**	**3.40E-04**	**no**
1,2-Dibromoethane	**0**	**1.00E-02**	**6.50E-03**	**no**
1,2-Dichlorobenzene	0	5.00E-01	3.70E+02	yes
1,2-Dichloroethane	**0**	**5.00E-01**	**1.50E-01**	**no**
1,2-Dichloropropane	**0**	**5.00E-01**	**3.90E-01**	**no**
1,3,5-Trimethylbenzene	0	5.00E-01	3.70E+02	yes
1,3-Dichlorobenzene	0	5.00E-01	NA	-
1,3-Dichloropropane	0	5.00E-01	7.30E+02	yes
1,3-Dichloropropene	**0**	**5.00E-01**	**4.30E-01**	**no**
1,4-Dichlorobenzene	**0**	**5.00E-01**	**4.30E-01**	**no**
2,2-Dichloropropane	0	5.00E-01	NA	-
2,4,5-TP	0	2.00E-01	2.00E+01	yes
2,4-D	0	1.00E-01	3.70E+02	yes
3-Hydroxycarbofuran	0	5.00E-01	NA	-
Aldrin	**0**	**1.00E-02**	**4.00E-03**	**no**
Alicarb	0	5.00E-01	3.70E+01	yes
Alicarb Sulfone	0	5.00E-01	3.70E+01	yes
Alicarb Sulfoxide	0	5.00E-01	NA	-
alpha-Chlordane	0	1.00E-02	1.90E-01	yes
Arochlor 1016	0	8.00E-02	9.60E-01	yes
Arochlor 1221	**0**	**1.00E-01**	**6.80E-03**	**no**
Arochlor 1232	**0**	**1.00E-01**	**6.80E-03**	**no**
Arochlor 1242	**0**	**1.00E-01**	**3.40E-02**	**no**
Arochlor 1248	**0**	**1.00E-01**	**3.40E-02**	**no**
Arochlor 1254	**0**	**1.00E-01**	**3.40E-02**	**no**
Arochlor 1260	**0**	**1.00E-01**	**3.40E-02**	**no**
Benzene	**0**	**5.00E-01**	**4.10E-01**	**no**
Bromobenzene	0	5.00E-01	8.80E+01	yes
Bromochloromethane	0	5.00E-01	NA	-
Bromodichloromethane	**0**	**5.00E-01**	**1.20E-01**	**no**
Bromoform	0	5.00E-01	8.50E+00	yes
Bromomethane	0	5.00E-01	8.70E+00	yes
Carbaryl	0	5.00E-01	3.70E+03	yes
Carbofuran	0	5.00E-01	1.80E+02	yes

Table 2-3
Comparison of MRLs for 2010 Groundwater Data to EPA RSLs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Detection frequency (%)	MRL (µg/L)	EPA RSL[1] (µg/L)	EPA RSL greater than MRL?
Carbon Tetrachloride	0	5.00E-01	4.40E+01	yes
Chlordane	**0**	**2.00E-01**	**1.90E-01**	**no**
Chlorobenzene	0	5.00E-01	9.10E+01	yes
Chloroethane	0	5.00E-01	2.10E+04	yes
Chloroform	**0**	**5.00E-01**	**1.90E-01**	**no**
Chloromethane	0	5.00E-01	1.90E+02	yes
cis-1,2-dichloroethene	0	5.00E-01	3.70E+02	yes
cis-1,3-dichloropropene	**0**	**5.00E-01**	**4.30E-01**	**no**
Dalapon	0	1.00E+00	1.10E+03	yes
Dibromochloromethane	**0**	**5.00E-01**	**1.50E-01**	**no**
Dibromomethane	0	5.00E-01	8.20E+00	yes
Dicamba	0	3.00E-01	1.10E+03	yes
Dichlorodifluoromethane	0	5.00E-01	3.90E+02	yes
Dieldrin	**0**	**1.00E-02**	**4.20E-03**	**no**
Dinoseb	0	2.00E-01	3.70E+01	yes
Endothall	0	1.80E+00	7.30E+02	yes
Endrin	0	1.00E-02	1.10E+01	yes
Ethylbenzene	0	5.00E-01	1.50E+00	yes
gamma-BHC (Lindane)	0	1.00E-02	6.10E-02	yes
gamma-Chlordane	0	1.00E-02	1.90E-01	yes
Heptachlor	0	1.00E-02	1.50E-02	yes
Heptachlor Epoxide	**0**	**1.00E-02**	**7.43E-03**	**no**
Hexachlorobenzene	0	2.00E-02	4.20E-02	yes
Hexachlorobutadiene	0	5.00E-01	8.60E-01	yes
Hexachlorocyclopentadiene	0	5.00E-02	2.20E+02	yes
Isopropylbenzene	0	5.00E-01	6.80E+02	yes
m,p-Xylene	0	5.00E-01	1.20E+03	yes
Methiocarb	0	5.00E-01	NA	-
Methiomyl	0	5.00E-01	9.10E+02	yes
Methoxychlor	0	5.00E-02	1.80E+02	yes
Methylene chloride	0	5.00E-01	4.80E+00	yes
Naphthalene	**0**	**5.00E-01**	**1.40E-01**	**no**
n-Butylbenzene	0	5.00E-01	NA	-
n-propylbenzene	0	5.00E-01	1.30E+03	yes
o-Chlorotoluene	0	5.00E-01	7.30E+02	yes
Oxamyl	0	5.00E-01	9.10E+01	yes
o-Xylene	0	5.00E-01	1.20E+03	yes
p-Chlorotoluene	0	5.00E-01	2.60E+03	yes
Pentachlorophenol	0	4.00E-02	5.60E-01	yes
Picloram	0	1.00E-01	2.60E+03	yes
p-Isopropyltoluene	0	5.00E-01	NA	-
Propoxur	0	5.00E-01	1.50E+02	yes
sec-Butylbenzene	0	5.00E-01	NA	-
Styrene	0	5.00E-01	1.60E+03	yes
tert-Butylbenzene	0	5.00E-01	NA	-

Table 2-3
Comparison of MRLs for 2010 Groundwater Data to EPA RSLs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Detection frequency (%)	MRL (µg/L)	EPA RSL[1] (µg/L)	EPA RSL greater than MRL?
Tetrachloroethene	**0**	**5.00E-01**	**1.10E-01**	**no**
Toluene	0	5.00E-01	2.30E+03	yes
Toxaphene	**0**	**5.00E-01**	**6.10E-02**	**no**
trans-1,2-dichloroethene	0	5.00E-01	1.10E+02	yes
trans-1,3-dichloropropene	**0**	**5.00E-01**	**4.30E-01**	**no**
Trichloroethene	0	5.00E-01	2.00E+00	yes
Trichlorofluoromethane	0	5.00E-01	1.30E+03	yes
Vinyl chloride	**0**	**5.00E-01**	**1.60E-02**	**no**

Notes:

Bold text indicates the EPA RSL is lower than the MRL. The MRL is not adequate for a HHRA.

[1]EPA Regional Screening values for residential tapwater May 2010.

RSL = regional screening values: Health effects are not expected to occur at or below this level.

MRL = method reporting limit: Results less than this level were reported as not detected.

NA = not available

µg/L = micrograms per liter

% = percent

Table 2-4

Summary Statistics and Selection of COPCs by Comparison to EPA RSL[1]

2005-2010 Ambient Air Data Bell-Melton Ranch Monitoring Station

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	EPA RSL[1] (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Detected Concentration ≥ 1/10 EPA RSL?	Mean Concentration (µg/m^3)	COPC?
1,1,1-Trichloroethane	71-55-6	29	0	0	no	-	-	-	-	-	no
1,1,2,2-Tetrachloroethane	79-34-5	29	0	0	no	-	-	-	-	-	no
1,1,2-Trichloroethane	79-00-5	29	0	0	no	-	-	-	-	-	no
1,1-Dichloroethane	75-34-3	29	0	0	no	-	-	-	-	-	no
1,1-Dichloroethene	75-35-4	29	0	0	no	-	-	-	-	-	no
1,2,3-Trimethylbenzene	**526-73-8**	**128**	**44**	**34**	**yes**	**8.47E-01**	**NA**	**NA**	**-**	**8.10E-02**	**yes**
1,2,4-Trimethylbenzene	**95-63-6**	**128**	**121**	**95**	**yes**	**3.09E+00**	**7.30E+00**	**7.30E-01**	**yes**	**2.75E-01**	**yes**
1,2-Dibromoethane	106-93-4	29	0	0	no	-	-	-	-	-	no
1,2-Dichlorobenzene	95-50-1	29	0	0	no	-	-	-	-	-	no
1,2-Dichloroethane	107-06-2	29	0	0	no	-	-	-	-	-	no
1,2-Dichloropropane	78-87-5	29	0	0	no	-	-	-	-	-	no
1,3,5-Trimethylbenzene	**108-67-8**	**128**	**101**	**79**	**yes**	**1.20E+00**	**NA**	**NA**	**-**	**1.51E-01**	**yes**
1,3-Butadiene	**106-99-0**	**128**	**9**	**7**	**yes**	**1.53E-01**	**8.10E-02**	**8.10E-03**	**yes**	**5.58E-02**	**yes**
1,3-Dichlorobenzene	541-73-1	29	0	0	no	-	-	-	-	-	no
1,4-Dichlorobenzene	**106-46-7**	**29**	**1**	**3**	**no**	**2.30E+00**	**2.20E-01**	**2.20E-02**	**yes**	**9.36E-01**	**yes**
1-Decene	872-05-9	128	0	0	no	-	-	-	-	-	no
1-Dodecene	**112-41-4**	**128**	**32**	**25**	**yes**	**1.02E+00**	**NA**	**NA**	**-**	**1.44E-01**	**yes**
1-Heptene	**592-76-7**	**128**	**123**	**96**	**yes**	**2.98E+00**	**NA**	**NA**	**-**	**6.30E-01**	**yes**
1-Hexene	**592-41-6**	**128**	**69**	**54**	**yes**	**2.77E-01**	**NA**	**NA**	**-**	**9.55E-02**	**yes**
1-Nonene	**124-11-8**	**128**	**59**	**46**	**yes**	**4.28E-01**	**NA**	**NA**	**-**	**1.07E-01**	**yes**
1-Octene	**111-66-0**	**128**	**24**	**19**	**yes**	**1.37E+00**	**NA**	**NA**	**-**	**1.06E-01**	**yes**
1-Pentene	**109-67-1**	**128**	**124**	**97**	**yes**	**3.80E-01**	**NA**	**NA**	**-**	**1.04E-01**	**yes**
1-Tridecene	**2437-56-1**	**128**	**12**	**9**	**yes**	**2.04E-01**	**NA**	**NA**	**-**	**1.06E-01**	**yes**
1-Undecene	**821-95-4**	**128**	**35**	**27**	**yes**	**1.07E+00**	**NA**	**NA**	**-**	**1.21E-01**	**yes**
2,2,3-Trimethylpentane	**564-02-3**	**128**	**58**	**45**	**yes**	**1.64E+00**	**NA**	**NA**	**-**	**1.49E-01**	**yes**
2,2,4-Trimethylpentane	**540-84-1**	**128**	**58**	**45**	**yes**	**2.48E+00**	**NA**	**NA**	**-**	**1.52E-01**	**yes**
2,2-Dimethylbutane	**75-83-2**	**128**	**128**	**100**	**yes**	**2.34E+00**	**NA**	**NA**	**-**	**6.15E-01**	**yes**
2,3,4-Trimethylpentane	**565-75-3**	**128**	**74**	**58**	**yes**	**1.79E+00**	**NA**	**NA**	**-**	**9.21E-02**	**yes**
2,3-Dimethylbutane	**79-29-8**	**128**	**128**	**100**	**yes**	**5.05E+00**	**NA**	**NA**	**-**	**1.22E+00**	**yes**
2,3-Dimethylpentane	**565-59-3**	**128**	**128**	**100**	**yes**	**2.08E+00**	**NA**	**NA**	**-**	**5.26E-01**	**yes**

Table 2-4

Summary Statistics and Selection of COPCs by Comparison to EPA RSL[1]

2005-2010 Ambient Air Data Bell-Melton Ranch Monitoring Station

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	EPA RSL[1] (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Detected Concentration ≥ 1/10 EPA RSL?	Mean Concentration (µg/m^3)	COPC?
2,4-Dimethylpentane	**108-08-7**	**128**	**127**	**99**	**yes**	**1.48E+00**	**NA**	**NA**	**-**	**3.69E-01**	**yes**
2,5-Dimethylbenzaldehyde	5779-94-2	128	0	0	no	-	-	-	-	-	no
2-Butanone (MEK)	78-93-3	29	16	55	yes	9.80E+00	5.20E+03	5.20E+02	no	2.62E+00	no
2-Ethyl-1-butene	760-21-4	128	1	1	no	2.75E+00	NA	NA	-	1.19E-01	no
2-Hexanone	**591-78-6**	**29**	**1**	**3**	**no**	**4.40E+00**	**3.10E+01**	**3.10E+00**	**yes**	**1.00E+00**	**yes**
2-Methyl-1-butene	**563-46-2**	**128**	**44**	**34**	**yes**	**3.94E+01**	**NA**	**NA**	**-**	**5.98E-01**	**yes**
2-Methyl-1-pentene	763-29-1	128	2	2	no	1.52E-01	NA	NA	-	9.82E-02	no
2-Methyl-2-butene	**513-35-9**	**128**	**51**	**40**	**yes**	**4.17E-01**	**NA**	**NA**	**-**	**8.95E-02**	**yes**
2-Methylheptane	**592-27-8**	**128**	**128**	**100**	**yes**	**2.93E+00**	**NA**	**NA**	**-**	**6.28E-01**	**yes**
2-Methylhexane	**591-76-4**	**128**	**126**	**98**	**yes**	**5.71E+00**	**NA**	**NA**	**-**	**1.39E+00**	**yes**
2-Methylpentane	**107-83-5**	**128**	**128**	**100**	**yes**	**2.20E+01**	**NA**	**NA**	**-**	**5.39E+00**	**yes**
3-Methyl-1-butene	**563-45-1**	**128**	**9**	**7**	**yes**	**2.00E-01**	**NA**	**NA**	**-**	**6.16E-02**	**yes**
3-Methylheptane	**589-81-1**	**128**	**128**	**100**	**yes**	**3.53E+00**	**NA**	**NA**	**-**	**4.17E-01**	**yes**
3-Methylhexane	**589-34-4**	**128**	**116**	**91**	**yes**	**4.84E+00**	**NA**	**NA**	**-**	**1.11E+00**	**yes**
3-Methylpentane	**96-14-0**	**128**	**128**	**100**	**yes**	**1.16E+01**	**NA**	**NA**	**-**	**2.80E+00**	**yes**
4-Methyl-1-pentene	**691-37-2**	**128**	**13**	**10**	**yes**	**4.68E+00**	**NA**	**NA**	**-**	**1.41E-01**	**yes**
4-Methyl-2-pentanone	108-10-1	29	0	0	no	-	-	-	-	-	no
Acetaldehyde	**75-07-0**	**128**	**128**	**100**	**yes**	**1.96E+00**	**1.10E+00**	**1.10E-01**	**yes**	**7.98E-01**	**yes**
Acetone	67-64-1	128	124	97	yes	5.70E+01	3.20E+04	3.20E+03	no	6.88E+00	no
Acetylene	**74-86-2**	**128**	**128**	**100**	**yes**	**2.92E+00**	**NA**	**NA**	**-**	**6.30E-01**	**yes**
a-Pinene	**80-56-8**	**128**	**75**	**59**	**yes**	**3.37E+00**	**NA**	**NA**	**-**	**1.74E-01**	**yes**
Benzaldehyde	**100-52-7**	**128**	**125**	**98**	**yes**	**2.04E-01**	**NA**	**NA**	**-**	**7.10E-02**	**yes**
Benzene	**71-43-2**	**128**	**112**	**88**	**yes**	**1.36E+01**	**3.10E-01**	**3.10E-02**	**yes**	**1.47E+00**	**yes**
b-Pinene	**127-91-3**	**128**	**10**	**8**	**yes**	**1.43E+00**	**NA**	**NA**	**-**	**8.08E-02**	**yes**
Bromodichloromethane	75-27-4	29	0	0	no	-	-	-	-	-	no
Bromoform	75-25-2	29	0	0	no	-	-	-	-	-	no
Bromomethane	74-83-9	29	0	0	no	-	-	-	-	-	no
Butyraldehyde	**123-72-8**	**128**	**126**	**98**	**yes**	**2.71E-01**	**NA**	**NA**	**-**	**6.98E-02**	**yes**
Carbon Disulfide	75-15-0	29	0	0	no	-	-	-	-	-	no
Carbon Tetrachloride	56-23-5	29	0	0	no	-	-	-	-	-	no

Table 2-4

Summary Statistics and Selection of COPCs by Comparison to EPA RSL[1]

2005-2010 Ambient Air Data Bell-Melton Ranch Monitoring Station

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	EPA RSL[1] (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Detected Concentration ≥ 1/10 EPA RSL?	Mean Concentration (µg/m^3)	COPC?
Chlorobenzene	108-90-7	29	0	0	no	-	-	-	-	-	no
Chloroethane	75-00-3	29	0	0	no	-	-	-	-	-	no
Chloroform	67-66-3	29	0	0	no	-	-	-	-	-	no
Chloromethane	74-87-3	29	0	0	no	-	-	-	-	-	no
cis-1,2-Dichloroethene	156-59-2	29	0	0	no	-	-	-	-	-	no
cis-1,3-Dichloropropene	10061-01-5	29	0	0	no	-	-	-	-	-	no
cis-2-Butene	**590-18-1**	**128**	**63**	**49**	**yes**	**3.73E-01**	**NA**	**NA**	**-**	**6.79E-02**	**yes**
cis-2-Hexene	**7688-21-3**	**128**	**21**	**16**	**yes**	**7.00E-01**	**NA**	**NA**	**-**	**9.97E-02**	**yes**
cis-2-Pentene	**627-20-3**	**128**	**34**	**27**	**yes**	**1.45E-01**	**NA**	**NA**	**-**	**5.37E-02**	**yes**
Crotonaldehyde	**123-73-9**	**128**	**128**	**100**	**yes**	**5.53E-01**	**NA**	**NA**	**-**	**1.26E-01**	**yes**
Cyclohexane	110-82-7	128	128	100	yes	1.05E+02	6.30E+03	6.30E+02	no	3.85E+00	no
Cyclopentane	**287-92-3**	**128**	**128**	**100**	**yes**	**2.94E+00**	**NA**	**NA**	**-**	**7.28E-01**	**yes**
Cyclopentene	**142-29-0**	**128**	**67**	**52**	**yes**	**9.58E-01**	**NA**	**NA**	**-**	**1.34E-01**	**yes**
Dibromochloromethane	124-48-1	29	0	0	no	-	-	-	-	-	no
Ethane	**74-84-0**	**128**	**128**	**100**	**yes**	**4.11E+02**	**NA**	**NA**	**-**	**8.00E+01**	**yes**
Ethylbenzene	**100-41-4**	**128**	**92**	**72**	**yes**	**4.34E+00**	**9.70E-01**	**9.70E-02**	**yes**	**3.78E-01**	**yes**
Ethylene	**74-85-1**	**128**	**128**	**100**	**yes**	**2.94E+00**	**NA**	**NA**	**-**	**1.00E+00**	**yes**
Formaldehyde	**50-00-0**	**128**	**128**	**100**	**yes**	**1.02E+01**	**1.90E-01**	**1.90E-02**	**yes**	**1.17E+00**	**yes**
Hexaldehyde	**66-25-1**	**128**	**113**	**88**	**yes**	**1.31E-01**	**NA**	**NA**	**-**	**4.21E-02**	**yes**
Isobutane	**75-28-5**	**128**	**128**	**100**	**yes**	**1.18E+02**	**NA**	**NA**	**-**	**2.34E+01**	**yes**
Isobutene/1-Butene	**-11-7 / 106-9**	**128**	**84**	**66**	**yes**	**1.36E+01**	**NA**	**NA**	**-**	**1.29E+00**	**yes**
Isopentane	**78-78-4**	**128**	**123**	**96**	**yes**	**1.23E+02**	**NA**	**NA**	**-**	**1.97E+01**	**yes**
Isoprene	**78-79-5**	**128**	**82**	**64**	**yes**	**3.33E+00**	**NA**	**NA**	**-**	**3.13E-01**	**yes**
Isopropylbenzene (cumene)	98-82-8	128	34	27	yes	3.27E-01	4.20E+02	4.20E+01	no	7.80E-02	no
Isovaleraldehyde	**590-86-3**	**128**	**71**	**55**	**yes**	**1.13E-01**	**NA**	**NA**	**-**	**5.69E-03**	**yes**
m-Diethylbenzene	**141-93-5**	**128**	**44**	**34**	**yes**	**8.84E-01**	**NA**	**NA**	**-**	**9.25E-02**	**yes**
Methyl tert-Butyl Ether	1634-04-4	29	0	0	no	-	-	-	-	-	no
Methylcyclohexane	**108-87-2**	**128**	**128**	**100**	**yes**	**2.39E+01**	**NA**	**NA**	**-**	**5.38E+00**	**yes**
Methylcyclopentane	**96-37-7**	**128**	**128**	**100**	**yes**	**1.04E+01**	**NA**	**NA**	**-**	**2.60E+00**	**yes**
Methylene chloride	**75-09-2**	**29**	**1**	**3**	**no**	**2.90E+00**	**5.20E+00**	**5.20E-01**	**yes**	**9.59E-01**	**yes**

Table 2-4

Summary Statistics and Selection of COPCs by Comparison to EPA RSL[1]

2005-2010 Ambient Air Data Bell-Melton Ranch Monitoring Station

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	EPA RSL[1] (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Detected Concentration ≥ 1/10 EPA RSL?	Mean Concentration (µg/m^3)	COPC?
m-Ethyltoluene	**620-14-4**	**128**	**122**	**95**	**yes**	**1.63E+00**	**NA**	**NA**	**-**	**1.87E-01**	**yes**
m-Xylene/p-Xylene	-38-3 / 106-4	128	119	93	yes	1.40E+01	7.30E+02	7.30E+01	no	1.69E+00	no
n-Butane	**106-97-8**	**128**	**128**	**100**	**yes**	**1.57E+02**	**NA**	**NA**	**-**	**2.79E+01**	**yes**
n-Decane	**124-18-5**	**128**	**126**	**98**	**yes**	**6.98E+01**	**NA**	**NA**	**-**	**1.11E+00**	**yes**
n-Dodecane	**112-40-3**	**128**	**107**	**84**	**yes**	**7.14E+01**	**NA**	**NA**	**-**	**1.24E+00**	**yes**
n-Heptane	**142-82-5**	**128**	**128**	**100**	**yes**	**1.14E+01**	**NA**	**NA**	**-**	**2.55E+00**	**yes**
n-Hexane	110-54-3	128	128	100	yes	2.50E+01	7.30E+02	7.30E+01	no	5.89E+00	no
n-Nonane	111-84-2	128	127	99	yes	3.08E+00	2.10E+02	2.10E+01	no	6.36E-01	no
n-Octane	**111-65-9**	**128**	**128**	**100**	**yes**	**6.72E+00**	**NA**	**NA**	**-**	**1.45E+00**	**yes**
n-Pentane	109-66-0	128	128	100	yes	6.20E+01	1.00E+03	1.00E+02	no	1.36E+01	no
n-Propylbenzene	103-65-1	128	76	59	yes	7.10E-01	1.00E+03	1.00E+02	no	8.26E-02	no
n-Tridecane	**629-50-5**	**128**	**45**	**35**	**yes**	**5.68E+00**	**NA**	**NA**	**-**	**2.05E-01**	**yes**
n-Undecane	**1120-21-4**	**128**	**125**	**98**	**yes**	**2.55E+02**	**NA**	**NA**	**-**	**2.81E+00**	**yes**
o-Ethyltoluene	**611-14-3**	**128**	**86**	**67**	**yes**	**1.44E+00**	**NA**	**NA**	**-**	**1.31E-01**	**yes**
o-Xylene	95-47-6	128	97	76	yes	3.61E+00	7.30E+02	7.30E+01	no	4.35E-01	no
p-Diethylbenzene	**105-05-5**	**128**	**31**	**24**	**yes**	**4.20E-01**	**NA**	**NA**	**-**	**5.50E-02**	**yes**
p-Ethyltoluene	**622-96-8**	**128**	**93**	**73**	**yes**	**1.26E+00**	**NA**	**NA**	**-**	**1.33E-01**	**yes**
Propane	**74-98-6**	**128**	**128**	**100**	**yes**	**3.16E+02**	**NA**	**NA**	**-**	**6.15E+01**	**yes**
Propionaldehyde	123-38-6	60	57	95	yes	2.04E-01	8.30E+00	8.30E-01	no	8.14E-02	no
Propylene	115-07-1	128	128	100	yes	2.46E+00	3.10E+03	3.10E+02	no	3.62E-01	no
Propyne	74-99-7	128	1	1	no	3.50E-01	NA	NA	-	5.45E-02	no
Styrene	100-42-5	157	11	7	yes	3.45E+00	1.00E+03	1.00E+02	no	2.49E-01	no
Tetrachloroethene	127-18-4	29	0	0	no	-	-	-	-	-	no
Tolualdehydes	**NA**	**60**	**56**	**93**	**yes**	**2.51E-01**	**NA**	**NA**	**no**	**8.16E-02**	**yes**
Toluene	108-88-3	157	156	99	yes	7.91E+01	5.20E+03	5.20E+02	no	4.02E+00	no
trans-1,2-Dichloroethene	156-60-5	29	0	0	no	-	-	-	-	-	no
trans-1,3-Dichloropropene	10061-02-6	29	0	0	no	-	-	-	-	-	no
trans-2-Butene	**624-64-6**	**128**	**102**	**80**	**yes**	**3.34E+00**	**NA**	**NA**	**-**	**1.13E-01**	**yes**
trans-2-Hexene	4050-45-7	128	1	1	no	3.04E-02	NA	NA	-	9.83E-02	no
trans-2-Pentene	**4050-45-7**	**128**	**58**	**45**	**yes**	**3.18E-01**	**NA**	**NA**	**-**	**6.72E-02**	**yes**

Table 2-4

Summary Statistics and Selection of COPCs by Comparison to EPA RSL[1]

2005-2010 Ambient Air Data Bell-Melton Ranch Monitoring Station

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	EPA RSL[1] (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Detected Concentration ≥ 1/10 EPA RSL?	Mean Concentration (µg/m^3)	COPC?
Trichloroethene	79-01-6	29	0	0	no	-	-	-	-	-	no
Trichlorofluoromethane	75-69-4	29	0	0	no	-	-	-	-	-	no
Trichlorotrifluoroethane	76-13-1	29	0	0	no	-	-	-	-	-	no
Valeraldehyde	**110-62-3**	**60**	**32**	**53**	**yes**	**8.10E-02**	**NA**	**NA**	**-**	**2.25E-02**	**yes**
Vinyl Acetate	108-05-4	29	5	17	yes	1.30E+01	2.10E+02	2.10E+01	no	1.85E+00	no
Vinyl Chloride	75-01-4	29	0	0	no	-	-	-	-	-	no

Notes:

Bold text indicates contaminant selected as a COPC.

µg/m^3: micrograms per cubic meter

CAS: Chemical Abstract Service

COPC: Contaminant of potential concern

EPA: United States Environmental Protection Agency

NA: Not Available

[1]RSL = EPA regional screening levels for ambient air based on exposure of 24 hours per day for 350 days per year for 30 years :
Health effects are not expected to occur at or below the RSL. To select COPCs, maximum detected concentration was compared to 1/10 the RSL to account for additive health effects from multiple chemicals. : http://www.epa.gov/region9/superfund/prg/index.html, May 2010

Table 2-5

Summary Statistics and Selection of COPCs by Comparision to EPA RSLs[1] Summer 2008 Ambient Air Data Well Completion Operations

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	Mean Concentration (µg/m^3)	EPA RSL (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Concentration > 1/10 EPA RSL?	COPC?
1,2,3-Trimethylbenzene	526-73-8	16	16	100	yes	1.17E+01	1.32E+00	NA	-	-	yes
1,2,4-Trimethylbenzene	95-63-6	16	16	100	yes	8.30E+01	7.66E+00	7.30E+00	7.30E-01	yes	yes
1,3,5-Trimethylbenzene	108-67-8	16	16	100	yes	7.75E+01	6.77E+00	NA	-	-	yes
1,3-Butadiene	106-99-0	16	7	44	yes	1.66E-01	1.02E-01	8.10E-02	8.10E-03	yes	yes
1-Decene	872-05-9	16	0	0	no	-	-	-	-	-	no
1-Dodecene	112-41-4	16	12	75	yes	6.08E+00	9.54E-01	NA	-	-	yes
1-Heptene	592-76-7	16	16	100	yes	6.08E+01	7.23E+00	NA	-	-	yes
1-Hexene	592-41-6	16	16	100	yes	1.63E-01	8.23E-02	NA	-	-	yes
1-Nonene	124-11-8	16	15	94	yes	1.68E+01	1.56E+00	NA	-	-	yes
1-Octene	111-66-0	16	11	69	yes	3.16E+00	3.94E-01	NA	-	-	yes
1-Pentene	109-67-1	16	16	100	yes	3.89E-01	1.31E-01	NA	-	-	yes
1-Tridecene	2437-56-1	16	6	38	yes	3.63E-01	2.05E-01	NA	-	-	yes
1-Undecene	821-95-4	16	11	69	yes	4.72E+00	5.25E-01	NA	-	-	yes
2,2,3-Trimethylpentane	564-02-3	16	16	100	yes	2.47E+01	2.62E+00	NA	-	-	yes
2,2,4-Trimethylpentane	540-84-1	16	1	6	yes	1.98E-01	1.33E-01	NA	-	-	yes
2,2-Dimethylbutane	75-83-2	16	16	100	yes	4.12E+01	4.73E+00	NA	-	-	yes
2,3,4-Trimethylpentane	565-75-3	16	16	100	yes	1.21E+00	2.17E-01	NA	-	-	yes
2,3-Dimethylbutane	79-29-8	16	16	100	yes	6.58E+01	8.49E+00	NA	-	-	yes
2,3-Dimethylpentane	565-59-3	16	16	100	yes	3.56E+01	4.46E+00	NA	-	-	yes
2,4-Dimethylpentane	108-08-7	16	16	100	yes	2.36E+01	2.92E+00	NA	-	-	yes
2-Ethyl-1-butene	760-21-4	16	0	0	no	-	-	-	-	-	no
2-Methyl-1-butene	563-46-2	16	9	56	yes	1.26E+00	3.28E-01	NA	-	-	yes
2-Methyl-1-pentene	763-29-1	16	1	6	yes	8.43E-02	2.37E-01	NA	-	-	yes
2-Methyl-2-butene	513-35-9	16	9	56	yes	3.87E-01	1.28E-01	NA	-	-	yes
2-Methylheptane	592-27-8	16	16	100	yes	1.46E+02	1.50E+01	NA	-	-	yes
2-Methylhexane	591-76-4	16	16	100	yes	1.21E+02	1.45E+01	NA	-	-	yes
2-Methylpentane	107-83-5	16	16	100	yes	2.21E+02	3.18E+01	NA	-	-	yes
3-Methyl-1-butene	563-45-1	16	1	6	yes	2.49E-01	1.23E-01	NA	-	-	yes
3-Methylheptane	589-81-1	16	16	100	yes	9.74E+01	9.73E+00	NA	-	-	yes
3-Methylhexane	589-34-4	16	16	100	yes	1.14E+02	1.38E+01	NA	-	-	yes
3-Methylpentane	96-14-0	16	16	100	yes	1.29E+02	1.80E+01	NA	-	-	yes

Table 2-5

Summary Statistics and Selection of COPCs by Comparision to EPA RSLs[1] Summer 2008 Ambient Air Data Well Completion Operations

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	Mean Concentration (µg/m^3)	EPA RSL (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Concentration > 1/10 EPA RSL?	COPC?
4-Methyl-1-pentene	691-37-2	16	8	50	yes	9.35E-01	3.05E-01	NA	-	-	yes
Acetylene	74-86-2	16	16	100	yes	8.40E-01	3.97E-01	NA	-	-	yes
a-Pinene	80-56-8	16	16	100	yes	3.09E+01	3.04E+00	NA	-	-	yes
Benzene	71-43-2	16	16	100	yes	6.85E+01	8.85E+00	3.10E-01	3.10E-02	yes	yes
b-Pinene	127-91-3	16	7	44	yes	8.96E+00	7.96E-01	NA	-	-	yes
cis-2-Butene	590-18-1	16	15	94	yes	1.97E-01	7.65E-02	NA	-	-	yes
cis-2-Hexene	7688-21-3	16	13	81	yes	2.93E-01	2.01E-01	NA	-	-	yes
cis-2-Pentene	627-20-3	16	9	56	yes	1.48E-01	8.14E-02	NA	-	-	yes
Cyclohexane	110-82-7	16	16	100	yes	2.04E+02	2.64E+01	6.30E+03	6.30E+02	no	no
Cyclopentane	287-92-3	16	16	100	yes	2.23E+01	3.84E+00	NA	-	-	yes
Cyclopentene	142-29-0	16	16	100	yes	6.51E-01	2.34E-01	NA	-	-	yes
Ethane	74-84-0	16	16	100	yes	2.41E+03	4.08E+02	NA	-	-	yes
Ethylbenzene	100-41-4	16	16	100	yes	2.28E+02	1.74E+01	9.70E-01	9.70E-02	yes	yes
Ethylene	74-85-1	16	16	100	yes	4.19E+00	1.17E+00	NA	-	-	yes
Isobutane	75-28-5	16	16	100	yes	1.60E+03	1.65E+02	NA	-	-	yes
Isobutene/1-Butene	NA	16	8	50	yes	6.71E+00	2.05E+00	NA	-	-	yes
Isopentane	78-78-4	16	16	100	yes	8.32E+02	1.14E+02	NA	-	-	yes
Isoprene	78-79-5	16	16	100	yes	1.15E+00	4.64E-01	NA	-	-	yes
Isopropylbenzene (cumene)	98-82-8	16	14	88	yes	4.85E+00	5.97E-01	4.20E+02	4.20E+01	no	no
m-Diethylbenzene	141-93-5	16	16	100	yes	7.08E+00	7.98E-01	NA	-	-	yes
Methylcyclohexane	108-87-2	16	16	100	yes	7.23E+02	8.00E+01	NA	-	-	yes
Methylcyclopentane	96-37-7	16	16	100	yes	1.20E+02	1.77E+01	NA	-	-	yes
m-Ethyltoluene	620-14-4	16	16	100	yes	4.45E+01	4.26E+00	NA	-	-	yes
m&p-Xylene	1330-20-7	16	16	100	yes	8.84E+02	9.47E+01	7.30E+02	7.30E+01	yes	yes
n-Butane	106-97-8	16	16	100	yes	1.29E+03	1.48E+02	NA	-	-	yes
n-Decane	124-18-5	16	16	100	yes	2.08E+02	1.89E+01	NA	-	-	yes
n-Dodecane	112-40-3	16	16	100	yes	5.15E+01	7.71E+00	NA	-	-	yes
n-Heptane	142-82-5	16	16	100	yes	3.04E+02	3.55E+01	NA	-	-	yes
n-Hexane	110-54-3	16	16	100	yes	2.55E+02	3.72E+01	7.30E+02	7.30E+01	yes	yes
n-Nonane	111-84-2	16	16	100	yes	3.03E+02	2.71E+01	2.10E+02	2.10E+01	yes	yes
n-Octane	111-65-9	16	16	100	yes	4.17E+02	4.10E+01	NA	-	-	yes

Table 2-5

Summary Statistics and Selection of COPCs by Comparision to EPA RSLs[1] Summer 2008 Ambient Air Data Well Completion Operations

Human Health Risk Assessment

Battlement Mesa Health Impact Assessment

Chemical	CAS Number	Number of samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥ 5%?	Maximum Detected Concentration (µg/m^3)	Mean Concentration (µg/m^3)	EPA RSL (µg/m^3)	1/10 EPA RSL (µg/m^3)	Maximum Concentration > 1/10 EPA RSL?	COPC?
n-Pentane	**109-66-0**	**16**	**16**	**100**	**yes**	**5.53E+02**	**1.05E+02**	**1.00E+03**	**1.00E+02**	**yes**	**yes**
n-Propylbenzene	103-65-1	16	16	100	yes	1.20E+01	1.28E+00	1.00E+03	1.00E+02	no	no
n-Tridecane	**629-50-5**	**16**	**16**	**100**	**yes**	**9.05E+00**	**1.64E+00**	**NA**	**-**	**-**	**yes**
n-Undecane	**1120-21-4**	**16**	**16**	**100**	**yes**	**1.21E+02**	**1.36E+01**	**NA**	**-**	**-**	**yes**
o-Ethyltoluene	**611-14-3**	**16**	**16**	**100**	**yes**	**2.92E+01**	**2.77E+00**	**NA**	**-**	**-**	**yes**
o-Xylene	**95-47-6**	**16**	**16**	**100**	**yes**	**1.90E+02**	**1.79E+01**	**730**	**7.30E+01**	**-**	**yes**
p-Diethylbenzene	**105-05-5**	**16**	**13**	**81**	**yes**	**5.01E+00**	**5.45E-01**	**NA**	**-**	**-**	**yes**
p-Ethyltoluene	**622-96-8**	**16**	**16**	**100**	**yes**	**3.22E+01**	**3.10E+00**	**NA**	**-**	**-**	**yes**
Propane	**74-98-6**	**16**	**16**	**100**	**yes**	**4.67E+03**	**4.37E+02**	**NA**	**-**	**-**	**yes**
Propylene	115-07-1	16	16	100	yes	1.94E+00	5.05E-01	3.10E+03	3.10E+02	no	no
Propyne	74-99-7	16	0	0	no	-	-	-	-	-	no
Styrene	100-42-5	16	3	19	yes	5.90E+00	5.57E-01	1.00E+03	1.00E+02	no	no
Toluene	108-88-3	16	16	100	yes	3.19E+02	3.63E+01	5.20E+03	5.20E+02	no	no
trans-2-Butene	**624-64-6**	**16**	**15**	**94**	**yes**	**1.89E+00**	**3.04E-01**	**NA**	**-**	**-**	**yes**
trans-2-Hexene	**4050-45-7**	**16**	**1**	**6**	**yes**	**4.53E-02**	**2.34E-01**	**NA**	**-**	**-**	**yes**
trans-2-Pentene	**646-04-8**	**16**	**14**	**88**	**yes**	**3.05E-01**	**1.07E-01**	**NA**	**-**	**-**	**yes**

Notes:

Bold text indicates contaminant selected as a COPC

µg/m^3: micrograms per cubic meter

CAS: Chemical Abstract Service

COPC: Contaminant of potential concern

EPA: United States Environmental Protection Agency

NA: Not Available

[1]RSL = EPA regional screening levels for ambient air based on exposure of 24 hours per day for 350 days per year for 30 years : Health effects are not expected to occur at or below the RSL. To select COPCs, maximum detected concentration was compared to 1/10 the RSL to account for additive health effects from multiple chemicals. : http://www.epa.gov/region9/superfund/prg/index.html, May 2010

Table 2-6
Summary Statistics and Selection of COPCs by Comparison to EPA RSLs[1] Odor Thresholds[2]
2005-2007 Odor Events
Human Health Risk Assessment
Battlement Mesa HIA

Chemical	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥5%?	Maximum Detected Concentration (µg/m^3)	Mean (µg/m3)	EPA RSL (µg/m3)	1/10 EPA RSL (µg/m3)	Maximum Concentration > 1/10 EPA RSL	COPC?	Texas Acute Odor ESL (µg/m^3)
1,1,1-Trichloroethane	71-55-6	28	0	0	no	-	-	-	-	-	no	-
1,1,2,2-Tetrachloroethane	79-34-5	28	0	0	no	-	-	-	-	-	no	-
1,1,2-Trichloroethane	79-00-5	28	0	0	no	-	-	-	-	-	no	-
1,1-Dichloroethane	75-34-3	28	0	0	no	-	-	-	-	-	no	-
1,1-Dichloroethene	75-35-4	28	0	0	no	-	-	-	-	-	no	-
1,2-Dibromoethane	106-93-4	28	0	0	no	-	-	-	-	-	no	-
1,2-Dichlorobenzene	95-50-1	28	0	0	no	-	-	-	-	-	no	-
1,2-Dichloroethane	107-06-2	28	0	0	no	-	-	-	-	-	no	-
1,2-Dichloropropane	78-87-5	28	0	0	no	-	-	-	-	-	no	-
1,3-Dichlorobenzene	541-73-1	28	0	0	no	-	-	-	-	-	no	-
1,4-Dichlorobenzene	106-46-7	28	0	0	no	-	-	-	-	-	no	-
2-Butanone (MEK)	78-93-3	28	20	71	yes	1.00E+01	3.19E+00	5.20E+03	5.20E+02	no	no	3.90E+03
2-Hexanone	591-78-6	28	4	14	yes	2.40E+00	1.47E+00	3.10E+01	3.10E+00	no	no	9.80E+01
4-Methyl-2-pentanone	108-10-1	28	0	0	no	-	-	-	-	-	no	-
Acetone	67-64-1	28	22	79	yes	8.10E+01	2.81E+01	3.20E+04	3.20E+03	no	no	8.50E+03
Benzene	**71-43-2**	**28**	**26**	**93**	**yes**	**1.80E+02**	**3.16E+01**	**3.10E-01**	**3.10E-02**	**yes**	**yes**	**8.60E+03**
Bromodichloromethane	75-27-4	28	0	0	no	-	-	-	-	-	no	-
Bromoform	75-25-2	28	0	0	no	-	-	-	-	-	no	-
Bromomethane	74-83-9	28	0	0	no	-	-	-	-	-	no	-
Carbon Disulfide	75-15-0	28	0	0	no	-	-	-	-	-	no	-
Carbon Tetrachloride	56-23-5	28	0	0	no	-	-	-	-	-	no	-
Chlorobenzene	108-90-7	28	0	0	no	-	-	-	-	-	no	-
Chloroethane	75-00-3	28	0	0	no	-	-	-	-	-	no	-
Chloroform	**67-66-3**	**28**	**1**	**4**	**no**	**1.60E+00**	**1.34E+00**	**1.10E-01**	**1.10E-02**	**yes**	**yes**	**4.20E+05**
Chloromethane	74-87-3	28	1	4	no	2.20E+00	1.37E+00	9.40E+01	9.40E+00	no	no	-
cis-1,2-Dichloroethene	156-59-2	28	0	0	no	-	-	-	-	-	no	-
cis-1,3-Dichloropropene	10061-01-5	28	0	0	no	-	-	-	-	-	no	-
Dibromochloromethane	124-48-1	28	0	0	no	-	-	-	-	-	no	-
Ethylbenzene	**100-41-4**	**28**	**19**	**68**	**yes**	**9.60E+01**	**8.87E+00**	**9.70E-01**	**9.70E-02**	**yes**	**yes**	**2.00E+03**
m,p-Xylenes	**179601-23-1**	**28**	**26**	**93**	**yes**	**1.50E+03**	**1.38E+02**	**7.30E+02**	**7.30E+01**	**yes**	**yes**	**3.50E+02**

Table 2-6
Summary Statistics and Selection of COPCs by Comparison to EPA RSLs[1] Odor Thresholds[2]
2005-2007 Odor Events
Human Health Risk Assessment
Battlement Mesa HIA

Chemical	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Detection frequency ≥5%?	Maximum Detected Concentration (µg/m^3)	Mean (µg/m3)	EPA RSL (µg/m3)	1/10 EPA RSL (µg/m3)	Maximum Concentration > 1/10 EPA RSL	COPC?	Texas Acute Odor ESL (µg/m^3)
Methyl tert-Butyl Ether	1634-04-4	28	0	0	no	-	-	-	-	-	no	-
Methylene chloride	75-09-2	28	0	0	no	-	-	-	-	-	no	-
o-Xylene	**95-47-6**	**28**	**24**	**86**	**yes**	**2.60E+02**	**2.22E+01**	**7.30E+02**	**7.30E+01**	**yes**	**yes**	**1.60E+03**
Styrene	100-42-5	28	0	0	no	-	-	-	-	-	no	-
Tetrachloroethene	127-18-4	28	0	0	no	-	-	-	-	-	no	-
Toluene	**108-88-3**	**28**	**26**	**93**	**yes**	**5.40E+02**	**1.05E+02**	**5.20E+03**	**5.20E+02**	**yes**	**yes**	**6.40E+02**
trans-1,2-Dichloroethene	156-60-5	28	0	0	no	-	-	-	-	-	no	-
trans-1,3-Dichloropropene	10061-02-6	28	0	0	no	-	-	-	-	-	no	-
Trichloroethene	79-01-6	28	0	0	no	-	-	-	-	-	no	-
Trichlorofluoromethane	75-69-4	28	2	7	yes	1.50E+00	1.36E+00	7.30E+02	7.30E+01	no	no	2.80E+04
Trichlorotrifluoroethane	76-13-1	28	0	0	no	-	-	-	-	-	no	-
Vinyl Acetate	108-05-4	28	4	14	yes	1.50E+01	2.60E+00	2.10E+02	2.10E+01	no	no	NA
Vinyl Chloride	75-01-4	28	0	0	no	-	-	-	-	-	no	-

Notes:
Bold text indicates contaminant was selected as a COPC.
µg/m^3: micrograms per cubic meter
CAS: Chemical Abstract Service
COPC: Contaminant of potential concern
EPA: United States Environmental Protection Agency
HIA: Health Impact Assessment
NA: Not Available

[1]RSL = EPA regional screening levels for ambient air based on exposure of 24 hours per day for 350 days per year for 30 years :
Health effects are not expected to occur at or below the RSL. To select COPCs, maximum detected concentration was compared to 1/10 the RSL to account for additive health effects from multiple chemicals. : http://www.epa.gov/region9/superfund/prg/index.html, May 2010

[2]Texas acute odor ESLs are odor based effects screening levels at which 50 percent of human subjects detect an odor (Texas Commission on Environmental Quality 2006).

Table 2-7
Ambient Air Summary Statistics and BTVs[1] for Background Samples
2005 - 2008
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Number of Samples	Number of detects	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	Minimum Detected value (µg/m3)	Maximum detected value (µg/m3)	Mean (µg/m3)	BTV (µg/m3)	Statistical Basis for BTV
1,1,1-Trichloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,1,2,2-Tetrachloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,1,2-Trichloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,1-Dichloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,1-Dichloroethene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,2,3-Trimethylbenzene	7	7	100	1.20E-01	1.20E-01	4.40E-02	1.48E-01	9.54E-02	1.48E-01	< 8 observations, Maximum detected value
1,2,4-Trimethylbenzene	7	7	100	1.31E-01	1.31E-01	1.94E-01	8.79E-01	4.24E-01	8.79E-01	< 8 observations, Maximum detected value
1,2-Dibromoethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,2-Dichlorobenzene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,2-Dichloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,2-Dichloropropane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,3,5-Trimethylbenzene	7	7	100	1.09E-01	1.09E-01	9.50E-02	4.63E-01	2.59E-01	4.63E-01	< 8 observations, Maximum detected value
1,3-Butadiene	7	0	0	1.05E-01	1.05E-01	-	-	-	1.05E-01	Not detected, maximum MRL
1,3-Dichlorobenzene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
1,4-Dichlorobenzene	18	1	6	1.60E+00	2.30E+00	4.60E+00	4.60E+00	1.11E+00	4.60E+00	< 7 detections, maximum detected value
1-Decene	7	0	0	1.15E-01	1.15E-01	-	-	-	1.15E-01	Not detected, maximum MRL
1-Dodecene	7	5	71	2.41E-01	2.41E-01	1.40E-01	8.83E-01	3.05E-01	8.83E-01	< 8 observations, Maximum detected value
1-Heptene	7	7	100	2.24E-01	2.24E-01	4.25E-01	1.28E+00	7.82E-01	1.28E+00	< 8 observations, Maximum detected value
1-Hexene	7	7	100	2.47E-01	2.47E-01	4.93E-02	1.01E-01	7.19E-02	1.01E-01	< 8 observations, Maximum detected value
1-Nonene	7	5	71	1.83E-01	1.83E-01	4.47E-02	1.49E-01	1.05E-01	1.49E-01	< 8 observations, Maximum detected value
1-Octene	7	3	43	1.78E-01	1.78E-01	7.51E-02	1.42E-01	9.53E-02	1.42E-01	< 8 observations, Maximum detected value
1-Pentene	7	7	100	6.88E-02	6.88E-02	7.11E-02	1.50E-01	9.59E-02	1.50E-01	< 8 observations, Maximum detected value
1-Tridecene	7	1	14	2.41E-01	2.41E-01	2.69E-02	2.69E-02	1.07E-01	2.69E-02	< 8 observations, Maximum detected value
1-Undecene	7	0	0	9.75E-02	9.75E-02	-	-	-	9.75E-02	Not detected, maximum MRL
2,2,3-Trimethylpentane	7	7	100	1.81E-01	1.81E-01	9.39E-02	4.29E-01	2.30E-01	4.29E-01	< 8 observations, Maximum detected value
2,2,4-Trimethylpentane	7	1	14	1.28E-01	1.28E-01	2.46E-01	2.46E-01	9.02E-02	2.46E-01	< 8 observations, Maximum detected value
2,2-Dimethylbutane	7	7	100	8.22E-02	8.22E-02	3.88E-01	1.00E+00	5.82E-01	1.00E+00	< 8 observations, Maximum detected value
2,3,4-Trimethylpentane	7	6	86	1.05E-01	1.05E-01	5.48E-02	2.25E-01	1.08E-01	2.25E-01	< 8 observations, Maximum detected value
2,3-Dimethylbutane	7	7	100	1.17E-01	1.17E-01	5.68E-01	1.85E+00	9.75E-01	1.85E+00	< 8 observations, Maximum detected value
2,3-Dimethylpentane	7	7	100	2.28E-01	2.28E-01	3.43E-01	9.48E-01	5.34E-01	9.48E-01	< 8 observations, Maximum detected value
2,4-Dimethylpentane	7	7	100	1.40E-01	1.40E-01	2.14E-01	6.55E-01	3.64E-01	6.55E-01	< 8 observations, Maximum detected value
2-Butanone (MEK)	18	9	50	1.60E+00	2.30E+00	2.10E+00	3.70E+00	1.63E+00	3.26E+00	95% KM UTL
2-Ethyl-1-butene	7	0	0	2.47E-01	2.47E-01	-	-	-	2.47E-01	Not detected, maximum MRL
2-Hexanone	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL

Table 2-7
Ambient Air Summary Statistics and BTVs[1] for Background Samples
2005 - 2008
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Number of Samples	Number of detects	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	Minimum Detected value (µg/m3)	Maximum detected value (µg/m3)	Mean (µg/m3)	BTV (µg/m3)	Statistical Basis for BTV
2-Methyl-1-butene	7	5	71	1.15E-01	1.15E-01	6.76E-02	1.38E+00	3.88E-01	1.38E+00	< 8 observations, Maximum detected value
2-Methyl-1-pentene	7	0	0	2.47E-01	2.47E-01	-	-	-	2.47E-01	Not detected, maximum MRL
2-Methyl-2-butene	7	5	71	1.15E-01	1.15E-01	9.23E-02	3.05E-01	1.35E-01	3.05E-01	< 8 observations, Maximum detected value
2-Methylheptane	7	7	100	1.05E-01	1.05E-01	4.41E-01	1.61E+00	9.18E-01	1.61E+00	< 8 observations, Maximum detected value
2-Methylhexane	7	7	100	1.05E-01	1.05E-01	9.83E-01	2.71E+00	1.64E+00	2.71E+00	< 8 observations, Maximum detected value
2-Methylpentane	7	7	100	4.70E-02	4.70E-02	2.73E+00	8.75E+00	4.58E+00	8.75E+00	< 8 observations, Maximum detected value
3-Methyl-1-butene	7	0	0	1.15E-01	1.15E-01	-	-	-	1.15E-01	Not detected, maximum MRL
3-Methylheptane	7	7	100	1.17E-01	1.17E-01	2.98E-01	1.17E+00	7.18E-01	1.17E+00	< 8 observations, Maximum detected value
3-Methylhexane	7	7	100	1.35E-01	1.35E-01	8.02E-01	2.72E+00	1.53E+00	2.72E+00	< 8 observations, Maximum detected value
3-Methylpentane	7	7	100	1.06E-01	1.06E-01	1.38E+00	5.63E+00	2.60E+00	5.63E+00	< 8 observations, Maximum detected value
4-Methyl-1-pentene	7	2	29	2.47E-01	2.47E-01	2.50E-01	7.00E-01	2.24E-01	7.00E-01	< 8 observations, Maximum detected value
4-Methyl-2-pentanone	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Acetone	18	15	83	8.20E+00	1.10E+01	1.00E+01	3.10E+01	1.47E+01	2.96E+01	95% KM UTL
Acetylene	7	7	100	5.85E-02	5.85E-02	1.95E-01	3.03E-01	2.28E-01	3.03E-01	< 8 observations, Maximum detected value
a-Pinene	7	7	100	1.78E-01	1.78E-01	2.23E-01	5.90E-01	3.75E-01	5.90E-01	< 8 observations, Maximum detected value
Benzene	25	8	32	1.28E-01	2.30E+00	8.71E-01	2.70E+00	1.06E+00	1.83E+00	95% KM UTL
b-Pinene	7	5	71	1.11E-01	1.11E-01	9.63E-02	3.72E-01	1.85E-01	3.72E-01	< 8 observations, Maximum detected value
Bromodichloromethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Bromoform	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Bromomethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Carbon Disulfide	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Carbon Tetrachloride	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Chlorobenzene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Chloroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Chloroform	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Chloromethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
cis-1,2-Dichloroethene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
cis-1,3-Dichloropropene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
cis-2-Butene	7	5	71	1.09E-01	1.09E-01	4.59E-02	8.14E-02	5.91E-02	8.14E-02	< 8 observations, Maximum detected value
cis-2-Hexene	7	6	86	2.47E-01	2.47E-01	5.56E-02	2.95E-01	1.69E-01	2.95E-01	< 8 observations, Maximum detected value
cis-2-Pentene	7	2	29	1.09E-01	1.09E-01	3.84E-02	6.07E-02	5.31E-02	6.07E-02	< 8 observations, Maximum detected value
Cyclohexane	7	7	100	1.26E-01	1.26E-01	1.79E+00	7.57E+00	3.32E+00	7.57E+00	< 8 observations, Maximum detected value
Cyclopentane	7	7	100	4.58E-02	4.58E-02	3.27E-01	9.63E-01	5.33E-01	9.63E-01	< 8 observations, Maximum detected value
Cyclopentene	7	7	100	1.11E-01	1.11E-01	1.64E-01	4.72E-01	2.92E-01	4.72E-01	< 8 observations, Maximum detected value

Table 2-7
Ambient Air Summary Statistics and BTVs[1] for Background Samples
2005 - 2008
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Number of Samples	Number of detects	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	Minimum Detected value (µg/m3)	Maximum detected value (µg/m3)	Mean (µg/m3)	BTV (µg/m3)	Statistical Basis for BTV
Dibromochloromethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Ethane	7	7	100	5.54E-02	5.54E-02	3.28E+01	8.30E+01	5.85E+01	8.30E+01	< 8 observations, Maximum detected value
Ethylbenzene	25	7	28	1.14E-01	2.30E+00	1.80E-01	7.05E-01	7.68E-01	6.37E-01	95% KM UTL
Ethylene	7	7	100	4.01E-02	4.01E-02	3.71E-01	9.39E-01	6.48E-01	9.39E-01	< 8 observations, Maximum detected value
Isobutane	7	7	100	4.75E-02	4.75E-02	6.71E+00	2.28E+01	1.29E+01	2.28E+01	< 8 observations, Maximum detected value
Isobutene/1-Butene	7	6	86	8.03E-02	8.03E-02	4.61E+00	1.07E+01	6.08E+00	1.07E+01	< 8 observations, Maximum detected value
Isopentane	7	7	100	1.00E-01	1.00E-01	9.91E+00	2.38E+01	1.52E+01	2.38E+01	< 8 observations, Maximum detected value
Isoprene	7	7	100	1.11E-01	1.11E-01	1.67E-01	1.10E+00	5.45E-01	1.10E+00	< 8 observations, Maximum detected value
Isopropylbenzene	7	3	43	1.75E-01	1.75E-01	5.19E-02	9.06E-02	7.97E-02	9.06E-02	< 8 observations, Maximum detected value
m,p -Xylenes	25	10	40	1.68E-01	2.30E+00	9.88E-01	4.90E+00	1.44E+00	3.68E+00	95% KM UTL
m-Diethylbenzene	7	6	86	9.87E-02	9.87E-02	7.62E-02	4.10E-01	1.95E-01	4.10E-01	< 8 observations, Maximum detected value
Methyl tert-Butyl Ether	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Methylcyclohexane	7	7	100	8.60E-02	8.60E-02	3.44E+00	1.16E+01	6.62E+00	1.16E+01	< 8 observations, Maximum detected value
Methylcyclopentane	7	7	100	7.46E-02	7.46E-02	1.33E+00	5.85E+00	2.65E+00	5.85E+00	< 8 observations, Maximum detected value
Methylene chloride	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
m-Ethyltoluene	7	7	100	8.19E-02	8.19E-02	1.72E-01	6.28E-01	3.32E-01	6.28E-01	< 8 observations, Maximum detected value
n-Butane	7	7	100	6.53E-02	6.53E-02	7.66E+00	2.61E+01	1.39E+01	2.61E+01	< 8 observations, Maximum detected value
n-Decane	7	7	100	1.16E-01	1.16E-01	4.72E-01	1.81E+00	1.06E+00	1.81E+00	< 8 observations, Maximum detected value
n-Dodecane	7	7	100	2.44E-01	2.44E-01	2.34E-01	1.55E+00	6.80E-01	1.55E+00	< 8 observations, Maximum detected value
n-Heptane	7	7	100	1.17E-01	1.17E-01	1.58E+00	5.48E+00	3.00E+00	5.48E+00	< 8 observations, Maximum detected value
n-Hexane	7	7	100	1.35E-01	1.35E-01	2.88E+00	1.25E+01	5.56E+00	1.25E+01	< 8 observations, Maximum detected value
n-Nonane	7	7	100	9.90E-02	9.90E-02	4.34E-01	2.00E+00	1.16E+00	2.00E+00	< 8 observations, Maximum detected value
n-Octane	7	7	100	1.40E-01	1.40E-01	1.00E+00	3.74E+00	2.43E+00	3.74E+00	< 8 observations, Maximum detected value
n-Pentane	7	7	100	5.89E-02	5.89E-02	4.66E+00	1.48E+01	8.26E+00	1.48E+01	< 8 observations, Maximum detected value
n-Propylbenzene	7	6	86	1.04E-01	1.04E-01	8.52E-02	1.79E-01	1.05E-01	1.79E-01	< 8 observations, Maximum detected value
n-Tridecane	7	7	100	2.44E-01	2.44E-01	3.83E-02	3.12E-01	1.49E-01	3.12E-01	< 8 observations, Maximum detected value
n-Undecane	7	7	100	9.87E-02	9.87E-02	7.67E-01	2.17E+00	1.25E+00	2.17E+00	< 8 observations, Maximum detected value
o-Ethyltoluene	7	7	100	1.58E-01	1.58E-01	9.61E-02	3.08E-01	1.94E-01	3.08E-01	< 8 observations, Maximum detected value
o-Xylene	25	7	28	9.22E-02	2.30E+00	2.36E-01	8.25E-01	7.94E-01	7.22E-01	95% KM UTL
p-Diethylbenzene	7	5	71	6.58E-02	6.58E-02	6.69E-02	1.12E-01	7.29E-02	1.12E-01	< 8 observations, Maximum detected value
p-Ethyltoluene	7	7	100	1.42E-01	1.42E-01	9.50E-02	3.60E-01	1.95E-01	3.60E-01	< 8 observations, Maximum detected value
Propane	7	7	100	1.08E-01	1.08E-01	2.01E+01	5.26E+01	3.33E+01	5.26E+01	< 8 observations, Maximum detected value
Propylene	7	7	100	4.02E-02	4.02E-02	2.22E-01	4.34E-01	2.89E-01	4.34E-01	< 8 observations, Maximum detected value
Propyne	7	0	0	9.83E-02	9.83E-02	-	-	-	9.83E-02	Not detected, maximum MRL

Table 2-7
Ambient Air Summary Statistics and BTVs[1] for Background Samples
2005 - 2008
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Number of Samples	Number of detects	Detection frequency (%)	Minimum MRL (µg/m^3)	Maximum MRL (µg/m3)	Minimum Detected value (µg/m3)	Maximum detected value (µg/m3)	Mean (µg/m3)	BTV (µg/m3)	Statistical Basis for BTV
Styrene	25	1	4	1.33E-01	2.30E+00	7.23E-01	7.23E-01	7.31E-01	7.23E-01	< 7 detections, maximum detected value
Tetrachloroethene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Toluene	25	14	56	1.78E-01	2.30E+00	1.81E+00	1.77E+01	2.65E+00	1.49E+01	95% KM UTL
trans-1,2-Dichloroethene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
trans-1,3-Dichloropropene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
trans-2-Butene	7	6	86	7.45E-02	7.45E-02	8.26E-02	2.06E-01	1.19E-01	2.06E-01	< 8 observations, Maximum detected value
trans-2-Hexene	7	1	14	2.47E-01	2.47E-01	1.03E-01	1.03E-01	1.20E-01	1.03E-01	< 8 observations, Maximum detected value
trans-2-Pentene	7	5	71	1.09E-01	1.09E-01	5.96E-02	1.27E-01	7.56E-02	1.27E-01	< 8 observations, Maximum detected value
Trichloroethene	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Trichlorofluoromethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Trichlorotrifluoroethane	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL
Vinyl Acetate	18	5	28	1.60E+00	2.30E+00	3.20E+00	7.90E+00	1.78E+00	7.90E+00	< 7 detections, maximum detected value
Vinyl Chloride	18	0	0	1.60E+00	2.30E+00	-	-	-	2.30E+00	Not detected, maximum MRL

Notes:

[1]BTV: Background Threshold Value: BTVs are background contaminant concentrations computed based upon the sampled data collected from the site- specific background locations.
95% KM UTL: 95 percentileKaplan Meier Upper Tolerance Limit

MRL: Method Reporting Limit

Table 2-8
95% UCLs and Selection of EPCs[1]
2005 to 2010 Bell-Melton Ranch Monitoring Station
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Maximum Detected Value (µg/m^3)	Mean Value (µg/m^3)	95% UCL[2] (µg/m^3)	Statistical Method to Calculate 95% UCL	EPC (µg/m^3)
1,2,3-Trimethylbenzene	8.47E-01	8.10E-02	1.01E-01	KM (t)	1.01E-01
1,2,4-Trimethylbenzene	3.09E+00	2.75E-01	3.39E-01	KM (BCA)	3.39E-01
1,3,5-Trimethylbenzene	1.20E+00	1.51E-01	1.78E-01	KM (BCA)	1.78E-01
1,3-Butadiene	1.53E-01	5.58E-02	NC	NC	1.53E-01
1,4-Dichlorobenzene	2.30E+00	9.36E-01	NC	NC	2.30E+00
1-Dodecene	1.02E+00	1.44E-01	1.74E-01	KM (t)	1.74E-01
1-Heptene	2.98E+00	6.30E-01	7.10E-01	KM (BCA)	7.10E-01
1-Hexene	2.77E-01	9.55E-02	9.72E-02	KM (t)	9.72E-02
1-Nonene	4.28E-01	1.07E-01	1.20E-01	(%bootstrap)	1.20E-01
1-Octene	1.37E+00	1.06E-01	1.13E-01	KM (t)	1.13E-01
1-Pentene	3.80E-01	1.04E-01	1.12E-01	KM (BCA)	1.12E-01
1-Tridecene	2.04E-01	1.06E-01	8.89E-02	KM (%bootstrap)	8.89E-02
1-Undecene	1.07E+00	1.21E-01	1.48E-01	KM (t)	1.48E-01
2,2,3-Trimethylpentane	1.64E+00	1.49E-01	1.91E-01	KM (%bootstrap)	1.91E-01
2,2,4-Trimethylpentane	2.48E+00	1.52E-01	2.14E-01	KM (%bootstrap)	2.14E-01
2,2-Dimethylbutane	2.34E+00	6.15E-01	6.76E-01	H-UCL	6.76E-01
2,3,4-Trimethylpentane	1.79E+00	9.21E-02	1.27E+00	KM (%bootstrap)	1.27E+00
2,3-Dimethylbutane	5.05E+00	1.22E+00	1.36E+00	H-UCL	1.36E+00
2,3-Dimethylpentane	2.08E+00	5.26E-01	5.70E-01	H-UCL	5.70E-01
2,4-Dimethylpentane	1.48E+00	3.69E-01	4.06E-01	KM (BCA)	4.06E-01
2-Hexanone	4.40E+00	1.00E+00	NC	NC	4.40E+00
2-Methyl-1-butene	3.94E+01	5.98E-01	1.23E+00	KM (BCA)	1.23E+00
2-Methyl-1-pentene	1.52E-01	9.82E-02	NC	NC	1.52E-01
2-Methyl-2-butene	4.17E-01	8.95E-02	1.07E-01	KM (t)	1.07E-01
2-Methylheptane	2.93E+00	6.28E-01	7.01E-01	H-UCL	7.01E-01
2-Methylhexane	5.71E+00	1.39E+00	1.54E+00	KM (BCA)	1.54E+00
2-Methylpentane	2.20E+01	5.39E+00	5.98E+00	H-UCL	5.98E+00
3-Methyl-1-butene	2.00E-01	6.16E-02	NC	NC	2.00E-01
3-Methylheptane	3.53E+00	4.17E-01	4.55E-01	H-UCL	4.55E-01
3-Methylhexane	4.84E+00	1.11E+00	1.27E+00	KM (BCA)	1.27E+00
3-Methylpentane	1.16E+01	2.80E+00	3.12E+00	H-UCL	3.12E+00
4-Methyl-1-pentene	4.68E+00	1.41E-01	2.28E-01	KM (BCA)	2.28E-01
Acetaldehyde	1.96E+00	7.98E-01	8.74E-01	Student-t	8.74E-01
Acetylene	2.92E+00	6.30E-01	6.97E-01	H-UCL	6.97E-01
a-Pinene	3.37E+00	1.74E-01	2.31E-01	KM (%bootstrap)	2.31E-01
Benzaldehyde	2.04E-01	7.10E-02	9.74E-02	KM (Chebyshev)	9.74E-02
Benzene	1.36E+01	1.47E+00	1.67E+00	KM (BCA)	1.67E+00
b-Pinene	1.43E+00	8.08E-02	1.23E-01	KM (t)	1.23E-01
Butyraldehyde	2.71E-01	6.98E-02	8.11E-02	KM (BCA)	8.11E-02
cis-2-Butene	3.73E-01	6.79E-02	7.95E-02	KM (t)	7.95E-02
cis-2-Hexene	7.00E-01	9.97E-02	1.00E-01	KM (Chebyshev)	1.00E-01
cis-2-Pentene	1.45E-01	5.37E-02	6.12E-02	KM (t)	6.12E-02
Crotonaldehyde	5.53E-01	1.26E-01	2.02E-01	Chebyshev (mean, s	2.02E-01

Table 2-8
95% UCLs and Selection of EPCs[1]
2005 to 2010 Bell-Melton Ranch Monitoring Station
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Maximum Detected Value ($\mu g/m^3$)	Mean Value ($\mu g/m^3$)	95% UCL[2] ($\mu g/m^3$)	Statistical Method to Calculate 95% UCL	EPC ($\mu g/m^3$)
Cyclopentane	2.94E+00	7.28E-01	8.00E-01	H-UCL	8.00E-01
Cyclopentene	9.58E-01	1.34E-01	1.66E-01	KM (%bootstrap)	1.66E-01
Ethane	4.11E+02	8.00E+01	9.02E+01	H-UCL	9.02E+01
Ethylbenzene	4.34E+00	3.78E-01	3.33E-01	KM (Chebyshev)	4.11E-01
Ethylene	2.94E+00	1.00E+00	1.09E+00	Gamma	1.09E+00
Formaldehyde	1.02E+01	1.17E+00	1.26E+00	H-UCL	1.26E+00
Formaldehyde w/o outlier	2.24E+00	1.02E+00	1.11E+00	Student-t	1.11E+00
Hexaldehyde	1.31E-01	4.21E-02	2.56E-02	KM (Chebyshev)	2.56E-02
Isobutane	1.18E+02	2.34E+01	2.62E+01	Gamma	2.62E+01
Isobutene/1-Butene	1.36E+01	1.29E+00	1.60E+00	KM (% bootstrap)	1.60E+00
Isopentane	1.23E+02	1.97E+01	2.24E+01	KM (BCA)	2.24E+01
Isoprene	3.33E+00	3.13E-01	5.03E-01	KM (Chebyshev)	5.03E-01
Isovaleraldehyde	1.13E-01	5.69E-03	3.29E-02	KM (t)	3.29E-02
m&p-Xylene	1.40E+01	1.69E+00	1.98E+00	KM (BCA)	1.98E+00
m-Diethylbenzene	8.84E-01	9.25E-02	1.18E-01	KM (%bootstrap)	1.18E-01
Methylcyclohexane	2.39E+01	5.38E+00	5.96E+00	Gamma	5.96E+00
Methylcyclopentane	1.04E+01	2.60E+00	2.89E+00	H-UCL	2.89E+00
Methylene Chloride	2.90E+00	9.59E-01	NC	NC	2.90E+00
m-Ethyltoluene	1.63E+00	1.87E-01	2.21E-01	KM (BCA)	2.21E-01
n-Butane	1.57E+02	2.79E+01	3.14E+01	H-UCL	3.14E+01
n-Decane	6.98E+01	1.11E+00	2.24E+00	KM (BCA)	2.24E+00
n-Dodecane	7.14E+01	1.24E+00	3.74E+00	KM (Chebyshev)	3.74E+00
n-Heptane	1.14E+01	2.55E+00	2.85E+00	H-UCL	2.85E+00
n-Hexane	2.50E+01	5.89E+00	6.53E+00	H-UCL	6.53E+00
n-Nonane	3.08E+00	6.36E-01	7.23E-01	KM (BCA)	7.23E-01
n-Octane	6.72E+00	1.45E+00	1.61E+00	H-UCL	1.61E+00
n-Pentane	6.20E+01	1.36E+01	1.50E+01	Gamma	1.50E+01
n-Tridecane	5.68E+00	2.05E-01	2.92E-01	KM (BCA)	2.92E-01
n-Undecane	2.55E+02	2.81E+00	1.15E+01	KM (Chebyshev)	1.15E+01
o-Ethyltoluene	1.44E+00	1.31E-01	1.65E-01	KM (BCA)	1.65E-01
o-Xylene	3.61E+00	4.35E-01	4.03E-01	KM (Chebyshev)	4.94E-01
p-Diethylbenzene	4.20E-01	5.50E-02	7.00E-02	KM (%bootstrap)	7.00E-02
p-Ethyltoluene	1.26E+00	1.33E-01	1.62E-01	KM (BCA)	1.62E-01
Propane	3.16E+02	6.15E+01	6.94E+01	H-UCL	6.94E+01
Tolualdehydes	2.51E-01	8.16E-02	9.32E-02	KM (BCA)	9.32E-02
trans-2-Butene	3.34E+00	1.13E-01	1.74E-01	KM (BCA)	1.74E-01
trans-2-Hexene	3.04E-02	9.83E-02	NC	NC	3.04E-02
trans-2-Pentene	3.18E-01	6.72E-02	8.08E-02	KM (t)	8.08E-02
Valeraldehyde	8.10E-02	2.25E-02	3.49E-02	KM (%bootstrap)	3.49E-02

[1]EPC = Exposure Point Concentration: The lower value between the UCL and maximum detected value.
For contaminants with < 11 detections a UCL was not calculated and the maximum value was used for the EPC

Table 2-8
95% UCLs and Selection of EPCs[1]
2005 to 2010 Bell-Melton Ranch Monitoring Station
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Maximum Detected Value (µg/m^3)	Mean Value (µg/m^3)	95% UCL[2] (µg/m^3)	Statistical Method to Calculate 95% UCL	EPC (µg/m^3)

[2]UCL = Upper Confidence Limit calculated for 2005 - 2010 Bell-Melton Ranch data using EPA's ProUCL v. 4.005 (EPA 2010)
H-UCL = UCL based upon Land's H-statistic
KM (%bootstrap) = UCL based upon Kaplan-Meier estimates using the percentile bootstrap method
KM (chebyshev) UCL based upon Kaplan-Meier estimates using the Chebyshev inequality
KM (t) UCL based upon Kaplan-Meier estimates using the Student's t-distribution cutoff value
KM (BCA) UCL based upon Kaplan-Meier bias-corrected accelerated bootstrap method
NC = Not calculated because less than 10 detected values
Student t: UCL based upon the Student t-distribution cutoff value
Gamma: UCL based upon the Gamma distribution cutoff value.
µg/m^3 = micrograms per cubic meter
CAS = Chemical Abstract Service

Table 3-1
Cancer and Non-Cancer Air Intake Values for Chronic Exposures
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Chronic EPC[1] (µg/m^3)	Intermediate EPC[2] (µg/m^3)	TWA[3] (µg/m^3)	Chronic Non-cancer Intake (µg/m^3)	TWA Non-cancer Intake (µg/m^3)	Chronic Cancer Intake (µg/m^3)	TWA Cancer Intake (µg/m^3)
1,2,3-Trimethylbenzene	1.01E-01	1.17E+01	4.23E-01	9.68E-02	4.05E-01	4.15E-02	1.74E-01
1,2,4-Trimethylbenzene	3.39E-01	8.30E+01	2.63E+00	3.25E-01	2.53E+00	1.39E-01	1.08E+00
1,3,5-Trimethylbenzene	1.78E-01	7.75E+01	2.33E+00	1.70E-01	2.23E+00	7.30E-02	9.56E-01
1,3-Butadiene	1.53E-01	1.66E-01	1.53E-01	1.47E-01	1.47E-01	6.29E-02	6.30E-02
1,4-Dichlorobenzene	2.30E+00	NM	NC	2.21E+00	2.21E+00	9.45E-01	9.45E-01
1-Dodecene	1.74E-01	6.08E+00	3.37E-01	1.66E-01	3.24E-01	7.13E-02	1.39E-01
1-Heptene	7.10E-01	6.08E+01	2.38E+00	6.80E-01	2.28E+00	2.92E-01	9.77E-01
1-Hexene	9.72E-02	1.63E-01	9.91E-02	9.32E-02	9.50E-02	4.00E-02	4.07E-02
1-Nonene	1.20E-01	1.68E+01	5.83E-01	1.15E-01	5.59E-01	4.94E-02	2.40E-01
1-Octene	1.13E-01	3.16E+00	1.97E-01	1.08E-01	1.89E-01	4.63E-02	8.11E-02
1-Pentene	1.12E-01	3.89E-01	1.20E-01	1.08E-01	1.15E-01	4.62E-02	4.93E-02
1-Tridecene	8.89E-02	3.63E-01	9.65E-02	8.53E-02	9.26E-02	3.65E-02	3.97E-02
1-Undecene	1.48E-01	4.72E+00	2.75E-01	1.42E-01	2.64E-01	6.09E-02	1.13E-01
2,2,3-Trimethylpentane	1.91E-01	2.47E+01	8.73E-01	1.83E-01	8.37E-01	7.84E-02	3.59E-01
2,2,4-Trimethylpentane	2.14E-01	1.98E-01	2.14E-01	2.05E-01	2.05E-01	8.81E-02	8.79E-02
2,2-Dimethylbutane	6.76E-01	4.12E+01	1.80E+00	6.48E-01	1.73E+00	2.78E-01	7.41E-01
2,3,4-Trimethylpentane	1.27E+00	1.21E+00	1.26E+00	1.21E+00	1.21E+00	5.20E-01	5.19E-01
2,3-Dimethylbutane	1.36E+00	6.58E+01	3.15E+00	1.30E+00	3.02E+00	5.59E-01	1.29E+00
2,3-Dimethylpentane	5.70E-01	3.56E+01	1.54E+00	5.47E-01	1.48E+00	2.34E-01	6.35E-01
2,4-Dimethylpentane	4.06E-01	2.36E+01	1.05E+00	3.89E-01	1.01E+00	1.67E-01	4.31E-01
2-Hexanone	4.40E+00	NM	NC	4.22E+00	4.22E+00	1.81E+00	1.81E+00
2-Methyl-1-butene	1.23E+00	1.26E+00	1.23E+00	1.17E+00	1.18E+00	5.03E-01	5.04E-01
2-Methyl-2-butene	1.07E-01	8.43E-02	1.07E-01	1.03E-01	1.02E-01	4.41E-02	4.38E-02
2-Methyl-1-pentene	1.52E-01	3.87E-01	1.59E-01	1.46E-01	1.52E-01	6.25E-02	6.51E-02
2-Methylheptane	7.01E-01	1.46E+02	4.75E+00	6.72E-01	4.55E+00	2.88E-01	1.95E+00
2-Methylhexane	1.54E+00	1.21E+02	4.85E+00	1.48E+00	4.65E+00	6.33E-01	1.99E+00
2-Methylpentane	5.98E+00	2.21E+02	1.20E+01	5.73E+00	1.15E+01	2.46E+00	4.91E+00
3-Methyl-1-butene	2.00E-01	2.49E-01	2.01E-01	1.92E-01	1.93E-01	8.22E-02	8.28E-02
3-Methylheptane	4.55E-01	9.74E+01	3.15E+00	4.36E-01	3.02E+00	1.87E-01	1.29E+00
3-Methylhexane	1.27E+00	1.14E+02	4.40E+00	1.21E+00	4.22E+00	5.21E-01	1.81E+00
3-Methylpentane	3.12E+00	1.29E+02	6.62E+00	2.99E+00	6.35E+00	1.28E+00	2.72E+00
4-Methyl-1-pentene	2.28E-01	9.35E-01	2.47E-01	2.18E-01	2.37E-01	9.36E-02	1.02E-01
Acetaldehyde	8.74E-01	NM	NC	8.38E-01	8.38E-01	3.59E-01	3.59E-01
Acetylene	6.97E-01	8.40E-01	7.01E-01	6.68E-01	6.72E-01	2.86E-01	2.88E-01
a-Pinene	2.31E-01	3.09E+01	1.08E+00	2.21E-01	1.04E+00	9.48E-02	4.45E-01
Benzaldehyde	9.74E-02	NM	NC	9.34E-02	9.34E-02	4.00E-02	4.00E-02
Benzene	1.67E+00	6.85E+01	3.53E+00	1.60E+00	3.38E+00	6.87E-01	1.45E+00
b-Pinene	1.23E-01	8.96E+00	3.69E-01	1.18E-01	3.54E-01	5.07E-02	1.52E-01
Butyraldehyde	8.11E-02	NM	NC	7.78E-02	7.78E-02	3.33E-02	3.30E-02
cis-2-Butene	7.95E-02	1.97E-01	8.28E-02	7.63E-02	7.94E-02	3.27E-02	3.40E-02
cis-2-Hexene	1.00E-01	2.93E-01	1.05E-01	9.59E-02	1.01E-01	4.11E-02	4.33E-02
cis-2-Pentene	6.12E-02	1.48E-01	6.36E-02	5.87E-02	6.10E-02	2.51E-02	2.61E-02
Crotonaldehyde	2.02E-01	NM	NC	1.94E-01	1.94E-01	8.30E-02	8.30E-02
Cyclopentane	8.00E-01	2.23E+01	1.40E+00	7.67E-01	1.34E+00	3.29E-01	5.74E-01
Cyclopentene	1.66E-01	6.51E-01	1.79E-01	1.59E-01	1.72E-01	6.81E-02	7.37E-02
Ethane	9.02E+01	2.41E+03	1.54E+02	8.65E+01	1.48E+02	3.71E+01	6.35E+01
Ethylbenzene	4.11E-01	2.28E+02	6.75E+00	3.94E-01	6.47E+00	1.69E-01	2.77E+00
Ethylene	1.09E+00	4.19E+00	1.17E+00	1.04E+00	1.12E+00	4.46E-01	4.81E-01

Table 3-1
Cancer and Non-Cancer Air Intake Values for Chronic Exposures
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Chronic EPC[1] (µg/m^3)	Intermediate EPC[2] (µg/m^3)	TWA[3] (µg/m^3)	Chronic Non-cancer Intake (µg/m^3)	TWA Non-cancer Intake (µg/m^3)	Chronic Cancer Intake (µg/m^3)	TWA Cancer Intake (µg/m^3)
Formaldehyde	1.26E+00	NM	NC	1.20E+00	1.20E+00	5.16E-01	5.16E-01
Formaldehyde w/o outlier	1.11E+00	NM	NC	1.06E+00	1.06E+00	4.54E-01	4.54E-01
Hexaldehyde	2.56E-02	NM	NC	2.45E-02	2.45E-02	1.05E-02	1.05E-02
Isobutane	2.62E+01	1.60E+03	7.00E+01	2.51E+01	6.71E+01	1.07E+01	2.87E+01
Isobutene/1-Butene	1.60E+00	6.71E+00	1.74E+00	1.54E+00	1.67E+00	6.58E-01	7.17E-01
Isopentane	2.24E+01	8.32E+02	4.49E+01	2.15E+01	4.31E+01	9.22E+00	1.85E+01
Isoprene	5.03E-01	1.15E+00	5.21E-01	4.82E-01	4.99E-01	2.07E-01	2.14E-01
Isovaleraldehyde	3.29E-02	NM	NC	3.15E-02	3.15E-02	1.35E-02	1.35E-02
m-Diethylbenzene	1.18E-01	7.08E+00	3.11E-01	1.13E-01	2.98E-01	4.84E-02	1.28E-01
Methylcyclohexane	5.96E+00	7.23E+02	2.59E+01	5.72E+00	2.48E+01	2.45E+00	1.06E+01
Methylcyclopentane	2.89E+00	1.20E+02	6.14E+00	2.77E+00	5.89E+00	1.19E+00	2.52E+00
Methylene Chloride	2.90E+00	NM	NC	2.78E+00	4.33E+00	1.19E+00	1.86E+00
m-Ethyltoluene	2.21E-01	4.45E+01	1.45E+00	2.12E-01	1.39E+00	9.07E-02	5.96E-01
m&p-Xylene	1.98E+00	8.84E+02	2.65E+01	1.90E+00	2.54E+01	8.14E-01	1.09E+01
n-Butane	3.14E+01	1.29E+03	6.63E+01	3.01E+01	6.36E+01	1.29E+01	2.72E+01
n-Decane	2.24E+00	2.08E+02	7.96E+00	2.14E+00	7.63E+00	9.19E-01	3.27E+00
n-Dodecane	3.74E+00	5.15E+01	5.07E+00	3.59E+00	4.86E+00	1.54E+00	2.08E+00
n-Heptane	2.85E+00	3.04E+02	1.12E+01	2.73E+00	1.08E+01	1.17E+00	4.61E+00
n-Hexane	6.53E+00	2.55E+02	1.34E+01	6.26E+00	1.29E+01	2.68E+00	5.52E+00
n-Nonane	7.23E-01	3.03E+02	9.11E+00	6.93E-01	8.74E+00	2.97E-01	3.75E+00
n-Octane	1.16E+00	4.17E+02	1.27E+01	1.11E+00	1.22E+01	4.77E-01	5.23E+00
n-Pentane	1.50E+01	5.53E+02	3.00E+01	1.44E+01	2.87E+01	6.18E+00	1.23E+01
n-Tridecane	2.92E-01	9.05E+00	5.36E-01	2.80E-01	5.14E-01	1.20E-01	2.20E-01
n-Undecane	1.15E+01	1.21E+02	1.45E+01	1.10E+01	1.39E+01	4.73E+00	5.97E+00
o-Ethyltoluene	1.65E-01	2.92E+01	9.71E-01	1.59E-01	9.31E-01	6.80E-02	3.99E-01
o-Xylene	4.94E-01	1.90E+02	5.77E+00	4.74E-01	5.53E+00	2.03E-01	2.37E+00
p-Diethylbenzene	7.00E-02	5.01E+00	2.07E-01	6.72E-02	1.99E-01	2.88E-02	8.52E-02
p-Ethyltoluene	1.62E-01	3.22E+01	1.05E+00	1.56E-01	1.01E+00	6.67E-02	4.33E-01
Propane	6.94E+01	4.67E+03	1.97E+02	6.65E+01	1.89E+02	2.85E+01	8.11E+01
Tolualdehydes	9.32E-02	NM	NC	8.94E-02	7.74E-02	3.83E-02	3.32E-02
trans-2-Butene	1.74E-01	1.89E+00	2.22E-01	1.67E-01	2.13E-01	7.16E-02	9.12E-02
trans-2-Hexene	3.04E-02	4.53E-02	3.08E-02	2.92E-02	2.95E-02	1.25E-02	1.27E-02
trans-2-Pentene	8.08E-02	3.05E-01	8.70E-02	7.74E-02	8.34E-02	3.32E-02	3.58E-02
Valeraldehyde	3.49E-02	NM	NC	3.35E-02	3.35E-02	1.44E-02	1.44E-02

Notes:

µg/m^3: micrograms per cubic meter
EPC: Exposure Concentration
NC: Not calculated
NM: Not measured
TWA: Time weighted average

[1]EPC for chronic exposure (30 year duration) of all Battlement Mesa residents from 2005 to 2010 Bell Melton Ranch Data (Table 2-8)

[2]EPC for intermediate 10 month exposure of Battlement Mesa residents living adjacent to a well pad from 2008 Well completion data (Maximum value Table 2-5)

[3]TWA for a chronic 30 year duration for Battlement Mesa residents living adjacent to a well pad calculated from chronic (350 months) and intermediate (10 months) EPCs.

Table 3-2
EPCs, Dermal Permeability Constants and Surface Water Intakes for Acute Exposure of Child Resident
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	EPC[1] (mg/L)	[2]PC (cm/hr)	Dermal Intake (mg/kg-day)
Benzene	1.70E-02	0.11	2.00E-03
Ethylbenzene	8.30E-03	1.38	1.23E-02
m&p-Xylene	5.60E-02	0.08	4.79E-03
o-Xylene	2.00E-02	0.08	1.71E-03
Toluene	4.50E-02	1.01	4.86E-02

Notes:

[1]EPCs from URS (2008). Second Quarter 2008 Report: Operational and Environmental Monitoring within a Three-Mile Radius of Project Rulison, Noble Energy, Williams, and EnCana

[2]PC: permeability constants: EPA EPA/600/8-91/011B 1992, Dermal Exposure Assessment: Principles and Applications
cm/hr: centimeters per hour
mg/kg-day: mg per kilogram per day
mg/L: Milligrams per Liter

Table 4-1
Cancer and Non-Cancer Inhalation Toxicity Values
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Available Toxicity Factors	RfC - chronic (mg/m^3)	Source	RfC - acute (mg/m^3)	Source	IUR ($1/(\mu g/m^3)$)	Source
1,2,3-Trimethylbenzene	nc	7.00E-03	based on 1,2,4-TMB	NA	NA	NA	NA
1,2,4-Trimethylbenzene	nc	7.00E-03	PPTRV	NA	NA	NA	NA
1,3,5-Trimethylbenzene	nc	7.00E-03	based on 1,2,4-TMB	NA	NA	NA	NA
1,3-Butadiene	c/nc	2.00E-03	ATW-IRIS	NA	NA	3.00E-05	ATW-IRIS
1,4-Dichlorobenzene	c/nc	8.00E-01	ATW-IRIS	1.20E+01	ATW-MRL	1.10E-05	ATW-CAL
2-Hexanone	nc	3.00E-02	ATW-IRIS	NA	NA	NA	NA
Acetaldehyde	c/nc	9.00E-03	ATW-IRIS	NA	NA	2.20E-06	ATW-IRIS
Benzene	c/nc	3.00E-02	ATW-ATSDR	2.90E-02	ATW-MRL	7.80E-06	ATW-IRIS
Chloroform	nc	9.80E-02	ATW-ATSDR	4.90E-01	ATW-MRL	2.30E-05	IRIS
Crotonaldehyde	c	NA	NA	NA	NA	5.43E-04	HEAST
Ethylbenzene	c/nc	1.00E+00	ATW-ATSDR	4.30E+01	ATW-MRL	2.50E-06	ATW-CAL
Formaldehyde	c/nc	9.80E-03	ATW-ATSDR	4.90E-02	ATSDR-MRL	1.30E-05	ATW-IRIS
Methylcyclohexane	nc	3.01E+00	HEAST	NA	NA	NA	NA
Methylene Chloride	c/nc	1.00E+00	ATW-ATSDR	2.10E+00	ATW-MRL	4.70E-07	ATW-IRIS
m-Xylene/p-Xylene	nc	1.00E-01	ATW-IRIS	8.70E+00	ATW-MRL	NA	NA
n-Hexane	nc	7.00E-01	ATW-IRIS	NA	NA	NA	NA
n-Nonane	nc	2.00E-01	PPTRV	NA	NA	NA	NA
n-Pentane	nc	1.00E+00	PPTRV	NA	NA	NA	NA
o-Xylene	nc	7.00E-01	CAL	NA	NA	NA	NA
Toluene	nc	5.00E+00	ATW-IRIS	3.80E+00	ATW-MRL	NA	NA

Notes:

µg/m3 = microgram per cubic meter

ATSDR-MRL: Agency for Toxic Substances Disease Registry Minimal Risk Level for Hazardous Substances, 2009

ATW-CAL: Value from EPA's Air Toxic Web-Site searched on 7/28/10. ATW obtained value from CAL.

ATW-IRIS: Value from EPA's Air Toxic Web-Site searched on 7/28/10. ATW obtained value from IRIS.

ATW-MRL: Value from EPA's Air Toxic Web-Site searched on 7/28/10. ATW obtained value from ATSDR MRL.

c = IUR for cancer available, nc = RfC for non-cancer effects available , c/nc = both are available

CAL: California EPA Office of Environmental Health Hazard Assessment Toxicity Criteria Database searched 7/28/10

CAS = Chemical Abstract Service

HEAST: EPA Health Effects Assessment Summary Tables 1997

IRIS: Value from EPA integrated risk information system searched on 7/28/10

IUR = incremental unit risk

mg/m3 = milligram per cubic meter

NA = Not available

PPTRV: EPA's Provisional Peer-Reviewed Toxicity Values from May 2010 risk screening level table

RfC = Reference concentration

Table 4-2
Contaminants of Potential Concern for without Toxicity Values
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Contaminant	CAS Number	Contaminant	CAS Number
1-Dodecene	112-41-4	cis-2-Butene	590-18-1
1-Heptene	592-76-7	cis-2-Hexene	7688-21-3
1-Hexene	592-41-6	cis-2-Pentene	627-20-3
1-Nonene	124-11-8	Cyclopentane	287-92-3
1-Octene	111-66-0	Cyclopentene	142-29-0
1-Pentene	109-67-1	Ethane	74-84-0
1-Tridecene	2437-56-1	Ethylene	74-85-1
1-Undecene	821-95-4	Hexaldehyde	66-25-1
2,2,3-Trimethylpentane	564-02-3	Isobutane	75-28-5
2,2,4-Trimethylpentane	540-84-1	Isobutene/1-Butene	115-11-7 / 106-98-9
2,2-Dimethylbutane	75-83-2	Isopentane	78-78-4
2,3,4-Trimethylpentane	565-75-3	Isoprene	78-79-5
2,3-Dimethylbutane	79-29-8	Isovaleraldehyde	590-86-3
2,3-Dimethylpentane	565-59-3	m-Diethylbenzene	141-93-5
2,4-Dimethylpentane	108-08-7	Methylcyclopentane	96-37-7
2-Methyl-1-butene	563-46-2	m-Ethyltoluene	620-14-4
2-Methyl-2-butene	513-35-9	n-Butane	106-97-8
2-Methyl-2-butene	513-35-9	n-Decane	124-18-5
2-Methylheptane	592-27-8	n-Dodecane	112-40-3
2-Methylhexane	591-76-4	n-Heptane	142-82-5
2-Methylpentane	107-83-5	n-Octane	111-65-9
3-Methyl-1-butene	563-45-1	n-Tridecane	629-50-5
3-Methylheptane	589-81-1	n-Undecane	1120-21-4
3-Methylhexane	589-34-4	o-Ethyltoluene	611-14-3
3-Methylpentane	96-14-0	p-Diethylbenzene	105-05-5
4-Methyl-1-pentene	691-37-2	p-Ethyltoluene	622-96-8
Acetylene	74-86-2	Propane	74-98-6
a-Pinene	80-56-8	Tolualdehydes	NA
Benzaldehyde	100-52-7	trans-2-Butene	624-64-6
b-Pinene	127-91-3	trans-2-Hexene	4050-45-7
Butyraldehyde	123-72-8	trans-2-Pentene	4050-45-7
		Valeraldehyde	110-62-3

Table 4-3
Oral/Dermal Non-cancer Toxicity Factors
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	Available Toxicity Values	RfD-acute (mg/kg-day)	Source	RFD-intermediate (mg/kg-day)	Source	RfD-chronic (mg/kg-day)	Source
Benzene	c/nc	NA	NA	NA	NA	4.00E-03	IRIS
Ethylbenzene	c/nc	NA	NA	5.00E-01	ATSDR-MRL	-	-
m&p-Xylene	nc	1.00E+00	ATSDR-MRL	-	-	-	-
o-Xylene	nc	1.00E+00	from m&p-xylene	-	-	-	-
Toluene	nc	8.00E-01	ATSDR-MRL	-	-	-	-

NA = Not available
- = Not applicable
c = carcinogen

c = Slope factor for cancer available, nc = RfD for non-cancer effects available , c/nc = both are available
RfD = Reference Dose
mg/kg-day = millgrams per kilogram per day
CAS = Chemical Abstract Service
IRIS: Value from EPA integrated risk information system searched on 7/28/10
ATSDR-MRL: Agency for Toxic Substances Disease Registry Minimal Risk Level for Hazardous Substances, 2009

Table 5-1
Chronic Risk Characterization for all Battlement Mesa Residents - 30 year Duration
Human Health Risk Assessment
Health Impact Assessment

	Non-Cancer Hazards			*Cancer Risks*			
Chemical	**RfC - chronic (µg/m^3)**	**Chronic Non-Cancer Intake (µg/m^3)**	**HQ**	**EPA WOE**	**IUR (1/(µg/m3)**	**Chronic Cancer Intake (µg/m^3)**	**Cancer Risk**
1,2,3-Trimethylbenzene	7.00E+00	9.68E-02	1.38E-02	-	-	-	-
1,2,4-Trimethylbenzene	7.00E+00	3.25E-01	4.65E-02	D	-	-	-
1,3,5-Trimethylbenzene	7.00E+00	1.70E-01	2.43E-02	-	-	-	-
1,3-Butadiene	2.00E+00	1.47E-01	7.35E-02	A	3.00E-05	6.29E-02	1.89E-06
1,4-Dichlorobenzene	8.00E+02	2.21E+00	2.76E-03	C	1.10E-05	9.45E-01	1.04E-05
2-Hexanone	3.00E+01	4.22E+00	1.41E-01	D	-	-	-
Acetaldehyde	9.00E+00	8.30E-01	9.22E-02	B2	2.20E-06	3.59E-01	7.90E-07
Benzene	3.00E+01	1.60E+00	5.33E-02	A	7.80E-06	6.87E-01	5.36E-06
Crotonaldehyde	-	-	-	C	5.43E-04	8.30E-02	4.51E-05
Ethylbenzene	1.00E+03	3.94E-01	3.94E-04	D	2.50E-06	1.69E-01	4.23E-07
Formaldehyde	9.80E+00	1.20E+00	1.22E-01	B1	1.30E-05	5.16E-01	6.70E-06
Methylcyclohexane	3.01E+03	5.72E+00	1.90E-03	-	-	-	-
Methylene Chloride	1.00E+03	2.78E+00	2.78E-03	B2	4.70E-07	1.19E+00	5.59E-07
Hazard Index (HI)			**6.E-01**	**Total Cancer Risk**			**7.1E-05**

Notes:
µg/m^3: michrograms per cubic meter
EPA: Environmental Protection Agency
HQ: Hazard Quotient
IUR: Incremental Unit Risk
RfC: Reference Concentration
WOE: Weight of Evidence: A - known human carcinogen; B1&B2 probable human carcinogen;
C-possible human carcinogen; D-Not enough evidence to classify carcinogencity

Table 5-2
Comparison of EPCs to BTVs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS	BTV	EPC Bell-Melton Ranch 2005-2010 (µg/m^3)	EPC> BTV?	Maximum Detected Concentration 2008 Well Completion (µg/m^3)	Maximum Detected Concentration > BTV?
1-Dodecene	112-41-4	8.83E-01	1.74E-01	no	6.08E+00	yes
1-Heptene	592-76-7	1.28E+00	7.10E-01	no	6.08E+01	yes
1-Hexene	592-41-6	1.01E-01	9.72E-02	no	1.63E-01	yes
1-Nonene	124-11-8	1.49E-01	1.20E-01	no	1.68E+01	yes
1-Octene	111-66-0	1.42E-01	1.13E-01	no	3.16E+00	yes
1-Pentene	109-67-1	1.50E-01	1.12E-01	no	3.89E-01	yes
1-Tridecene	2437-56-1	2.69E-02	8.89E-02	yes	3.63E-01	yes
1-Undecene	821-95-4	9.75E-02	1.48E-01	yes	4.72E+00	yes
2,2,3-Trimethylpentane	564-02-3	4.29E-01	1.91E-01	no	2.47E+01	yes
2,2,4-Trimethylpentane	540-84-1	2.46E-01	2.14E-01	no	1.98E-01	no
2,2-Dimethylbutane	75-83-2	1.00E+00	6.76E-01	no	4.12E+01	yes
2,3,4-Trimethylpentane	565-75-3	2.25E-01	1.27E+00	yes	1.21E+00	yes
2,3-Dimethylbutane	79-29-8	1.85E+00	1.36E+00	no	6.58E+01	yes
2,3-Dimethylpentane	565-59-3	9.48E-01	5.70E-01	no	3.56E+01	yes
2,4-Dimethylpentane	108-08-7	6.55E-01	4.06E-01	no	2.36E+01	yes
2-Methyl-1-butene	563-46-2	1.38E+00	1.23E+00	no	1.26E+00	no
2-Methyl-1-pentene	763-29-1	2.47E-01	1.52E-01	no	8.43E-02	no
2-Methyl-2-butene	513-35-9	3.05E-01	1.07E-01	no	3.87E-01	yes
2-Methylheptane	592-27-8	1.61E+00	7.01E-01	no	1.46E+02	yes
2-Methylhexane	591-76-4	2.71E+00	1.54E+00	no	1.21E+02	yes
2-Methylpentane	107-83-5	8.75E+00	5.98E+00	no	2.21E+02	yes
3-Methyl-1-butene	563-45-1	1.15E-01	9.44E-02	no	2.49E-01	yes
3-Methylheptane	589-81-1	1.17E+00	4.55E-01	no	9.74E+01	yes
3-Methylhexane	589-34-4	2.72E+00	1.27E+00	no	1.14E+02	yes
3-Methylpentane	96-14-0	5.63E+00	3.12E+00	no	1.29E+02	yes
4-Methyl-1-pentene	691-37-2	7.00E-01	2.28E-01	no	9.35E-01	yes
Acetylene	74-86-2	3.03E-01	6.97E-01	yes	8.40E-01	yes
a-Pinene	80-56-8	5.90E-01	2.31E-01	no	3.09E+01	yes
b-Pinene	127-91-3	3.72E-01	1.23E-01	no	8.96E+00	yes
cis-2-Butene	590-18-1	8.14E-02	7.95E-02	no	1.97E-01	yes
cis-2-Hexene	7688-21-3	2.95E-01	1.00E-01	no	2.93E-01	no
cis-2-Pentene	627-20-3	6.07E-02	6.12E-02	yes	1.48E-01	yes
Cyclopentane	287-92-3	9.63E-01	8.00E-01	no	2.23E+01	yes
Cyclopentene	142-29-0	4.72E-01	1.66E-01	no	6.51E-01	yes
Ethane	74-84-0	8.30E+01	9.02E+01	yes	2.41E+03	yes
Ethylene	74-85-1	9.39E-01	1.09E+00	yes	4.19E+00	yes
Isobutane	75-28-5	2.28E+01	2.62E+01	yes	1.60E+03	yes
Isobutene/1-Butene	115-11-7 / 106-98-9	1.07E+01	1.60E+00	no	6.71E+00	no
Isopentane	78-78-4	2.38E+01	2.24E+01	no	8.32E+02	yes
Isoprene	78-79-5	1.10E+00	5.03E-01	no	1.15E+00	yes
m-Diethylbenzene	141-93-5	4.10E-01	1.18E-01	no	7.08E+00	yes
Methylcyclopentane	96-37-7	5.85E+00	2.89E+00	no	1.20E+02	yes
m-Ethyltoluene	620-14-4	6.28E-01	2.21E-01	no	4.45E+01	yes

Table 5-2
Comparison of EPCs to BTVs
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS	BTV	EPC Bell-Melton Ranch 2005-2010 (µg/m^3)	EPC> BTV?	Maximum Detected Concentration 2008 Well Completion (µg/m^3)	Maximum Detected Concentration > BTV?
n-Butane	106-97-8	2.61E+01	3.14E+01	yes	1.29E+03	yes
n-Decane	124-18-5	1.81E+00	2.24E+00	yes	2.08E+02	yes
n-Dodecane	112-40-3	1.55E+00	3.74E+00	yes	5.15E+01	yes
n-Heptane	142-82-5	5.48E+00	2.85E+00	no	3.04E+02	yes
n-Octane	111-65-9	3.74E+00	1.61E+00	no	4.17E+02	yes
n-Tridecane	629-50-5	3.12E-01	2.92E-01	no	9.05E+00	yes
n-Undecane	1120-21-4	2.17E+00	1.15E+01	yes	1.21E+02	yes
o-Ethyltoluene	611-14-3	3.08E-01	1.65E-01	no	2.92E+01	yes
p-Diethylbenzene	105-05-5	1.12E-01	7.00E-02	no	5.01E+00	yes
p-Ethyltoluene	622-96-8	3.60E-01	1.62E-01	no	3.22E+01	yes
Propane	74-98-6	5.26E+01	6.94E+01	yes	4.67E+03	yes
trans-2-Butene	624-64-6	2.06E-01	1.74E-01	no	1.89E+00	yes
trans-2-Hexene	4050-45-7	1.03E-01	3.04E-02	no	4.53E-02	no
trans-2-Pentene	4050-45-7	1.27E-01	8.08E-02	no	3.05E-01	yes

Notes
BTV: Background Threshold Value
EPC: Exposure Point Concentration
CAS: Chemical Abstract Service
µg/m^3: micrograms per cubic meter

Table 5-3
Chronic Risk Characterization for Residents Living Adjacent to a Well Pad - 30 Year Duration
Human Health Risk Assessment
Health Impact Assessment

	Non-Cancer Hazards			*Cancer Risks*			
Chemical	**RfC - chronic ($\mu g/m^3$)**	**TWA Inon-Cancer Intake ($\mu g/m^3$)**	**HQ**	**EPA WOE**	**IUR (1/(µg/m3)**	**TWA Cancer Intake ($\mu g/m^3$)**	**Cancer Risk**
1,2,3-Trimethylbenzene	7.00E+00	4.05E-01	5.79E-02	-	-	-	-
1,2,4-Trimethylbenzene	7.00E+00	2.53E+00	3.61E-01	D	-	-	-
1,3,5-Trimethylbenzene	7.00E+00	2.23E+00	3.19E-01	-	-	-	-
1,3-Butadiene	2.00E+00	1.47E-01	7.35E-02	A	3.00E-05	6.30E-02	1.89E-06
1,4-Dichlorobenzene	8.00E+02	2.21E+00	2.76E-03	C	1.10E-05	9.45E-01	1.04E-05
2-Hexanone	3.00E+01	4.22E+00	1.41E-01	D	-	-	-
Acetaldehyde	9.00E+00	8.38E-01	9.31E-02	B2	2.20E-06	3.59E-01	7.90E-07
Benzene	3.00E+01	3.38E+00	1.13E-01	A	7.80E-06	1.45E+00	1.13E-05
Crotonaldehyde	-	-	-	C	5.43E-04	8.30E-02	4.51E-05
Ethylbenzene	1.00E+03	6.47E+00	6.47E-03	D	2.50E-06	2.77E+00	6.93E-06
Formaldehyde	9.80E+00	1.20E+00	1.22E-01	B1	1.30E-05	5.16E-01	6.70E-06
Methylcyclohexane	3.01E+03	2.48E+01	8.24E-03	-	-	-	-
Methylene Chloride	1.00E+03	4.33E+00	4.33E-03	B2	4.70E-07	1.86E+00	8.74E-07
m&p-Xylene	1.00E+02	2.54E+01	2.54E-01	D	-	-	-
n-Hexane	7.00E+02	1.29E+01	1.84E-02	D	-	-	-
n-Nonane	2.00E+02	8.74E+00	4.37E-02	-	-	-	-
n-Pentane	1.00E+03	2.87E+01	2.87E-02	-	-	-	-
o-Xylene	7.00E+02	5.53E+00	7.91E-03	D	-	-	-
Hazard Index (HI)			**2.E+00**	**Total Cancer Risk**			**8.3E-05**

Notes:
$\mu g/m^3$: micrograms per cubic meter
EPA: Environmental Protection Agency
HQ: Hazard Quotient
IUR: Incremental Unit Risk
RfC: Reference Concentration
TWA: Time weighted average
WOE: Weight of Evidence: A - known human carcinogen; B1&B2 probable human carcinogen; C-possible human carcinogen; D-Not enough evidence to classify carcinogencity

Table 5-4
Acute Risk Characterization for Child Resident Living Adjacent to Well Pad - 7-day Duration
Human Health Risk Assessement
Health Impact Assessment

Chemical	Primary target system	RfC - acute ($\mu g/m^3$)	Acute Intake ($\mu g/m^3$)	HQ
Ambient Air				
1,2,3-Trimethylbenzene	Neurologic, Respiratory, Immunologic	7.00E+00	1.17E+01	1.67E+00
1,2,4-Trimethylbenzene	Neurologic, Respiratory, Immunologic	7.00E+00	8.30E+01	1.19E+01
1,3,5-Trimethylbenzene	Neurologic, Respiratory, Immunologic	7.00E+00	7.75E+01	1.11E+01
1,3-Butadiene	Reproductive	2.00E+00	1.66E-01	8.29E-02
2-Hexanone	Neurologic	3.00E+01	4.22E+00	1.41E-01
Acetaldehyde	Respiratory	9.00E+00	1.96E+00	2.18E-01
Benzene	Immunologic	2.90E+01	1.80E+02	6.21E+00
Chloroform	Neurologic	4.90E+02	1.60E+00	3.27E-03
Ethylbenzene	Developmental	4.30E+04	9.60E+01	2.23E-03
Formaldehyde	Respiratory	4.90E+01	1.02E+01	2.08E-01
Methylcyclohexane	Renal	3.01E+03	7.23E+02	2.40E-01
m&p-Xylene	Neurologic	8.70E+03	1.50E+03	1.72E-01
n-Hexane	Neurologic	7.00E+02	2.55E+02	3.64E-01
n-Nonane	Neurologic	2.00E+02	3.03E+02	1.51E+00
n-Pentane	Neurologic	1.00E+03	5.53E+02	5.53E-01
o-Xylene	Neurologic	7.00E+02	2.60E+02	3.71E-01
Toluene	Neurological and Respiratory	3.80E+03	5.40E+02	1.42E-01
Hazard Index (HI)				***3.47E+01***
		RfD - acute (mg/kg-day)	**Acute Intake (mg/kg-day)**	**HQ**
Surface Water				
Benzene	Immunologic	4.00E-03	2.00E-03	5.00E-01
Ethylbenzene	Developmental	5.00E-01	1.23E-02	2.45E-02
m&p-Xylene	Neurologic	1.00E+00	4.79E-03	4.79E-03
o-Xylene	Neurologic	1.00E+00	1.71E-03	1.71E-03
Toluene	Neurological and Respiratory	8.00E-01	4.86E-02	6.08E-02
Hazard Index (HI)				***5.92E-01***
Ambient Air and Surface Water				
Total Hazard Index (HI)				**4.E+01**

Notes:
$\mu g/m^3$: michrograms per cubic meter
EPA: Environmental Protection Agency
HQ: Hazard Quotient
mg/kg-day: milligrams per kilogram per day
RfC: Reference Concentration
RfD: Reference Dose

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
#1 diesel	8008-20-6
#2 Diesel	68476-34-6
(sulfonic acids, petroleum, calcium salts)	61789-86-4
1,2 benzanthracene	56-55-3
1,2-benzphenanthrene	218-01-9
2-Aminoethanol	141-43-5
2-ethoxyethanol	110-80-5
2-methyl-4-isothiazolin-3-one	2682-20-40
2-pentanone, 4 -methyl(hexone)	108101
5-cholro-2-methyl-4-isothiazolin-3-one	26172-55-4
acenaphthene	83-32-9
Additives	proprietary
aliminum oxide	1344-28-1
aliphatic glyicdyl ether	2461-15-6
Aliphatic petroleum distallates	64742-89-8
alkali carbonates	584-08-7
alkoxylated long-chain alkyl amine	proprietary
alkyd resin	Not listed
Alkyl (C12-16) dimethylbenzylammonium chloride	68424-85-1
aluminum	7429-90-5
aluminum stearate	68442-97-7
Amino Methylene Phosphonic Acid Salt	proprietary
amino silane	1760-24-3
ammonium sulfate	7783-20-2
amorphous fumed silica	112945-52-5
anthracene	120-12-7
antioxidant	trade secret
argon	7440-37-1
aromatic petroleum distallates	64742-96-6
asphalt	8052-42-4
attaclay	8031-18-3
barium sulfate	7727-43-7
bentonite	1302-78-9
benzo(a)pyrene	50-32-8
benzo(b)fluoranthene	205-99-2
benzo(g,h,i)perylene	191-24-2
benzo(J)fluoranthene	205-82-3
benzo(K)fluoranthene	207-08-9
benzyldimethlamine	103-83-3
bisphenol A	80-05-7
bisphenol'A'/epichlorohydrin based epoxy	25068-38-6
boric acid	10043-35-3
calcium aluminate	12042783
calcium aluminate /iron oxide	12068358
calcium carbonate	471-34-1
calcium carbonate	1317-65-3
calcium fluoride	7789755
calcium hydroxide	01305-62-0

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
calcium hypochlorite	7778-54-3
calcium oxide	1305-78-8
calcium oxide, magnesium oxide, potassium sulfate, sodium sulfate	1003
calcium silicates	various
calcium sulfate	13397245
carbon	7440-44-0
carbon black	1333-86-4
carbon dioxide	124-38-9
carbon monoxide	0630-08-0
cellulose	65996-61-4
chlorinated paraffin	Not listed
chromium	7440-47-3
chromium (VI) as Cr	7440-47-3
Copper	7440-50-8
corrosion inhibitor	mixture
crystalline silica (cristobalite)	14464-46-1
crystalline silica (quartz)	14808-60-7
dibenz(A,H)anthracene	53-70-3
dibenzo(a)pyrene	189-55-9
dibenzo(a,e)pyrene	192-65-4
dibenzo(a,h)pyrene	189-64-0
dibutyl phthalate	84-74-2
diethylene glycol	111-46-6
diethylene glycol monoethyl ether	111-90-0
dipentamethylene thiuram tetrasulfide	120-54-7
dipotassium phosphate	2139900
dipropylene glycol	34590948
di-tocopherol	59-02-9
epoxy resin	25085-99-8
ethanol	64-17-5
ethyl acetate	141-78-6
ethyl ether	60-29-7
ethyl mercaptan	75-08-1
ethyl silicate	78-10-4
ethylene glycol	107-21-1
ethylene glycol monobutyl ether	111-76-2
ethylene glycol monoethyl ether acetate	111-15-9
ethylene glycol monomethyl ether	109-86-4
feldspar	Not listed
ferric oxide hydroxide	51274-00-0
fluoranthene	206-44-0
fluorene	86-73-7
fluorides	7789-75-5
fumed silica	67762-90-7
gasoline	mixture
Glutaraldehyde	111-30-8
glycerine (glycerol)	56-81-5

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
glycerol	56-81-5
glycol ether EB acetate	112-07-2
graphite	7782-42-5
gypsum	777-8-18-9
heavy aromatic naphtha	68603-08-7
helium	7440-59-7
highly refined base oils	mixture
highly refined mineral oil C15-C50	mixture
highly solvent-refinded base oils	64741-88-4
	64742-01-4
hydrocarbon propellant	684 76-86-8
Hydrochloric acid	7647-01-0
hydrogen	133-74-0
hydrogen sulfide	7783-06-4
hydrosulferized kerosene C9-16	64742-81-0
hydrotreated distallate, light C9-16	64742-47-8
hydrotreated heavy naphtha (petroleum(	64742489
hydrous alluminum silicate	Not listed
indeno (1,2,3-cd) pyrene	193-39-5
iron	7439-89-6
iron oxides	65996-74-9
isohexane isomers	107-83-5
Isopropanol	67-63-0
isopropyl acetate	108-21-4
lead chromate	1344372
leonardite	1414-93-6
lithium compounds	554-13-2
lithium sterate soap	7620-77-1
lubicant base oil	various
magnesite	1309-48-4
magnesium	7439954
magnesium carbonate	546-93-0
magnesium oxide	1309-58-4
manganese	7439-96-5
mercaptobenzothiazole	149-30-4
metallic coating	mixture
Methanaminium, N N N trimethyl-,chloride	75-57-0
methane	0074-82-8
Methanol	67-56-1
methyl n-amyl ketone	110-43-0
methyl n-propyl ketone	107-87-9
mica	12001-26-2
mineral oil	8042-47-5
Mineral oil, petroleum distallates, hydrotreated (severe) heavy naphthenic; (mineral oil)	64742525
Mineral oil, petroleum distallates, hydrotreated (severe) light naphthenic; (mineral oil petroleum distallates)	64742536
mineral silicates	1332-58-7

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
mineral spirits	8052-41-3
mineral spirits (F)	64742-88-7
modified aliphatic amine	Not listed
molybdenum	7439-98-7
mono ammonium phosphate	7733-76-1
N-aminoethypiperazine	140-31-8
Naphthalene	91-20-3
n-butanol	71-36-3
nickel	7440-02-0
nitrogen	7727-37-9
non-phenol ethoyxalates	Not listed
nonyl phenol	25154-52-3
nonylphenol ethoxylates	9016-45-9
nut shells	NA
octyl alcohol	111-87-5
oil mists	mixture
organic cobalt compounds	various
organophillic clay	71011-26-2
partially hydrolized polyacrylamide	Not listed
perchloroethylene	127-18-4
petroleum base oil	64742-65-0
Petroleum Grease Mixture	64742-52-5, 7620-77-1, 68783-36-8, Mixture
petroleum product additive	Not listed
phenanthrene	85-01-8
phosphated polyester	proprietary
phosphorous (yellow)	7723-14-0
poly[oxyethylene(dimethylimino)ethylene(dimethyleimino)ethylenedichloride	31512-74-0
polyamide resin	68410-23-1
polyanionic carboxymethyl cellulose	Not listed
polyethelene co-polymer	Not listed
polyethylene	9002884
polyethylene or polyethylene-butene copolymer or polyethylene-hekene copolymer	9002883
polyethylene-butene	25087347
polyethylene-hexene	25213029
Polytef [USAN]	9002-84-0
polyvinyl chloride	Not listed
Polyvinyl Chloride Resin	non/haz
portland cement	65997-15-1
potassium acid fluoride	7789-29-9
potassium aluminum silicate (potassium feldspar)	68476255
potassium borate	1332-77-0
potassium pentaborate	11128-29-3
potassium silicate	1312761
proprietary additives	proprietary

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
proprietary pigment (nuisance dust)	proprietary
propylene carbonate	108-32-7
PVC resin	9002-86-2
pyrene	129-00-0
red dye	4477-79-6
red iron oxide	1309-37-1
refined coal tar pitch (contains PAH's)	65996-93-2
silica (precipitated)	112926-00-8
silica amorphous	7631-86-9
silica, crystalline, quartz	148-06-60-7
silica, crystalline, tridymite	15468-32-3
silicic acid, disodium salt (sodium silicate)	6834920
silicon	7440-21-3
silicon fluid (poly (dimethylsiloxane), dimethyl	63148629
silicone oil	63148-57-2
slag coal	Not listed
sodium carbonate	497-19-8
sodium acid pyrophosphate	7758-16-9
sodium bicarbonate	7447-40-7
sodium carbomethyl starch	9063-38-1
sodium chloride	7647-14-5
sodium fluoride	7681-49-4
sodium hydroxide	1310-73-2
sodium silicate	1344-09-8
soft/hard wood sawdust ex W red cedar	mixture
soluble barium compound	Not listed
subtilisin	1/1/9014
sulfamic acids	5329-14-6
sulfur	7404-34-9
talc (respirable dust)	14807-96-9
talc [JAN]	14807-96-6
tetrahydrofuran	109-99-9
thiocarbamates	Not listed
tin	7440-31-5
titanium	12719-90-5
titanium dioxide	13463-67-7
triclosan	3380-34-5
triethylenetetramine	112-24-3
Triisopropanolamine	122-20-3
vanadium	1314-62-1
violet dye	81-48-1
yellow pigment	5468-75-7
zinc	1314-13-2
zinc compound	proprietary
Zinc dialkyldithiophosphate	68649-42-3
zinc oxide	1314-13-2
zirconium	12004-83-0
Zirconium acetate lactate ammonium complex	68909-34-2

Table 6-1
Chemicals Identified from Antero's MSDS
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Chemical	CAS Number
zirconium dioxide (zirconium silicate)	7440677
zirconium silicate	14940-68-2

Table 7-1
Summary of Risk Characterization
Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Exposure Scenario	Exposure	Hazard Index (HI)	Cancer Risk
All Battlement Mesa Residents - 30 years	Chronic	1	7.1E-05
Residents living near a well pad - 30 years	Chronic	2	8.3E-05
Child Resident living near a well pad - 7 days			
-Ambient Air Exposure Pathway[1]	Acute	35	-
-Surface Water Exposure Pathway	Acute	0.6	-
'-Ambient Air plus Surface Water Pathways	Acute	40	-

[1]Also applies to adult residents for 7-day acute exposure

Figure 2-1
Temporal Trends of BTEX at Bell-Melton Monitoring Station - 2005 to 2010

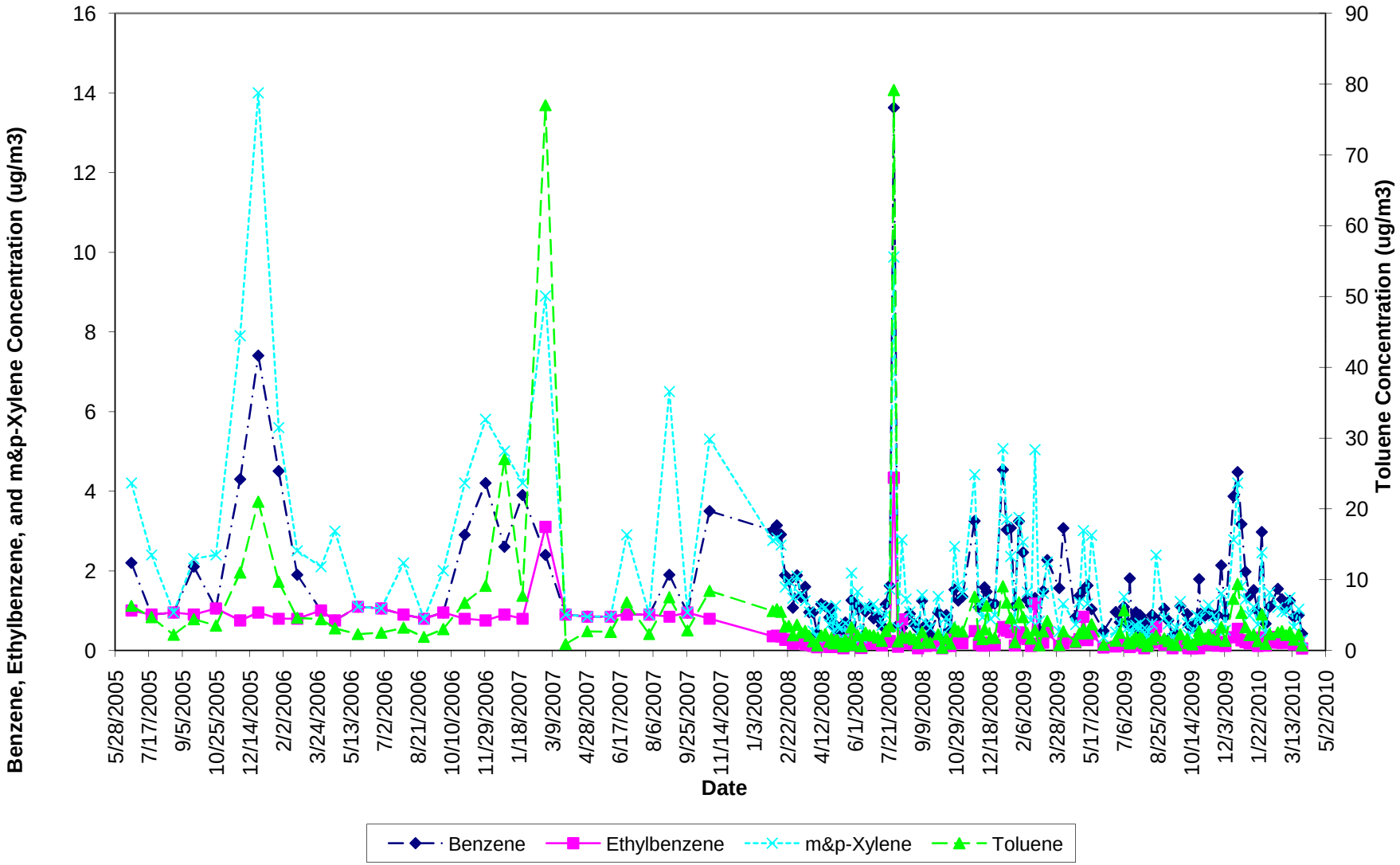
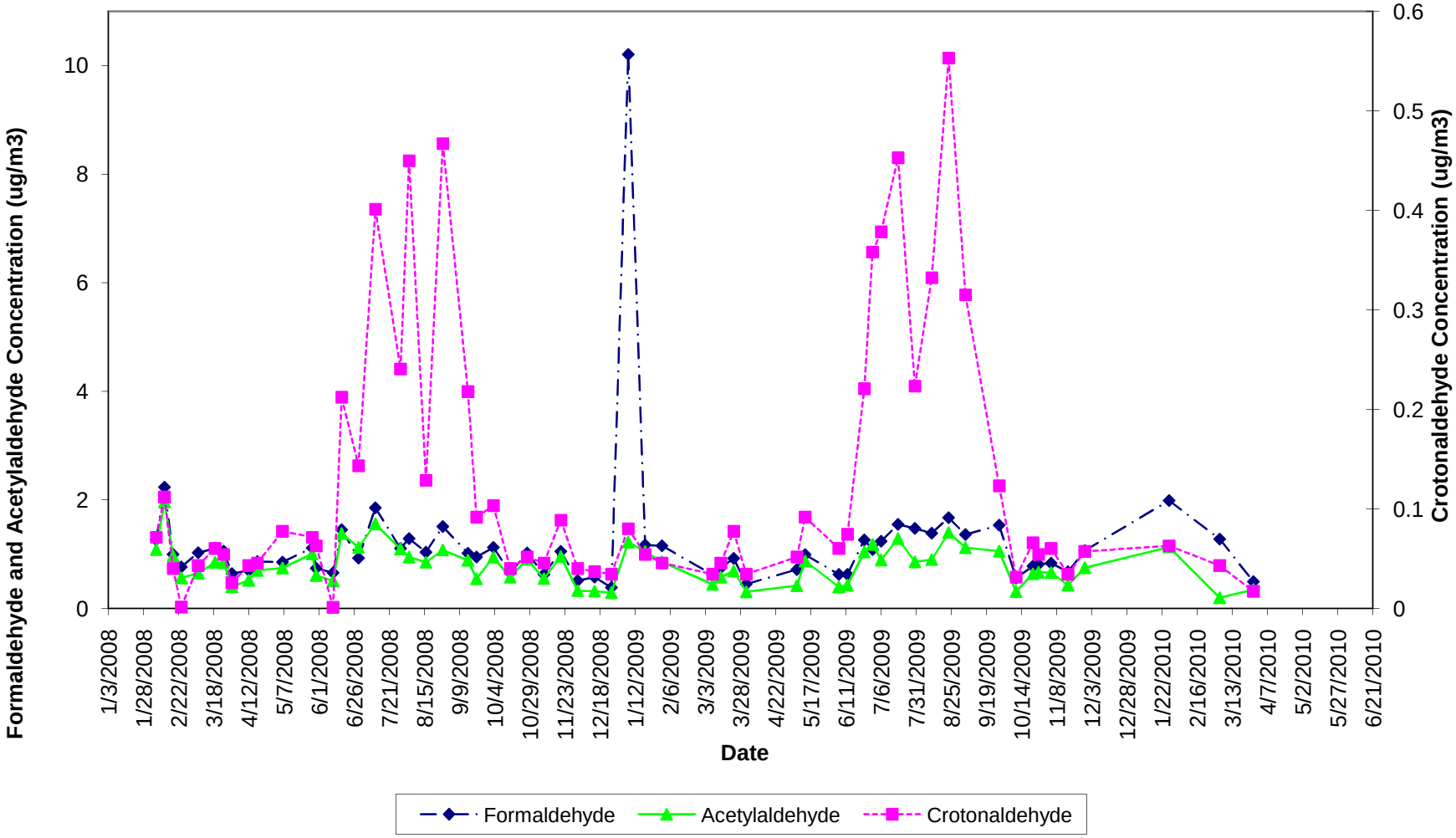


Figure 2-2
Temporal Trends for Carbonyls
Bell Melton Ranch Monitoring Station



Sources	Potential Releases	Exposure Media	Secondary Media	Receptors: Resident Ingestion	Resident Dermal	Resident Inhalation
Natural Gas, Drilling Mud, and Fracking Fluids	Well Installation errors/leaks	Groundwater		P	P	P
			Indoor Air	NA	NA	P
		Subsurface Soil		I	I	I
		Ambient Air		NA	NA	C
	Well Blow-outs/Uncontrolled releases/Fires	Groundwater		P	P	P
			Indoor Air	NA	NA	P
		Subsurface Soil		I	I	I
		Surface Soil		C	C	C
		Surface Water		P	C	I
		Ambient Air		NA	NA	C
	Venting	Ambient Air		NA	NA	C
Drilling Mud, Fracking Fluids, Diesel, and Condensate and Produced Water	Spills	Surface Soil	Surface Water	P	C	I
				C	C	C
			Groundwater	P	P	P
			Indoor Air	NA	NA	P
			Subsurface Soil	I	I	I
		Ambient Air		NA	NA	C
Trucks and Generators	Exhaust	Ambient Air		NA	NA	C
			Surface Soil	C	C	C
Drill Cuttings and Produced Water	Surface Run-off	Surface Soil	Groundwater	P	P	P
			Indoor Air	NA	NA	P
			Subsurface Soil	I	I	I
		Surface Water		C	C	C
	Infiltration	Subsurface Soil	Groundwater	P	C	I
				P	P	P
			Indoor Air	I	I	I
	Evaporation	Ambient Air		NA	NA	P
				NA	NA	C
Condensers/Glycol Dehydrators	Venting	Ambient Air		NA	NA	C
Pneumatic Pumps and Devices, Pipeline and valves	Leaks	Ambient Air		NA	NA	C

Figure 3-2: Conceptual Site Model for Battlement Mesa Health Impact Assessment
C = Complete Pathway I = Incomplete Pathway P = Potential Pathway NA = Not Applicable

Figure 3-2:
Domestic Water Supply and
Proposed Well Pad Locations
2010 Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

Water Supply Well Pad

Parachute
Backup Groundwater Wells
Water Treatment Plant Intakes
Monumet Creek Diversion
Parks and Rec Pad
Pad A
Pad B
Pad D
Pad L
Pad N
Pad M
Pad E
Pad K
Pad G
Battlement Mesa
Proposed Water Handling Facility

Image © 2010 DigitalGlobe
Image USDA Farm Service Agency
© 2010 Google
©2010 Google
Imagery Dates: Jun 17, 2005 - Sep 11, 2005 39°26'20.80" N 108°02'02.92" W elev 5375 ft Eye alt 21261 ft

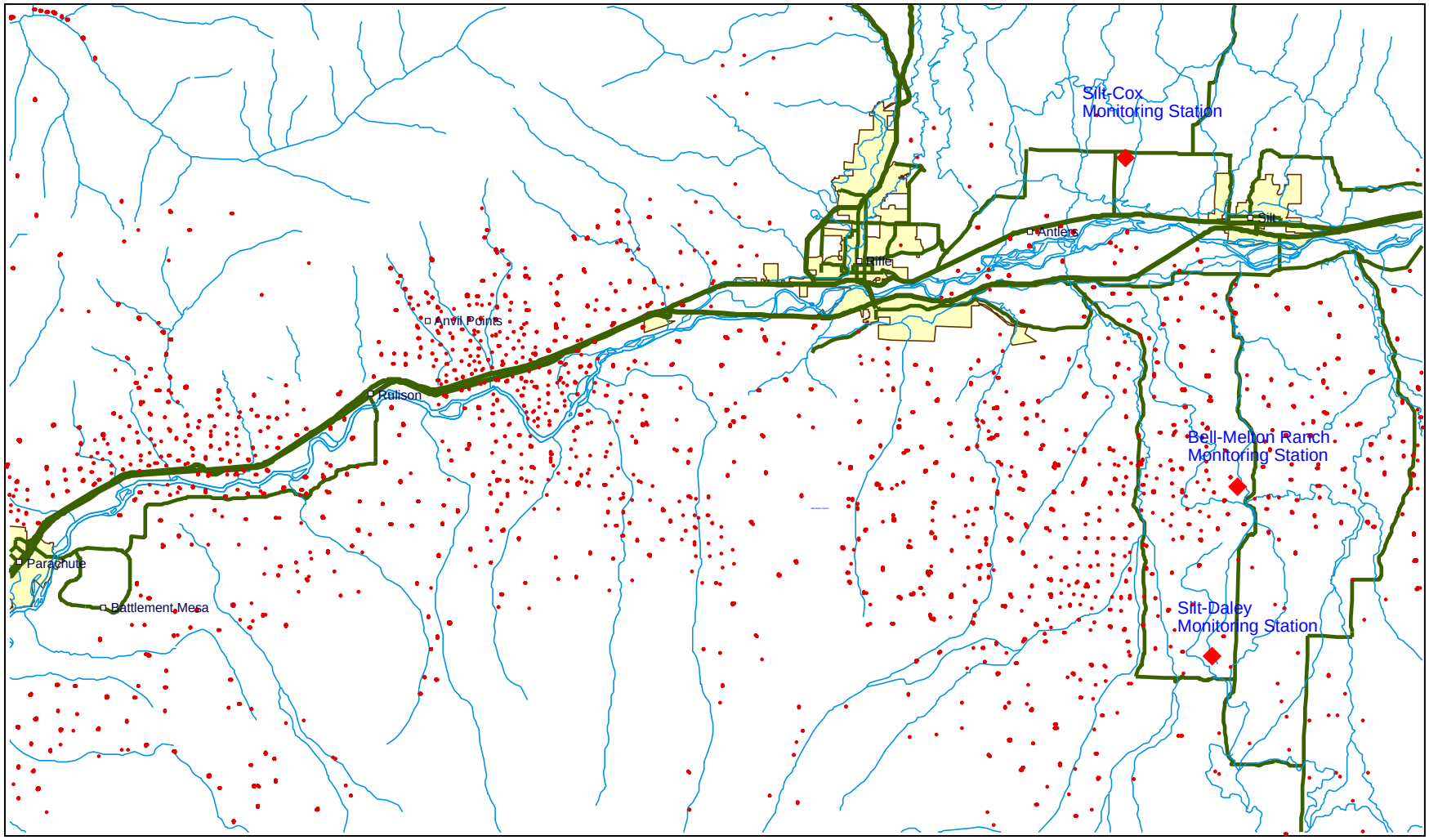


Figure 3-3: Locations of Baseline and Bell-Melton Ranch Monitoring Stations
2010 Human Health Risk Assessment
Battlement Mesa Health Impact Assessment

● = Natural gas or oil well ■ = Monitoring Station ——— = Road

BATTLEMENT CONCERNED CITIZENS

Battlement Mesa, Colorado

November 6, 2009

Garfield County Dept. of Public Health
195 W. 14th Street
Rifle, CO 81650

Dear Ms. Meisner and Mr. Rada:

On behalf of the Battlement Concerned Citizens (BCC), a committee of the Grand Valley Citizens Alliance, we thank you for the opportunity to discuss the special public health concerns associated with natural gas development within the Battlement Mesa Planned Unit Development (PUD). We appreciate talking to public health officials who understand and appreciate the potentially serious health hazards from the drilling industry.

To be sure, drilling up to 200 wells, with some rigs planned within 400 feet of homes, has raised considerable health concerns within the community. Within two weeks in September, BCC members garnered over 400 signatures from Battlement Mesa residents on a petition to the Board of County Commission (BOCC), the Colorado Oil and Gas Conservation Commission (COGCC), and the Colorado Department of Public Health and Environment (CDPHE). That petition asked that these agencies defer any permitting decision until a thorough study of the public health, safety and welfare concerns has been completed.

In our discussion with you, BCC members stressed that Battlement Mesa is a unique community and therefore, a special health baseline study is warranted before drilling within the PUD continues from the Williams Production well pad or is expanded with Antero's Comprehensive Drilling Plan (CDP).

As noted in our discussion last week:

- Battlement Mesa has approximately 5000 residents, many of whom are seniors with existing health problems and compromised immune systems. Also included are three schools with about 600 students and Mesa Vista Assisted Living facility with 35 to 45 elderly citizens with 6 of them currently on oxygen.
- Because of the unknown chemical compositions used in drilling practices, oil-and-gas exploration operations within Battlement Mesa could expose a large number of vulnerable people to potentially long-term adverse health and environmental impacts -- making sick people sicker

- There are currently no effective means of monitoring drilling chemical use and its impacts on air and water quality within the Battlement community
- Data from the air quality study that was completed in 2008 was used by Dr. Russ Walker to show there are real hazards from drilling operations in close proximity to humans. Drs. Walker and Teresa Coons also went on to make a series of recommendations to protect public health based on the study data.

On behalf of Battlement Mesa citizens, BCC members have requested the county and state to conduct a "Health Impact Assessment" (HIA) before a Special Use Permit (SUP) is approved to **any** company drilling within the Battlement Mesa PUD.

We feel these subjects should be addressed in a Battlement HIA:

- The baseline health study should be specific to Battlement Mesa and it's population
- Conduct baseline monitoring of air and water quality within the Battlement PUD before any drilling operations continue
- Conduct a comprehensive and continuous air, water, and soil quality monitoring system at all well sites during all phases of operation
- Establish a medical monitoring system to identify any changes in baseline data or trends and/or anomalies in medical practices
- Require full disclosure of materials used in drilling and fracturing processes to health officials and scientists conducting these studies
- Test whether a buffer zone of not less than one thousand feet between any well operation and any residence, business, or public building will protect health standards

Recent COGCC Rule Amendments encourage responsible energy development and inter-agency collaboration. The CDPHE has the authority to participate in the permit review process and recommend additional measures to protect public health. In short, Garfield County has an opportunity to communicate with both state agencies to request additional public or environmental protections. Certainly, Battlement Mesa's unique situation requires additional oversight and analysis – and provides an opportunity for agencies to collaborate on a detailed HIA -- possibly the first such study conducted in the state in regards to energy development in an established residential area of people with compromised health issues.

Funding sources are many. For instance, the Robert Wood Johnson Foundation and the Pew Charitable Trusts are currently welcoming HIA proposals from local and state agencies, non-profit organizations, and business interests. We also feel that other sources of funding should be pursued. Recently Garfield County received an additional approximately $8 million in severance tax revenue from the state. Some of those funds, as well as monies from the Energy Mitigation Fund could be utilized. Also, if any funds are generated from fines to energy operators for violations of county regulations, those monies should also be considered. It may also be appropriate to require any organization seeking county approval for gas drilling or exploration operations in the PUD to

participate in the cost of an HIA as a condition of the application process. The CDPHE might also participate in such a project – either financially or otherwise.

Natural gas is an important domestic energy that merits responsible development. However, some of its development practices remain unsafe and there are particular areas where drilling proposals deserve additional scrutiny and oversight. Since our community will need additional levels of protection when so many wells are to be developed, we believe the people of Battlement Mesa deserve a public health risk and baseline environmental study to ensure public health protection during all stages of energy development.

We appreciate that you will take our concerns to the appropriate members of the BOCC, COGCC, and CDPHE and we look forward to further discussion with you regarding the HIA process.

Thank you for your consideration.

Battlement Concerned Citizens

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Dave Devanney, Co-Chair
285-2263
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Ron Galterio, Co-Chair
285-0243
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SURFACE USE AGREEMENT

This Surface Use Agreement ("Agreement") is entered into and made effective this 15th day of January, 2009 ("Effective Date") by and between Battlement Mesa Partners, LLC a Colorado limited liability company d/b/a Battlement Mesa Company, and Battlement Mesa Land Investments, LLC, Battlement Mesa Land Investments Parcel 1 LLC, Battlement Mesa Land Investments Parcel 2 LLC, Battlement Mesa Land Investments Parcel 3 LLC, Battlement Mesa Land Investments Parcel 6 LLC, Battlement Mesa Land Investments Parcel 7 LLC, Battlement Mesa Land Investments Parcel OHS LLC, Battlement Mesa Land Investments Parcel 5-1, TRK3 and 4 LLC, Battlement Mesa Land Investments Parcel 5-2, TRK 5 LLC, Battlement Mesa Land Investments Parcel 5-2, TRK 6 LLC, Battlement Mesa Land Investments Parcel Fairways LLC, Green Head Investments 1 LLC, Burning Rock B2L2 LLC, MCV2 Church Site LLC, Battlement Mesa Golf Course, LLC, Saddleback Village Convenience Center, LLC, Willow Park Apartments LLC, Battlement Mesa Land Investments Parcel 1-A, LLC, Paradise Valley Minerals LLC, Battlement Mesa Land Investments Town Center 1 LLC, Battlement Mesa Land Investments Town Center 2 LLC, Battlement Mesa Land Investments Town Center 3 LLC, Battlement Mesa Plaza Town Center, LLC, Battlement Mesa Land Investments Parcel 5-1, TRK 2 LLC, Battlement Mesa Land Investments OES LLC, Battlement Mesa RV Park LLC, Battlement Mesa RV Storage LLC, Battlement Mesa Office I LLC, Modular Homes LLC, Tamarisk Village Pads, LLC, Willow Ridge at Battlement Mesa LLC, , Battlement Mesa Parcel 5 LLC, Battlement Mesa Lot Holdings LLC, whose address is 73 G Sipprelle Drive, Battlement Mesa Colorado 81635 hereinafter, collectively, called "Owner", Exxon Mobil Corporation hereinafter called "ExxonMobil", and Antero Resources Piceance Corporation, 1625 Seventeenth Street, Suite 300, Denver, Colorado 80202, hereinafter called "Operator." Owner and Operator may be referred to individually as a "Party" and collectively as the "Parties."

WHEREAS, the Owner owns portions of the surface of a tract of land described in the attached Exhibit A located in Garfield County, Colorado, identified as a part of Battlement Mesa PUD, hereinafter referred to as the "Property" and currently is in the process of developing the same for residential and commercial uses;

WHEREAS, the Property is subject to a surface use agreement with predecessor of ExxonMobil dated December 12, 1989 ("BMP-ExxonMobil SUA") which agreement reserved to ExxonMobil the right to use portions of the Property to develop its mineral interest underlying the Property;

WHEREAS, Operator holds valid and subsisting oil and gas leasehold rights underlying portions of the Property from both ExxonMobil, Owner and other parties, and, as such has the right to reasonable use of the surface of the Property to explore for, develop, and produce certain of the oil, gas and other hydrocarbons ("Oil and Gas") that underlie the Property; and,

WHEREAS, the Parties desire to enter into this Agreement to supersede in part the BMP-ExxonMobil SUA and to set forth their understanding of the rights and obligations of the Parties concerning operations on and development of the Property and to provide for

the coexistence and joint development of the surface estate and the Oil and Gas estate and to delineate the process through which the two estates will be developed; and

WHEREAS, it is the intent of the Parties that all of the existing owners of the surface of the Property be included in this Agreement, and for that purpose and to the best of the Owners' knowledge, all of the entities related to Battlement Mesa Partners LLC that have an ownership interest in the surface estate in the Property are listed in the first attestation paragraph above. To the extent it is later determined that entities that have an ownership interest in the Property and that are related to Battlement Mesa Partners LLC are not parties to this agreement, Owner shall cause those omitted entities to ratify and endorse this Agreement when they are subsequently identified;

NOW, THEREFORE, in consideration of the mutual promises contained herein, and ten dollars ($10.00) and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

1. Grant of Easement. Owner hereby grants to Operator a right-of-way and easement on, over, through, under and across the Property for the purpose of drilling, completing, operating and producing gas wells, conducting reservoir fracture stimulation operations, re-completing and monitoring wells therefore, together with the right-of-way and easement on, over, through and across the Property necessary to construct operate, maintain and repair (including but not limited to) access roads, fluid retention reservoirs, well sites, tank batteries, compressors, electrical lines, facilities, pipelines for handling both production produced from the Property, as well as that produced from other lands which Owner may not have an interest, which may be necessary for Operator to have a continuous and efficient pipeline system, pigging facilities, tanks, water discharge, and any other actions deemed necessary by Operator for its operations. Operator shall provide, within ninety (90) days of the execution of this Agreement, legal descriptions of the pipeline easements granted herein as well as envelopes for Wellsite Locations and their access roads. These legal descriptions are to be provided by Schmueser, Gordon, Meyer, or an engineering firm selected by the agreement of Owner and Operator.

2. Conformance with Exhibit B. Operator shall locate and stake the proposed placement of all Wellsite Locations, all access roads, and all gas-gathering lines, as depicted on Exhibit B for inspection by Owner at leas[ ]calendar days prior to any construction operations for such proposed surface activity. Owner may inspect the staked locations and their boundaries to determine whether they conform to the locations as depicted on Exhibit B. Within[ ]calendar days of having been notified of such staking, Owner may object to the staked locations and their boundaries on the grounds that they do not conform to the locations as depicted on Exhibit B. If Owner objects, Operator shall either re-stake the locations if it does not actually conform to the survey, or confirm that it does actually conform with to the locations as depicted on Exhibit B. If Owner does not object within[ ]calendar days after having received the initial notice, then it will be deemed to have waived any objection to the staked locations.

3. Wellsite Locations. Exhibit B depicts locations of the planned well sites and central-water handling and treatment facilities ("Wellsite Locations") to be used by the

Operator to develop the Oil and Gas estate. Operator agrees to restrict its Oil and Gas Operations to the easements for the Wellsite Locations shown on Exhibits B. "Oil and Gas Operations" are defined to include, but are not limited to, drilling, completion, and maintenance of wells and equipment, production operations, workovers, well recompletions and deepenings, fracturing, twinning and the drilling of replacement wells and the location of associated Oil and Gas production equipment. Specific operational requirements applying to individual Wellsite Locations are shown in Exhibit C. Any material deviation from the planned location of the Wellsite Locations, as shown in Exhibits B will require Owner's prior written approval, which approval will not be unreasonably withheld. "Material Deviation" is defined as any proposed surface use or occupancy by Operator outside the boundaries of the Wellsite Locations identified on Exhibit B.

a. Operator shall locate, build, repair, and maintain tanks, separators, treaters, dehydrators, and all other associated oil and gas drilling and production equipment and facilities, and wellhead compressors, only within the Wellsite Locations shown on Exhibit B. Operator shall have the right to install, replace, operate and maintain equipment on Wellsite Locations. Operator shall only be permitted to have a repair and maintenance facility at the central water handling and treatment facilities located at Wellsite Location F, with use of such facility limited to operations conducting under this Agreement and conditioned upon the requirements specified on Exhibit C.

b. Without waiving its right to use the full dimensions of the Wellsite Location as described in Exhibit B, Operator shall use good faith efforts to construct the Wellsite Locations to be as small as reasonably feasible for drilling and completion activities and will attempt to reclaim the Wellsite Locations to an area no larger than is necessary to support production equipment and future workover and recompletion or re-drilling activity.

c. Supporting facilities that may be located on Wellsite Locations include but are not limited to, closed mud systems, well head equipment, lines to carry condensate, gas and water, tanks, dehydrators, treaters, and any other facilities related to Oil and Gas Operations and deemed necessary by Operator. It is expressly understood that no centralized compressors will be located on the Property, except that wellhead compression will be permitted subject to the noise abatement requirements provided for hereinafter.

d. Central water handling and treatment facilities are permitted to be located on the Property as identified on Exhibit B. Owner agrees to cooperate with Operator in obtaining necessary approvals for such facilities.

e. Any valve sites, exposed pipeline structures, wellhead compressor housing, permanent tanks intended to contain hydrocarbon substances or produced water installed during Oil and Gas Operations on the Wellsite Location shall all be low profile when technically feasible and painted with color tones, matched to the surrounding landscape as per COGCC Series 804 rule on Visual Impact Mitigation. Owner reserves the right to select the hue and

surface finish at the time of the initial installation of surface facilities. Owner and Operator shall jointly and in good faith cooperate to take mutually acceptable measures to protect the residential character of Property outside of the Wellsite Locations.

f. All wellheads or production facilities shall be located pursuant to COGCC rules applicable at the time they are installed and as shown on Exhibit B. COGCC regulations shall specify the required setbacks from any designated boundary line in the Battlement Mesa PUD or a designated outside activity area.

g. Operator, at its sole cost, risk and expense, will be responsible to obtain any governmental required approvals related to the Wellsite Locations. Owner agrees to cooperate with Operator to obtain any governmental required approvals. If Operator is precluded from obtaining required governmental approvals for any Wellsite Location, Owner agrees to work in good faith with Operator to locate a suitable replacement location.

4. Access Roads. Exhibit B depicts the approximate locations of the planned access roads ("Access Roads") to be used by the Operator to develop the Oil and Gas estate. Operator agrees to restrict its Oil and Gas Operations to the easements for the Access Roads shown on Exhibits B. Any material deviation from the planned location of the Access Roads, as shown in Exhibits B will require Owner's prior written approval, which approval will not be unreasonably withheld. "Material Deviation" is defined as any proposed surface use or occupancy by Operator outside the boundaries of the Access Roads identified on Exhibit B.

a. Access Roads constructed by Operator shall be no greater than 20 feet wide, gated and maintained in a good visual condition and in conformity with applicable state and local standards for oil and gas operations, including grading for proper drainage. Such road construction and maintenance shall be at the sole risk, cost and expense of Operator. Operator shall monitor the condition of the Access Roads and in those situations where warranted, apply dust suppressants such as water, soil tack, and/or magnesium chloride solution. Vehicle speed in excess of 20 miles per hour is prohibited. Operator will at least annually forward a "NOTICE TO ALL CONTRACTORS" regarding driving and traffic law adherence and a policy of discipline up to and including removal of the offending party from activities conducted under this Agreement for violators.

b. If Operator or its vendors cause damage to a road that is jointly used by Operator, its vendors and the persons residing within the Battlement Mesa PUD, Operator, as its sole cost, shall promptly repair any damage which it causes which is a direct result of its use of the road. Operator agrees to bear all expenses to remove mud, gravel and sand in a manner that will cause such roads to be returned to the condition of such roads before being impacted by Operator's Oil and Gas Operations.

c. The Parties agree to conduct their respective operations in a manner which minimizes interference with or delay of the ongoing operations of the other.

d. No employee (acting in an official capacity for Operator and not as a public person), agent, vendor, vendor's employee, consultant or any other person authorized by Operator to be on the Property shall bring alcohol, drugs, firearms, or animals upon the Property at any time. All gates and Access Roads on and at the Wellsite Locations and such other facilities as agreed to by the Parties will be kept closed when not in use in by Operator and Operator shall take all reasonable steps to keep the area served by the roadway as secure as possible.

e. Operator, at its sole cost, risk and expense, will be responsible to obtain any governmental required approvals related to the Access Roads. Owner agrees to cooperate with Operator to obtain any governmental required approvals. Owner agrees to cooperate with Owner in securing any and all such required approvals.

f. Authorized agents of Owner may utilize Access Roads, provided that such use does not interfere with Operator's ongoing activities on the Wellsite Locations.

5. Pipelines. Exhibit B depicts the locations of the planned gas gathering line ("Pipeline Easements") to be used only by the Operator to develop the Oil and Gas estate. Operator agrees to restrict its Oil and Gas Operations to the areas shown on Exhibits B. Any material deviation from the planned location of the Pipeline Easements, as shown in Exhibits B will require Owner's prior written approval, which approval will not be unreasonably withheld. "Material Deviation" is defined as any proposed surface use or occupancy by Operator outside the boundaries of the Pipeline Easements identified on Exhibit B.

a. Pipeline Easements shall consist of a 25-foot permanent easement and a temporary 50-foot construction easement and be for the use of Operator for the installation, operation, maintenance and repair of wells, utility lines, flowlines, pipelines, and appurtenant equipment that will be used to produce, gather, measure, treat, transport or distribute oil, gas, liquid hydrocarbons, and water, whether treated or untreated. Operator, its successors, assigns, affiliated companies, parent companies, and subsidiaries, may use any of the flowlines and pipelines located in the easements to produce, gather, transport or distribute oil, gas, liquid hydrocarbons and water.

b. Operator has the right to construct, use, repair, maintain and replace flowlines, pipelines and utility lines providing service to wells and facilities as shown on Exhibit B.

c. Gas gathering lines shall be installed at depths not less than approximately 48 inches below the surface of the ground, except in those areas shown on Exhibit B where Owner and Operator agree to install them at a greater or lesser depth to accommodate storm sewer lines, sewer lines, water lines or other similar gravity-dependent facilities ("Gravity Dependent Facilities"). Additionally, Operator shall bury its gas gathering lines at a greater or lesser depth at such points indicated on Exhibit B as necessary to provide Owner

with access roads to its development property and avoid existing structures. Operator will consult with Owner prior to installing the gas gathering lines to agree upon a burial depth necessary to avoid Owner's existing and anticipated utilities, access to its property and structures. Owner and Operator shall each consult in good faith to reasonably and mutually accommodate each other's economic interests in the Property and the underlying oil and gas leases.

d. In the event Owner desires to have existing gas gathering lines (or such other lines or utilities as Operator may have installed) redesigned or relocated due to Owner's development plans, Operator shall review Owner's detailed drawings and attempt to accommodate redesign or relocation of the gas gathering lines at Owner's expense. Locations of gas gathering line easements and depth of pipeline installation may be changed by mutual agreement of the Parties; provided, however, all costs and expenses of such relocations shall be borne by the Party requesting the relocation. In the event that the parties agree to the relocation of a pipeline or gathering line at the Owner's request, the Operator shall provide Owner with a written estimate of the relocation costs. Owner shall remit fifty percent (50%) of the amount of the estimate to the Operator 30 days prior to commencement of the relocation operations and the remaining 50% upon completion of the work and the submission of an itemized invoice as provided hereinafter. The final amount due shall be adjusted up or down upon completion of the work and after an itemized statement is provided to Owner.

e. Operator shall compact all trenches related to any phase of drilling and/or pipeline construction to no less than 95% SPD; provided that compaction shall be 100% SPD for all trenches which are in areas designated for public or private roads or paved trails.

f. Owner may cross gas gathering line easements affirmed or granted herein to install, operate and maintain streets, curbs, gutters, sidewalks, utility service lines, cables or facilities, including those for water, gas, sewer, electricity, telephone, television, and fiber optics, provided that Owner shall use its best efforts to minimize interference with Operator's use of the easements affirmed or granted herein, and provided further that 1) any such crossing shall be at substantially right angles to the easements affirmed or granted herein, if reasonably possible; 2) if any such streets, curbs, gutters, sidewalks lines, cables or facilities are laid substantially parallel to gathering lines or pipelines, they shall be located at a minimum horizontal distance of five feet from any gathering line or pipeline; and, 3) any lines, cables or facilities that cross gathering lines or pipelines shall be separated vertically by a minimum distance of two (2) feet center-to-center.

g. Owner, its agents, representatives, successors and assigns may use easements for other utilities, access and roadways as deemed necessary by the Owner; provided that utilities shall have a horizontal separation of at least five (5) feet (center to center) and a vertical separation of at least two (2) feet (center-to-center).

h. Within ninety (90) days following completion of construction of any working segment of pipeline or ancillary facilities, Operator shall, at its sole cost, provide Owner with as-built drawings of the completed pipeline segment or ancillary facilities.

i. Operator, at its sole cost, risk and expense, will be responsible to obtain any governmental required approvals related to the Pipeline Easements. Owner agrees to cooperate with Operator to obtain any governmental required approvals.

j. Pipelines serving each Wellsite Location shall be completed contemporaneously with the commencement of oil and gas operations at the respective Wellsite Locations A, B, C, D, E, L and M, on a location by location basis.

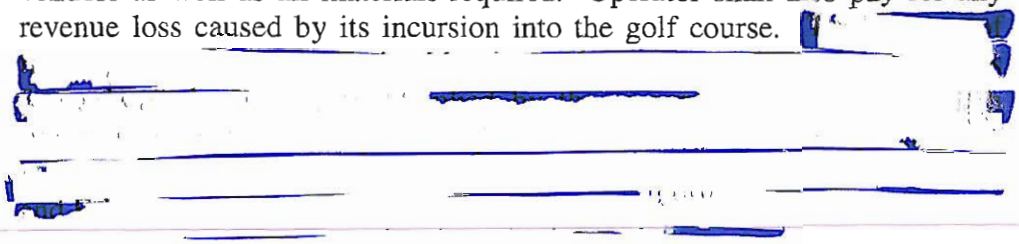
k. In the event Operator desires to permit a third party to utilize Operator's Pipeline Easements, which utilization is not in connection with Operator's Oil and Gas Operations, Operator shall obtain the permission of Owner to such use. Operator acknowledges that Owner may require compensation and other considerations for the grant of this permission.

l. Operator acknowledges this grant of pipeline easements is reflective of its agreement with Owner to greatly reduce or eliminate trucking at Battlement Mesa PUD by the transportation of oil, gas, liquid hydrocarbons and water by pipeline in its Oil and Gas Operations from the Wellsite Locations to the central water handling and treatment facility shown on Exhibit B.

m. If Owner intends to construct any improvements in any of the pipeline or access easements described in this Agreement that would potentially interfere with Operator's access to or use of such easement, Owner shall provide at least 180 days' Notice to Operator (the "Notice Period") of such intended activity. Notice shall be given in writing and shall be specific enough to allow Operator to determine the extent to which such activity would potentially interfere with Operator's use of any easement. Operator may construct pipelines or other facilities as provided in the Agreement, in such easements during the Notice Period without interference from Owner's activities. If Operator has not constructed pipelines or facilities in such easement during the Notice Period, and Owner has subsequently built improvements in such easement after the end of the Notice Period, then Operator may construct pipelines or facilities in such easement, but Operator shall be required to pay for actual damages to the improvements constructed in such easement that are caused by Operator's subsequent construction of pipelines or facilities in such easement. If Owner gives Notice, but has not constructed any improvements in the easements for which it has given Notice under this Paragraph by the end of 365 days from the date of such Notice, then such Notice shall be deemed to have lapsed, and the parties' relative rights in such easements shall return to the status quo that existed prior to the Owners' giving of Notice.

n. In the event Operator's Oil and Gas Operations impact the Battlement Mesa Golf Course, Operator agrees to restore that part of the golf course to its pre-impacted condition as soon as possible. In this restoration, Operator will work with the golf course superintendent to assume that all necessary steps are taken to return it to its pre-impacted condition. Operator agrees to utilize and pay for the golf course maintenance staff and/or its designated vendors as well as all materials required. Operator shall also pay for any revenue loss caused by its incursion into the golf course.

REDACTED



o. At such time as pipe is laid in the pipeline easements, it shall not be removed except for the purpose of repair. Upon the termination of Operator's Oil and Gas Operations, the pipelines shall be left in place and abandoned by Operator.

6. Power/Telephone/Transformers. Only power lines, transformers and data transmission lines necessary for the operation of wells drilled on the Wellsite Location, or production equipment ancillary thereto, may be installed on the Wellsite Location or in the easement of any Access Road or Pipeline Easement. No power line, data transmission line or transformers will be permitted outside of Wellsite Location, Access Road or Pipeline Easement shown Exhibit B.

7. Hours of Operation. There will be no time of day restrictions with regard to drilling, completing, re-completing, workover, reservoir fracture stimulation operations. With respect to other routine ongoing maintenance, development and production operations, Operator agrees to limit such activities (except in the case of emergency) to between the hours of 7:00 AM to 8:00 PM.

8. Noise Abatement. Stationary engines and their exhausts shall be located and oriented to direct noise away from the homes closest to Wellsite Locations as set forth by COGCC Series 802.e rule. Equipment initially installed on Wellsite Locations shall be modern and well maintained. Operator will evaluate noise generation from equipment and require contractors to refit mufflers etc. in situations where the volume of sound produced may exceed applicable standards. Operator shall at all times maintain compliance with applicable Colorado Oil and Gas Conservation Commission ("COGCC") rules and regulations pertaining to noise reduction standards in Residential/ Agricultural/Rural areas and employ best management practices as set out in the COGCC Series 802 Noise Abatement Rule. Neither Operator nor its vendors shall be permitted to utilize engine braking on the Property.

9. Lighting Abatement. If a drilling rig is within 1,000 feet of an occupied dwelling, Operator and its subcontractors will align the drilling rig lighting equipment to minimize the proportion of the lights that are directed toward the dwelling and will install lighting shield devices on all of the more conspicuous lights. Lighting shall

be directed inward and downward except as deemed necessary by Operator to illuminate other areas for safety reasons. Operator shall use appropriate technology to minimize light pollution emanating from the Property including, but not limited to, utilization of low density sodium vapor lighting.

10. Air Emissions and Odor Abatement. Operator will utilize mats, soil tack and/or liquid dust suppressants as necessary to mitigate fugitive dust emissions from Wellsite Locations. Completion processes shall be designed to consolidate the number of hydraulic fracture stimulation flow-back events. No flaring of wells shall be permitted within 2,000 feet of an occupied dwelling, except in the event of emergency. Operator may flare a well within 2,000 feet of an occupied dwelling if such flaring is conducted utilizing flare suppression containment. Glycol dehydrators, tanks, treaters, and flares shall comply with applicable CDPHE and COGCC regulations governing VOC emissions.

    Operator's operations shall be in compliance with the applicable Colorado Department of Public Health and Environment Air Quality Control Commission Regulations, including, but not limited to, the Regulation No. 2 requirement that no oil or gas operation may cause or allow the emission of odorous air from any single source that is detectible after the odorous air has been diluted with seven or more volumes of odor-free air. These measurements shall be made outside the property line of the property from which the emission originates.

11. Noxious Weed Management. Operator shall maintain a noxious weed management plan consistent with the requirements of Garfield County, Colorado and the COGCC Series 1003.f. and 1004.e. rules on noxious weed management.

12. Visual Impact Mitigation and Reclamation of Wellsite Locations. Operator agrees to construct each Wellsite Location to mitigate visual impacts, including specific Wellsite Location requirements described in Exhibit C. As soon as reasonably feasible (and consistent with best practices and growing seasons), Operator shall commence interim and final reclamation operations as per COGCC Series 1003 and 1004 rules. The timing to begin such reclamation operations will be determined in good faith negotiations between Operator and Owner, The reclamation standards are set forth in the attached Exhibit D, Reclamation Plan.

13. Environment and Safety. Operator will comply with all applicable COGCC, Colorado Department of Public Health and Environment (CDPHE), Environmental Protection Agency (EPA) spill control, cleanup, and reporting requirements, the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), The Resource Conservation and Recovery Act ("RCRA") the Oil Pollution Act ("OPA") and the Clean Water Act.

    a. Sanitary facilities will be on site at all times during drilling, testing and completion operations. Sewage will be placed in a portable chemical toilet. The toilet will be replaced periodically utilizing a licensed contractor. Toilet contents will be delivered to local wastewater treatment facilities in accordance with state and county regulations. Disposal will be in accordance with the State of Colorado and Garfield County rules and regulations regarding sewage treatment and disposal.

b. All refuse, trash and other solid waste, (including cans, paper, cable, etc.) generated during drilling, testing and completion operations will be contained in enclosed receptacles, removed from the location promptly, and hauled to an authorized disposal site.

c. Immediately after completion of construction, all debris and other waste materials will be cleaned up and removed from the location.

d. All project-related activities involving hazardous materials use will be conducted in a manner that minimizes potential environmental impacts. Operator shall maintain a file of current Material Safety Data Sheets (MSDS) for all chemicals, compounds, and/or substances that are used in the course of site preparation, drilling operations, production operations and reclamation. Compliance with the foregoing will be governed by the rules and regulations of the Colorado Oil and Gas Conservation Commission.

e. Any spills of oil, gas, or any other potentially hazardous substance shall be reported to (and within the timeframes specified by) local authorities, state authorities, federal authorities, and other responsible parties as required under EPA regulations – 40 CFR part 110, Discharge of Oil regulation, and 40 CFR part 112, Oil Pollution Prevention regulation, and COGCC and CDPHE spill reporting requirements. Such event shall be mitigated immediately, as appropriate, through cleanup or removal to an approved disposal site.

f. Operator will implement a spill prevention, control and counter measure control plan (SPCC). No hazardous materials in toxic concentrations will be permanently stored on any Wellsite Location. Hazardous materials for use in the production of oil, gas or water will be allowed but will be stored and in use in reasonable quantities necessary for Operator's activities on such Wellsite Location. No bulk storage of hazardous materials is allowed.

g. Operator shall ensure that all personnel and contractors employed in operations shall receive appropriate training in safety and environmental protection practices as required by state and federal laws and regulations.

h. Operator shall not house employees on the Property on a temporary or permanent basis without the express written consent of Owner. Notwithstanding the foregoing, Operator is permitted to allow key personnel to reside temporarily on Wellsite Locations provided such personnel are, in Operator's and Owner's jointly held opinion, necessary to maintain a safe operation.

i. The Operator will conduct and maintain its operations in a safe manner and protect the public from any hazardous conditions. In the event of an emergency, Operator will take immediate appropriate action to safeguard life and prevent significant environmental degradation.

14. Emergency Communications. Operator will comply with all local, state and federal reporting requirements in all emergency situations. Emergency contact information

shall be posted in a conspicuous location on the Property. In the event of an emergency requiring communication with the community, Operator will coordinate with the Garfield County Emergency Communications Authority to immediately contact surface owners living within 1,000 feet of such emergency. Further, Operator shall immediately contact Owner's representative advising of that emergency situation

15. Operator's Sole Risk; Insurance.

a. Operator shall conduct all operations on the Property at its sole risk, cost and expense. Operator assumes all risk and liability of any nature incident to, occasioned by or resulting in any manner, directly or indirectly, from Operator's operations hereunder.

b. Operator shall carry no less than [redacted] in general liability limits for any one occurrence and [redacted] in the aggregate, and shall name the Owner as an additional insured with respect to the liabilities assumed hereunder.

16. Surface Damage Payments. Operator shall conduct berming and landscaping at the Wellsite Locations as described in Exhibit C. The referenced berming and landscaping is not intended to waive any right or remedies the Owner may have, including the right to damages, if it is determined that the conduct of Operator, or its agents, employees, successors or assigns exceeds the scope of the those rights granted herein or Operator is in breach of its duties under this Agreement.

17. Owners' Utilities. To the degree that Operator requires any utility lines (i.e. communication, electric, etc) to service any of the facilities depicted on Exhibit B, Operator agrees to locate such utility lines underground at Operator's cost.

18. Compliance with Colorado Oil and Gas Conservation Rules and Regulations. Operator agrees to comply with all of the applicable rules and regulations of the COGCC concerning the development of the Property for oil and gas exploration, drilling, production and the Property's reclamation. Provided, however, that Operator has complied with applicable requirements of the COGCC Regulations for well permitting, Owner agrees, for itself, its successors and assigns, that it shall execute written waivers to allow the COGCC to issue permits to drill wells in the Wellsite Locations shown on Exhibit B, including without limitation, waivers of any setback requirements imposed by the COGCC's High Density Development Area regulations.

19. Indemnification. All use and occupancy of the surface of the Property of Owner, its successors and assigns, by Operator, its agents, employees, contractors, subcontractors, representatives, agents or assigns, shall be at the sole risk of Operator. Operator hereby agrees to indemnify, defend and hold harmless Owner, its employees, customers, golfers, agents, guests, successors and assigns from and against any and all losses, costs, damages, claims awards, attorneys fees (including Owner's attorneys fees and litigation expense, provided such fees and expenses are reasonable), expenses, demands, judgments or liabilities resulting from injuries or death of any person whomsoever, or losses, damages, destruction, pollution, hazardous material spills, discharges to any of Owner's or any third parties'

property whatsoever caused by Operator's oil and gas activities and operations at and below the surface of Battlement Mesa PUD, or by Operator's agents, representatives, contractors, and employees. Specifically excepted from Operator's foregoing indemnity in favor of the Owner shall be those losses suffered by Owner (or other third parties) that are caused by the negligence or fault of the Owner, or Owner's agents, contractors, subcontractors, representatives, or assigns. Operator further agrees to indemnify, hold harmless and defend Owner, its employees, agents, subcontractors, representatives, successors and assigns from any liability which may be asserted or determined by any individual, legal entity, county, state or federal agency based upon a violation of any of the provisions of CERCLA, RCRA, OPA, the Clean Water Act or common law resulting from the actions or inactions of the Operator on the Property.

20. No liens. Operator shall keep the Property free and clear of any and all liens for labor or work performed by it or its contractors and subcontractors upon the Property relating to its oil and gas exploration, development or production operations or for materials furnished thereto. Notwithstanding the above, Operator may contest the validity of any alleged lien, including the enforcement thereof. Operator agrees to pay any and all property taxes, assessments, governmental charges imposed upon its interest in the Property and upon any building, structure or other improvements, equipment or personal property placed or erected upon the Property.

21. Term. This Agreement will remain in effect for as long as Operator, its successors, or assigns is utilizing the easements granted under this Agreement, with no inactivity of greater than 24 continuous months (excluding event of force majeure).

22. BMP-ExxonMobil SUA Superseded in Part. Operator and ExxonMobil acknowledge that Owner is in the process of developing the Battlement Mesa PUD. ExxonMobil, Operator and Owner agree: (i) that future Wellsite Locations, wells and/or production facilities shall be placed; and (ii) that the real estate situated in Battlement Mesa PUD shall be developed, in a manner consistent with this Agreement. To the extent this Agreement is in conflict with the BMP-ExxonMobil SUA, this Agreement will prevail as among the parties. It is expressly understood and agreed that ExxonMobil is joining in this agreement solely for the purpose of being bound by this paragraph, and, paragraphs 23 to 24 and paragraph 26 below, and that the other terms and conditions of this agreement shall be between Owner and Operator, and shall not be applicable to ExxonMobil.

23. Successors and Assigns. This Agreement is binding upon the successors, heirs and assigns of Owner, Operator and ExxonMobil.

24. Counterparts/Facsimile Signatures. The Parties may execute this Agreement in any number of counterparts, each of which shall be deemed an original instrument, but all of which together shall constitute but one and the same instrument. The Parties agree that facsimile signatures are binding.

25. Breach. The Parties acknowledge that, in the event of a violation of this Agreement by either party, the breaching Party shall pay any actual damages found by the trier of fact to have been caused by such breach. In any litigation related to this

Agreement, the prevailing party shall be awarded its costs and fees, including without limitation, reasonable expert fees and reasonable attorney fees.

26. Notices. Any notice or other communication required or permitted under this Agreement shall be sufficient if deposited in the U. S. Mail, postage prepaid, or sent via expedited delivery service, with proof of delivery, or by facsimile transmission with proof of receipt by the notified party, addressed as follows:

If to Operator:

Antero Resources Piceance Corporation

[redacted]

If to Owner:

Battlement Mesa Partners, LLC

[redacted]

If to ExxonMobil:

Exxon Mobil Corporation

[redacted]

27. Annual Consultation with Owner. Operator agrees to meet annually with Owner at a mutually agreeable time and place to discuss Operator's planned upcoming year's Oil and Gas Operations including, but not limited to, drilling activity. Ten days prior to this meeting, Operator shall provide to Owner in writing its planned scheduled activities. Operator agrees to provide Owner written notice, immediately, of any change to Operator's stated schedule at any time such change is made. Further, at this meeting, Operator and Owner shall address Owner's concerns about past, present and the proposed future Oil and Gas Operations at Battlement Mesa PUD.

This Agreement may be amended only by means of a mutually executed written letter agreement.

IN WITNESS WHEREOF, this instrument is executed as of the date first above written.

OWNER: Battlement Mesa Partners, LLC

OWNERS:
Battlement Mesa Land Investments, LLC
Battlement Mesa Land Investments Parcel 1 LLC
Battlement Mesa Land Investments Parcel 2 LLC
Battlement Mesa Land Investments Parcel 3 LLC
Battlement Mesa Land Investments Parcel 6 LLC
Battlement Mesa Land Investments Parcel 7 LLC
Battlement Mesa Land Investments Parcel OHS LLC
Battlement Mesa Land Investments Parcel 5-1, TRK3 and 4 LLC
Battlement Mesa Land Investments Parcel 5-2, TRK 5 LLC
Battlement Mesa Land Investments Parcel 5-2, TRK 6 LLC
Battlement Mesa Land Investments Parcel Fairways LLC
Green Head Investments 1 LLC
Burning Rock B2L2 LLC
MCV2 Church Site LLC
Battlement Mesa Golf Course, LLC
Saddleback Village Convenience Center, LLC
Willow Park Apartments LLC
Battlement Mesa Land Investments Parcel 1-A, LLC
Paradise Valley Minerals LLC
Battlement Mesa Land Investments Town Center 1 LLC
Battlement Mesa Land Investments Town Center 2 LLC
Battlement Mesa Land Investments Town Center 3 LLC
Battlement Mesa Plaza Town Center, LLC
Battlement Mesa Land Investments Parcel 5-1, TRK 2 LLC
Battlement Mesa Land Investments OES LLC
Battlement Mesa RV Park LLC
Battlement Mesa RV Storage LLC
Battlement Mesa Office I LLC
Modular Homes LLC
Tamarisk Village Pads, LLC
Willow Ridge at Battlement Mesa LLC

Battlement Mesa Parcel 5 LLC
Battlement Mesa Lot Holdings LLC

Battlement Mesa Partners LLC

3-2-09

Name: Eric Schmela
Title: Authorized Agent

OPERATOR: Antero Resources Piceance Corporation

Name: Brian A. Kuhn
Title: Vice President

EXXON MOBIL CORPORATION:

Name: John C. Rothwell
Title: Agent and Attorney-in-Fact

ACKNOWLEDGMENTS

STATE OF COLORADO §
§
COUNTY OF DENVER §

The foregoing instrument was acknowledged before me on this 2nd day of March, 2009, by Eric Schmela, Authorized Agent for Battlement Mesa Partners, LLC a Colorado limited liability company d/b/a Battlement Mesa Company, and Battlement Mesa Land Investments, LLC, Battlement Mesa Land Investments Parcel 1 LLC, Battlement Mesa Land Investments Parcel 2 LLC, Battlement Mesa Land Investments Parcel 3 LLC, Battlement Mesa Land Investments Parcel 6 LLC, Battlement Mesa Land Investments Parcel 7 LLC, Battlement Mesa Land Investments Parcel OHS LLC, Battlement Mesa Land Investments Parcel 5-1, TRK3 and 4 LLC, Battlement Mesa Land Investments Parcel 5-2, TRK 5 LLC, Battlement Mesa Land Investments Parcel 5-2, TRK 6 LLC, Battlement Mesa Land Investments Parcel Fairways LLC, Green Head Investments 1 LLC, Burning Rock B2L2 LLC, MCV2 Church Site LLC, Battlement Mesa Golf Course, LLC, Saddleback Village Convenience Center, LLC, Willow Park Apartments LLC, Battlement Mesa Land Investments Parcel 1-A, LLC, Paradise Valley Minerals LLC, Battlement Mesa Land Investments Town Center 1 LLC, Battlement Mesa Land Investments Town Center 2 LLC, Battlement Mesa Land Investments Town Center 3 LLC, Battlement Mesa Plaza Town Center, LLC, Battlement Mesa Land Investments Parcel 5-1, TRK 2 LLC, Battlement Mesa Land Investments OES LLC, Battlement Mesa RV Park LLC, Battlement Mesa RV Storage LLC, Battlement Mesa Office I LLC, Modular Homes LLC, Tamarisk Village Pads, LLC, Willow Ridge at Battlement Mesa LLC, , Battlement Mesa Parcel 5 LLC, Battlement Mesa Lot Holdings LLC, on behalf of said entities.

My Commission Expires:

_____

Shelley K. Leo
Notary Public, State of Colorado

NOTARY PUBLIC
SHELLEY K.
LEO
STATE OF COLORADO

My Commission Expires 09/21/2012

STATE OF TEXAS §
§
COUNTY OF HARRIS §

The foregoing instrument was acknowledged before me on this 17 day of March, 2009, by John C. Rothwell, Agent and Attorney-in-fact for EXXON MOBIL CORPORATION, a New Jersey corporation, on behalf of said corporation.

My Commission Expires:

LAVERA JOHNSON
Notary Public
State of Texas
Comm. Exp. 10-06-2010

Notary Public, State of Texas

STATE OF COLORADO §
§
COUNTY OF DENVER §

The foregoing instrument was acknowledged before me on this 14th day of April, 2009, by Brian A. Kuhn, Vice President, for ANTERO RESOURCES PICEANCE CORPORATION, on behalf of said corporation.

My Commission Expires:
8/3/11

Notary Public, State of Colorado

KELLY HUFFMAN
NOTARY PUBLIC
STATE OF COLORADO
MY COMMISSION EXPIRES 08/03/2011

Wellsite Location A

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Exhibit A

Description of Battlement Mesa PUD

EXHIBIT A

LEGAL DESCRIPTION

A parcel of land lying in Sections 5, 6, 7, 8, 9, 10, 16, 17, 18, and 19, Township 7 South, Range 95 West and Sections 13 and 24, Township 7 South, Range 96 West, of the Sixth Principal Meridian, County of Garfield, State of Colorado, more particularly described as follows:

Beginning at the East 1/4 Corner of Section 5, Township 7 South, Range 95 West;
Thence along the East line of Section 5 South 00°15'43" West a distance of 1628.34 feet, to the Southeast Corner of the N1/2 NE1/4 SE1/4 SE1/4 of said Section 5;
Thence along the South line of the N1/2 NE1/4 SE1/4 SE1/4 North 87°19'30" West a distance of 664.56 feet, to the Southwest Corner of said N1/2 NE1/4 SE1/4 SE1/4;
Thence along the West line of the N1/2 NE1/4 SE1/4 SE1/4 of Section 5, North 00°23'16" East a distance of 324.34 feet to the Northwest Corner of said NE1/4 SE1/4 SE1/4;
Thence along the North line of the SE1/4 SE1/4 of said Section 5, North 87°26'14" West a distance of 863.79 feet, to the Northwest Corner of said SE1/4 SE1/4;
Thence along the West line of SE1/4 SE1/4 of said Section 5, South 00°30'52" West a distance of 1292.05 feet to the Southwest Corner of said SE1/4 SE1/4;
Thence along the South line of said Section 5, South 86°59'25" East a distance of 1333.74 feet to the Southeast Corner of said Section 5;
Thence along the North line of Section 9, Township 7 South, Range 95 West, South 87°59'43" East a distance of 1326.37 feet, to the Northeast Corner of the NW1/4 NW1/4 of said Section 9;
Thence along the East line of the NW1/4 NW1/4 of said Section 9, South 01°02'26" West a distance of 1301.45 feet to the Southeast Corner of said NW1/4 NW1/4;
Thence along the North line of the SE1/4 NW1/4 of said Section 9, South 88°02'23" East a distance of 1324.35 feet to the Northeast Corner of said SE1/4 NW1/4;
Thence along the North line of the SW1/4 NE1/4 of said Section 9, South 88°35'51" East a distance of 1275.60 feet, to the Northeast Corner of said SW1/4 NE1/4;
Thence along the West line of the NE1/4 NE1/4 of said Section 9, North 01°04'15" East a distance of 1311.84 feet to the Northwest Corner of said NE1/4 NE1/4;
Thence along the North line of said Section 9, South

89°06'43" East a distance of 1274.26 feet to the Northeast Corner of said Section 9;
Thence along the East line of said Section 9, South 01°00'49" West a distance of 1323.29 feet, to the Southeast Corner of the NE1/4 NE1/4 of said Section 9;
Thence along the North line of the SW1/4 NW1/4 of Section 10, Township 7 South, Range 95 West, South 88°46'55" East a distance of 631.29 feet to a point on the North line of the said SW1/4 NW1/4, 687 feet West of the Northeast Corner of said SW1/4 NW1/4, said point being the Northwest Corner of that parcel of land described in Document Number 198564 as recorded in Book 302 at Page 200 of the records of the Clerk and Recorder of Garfield County;
Thence along the boundary of said parcel the following five (5) courses:

(1) South 00°49'34" West a distance of 221.67 feet;
(2) South 48°09'56" East a distance of 361.92 feet to a point 456.00 feet, as measured at right angles, southerly from the North line of the SW1/4 NW1/4 of said Section 10;
(3) South 89°17'47" East a distance of 166.55 feet;
(4) South 00°49'34" West a distance of 201.43 feet;
(5) South 89°17'47" East a distance of 246.37 feet;

to a point on the East line of said SW1/4 NW1/4 655 feet South of the Northeast Corner of said SW1/4 NW1/4;
Thence departing said parcel boundary along the East line of the SW1/4 NW1/4 of said Section 10, South 00°54'36" West a distance of 667.20 feet to the Southeast Corner of said SW1/4 NW1/4;
Thence along the East line of the NW1/4 SW1/4 of said Section 10, South 00°54'36" West a distance of 1315.11 feet to the Southeast Corner of said NW1/4 SW1/4;
Thence along the South line of the NW1/4 SW1/4 of said Section 10, North 89°11'04" West a distance of 1323.06 feet to the Southwest Corner of said NW1/4 SW1/4;
Thence along the South line of the N1/2 SE1/4 of Section 9, Township 7 South, Range 95 West, North 87°19'11" West a distance of 2557.45 feet to the Southwest Corner of said N1/2 SE1/4;
Thence along the South line of the N1/2 SW1/4 of Section 9, North 88°38'08" West a distance of 2654.44 feet to the Southwest Corner of said N1/2 SW1/4;
Thence along the South line of the NE1/4 SE1/4 of Section 8, Township 7 South, Range 95 West, North 88°43'49" West a distance of 1331.33 feet to the Southwest Corner of said NE1/4 SE1/4 of Section 8;
Thence along the West line of the SE1/4 SE1/4 of Section 8, South 01°20'14" West a distance of 1316.23 feet to the

Southwest Corner of said SE1/4 SE1/4 of Section 8;
Thence along the East line of the W1/2 NE1/4 of Section 17, South 01°00'57" West a distance of 2639.16 feet to the Southeast Corner of said W1/2 NE1/4 of Section 17;
Thence along the North line of the NE1/4 SE1/4 of Section 17, South 88°46'04" East a distance of 1324.13 feet to the E1/4 Corner of Section 17;
Thence along the Easterly line of the NE1/4 SE1/4 of Section 17, South 01°01'24" West a distance of 1320.50 feet to the Southeast Corner of the NE1/4 SE1/4 of Section 17;
Thence along the North line of the SW1/4 SW1/4 of Section 16, Township 7 South, Range 95 West, South 87°41'13" East a distance of 1330.94 feet to the Northeast Corner of said SW1/4 SW1/4;
Thence along the East line of the SW1/4 SW1/4 of Section 16, South 01°03'30" West a distance of 1322.00 feet to the Southeast Corner of said SW1/4 SW1/4;
Thence along the South line of said Section 16 North 87°37'18" West a distance of 1330.20 feet to the Southwest Corner of said Section 16;
Thence along the South line of Section 17, Township 7 South, Range 95 West, North 88°44'01" West a distance of 1984.49 feet to the Southwest Corner of the E1/2 SW1/4 SE1/4;
Thence along the West line of the E1/2 SW1/4 SE1/4, North 00°59'11" East, a distance of 1319.91 feet to the Northwest Corner of said E1/2 SW1/4 SE1/4;
Thence along the South line of the NW1/4 SE1/4 of said Section 17, North 88°45'02" West a distance of 661.78 feet to the Southwest Corner of said NW1/4 SE1/4;
Thence along the South line of the NE1/4 SW1/4, North 88°45'02" West a distance of 1158.58 feet to a point 10 rods East of the Southwest Corner of said NE1/4 SW1/4;
Thence North 01°03'04" East a distance of 131.93 feet;
Thence North 88°43'44" West a distance of 165.63 feet;
Thence North 00°55'58" East a distance of 527.66 feet, along the West line of the NE1/4 SW1/4 to the Northeast Corner of the S1/2 NW1/4 SW1/4;
Thence North 88°45'33" West 1324.42 feet to the Northeast Corner of the E1/2 SE1/4, NE1/4 SE1/4 of Section 18, Township 7 South, Range 95 West;
Thence along the North line of the E1/2 SE1/4 NE1/4 SE1/4 of said Section 18, North 88°24'33" West a distance of 329.86 feet to the Northwest Corner of said E1/2 SE1/4 NE1/4 SE1/4;
Thence along the West line of the E1/2 SE1/4 NE1/4 SE1/4 of said Section 18, South 00°53'57" West a distance of 659.61 feet to the Southwest Corner of said E1/2 SE1/4 NE1/4 SE1/4;

Thence along the South line of the NE1/4 SE1/4 of said Section 16, North 88°26'07" West a distance of 989.54 feet to the Southwest Corner of said NE1/4 SE1/4;
Thence along the East line of the SW1/4 SE1/4 of said Section 18, South 00°55'21" West a distance of 1320.46 feet to the Southeast Corner of said SW1/4 SE1/4;
Thence along the East line of the W1/2 NE1/4 of Section 19, Township 7 South, Range 95 West, South 01°06'34" West a distance of 2642.08 feet to the Southeast Corner of said W1/2 NE1/4;
Thence along the South line of the NE1/4 of Section 19, North 88°41'12" West a distance of 1329.89 feet to the Southwest Corner of said NE1/4;
Thence continuing Westerly along the South line of the NW1/4 of said Section 19, North 88°41'12" West 2570.38 feet to the Southwest Corner of said NW1/4 of Section 19;
Thence continuing Westerly along the South line of the NE1/4 of Section 24, Township 7 South, Range 96 West, North 89°32'43" West a distance of 2673.12 feet to the Southwest Corner of said NE1/4;
Thence along the West line of said NE1/4, North 00°23'55" West 1023.06 feet;
Thence North 01°25'42" East 229.68 feet;
Thence North 66°11'04" West 236.83 feet;
Thence North 34°29'42" East 1613.03 feet;
Thence North 88°52'30" West 202.82 feet;
Thence North 00°00'00" East 461.13 feet;
Thence North 81°10'00" West 555.94 feet to the centerline of the Colorado River;
Thence along said center the following courses and distances;

North 26°28'25" East 232.98 feet;
North 30°21'25" East 206.15 feet;
North 35°25'25" East 644.58 feet;
North 29°37'25" East 829.36 feet;
North 40°24'25" East 99.86 feet;
North 36°27'25" East 350.05 feet;
North 34°54'25" East 163.27 feet;
North 31°12'21" East 266.75 feet;
North 50°36'25" East 886.79 feet;
North 72°23'50" East 390.96 feet;
North 76°17'12" East 152.22 feet;
North 77°42'27" East 463.54 feet;
North 79°53'07" East 281.99 feet;
North 79°03'50" East 87.91 feet;
North 62°52'39" East 257.89 feet;
North 27°17'27" East 312.44 feet;
North 40°46'59" East 126.43 feet;
North 24°17'40" East 197.27 feet;

North 32°26'39" East 124.13 feet;
North 69°01'18" East 109.42 feet;
North 74°02'49" East 226.07 feet;
North 78°19'08" East 154.27 feet;
North 59°40'20" East 444.46 feet;
North 35°52'21" East 149.32 feet;
North 26°41'02" East 150.34 feet;
North 14°13'25" East 511.69 feet;
North 24°54'46" East 241.07 feet;
North 14°40'02" East 996.76 feet;
North 04°23'25" West 274.60 feet;
North 08°35'04" East 215.19 feet;
North 20°08'11" East 79.88 feet;
North 32°27'48" East 71.69 feet;

Thence leaving said Colorado River centerline South 81°08'11" East 526.15 feet;
Thence North 01°04'10" East a distance of 485.22 feet;
Thence South 88°24'36" East a distance of 83.00 feet;
Thence North 53°18'25" East a distance of 635.50 feet to the southerly Right-Of-Way of the existing County Road;
Thence along said Right-Of-Way South 43°14'11" East a distance of 55.74 feet;
Thence continuing along said Right-Of-Way South 34°04'07" East 107.02 feet;
Thence continuing along said Right-Of-Way South 15°35'44" East 66.56 feet;
Thence North 72°19'16" West a distance of 13.56 feet;
Thence South 79°47'18" West a distance of 24.89 feet;
Thence South 37°23'26" West a distance of 100.52 feet;
Thence South 06°07'27" West a distance of 83.52 feet;
Thence North 88°48'43" East a distance of 85.28 feet to the westerly Right-Of-Way of the existing County Road;
Thence along said Right-Of-Way the following courses and distances: South 10°31'10" East a distance of 50.84 feet;
Thence 244.26 feet along the arc of a curve to the left having a radius of 1611.94 feet, the chord of said curve bears South 02°59'01" East a distance of 244.03 feet;
Thence 331.22 feet along the arc of a curve to the left having a radius of 270.10 feet the chord of said curve bears South 42°18'20" East 310.85 feet;
Thence South 77°25'36" East a distance of 249.91 feet;
Thence South 82°00'16" East 142.25 feet;
Thence leaving said County Road Right-Of-Way North 13°52'58" East a distance of 60.00 feet;
Thence South 76°07'01" East a distance of 196.00 feet;

Thence South 66°03'01" East a distance of 92.80 feet;
Thence North 64°50'00" East a distance of 12.20 feet;
Thence South 86°44'06" East a distance of 201.00 feet;
Thence North 01°36'29" East a distance of 650.00 feet;
Thence North 86°44'01" West a distance of 359.65 feet;
Thence North 01°36'06" East a distance of 469.21 feet;
Thence North 01°32'15" East a distance of 568.40 feet;
Thence North 01°39'14" East a distance of 355.62 feet;
Thence North 85°59'03" West a distance of 597.54 feet to the centerline of the Colorado River;
Thence along said centerline the following courses and distances:

North 30°34'03" East 126.48 feet;
North 11°14'23" East 262.86 feet;
North 03°21'52" East 244.98 feet;
North 06°43'43" East 149.36 feet;
North 09°50'22" West 130.18 feet;
North 15°44'44" West 249.17 feet;
North 23°23'56" East 595.97 feet;
North 29°30'40" East 146.50 feet;
North 43°21'22" East 437.13 feet;
North 53°22'38" East 517.59 feet;
North 60°37'24" East 639.69 feet;
North 58°44'59" East 242.35 feet;
North 68°18'39" East 236.76 feet;
North 74°06'42" East 340.87 feet;
North 86°52'08" East 446.66 feet;
North 88°43'46" East 270.56 feet;
South 83°05'32" East 198.26 feet;
North 78°27'53" East 618.98 feet;
North 76°29'45" East 483.05 feet;
North 49°07'36" East 593.26 feet;

Thence leaving said Colorado River centerline South 87°53'37" East a distance of 2282.68 feet along the North line of the SE1/4 of said Section 5, Township 7 South, Range 95 West of the Sixth Principal Meridian to the point of beginning.

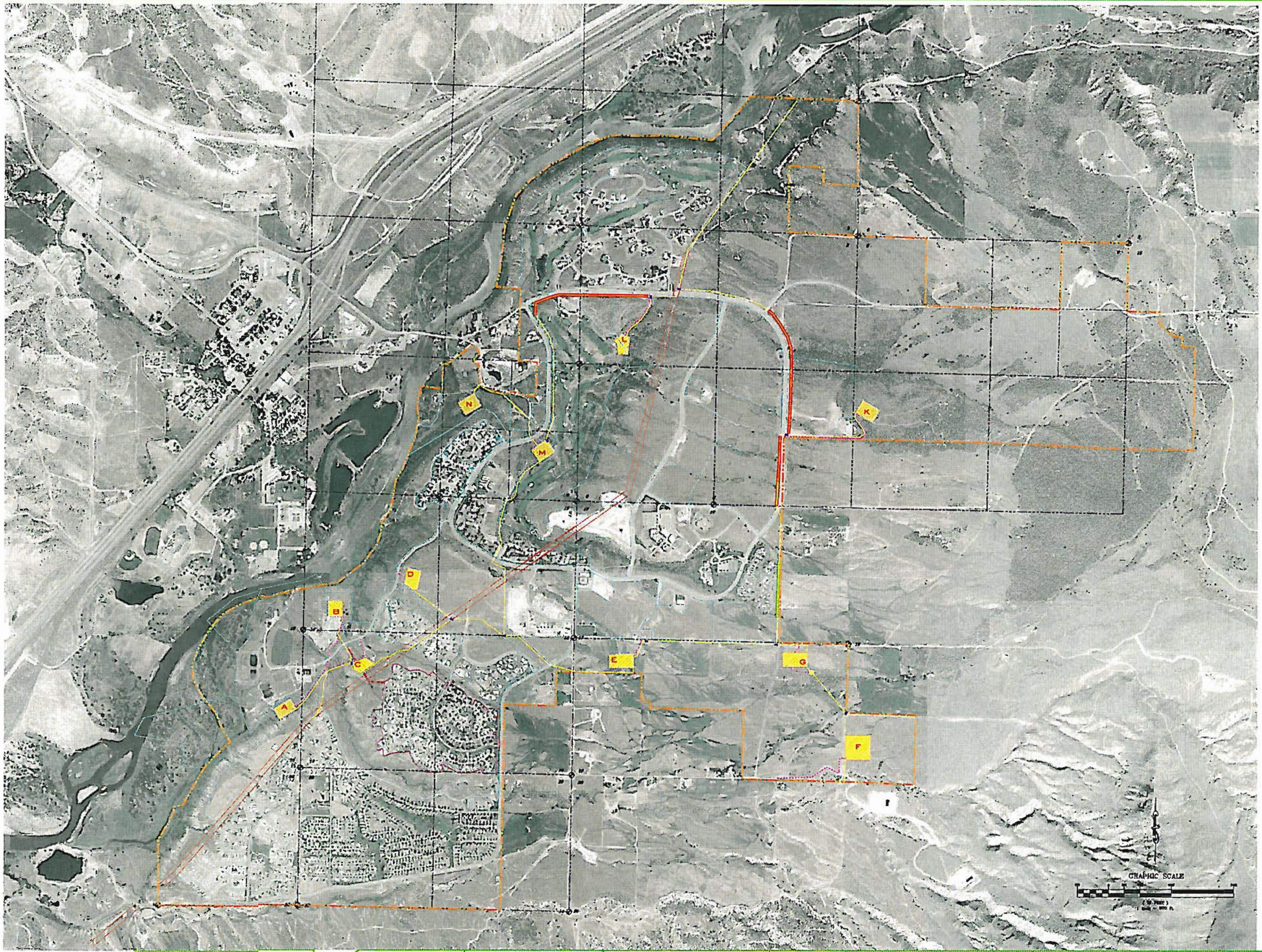
Wellsite Location B

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Exhibit B

Map Depicting General Location of
Wellsite Locations, Access Roads and Pipeline Easements

(Plat follows)



SCHMUESER | GORDON | MEYER
ENGINEERS & SURVEYORS

SCHMUESER GORDON MEYER
118 W. 6TH STREET, SUITE 200
GLENWOOD SPRINGS, COLORADO 81601
(970) 945-1004 FAX (970) 945-5948
ASPEN, COLORADO (970) 925-6727
CRESTED BUTTE, CO (970) 349-5355

Battlement Mesa PUD
Well Pads & Pipelines

Exhibit B to Surface Use Agreement

Job No.	2006-479.020
Drawn by	JK/MM
Date	1/20/09

1 OF 1

Exhibit C

Specific Operational Requirements
For
Wellsite Locations, Access Roads and Pipeline Easements

Wellsite Location A
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated1/20/09, including berming the access road into the Wellsite Location.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in a southwesterly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the southwest, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, Soiltac or its equivalent and/or liquid dust suppressants.

4. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

5. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

6. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location B
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated1/20/09, including berming the access road into the Wellsite Location.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in a northerly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the north, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soiltac and/or liquid dust suppressants.

4. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

5. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

6. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location C

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location C
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09 and the Schematic, Light Exposure and Planting plans dated 1/19/09 prepared by Design Workshop for this pad, including berming the access road into the Wellsite Location. Operator reserves the right to make minor adjustments to number, size and variety of plants, subject to Operator's obtaining Owner's written consent to same, which consent shall not be unreasonably withheld.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in a westerly direction as set forth in the above referenced Light Exposure plan. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the west, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Landscaping Plan. Operator agrees to landscape the Wellsite Location pursuant to the above referenced Planting Plan. Operator agrees to commence with such landscaping work as soon as initial dirt work at the site commences and complete the same prior to commencement of drilling activity at the Wellsite Location, taking into consideration the growing season. Operator will be responsible for maintaining such landscaping, including but not limited to installing irrigation.

4. Power at Site. Provided electrical power can be accessed under commercially reasonable terms from the local power distribution company servicing the area of the Wellsite Location, Operator shall only use electricity to power its drilling rigs at the site. To the extent third-party contractor equipment has the provisions to utilize electrical power, Operator shall require such third-party contractors to only use electricity to power its equipment at the site In emergency situations, Operator shall be permitted to utilize non-electric generators until such time as electrical power can be restored. Provided, however, these emergency generators shall be positioned in such a manner as to minimize noise impacts on the adjacent residences.

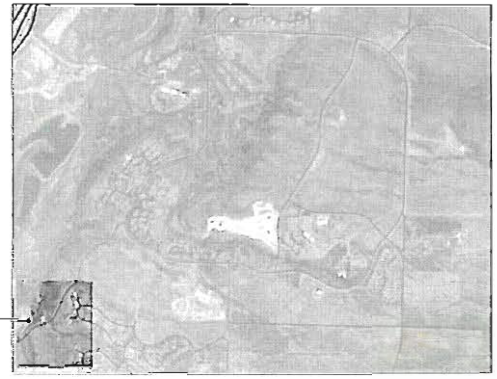
5. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soiltac and/or liquid dust suppressants.

6. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

7. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

8. Irrigation Water. If Operator chooses to purchase water from the Consolidated Metro District to provide its irrigation water, the cost of any tap will be at Operator's sole expense.

9. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.



Area of enlargement

1000 FEET

500 FEET

County Road 307

+/- 20' high berm

Well Pad C*
elevation 5202

+/- 20' high berm

Section A

Section B

24 Slips

325'

Deciduous Trees

Evergreen Trees

Shrub Massings

*Exact organization and layout of pad to be determined
Drawing for illustrative purposes only - subject to change

Not to Scale

NORTH

BATTLEMENT MESA PARACHUTE, COLORADO

01/19/09 SCHEMATIC DESIGN: PAD C

ANTERO RESOURCES

DESIGNWORKSHOP

Not to Scale

BATTLEMENT MESA PARACHUTE, COLORADO

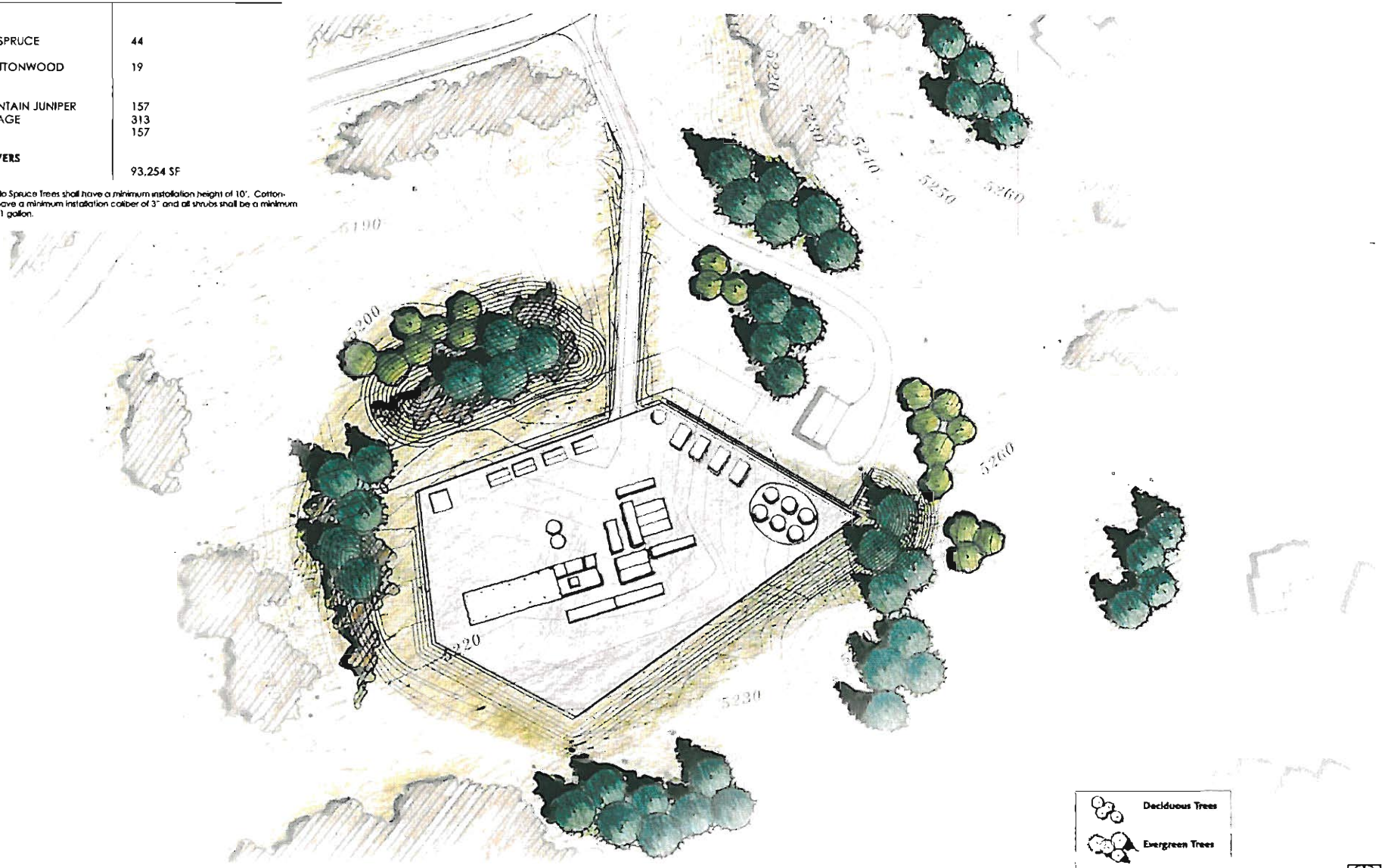
01/19/09 LIGHT EXPOSURE: PAD C

ANTERO RESOURCES

DESIGNWORKSHOP

PLANT TYPE	QUANTITY
TREES	
COLORADO SPRUCE	44
WESTERN COTTONWOOD	19
SHRUBS	
ROCKY MOUNTAIN JUNIPER	157
MOUNTAIN SAGE	313
RABBITBRUSH	157
GROUNDCOVERS	
SEEDMIX	93,254 SF

*Note: All Colorado Spruce Trees shall have a minimum installation height of 10'. Cottonwood trees shall have a minimum installation caliber of 3" and all shrubs shall be a minimum installation size of 1 gallon.



BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 PLANTING PLAN: PAD C

DESIGNWORKSHOP

Wellsite Location D

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location D
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09 and the Schematic, Light Exposure and Planting plans dated 1/19/09 by Design Workshop for this pad, including berming the access road into the Wellsite Location. Operator reserve the right to make minor adjustments to number size and variety of plants, subject to Operator's obtaining Owner's written consent to same, which consent shall not be unreasonably withheld.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in a northwesterly direction as set forth in the above referenced Light Exposure plan. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the northwest, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting, where feasible.

3. Landscaping Plan. Operator agrees to landscape the Wellsite Location pursuant to the above referenced Planting Plan. Operator agrees to commence with such landscaping work as soon as initial dirt work at the site commences and complete the same prior to commencement of drilling activity at the Wellsite Location, taking into consideration the growing season. Operator will be responsible for maintaining such landscaping, including but not limited to installing irrigation.

4. Power at Site. Provided electrical power can be accessed under commercially reasonable terms from the local power distribution company servicing the area of the Wellsite Location, Operator shall only use electricity to power its drilling rigs at the site. To the extent third-party contractor equipment has the provisions to utilize electrical power, Operator shall require such third-party contractors to only use electricity to power its equipment at the site In emergency situations, Operator shall be permitted to utilize non-electric generators until such time as electrical power can be restored. Provided, however, these emergency generators shall be positioned in such a manner as to minimize noise impacts on the adjacent residences.

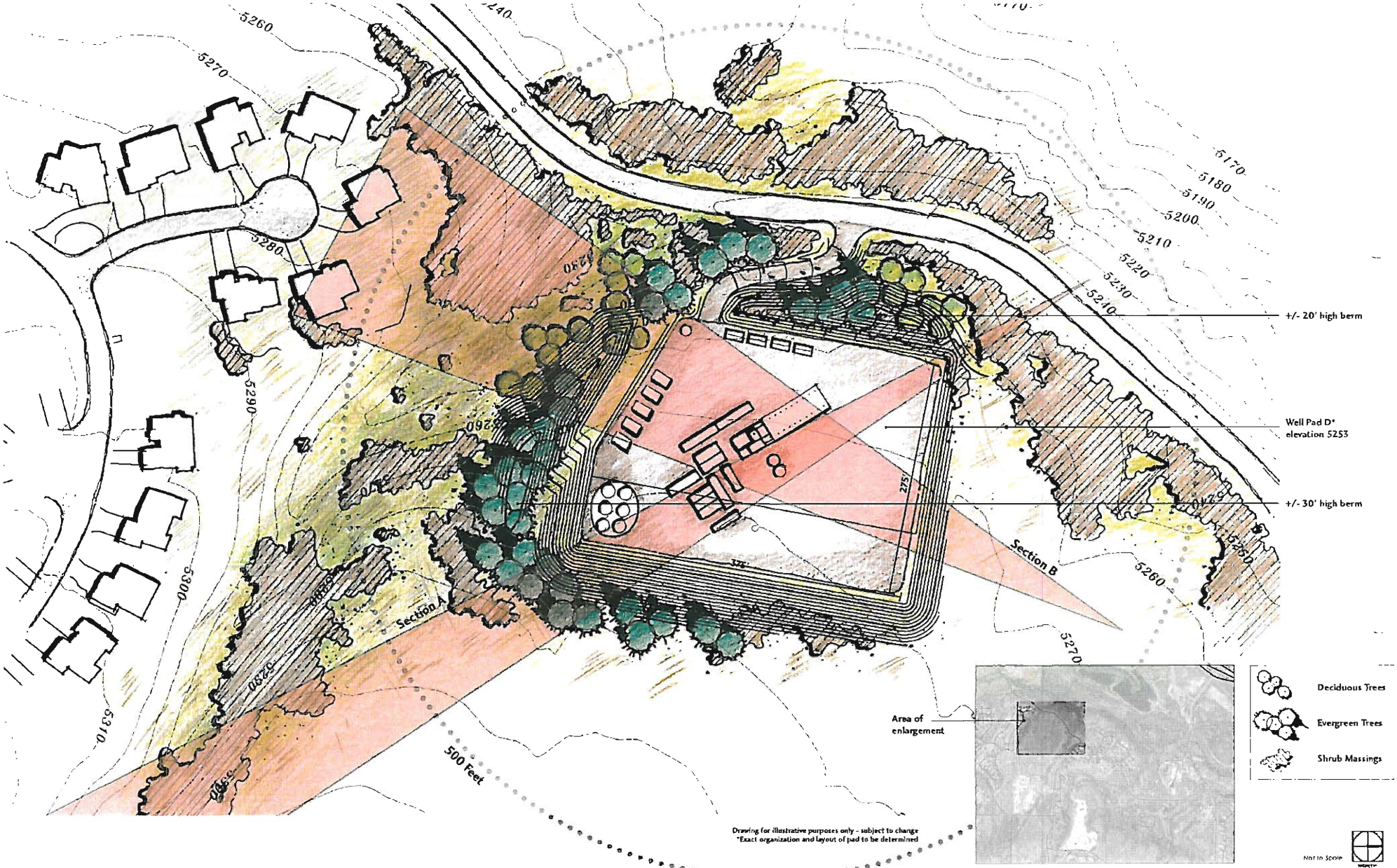
5. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soiltac and/or liquid dust suppressants.

6. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

7. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

8. Irrigation Water. If Operator chooses to purchase water from the Consolidated Metro District to provide its irrigation water, the cost of any tap will be at Operator's expense.

9. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.



BATTLEMENT MESA PARACHUTE, COLORADO

01/19/09 SCHEMATIC DESIGN: PAD D

ANTERO RESOURCES

DESIGNWORKSHOP

Not to Scale

BATTLEMENT MESA PARACHUTE, COLORADO

01/19/09 LIGHT EXPOSURE: PAD D

ANTERO RESOURCES

DESIGNWORKSHOP

PLANT TYPE	QUANTITY
TREES	
COLORADO SPRUCE	35
WESTERN COTTONWOOD	20
SHRUBS	
ROCKY MOUNTAIN JUNIPER	198
MOUNTAIN SAGE	395
RABBITBRUSH	198
GROUNDCOVERS	
SEEDMIX	82,935 SF

*Note: All Colorado Spruce Trees shall have a minimum installation height of 10', Cottonwood trees shall have a minimum installation caliber of 3" and all shrubs shall be a minimum installation size of 1 gallon.

Not to Scale

BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 PLANTING PLAN: PAD D

DESIGNWORKSHOP

Wellsite Location E

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location E
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09, including berming the access road into the Wellsite Location.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will most likely be oriented in a westerly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If this light orientation becomes a nuisance to the residences in the vicinity of Wellsite Location E, Operator and Owner will cooperate to reasonably mitigate the effects related to lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

4. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

5. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

6. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location F

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location F
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09, including berming the access road into the Wellsite Location. Operator agrees to utilize this Wellsite Location as a centralized fluid gathering site, Operator agrees to use all best visual resource management practices when implementing odor control and spill prevention measures and will do so in accordance with all COGCC regulations and/or guidelines.

2. Lighting. If Operator utilizes this Wellsite Location as a drilling location, all lights on the Wellsite Location above the top level of the berm will most likely be oriented in a southerly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the south, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the site, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

4. Storage and Parking. Operator agrees this site may be used for storage or parking of any property required by Operator for its drilling, development and production activities conducted pursuant to this Agreement.

5. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location G

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location G
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09 including berming the access road into the Wellsite Location.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will most likely be oriented in a westerly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If this light orientation becomes a nuisance to the residences in the vicinity of Wellsite Location G, Operator and Owner will cooperate to reasonably mitigate the effects related to lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

4. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

5. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

6. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location K

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location K
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09, including berming the access road into the Wellsite Location. If Operator utilizes this Wellsite Location as a drilling location, Operator agrees to build and maintain the Wellsite Location in accordance to Operator's highest standards during the drilling and completion phase, during the production phase (interim reclamation), and during the final reclamation phase. These standards are to meet or exceed all COGCC well-site regulations and/or guidelines. If Operator utilizes this Wellsite Location as a centralized fluid gathering site, Operator agrees to use all best management practices when implementing odor control and spill prevention measures and will do so in accordance with all COGCC regulations and/or guidelines. If Operator fails to utilize this site within three (3) years from the date of the Effective Date, Operator agrees to release this site from the potential of its development as a Wellsite Location.

2. Lighting. If Operator utilizes this Wellsite Location as a drilling location, all lights on the Wellsite Location above the top level of the berm will most likely be oriented in an easterly direction. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the east, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting.

3. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

4. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

5. Storage and Parking. Operator agrees this site may be used for storage or parking of any property required by Operator for its drilling, development and production activities conducted pursuant to this Agreement.

6. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a

conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

Wellsite Location L

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location L
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09and the Schematic, Light Exposure and Planting plans dated 1/19/09 prepared by Design Workshop, including berming the access road into the Wellsite Location, screening the valve sites and mitigating the impact of the Access Road entry way. Operator reserves the right to make minor adjustments to number, size and variety of plants, subject to Operator's obtaining Owner's written consent to same, which consent shall not be unreasonably withheld.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in a southerly direction as set forth in the above referenced Light Exposure plan. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the south, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding the color of the surrounding landscape on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting, where feasible.

3. Landscaping Plan. Operator agrees to landscape the Wellsite Location pursuant to the above referenced Planting Plan. Operator agrees to commence with such landscaping work as soon as initial dirt work at the site commences and complete the same prior to commencement of drilling activity at the Wellsite Location, taking into consideration the growing season. Operator will be responsible for maintaining such landscaping, including but not limited to installing irrigation.

4. Power at Site. Provided electrical power can be accessed under commercially reasonable terms from the local power distribution company servicing the area of the Wellsite Location, Operator shall only use electricity to power its drilling rigs at the site. To the extent third-party contractor equipment has the provisions to utilize electrical power, Operator shall require such third-party contractors to only use electricity to power its equipment at the site In emergency situations, Operator shall be permitted to utilize non-electric generators until such time as electrical power can be restored. Provided, however, these emergency generators shall be positioned in such a manner as to minimize noise impacts on the adjacent residences.

5. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

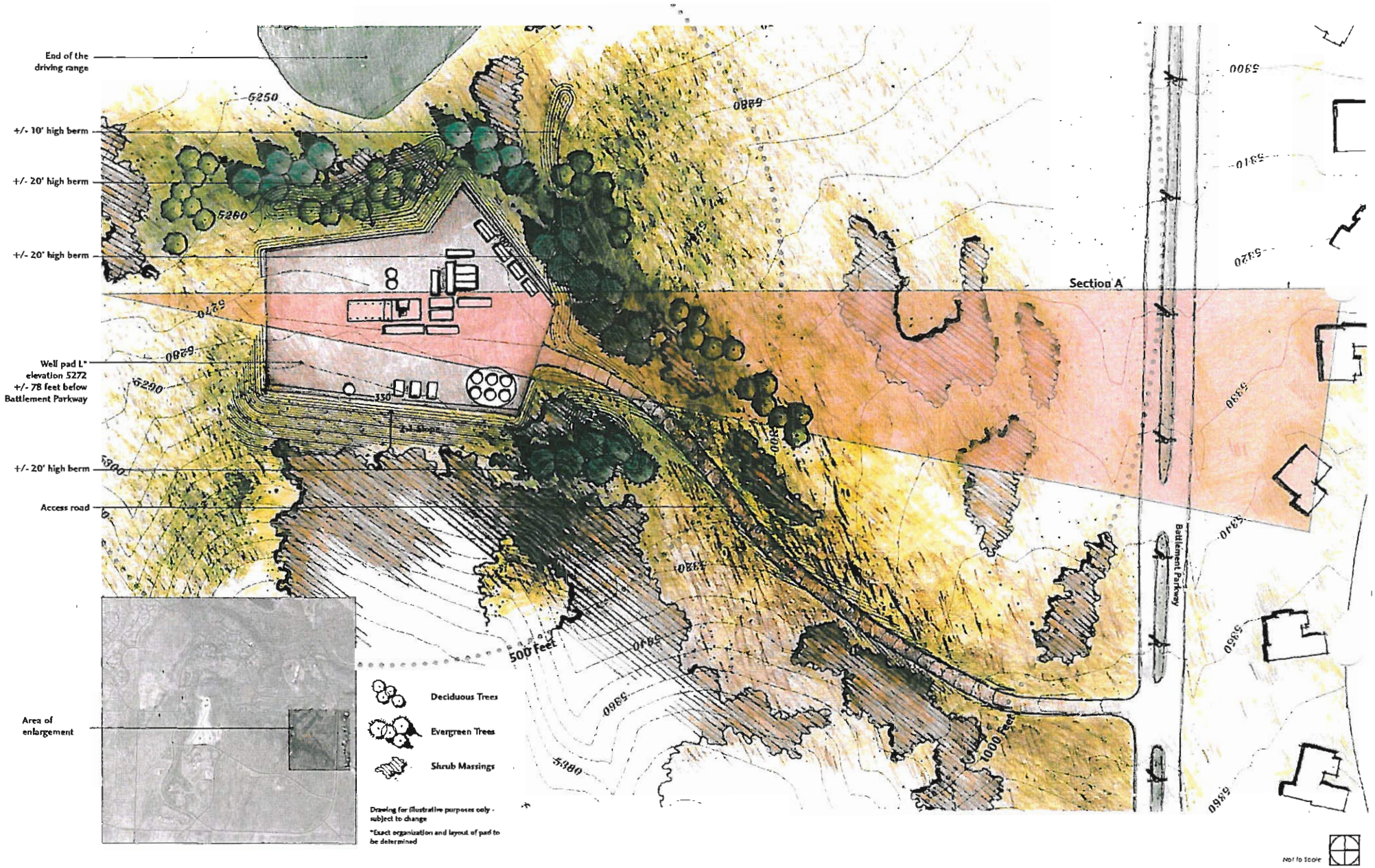
6. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

7. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

8. Irrigation Water. Owner shall provide Operator with access to the golf course irrigation system as well as a water supply to facilitate the irrigation and maintenance of the landscaping to be performed by Operator pursuant to paragraph five (5) above. Operator agrees to provide metering of the water utilized if requested in writing by Owner.

9. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

10. Consultation with Owner and Golf Course Operator. Operator agrees to consult with the Owner and the Golf Course Operator regarding mitigation of Oil and Gas Operations on the use and enjoyment of the golf course.



BATTLEMENT MESA PARACHUTE, COLORADO

01/19/09 SCHEMATIC DESIGN: PAD L

ANTERO RESOURCES

DESIGNWORKSHOP

Not to Scale

BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 LIGHT EXPOSURE: PAD L

DESIGNWORKSHOP

Wellsite Location M

Schematic prepared by Schmueser Gordon Meyer dated 1/20/09 is redacted

Wellsite Location M
Specific Operational Requirements

1. Visual Impact Mitigation. At Operator's sole expense, the Wellsite Location will be constructed to the ground level as depicted on the attached schematics created by Schmueser Gordon Meyer dated 1/20/09 and the Schematic, Light Exposure and Planting plans dated 1/19/09 prepared by Design Workshop, including berming the access road into the Wellsite Location. Operator reserves the right to make minor adjustments to number, size and variety of plants, subject to Operator's obtaining Owner's written consent to same, which consent shall not be unreasonably withheld.

2. Lighting. All lights on the Wellsite Location above the top level of the berm will be oriented in an easterly direction as set forth in the above referenced Light Exposure plan. Focus of lighting will be downward and directed, where applicable, away from residences. If for safety reasons, Operator deems it unreasonable to orient the lighting to the east, Owner will be notified and both will cooperate to reasonably mitigate the effects related to such reorientation of the lighting, including utilizing shrouding on three sides of the drilling rig on site as a mitigation measure, and the utilization of low density sodium vapor lighting, where feasible.

3. Bike Path Relocation. At Operator's sole expense, the current bike path will be relocated and reconnected with the existing bike path as shown on the attached plat in consultation with the Battlement Mesa Homeowners Association. The relocated bike path will be similar in width and constructed with similar materials as the existing bike path.

4. Golf Cart Path Relocation. At Operator's sole expense, the existing golf cart path located on the northeast side of the Wellsite Location will be relocated in consultation with the current owner of golf course. The relocated golf cart path will be similar in width and constructed with similar materials as the existing golf course path. If requested by the owner of the golf course, a safety fence will be installed on the edge of the golf cart path along areas of steep slope. This fencing shall consist of a split rail or other appropriate form of fencing (of similar expense) sufficient to protect persons in the area while not unnecessarily detracting from the natural setting of the golf course.

5. Landscaping Plan. Operator agrees to landscape the Wellsite Location pursuant to the attached schematic created by Schmueser Gordon Meyer dated 10/27/08 and the above referenced Planting Plan created by Design Workshop. Operator agrees to commence with such landscaping work as soon as initial dirt work at the site commences and complete the same prior to commencement of drilling activity at the Wellsite Location, taking into consideration the growing season. Operator will be responsible for maintaining such landscaping, including but not limited to installing irrigation. Operator also agrees to utilize such materials in the ditch

constituting a part of this Wellsite Location as to cause it be natural in appearance and in harmony with its surroundings.

6. Power at Site. Provided electrical power can be accessed under commercially reasonable terms from the local power distribution company servicing the area of the Wellsite Location, Operator shall only use electricity to power its drilling rigs at the site. To the extent third-party contractor equipment has the provisions to utilize electrical power, Operator shall require such third-party contractors to only use electricity to power its equipment at the site In emergency situations, Operator shall be permitted to utilize non-electric generators until such time as electrical power can be restored. Provided, however, these emergency generators shall be positioned in such a manner as to minimize noise impacts on the adjacent residences.

7. Dust Suppression. Operator shall utilize its best efforts at all times to suppress all dust emissions from the Wellsite Location, These efforts shall include, but not be limited to, the use as options of mats, soil tack and/or liquid dust suppressants.

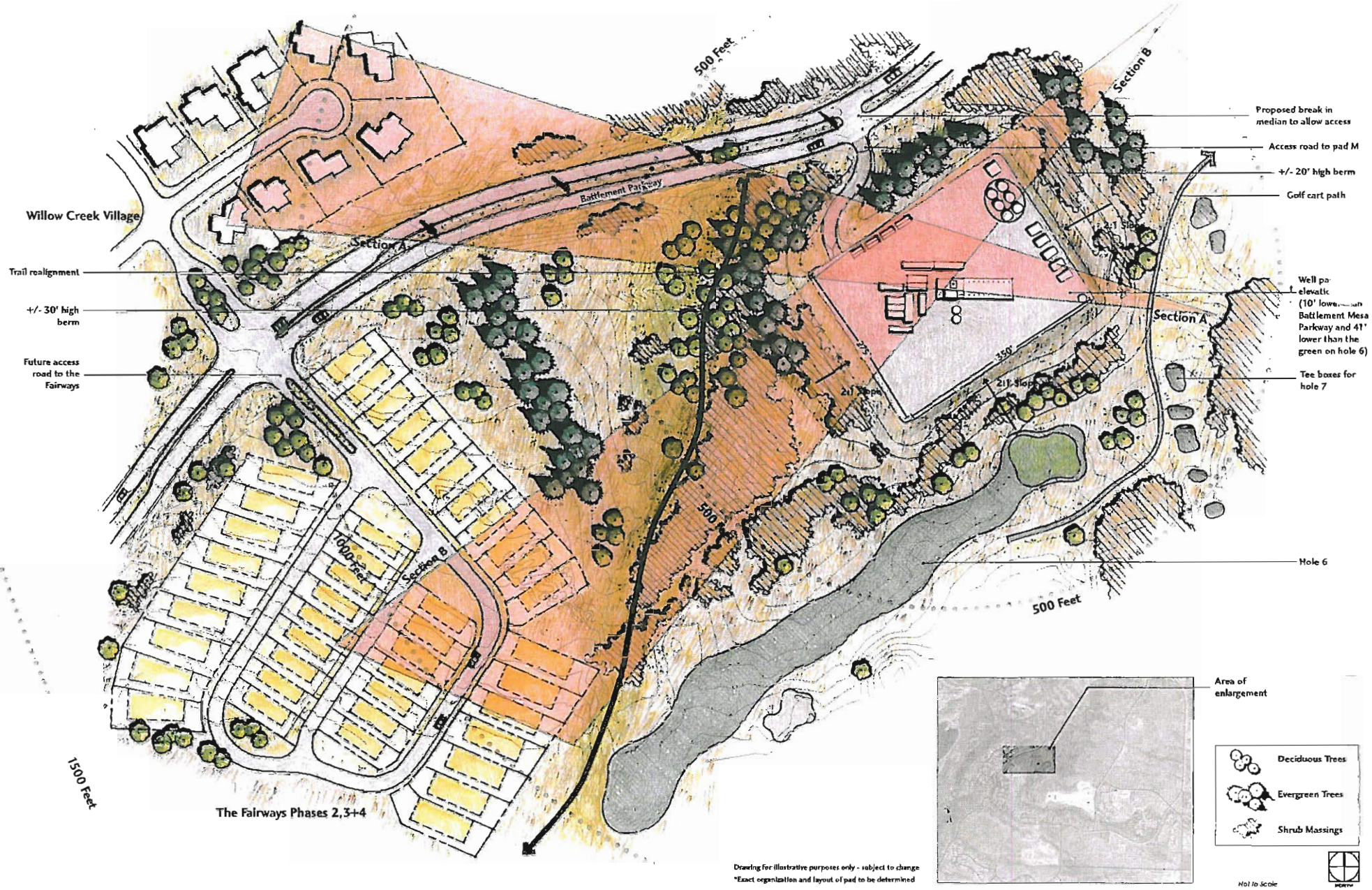
8. Wellhead Compression Housing. To the extent in Operator's opinion wellhead compression is necessary, Operator shall house all noise-related compression equipment in a structure that provides a high level of noise suppression available through the utilization of best management practices.

9. Storage and Parking. Operator agrees this site will not be used for storage or parking of any property other than that immediately required by Operator for its drilling, development and production activities.

10. Irrigation Water. Owner shall provide Operator with access to the golf course irrigation system as well as a water supply to facilitate the irrigation and maintenance of the landscaping to be performed by Operator pursuant to paragraph five (5) above.

11. Surface Use Agreement. These provisions incorporate and, at the same time, shall be considered a part of the SUA and all of its various exhibits. To the extent a conflict in the terms of this document and the SUA occurs, those terms more protective of the environmental and community interests of Owner and Battlement Mesa PUD shall control.

12. Consultation with Owner and Golf Course Operator. Operator agrees to consult with the Owner and Golf Course Operator regarding mitigation of Oil and Gas Operations on the use and enjoyment of the golf course.



BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 SCHEMATIC DESIGN: PAD M

DESIGNWORKSHOP

BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 LIGHT EXPOSURE: PAD M

Not to Scale DESIGNWORKSHOP

PLANT TYPE	QUANTITY
TREES	
COLORADO SPRUCE	58
WESTERN COTTONWOOD	75
SHRUBS	
ROCKY MOUNTAIN JUNIPER	775
MOUNTAIN SAGE	1,549
RABBITBRUSH	775
GROUNDCOVERS	
SEEDMIX	129,566 SF

*Note: All Colorado Spruce Trees shall have a minimum installation height of 10'. Cottonwood trees shall have a minimum installation caliber of 3" and all shrubs shall be a minimum installation size of 1 gallon.

Not to Scale

BATTLEMENT MESA PARACHUTE, COLORADO

ANTERO RESOURCES

01/19/09 PLANTING PLAN: PAD M

DESIGNWORKSHOP

Exhibit D

Reclamation Plan

AFFECTED COMMUNITIES/HABITATS

The affected community and habitats of each Wellsite Location and the Pipeline Easements will be established. Site vegetation may consist of sagebrush and grasses.

PRE-DISTURBANCE INVENTORY AND SITE PLANNING

Location plats for each Wellsite Location, Access Roads and Pipeline Easements will be created along with a legal description. The vegetation reference area will be identified for each will be documented by photographs.

Site planning and proposed fencing of disturbed areas will be documented.

TOPSOIL AND SUBSOIL DETERMINATION AND SALVAGE

An inspection of the soils at the proposed Wellsite Location, Access Roads and Pipeline Easements will be conducted. Immediately after soil samples are collected they will be placed in a cooler to preserve nitrate/nitrogen levels. Soil samples will be submitted to a lab for analysis of the following parameters:

- soil texture
- pH
- sodium absorption ratio
- electrical conductivity
- saturation percentage
- selenium
- nitrogen content
- phosphorus content
- potassium content
- cation exchange capacity
- organic matter content

The soil series and soil horizons will be identified for each well pad.

GUIDELINES FOR TOPSOIL AND SUBSOIL STRIPPING

The soil color differences and a slight texture difference will be identified for each soil series. The A horizon should be stripped to a depth as per the COGCC Series 1003 rule and stockpiled as topsoil separately. Soil salvaged in this manner will help assure a substantial volume of favorable growth media.

SOIL STOCKPILING

The stockpiled soil material not utilized in berming, wellpad construction and Access Roads for and to the various Wellsites shall be located on Wellsite F as indicated on the Schmueser Gordon Meyer schematics dated 1/20/09 and, where applicable, Design Workshop.

TEMPORARY REVEGETATION EFFORTS

The soil stockpile, as well as cut and fill slopes, will be seeded immediately after the well pad disturbance. The seed mixture will consist of grass species which appear on the BLM list of recommended seed mixes. The seed mixture may be hand broadcast and drag harrowed and/or hand raked to get good soil contact.

SOIL AMENDMENTS AND FERTILIZERS

The results of the soil inspection will be used to determine the appropriate soil amendments and fertilizers and the depth of their application.

STABILIZATION AND INTERIM RECLAMATION

Interim reclamation will be performed in accordance with COGCC Series 1003 rules. The objectives of stabilization and interim reclamation will be as follows:

1. Stabilization of the disturbed areas will be conducted by providing wind and water erosion control to reduce soil loss.

2. Utilize the prescribed seed mixture and additional vegetation practices as described below to establish a self-sustaining vegetative rangeland cover.

Operator shall utilize irrigation as necessary during the course of interim reclamation measures to assist in the establishment of plant life at the site consistent with good reclamation practice.

All interim reclamation shall be consistent with Exhibit C Wellsite requirements.

BACKFILLING, GRADING, AND RE-CONTOURING

Reclaimed areas will be sloped to 3:1 or less. A flat area will be maintained for well servicing and potential future additional drilling efforts. Further drill pad reduction may be possible based on landowner requirements and/or site conditions.

TOPSOIL REPLACEMENT

Soil salvaged when the wells are drilled will be redistributed over the soil surface after subsoil has been replaced and additional backfilling, grading, and re-contouring steps have been completed as described below. Soil will be replaced by using front-end loaders,

trackhoes, and dozers. Soil will not be replaced when it is excessively wet and frozen so as to jeopardize soil structure.

SEEDBED PREPARATION/SOIL TILLAGE

Seedbed preparation and soil tillage will be completed after the application of subsoil, topsoil, and any soil amendments. Soil tillage will be to a minimum depth of 4" utilizing a disk, chisel plow, or harrow. Seedbed preparation will also include removal of coarse fragments (rock material) that exceed 35% to 40% of the soil surface as well as rocks 8" in diameter that occupy more than 10% of the soil surface.

SEEDING METHODS AND TIMES

If interim seeding is performed in the spring, it will be accomplished by May 15; if fall seeding is performed, it will be completed after August 30 and before the soil freezes. Both temporary and interim vegetation efforts will consist of drill seeding with a rangeland drill to a planting depth of ¼" to ½" on slopes 3:1 or flatter. Broadcast seeding, followed by harrowing or hand raking to lightly cover the seed with soil, will be used on slopes steeper than 3:1 or areas inaccessible for drill seeding equipment. All well sites, access roads, and flow line and gathering line right-of-ways will be mulched immediately after seeding and no later than 24 hours after seeding with a weed-free straw or grass hay material. Grass hay mulch will be applied at 1 ½ tons per acre, or straw mulch will be applied at 2 tons per acre. Mulch material will be crimped into the soil surface with a commercial mulch crimper, a straight disc, or bulldozer tracks if too steep to otherwise crimp mulch in place.

SEED MIXTURES

The seed mixtures will be those as recommended by the BLM for the appropriate habitat or affected community and or as requested by the landowner.

EROSION CONTROL BLANKETS AND OTHER SPECIAL PROVISIONS FOR EROSION CONTROL

Erosion control procedures will be specified by the site specific Storm Water Management Plan (SWMP) as required by the Colorado Department of Public Health and Environment, Water Quality Control Division. The SWMP will include, among other things, detailed descriptions of erosion control best management practices (BMPs). The location of each site specific BMP will be identified on a plat.

NOXIOUS WEED CONTROL PLAN

The location will be inspected three times per year by a qualified person. Based on this inspection, methods, materials, and timing of weed control measures will be specified. Weed control inspections and response measures will be documented. A table of the noxious weeds of concern to Garfield County is presented below.

Table 1: Garfield County Noxious Weed List

Scientific Name/Common Name
Cirsium arvense Canada thistle
Cichorium intybus Chicory
Arctium minus Common burdock
Linaria dalmatica Dalmatian toadflax
Centaurea diffusa Diffuse knapweed
Cardaria draba Hoary cress
Cynoglossum officinale Houndstongue
Aegilops cylindrica Jointed goatgrass
Euphorbia esula Leafy spurge
Carduus spp. Musk thistle
Crysanthemum leucanthemum Oxeye daisy
Carduus acanthoides Plumeless thistle
Lythrum salicaria Purple loosestrife
Centaurea repens Russian knapweed
Elaeagnus angustifolia Russian olive
Tamarix parviflora, Salt Cedar
Tamarix ramosissima, Salt Cedar
Onopordum acanthium Scotch thistle
Centaurea maculosa Spotted knapweed
Centaurea solstitialis Yellow starthistle
Linaria vulgaris Yellow toadflax
Source: Garfield County - Noxious Weed List, 2007.

FINAL RECLAMATION

Successful final reclamation of the Property shall consist of compliance with the provisions of this Exhibit D and full compliance with the then-applicable provisions of COGCC Rule 1004.e or such comparable provision as is in effect at the time of such final reclamation.

Prior to final reclamation of Wellsites L and M, Operator and Owner agree to confer and determine between themselves what form the final reclamation of these Wellsites shall take. The agreement reached between these parties shall be reduced to writing and executed by both for submission to the COGCC, In the event no agreement can be reached, Operator shall reclaim these Wellsites as set forth above.

CURRICULUM VITAE

Daniel T. Teitelbaum, M.D.

Daniel Thau Teitelbaum, M.D., P.C.
50 S. Steele Street, Suite 588
Denver, Colorado 80209
(303) 355-2625

POSITION:

Medical Toxicologist
President
Daniel Thau Teitelbaum, M.D., P.C.
Medical Toxicology & Occupational Medicine

ADDRESS:

Daniel Thau Teitelbaum, M.D., P.C.
50 S. Steele Street, Suite 588
Denver, Colorado 80209
(303) 355-2625

SCOPE OF PRACTICE:

Medical Toxicology
Occupational Medicine
Occupational and Environmental Toxicology
Acute and Chronic Poisoning
Analytical Toxicology
Clinical Pharmacology

BORN:

May 26, 1935
New York, New York
Citizenship: U.S.A.

PROFESSIONAL EXPERIENCE:

Qualified Expert Witness in Clinical Toxicology since 1967.

Consultant to the Industrial Commission and State Compensation Fund of Colorado, The United States Food and Drug Administration and the Occupational Safety and Health Administration.

Consultant to industry, agriculture, and labor in occupational and environmental toxicology, including: IBM, CFI Steel, Dresser Industries, W.R. Grace, Coors, Monfort of Colorado, Dynalectron Corporation, Amoco, Xerox, Northern Telecom, Motorola, NCR, TRW, Intel Corporation, Heat and Frost and Asbestos Workers Union, Colorado Construction Trades Council, etc.

Lecturer and seminar leader in all aspects of toxicology practice. Fields of interest: solvents, asbestos, lead, carcinogenesis and biomedical and environmental monitoring.

Extensive experience in the practice of analytical, biomedical and occupational/environmental toxicology. Founder and former director of Poisonlab and Enbionics, independent toxicology laboratories licensed by CDC accredited by AIHA (#60.) Consultant in analytical and clinical toxicology to Bioscience Laboratories and other independent laboratories.

ACADEMIC AFFILIATIONS:

Adjunct Professor Occupational and Environmental Health, Colorado School of Public Health, University of Colorado at Denver, Denver, Colorado.

Adjunct Professor of Environmental Sciences, Colorado School of Mines.

Visiting Professor, Medicine and Toxicology, Israel Institute of Technology, The Technion, Haifa Israel.

Scope of teaching: Medical, occupational and environmental toxicology, and occupational medicine.

Former Member of Physicians' Poison Consultation Service	University of Colorado Medical Center, Denver, Colorado
Consultant in Medical Toxicology	Denver General Hospital and Rocky Mountain Poison Center 1967-1993

CDC licensed Clinical Laboratory Director

7/2008- Present	Private Practice, Limited 355 Ogden Street Denver, Colorado 80218
2006 – 2008	Private Practice Medical Toxicology 50 S. Steele Street, Suite 588 Denver, Colorado 80209
1988-2006	Private Practice Medical Toxicology 155 N. Madison Denver, CO 80206
1983 - 1988	Director / Occupational Medicine and Toxicology Denver Clinic (Accord Medical Center) 701 East Colfax Avenue Denver, Colorado 80203
1982 - 1983	Staff Physician / Occupational Medicine Denver Clinic 701 East Colfax Avenue

Denver, Colorado 80203

1982 - 1989 Medical Director, Analytitox Inc.
Denver, Colorado

1979 - 1982 President
Worksafe, Inc.
6825 East Tennessee
Denver, Colorado 80224

1973 - 1979 President, Poisonlab / Enbionics
Division of Chemed Corporation
1469 South Holly Street
Denver, Colorado 80222

Offices in Denver, San Diego, Cleveland
CLIA #05-1014 AIHA #60

1970 - 1973 Founder, President, and Toxicology Consultant
Poisonlab, Inc.
1469 South Holly Street
Denver, Colorado 80222

Private Practice - Clinical Toxicology
2045 Franklin Street
Denver, Colorado 80222

1970 - 1971 Director of Licensed Methadone Treatment Program
IND 6867
2045 Franklin Street
Denver, Colorado 80205

1968 - 1970 Director of Emergency Services
University of Colorado Medical Center
Denver, Colorado

Assistant Professor of Medicine and Preventive Medicine
University of Colorado Medical Center
Denver, Colorado

1967 - 1968 Clinical Instructor, Preventive Medicine
University of Colorado Medical Center
Denver, Colorado

EDUCATION:

1956 Bachelor of Arts — Hamilton College
Clinton, New York

1960	Master of Hebrew Letters and Rabbi	Jewish Theological Seminary of America
1964	Doctor of Medicine	Albert Einstein College of Medicine
1964 - 5	Intern, Mixed Medicine	Montefiore Hospital New York City, New York
1965 - 7	Resident, Internal Medicine	University of Colorado Medical Center Denver, Colorado
1967 - 8	Fellow in Medicine and Toxicology	University of Colorado Medical Center Denver, Colorado
1991 - 2	Occupational and Environmental Medicine Program	University of California San Francisco, California

BOARD CERTIFICATION:

Board Certified American Board of Medical Toxicology, 1975
Recertified by examination, August 1976
Board Certified American Board of Preventive Medicine in Occupational Medicine, January, 1994

COMMITTEES:

Physician Panel Member, U. S. Department of Energy, Office of Worker Advocacy

Member, Metalworking Fluids Standards Advisory Committee, Occupational Safety and Health Administration (OSHA)

Former Member, Toxicology Resource Committee, College of American Pathologists

Former Member, Education Committee, American Academy of Clinical Toxicology

Chairman, United States Food and Drug Administration Advisory Committee on toxicology diagnostic products. (Executive Appointment) 1976 - 1978

Special Consultant to OSHA, U.S. Department of Labor on Lead, 1977. Participant on behalf of OSHA in lead standards setting hearings

Member, Committee on Operation of Centers, American Association of Poison Control Centers

Chairman, Drug Abuse Committee, American Occupational Medical Association, 1977 -1978

Former Member, ASTM Committee E-34 on Safety in the Workplace

Former Member, Board of Trustees, American Academy of Clinical Toxicology

Former Member, Environmental Affairs Committee, W.R. Grace and Company

Former Member, Chemical Regulations Advisory Committee, Manufacturing Chemists Association

Member, Forensic Sciences Committee of the American Society for Testing and Materials

Member, Occupational Medicine Committee of the American Industrial Hygiene Association

Special Consultant to OSHA, USDOL on Access to Medical Records Standard, 1981

Former Member, State Poison Control Committee, Colorado Department of Health

Former Member, Joint Pesticide Advisory Committee, State of Colorado

Former Secretary - Treasurer to the American Academy of Clinical Toxicology

Former Chairman, Therapeutics Committee, American Academy of Clinical Toxicology

Special Consultant to OSHA, USDOL on Hazard Communication Standard, 1982

Special Consultant to OSHA, USDOL on Ethylene Dibromide Standard, 1984

Member, Editorial Board, Journal of Toxicology, Clinical Toxicology, 1968 - 1982

Peer Reviewer, Annals of Internal Medicine, 1970 - 1985

Peer Reviewer, Journal of the American Medical Association, 1975 - 1985

Member, Special Blue Ribbon Panel of the Executive Office of the President, National Science Foundation / Council on Environmental Quality on Future Health Implications of Emerging Technologies, 1984

Secretary of the Medical Executive Committee, Saint Joseph Hospital, Denver, Colorado, 1985 - 1986

Special Consultant to OSHA, USDOL on Benzene Standard, 1986

Witness before The Committee on Oversight and Government Reform on the public health implications of oil and gas development, Oct 2007

SOCIETIES:

American Academy of Clinical Toxicology
American Academy of Forensic Sciences
American Association for the Advancement of Science
American Association of Poison Control Centers
American College of Medical Toxicology
American College of Clinical Pharmacology
American College of Preventive Medicine
American Industrial Hygiene Association
American Medical Association
American Society of Clinical Pathologists
American Society for Testing and Materials
American Society of Veterinary Toxicologists
Colorado Medical Society
Denver Medical Society
Forensic Science Society
Occupational Medical Association
Rocky Mountain Academy of Industrial Medicine
Society for Risk Analysis
Society of Sigma Xi, The Scientific Research Society

HONORS:

Elected fellow of Collegium Ramazzini, November 1994
World Health Organization Traveling Fellowship in Clinical Toxicology
Founders Award, American Academy of Clinical Toxicology
Student Fellowship, Jackson Memorial Laboratory, 1952 - 3
Numerous Academic Prizes in College

FELLOWSHIPS:

Fellow, American College of Clinical Pharmacology, 1973
Fellow, American Academy of Clinical Toxicology, 1976

PUBLICATIONS:

THE SINAGOGA ITALIGNANA, GHETTO NUOVO, VENEZIA. A STUDY OF THE CONGREGATIONAL RECORDS OF THE YEARS 1643/4 - 1653/4, Jewish Theological Seminary, History A, Spring 1959.

USE OF SYRUP OF IPECAC, Rocky Mountain Medical Journal, June, 1967.

DETAILING IPECAC, Journal of Pediatrics, November, 1967.

POISONING DEATHS TOO HIGH IN U.S. (corr.) NEJM, November 9, 1967.

STRAMONIUM POISONING IN "TEENY-BOPPERS", Annals of Internal Medicine, January, 1968.

NEW DIRECTIONS IN POISON CONTROL, Clinical Toxicology, 1(1):3-13, 1968.

MANAGEMENT OF SNAKE BITE INJURIES, Rocky Mountain Medical Journal, October, 1968.

ARSINE POISONING, Archives of Environmental Health, July, 1969.

ELEMENTAL MERCURY SELF POISONING, Clinical Toxicology, September, 1969 with Dr. John E. Ott.

VEGETABLE OIL AEROSOL SPRAY POISONING, Rocky Mountain Medical Journal, October, 1969.

MISDIAGNOSIS OF DRUG ABUSE (Lett.), JAMA, December 16, 1969.

LONG HAIR, PECULIAR BEHAVIOR (Corr.), Lancet, November 18, 1969.

ACUTE STRYCHNINE INTOXICATION, Clinical Toxicology, June, 1970 with Dr. John E. Ott.

ISONIAZID SELF POISONING, Neurology, April, 1970 with Dr. David Terman.

POISONING WITH PSYCHOACTIVE DRUGS, Ped. Clin. N.A., August, 1970.

MANAGEMENT OF POISONING WITH ANTIDEPRESSANT DRUGS, Clinical Toxicology, September, 1971, with T. Slovis, J. Ott, et al.

POISONING - Chapter in Current Pediatric Diagnosis with Dr. John E. Ott, 1970 and 1972 editions.

METHADONE MAINTENANCE IN A PRIVATE PRACTICE SETTING - American Academy of Clinical Toxicology, August, 1972, Clinical Toxicology 6:2 (1973).

MANAGEMENT OF ORGANOPHOSPHORUS PESTICIDE POISONING. New York State Society of Anesthesiologists, December, 1972.

ROUND THE CLOCK SCREENING FOR DRUGS USING THE EMIT SYSTEM, Daniel T. Teitelbaum, Gyorgy Vidacs, Clinical Toxicology, 1973.

TOXICOLOGY MEDICAL AND LABORATORY SERVICES IN THE INDUSTRIAL SETTING: in Guidelines for Analytical Toxicology Programs. Vol. I., edited by J.J. Thoma, et al. CRC Press, Cleveland, 1977.

DIAGNOSIS AND MANAGEMENT OF RECREATIONAL, MESCALINE SELF POISONING, D. T. Teitelbaum, M.D. and D.C. Wingeleth, Ph.D., Journal of Analytical Toxicology, January / February, 1977.

NONCONCORDANCE BETWEEN CLINICAL IMPRESSION AND LABORATORY FINDINGS IN ACUTE POISONING, with Janet Morgan, M.A., and Gail Gray, M.A., Clinical Toxicology. No. 4, 1977.

ACETAMINOPHEN: CLINICO - PATHOLOGIC CORRELATIONS, A.A.C.C., Nov. 1979.

Contributor "The College of American Pathologists Toxicology Program" by David Sohn. Journal of Analytical Toxicology. Vol. 1, May / June 1977, p. 111 - 117.

REASSURANCE PRESCRIBED FOR NONTOXIC INGESTIONS, Saint Anthony Hospital Medical Staff News, Denver, Colorado, July / August, 1979.

INSULATE YOUR HOME WITH CAUTION, with Sheila Teitelbaum, M.A., National Health, September, 1979.

HOW ADEQUATE IS ADEQUATE VENTILATION?, with Sheila Teitelbaum, M.A., National Health, October, 1979.

INFORMATION AND THE PREVENTION OF GENETIC INJURY, Proceedings, National Safety Congress, 1979.

MICROWAVE OVENS: KEEPING THE RISKS LOW, with Sheila Teitelbaum, M.A., National Health, November, 1979.

CLINICAL RECOGNITION OF ASBESTOSIS, in Occupational Diseases: Steps for Positive Action, Hour 2, Home Continuing Medical Education, 15 Columbus Circle, NY, 10023.

WORKING WITH LEAD, with Ralene Reynolds, M.A., The Center for Toxicology, Man and Environment, Inc., May, 1980.

THE TOXICOLOGY OF MASS CHEMICAL ACCIDENTS, proceedings of the First International Symposium of the Israel Society of Critical Care Medicine, Haifa, June, 1980.

ACETAMINOPHEN POISONING IN CONTEMPORARY PRACTICE, California, F.P., June, 1982.

HOBBIES AND HAZARDS, with Sheila Teitelbaum, Consultant, March, 1982.

TRW HEALTH AND SAFETY MANUAL, with Ralene Reynolds and Sheila Teitelbaum, in cooperation with TRW Semiconductor Corporation, Lawndale, California, September 1981.

SEMICONDUCTOR PRODUCTION CAN BE NASTIER THAN YOU THINK, with Sheila Teitelbaum, Consultant, September, 1982.

ASPIRIN AND ACETAMINOPHEN POISONING: DIAGNOSIS AND CLINICAL MANAGEMENT, with Sheila Teitelbaum, Consultant, November 1982.

ROLE OF THE PHYSICIAN IN THE DEVELOPMENT OF TOXIC SUBSTANCES HAZARDS COMMUNICATION PROGRAMS, 2nd World Meeting of Clinical Toxicology, Vet Hum Toxicology 24(4):279, 1982.

TOXICOLOGIC IMPLICATIONS OF GROUNDWATER CONTAMINATION, Motorola Corporation, 1983, company confidential.

EVALUATION OF BENEFITS OF DRUG ANALYSIS IN THE ROUTINE CLINICAL MANAGEMENT OF ACUTE POISONING, J. Toxicol Clin Toxicol 22(6):589 - 92, 1984.

HUMAN HEALTH IMPLICATIONS OF EMERGING CHEMICAL TECHNOLOGIES, Proceedings of a National Science Foundation / Council on Environmental Quality special commission, September, 1984, Preliminary Publication March, 1985 (NSF / CEQ).

LABORATORY MANAGEMENT OF ACUTE POISONING, Diagnostic Medicine, in publication, Scheduled for late 1985.

ALCOHOL AND CRASHES, American Bar Association, 1st Annual Seminar on Transportation Negligence, Seminar Handbook, ABA 1985.

PHOTOACTIVE CHEMICALS USED IN PHOTORESIST SYSTEMS. State Art Rev Occup Med 1(1):59 - 68, 1986.

LEAD POISONING IN A CAPACITOR AND RESISTOR PLANT - COLORADO, MMWR 1985; 34(25) :384 - 85. With Alkes I; Kadushin F; Lampert K; Hopkins R; Ryan J; Novotny T.

NEUROBEHAVIORAL FINDINGS IN TWO CASES OF CHRONIC LOW LEVEL CARBON MONOXIDE POISONING, Vet Hum Toxicol 29(6):479, 1987, with FS Kadushin, AC Bronstein.

MEDICAL MANAGEMENT OF EXPOSURE TO CHEMICALS. Semi Conductor Safety Association, 10/17/88 from the Israel National Poison Information Center. With Uri Taitelman and Bianca Raikhlin.

DETECTION OF UNSUSPECTED, NON - FAVA BEAN SENSITIVE G6PD DEFICIENCY IN SEMICONDUCTOR FABRICATION WORKERS IN ISRAEL. Proceedings WHO conference, "Consultation on genetic predisposition to toxic effects of chemicals", Krefeld, FRG, 17 - 20 October, 1989, with B. Raikhlin.

ASBESTOSIS IN RETIRED STEAM RAILWAY CRAFTSMEN. Documentation of Exposure to Asbestos from Photographs in the Library of Congress Prints and Photographs Collection. Bulletin de la Societe des Sciences Medicales du Grand - Duche de Luxembourg. Proceedings of the International Congress on Clinical Toxicology, Poison Control and Analytic Toxicology LUX TOX '90, 2 - 5 May 1990, Luxembourg. pp. 325 - 330.

AMBIENT AIR POLLUTION FROM INDUSTRIAL SOURCES. In Air Pollution in Central and Eastern Europe: Health and Public Policy. BS Levy, ed. Management Sciences for Health, Boston, MA: 1991. p. 36.

REGULATION: LAWS AND GUIDELINES. In Air Pollution in Central and Eastern Europe: Health and Public Policy. BS Levy, ed. Management Sciences for Health, Boston, MA: 1991. p. 145.

WATER POLLUTION – Chapter 44. In Occupational & Environmental Medicine, 2nd ed., Joseph LaDou, ed. Stamford: Appleton & Lange: 1997, pp 733-51.

HOT TOPIC. LETTER TO THE EDITOR RE: ASBESTOS REVISITED. Scientific American 1997 Nov; 277(5):10.

ON THE BORDER: BUSINESS BOOMS, BUT AT WHAT COST? Safety + Health, 156(5):54-59, 1997 (with two photographs by Daniel T. Teitelbaum, M.D.)

SKIN ABSORPTION OF BENZENE AS A CONTAMINANT IN OTHER SOLVENTS, with David Brenner, Ph.D. and Jonas Kalnas, M.D., M.I.H. Presented at the annual meeting of the Collegium Ramazzini, October 24-26, 1997, Carpi, Italy. Eur J Oncol, 3(4): 399-405, 1998.

OPEN LETTER TO THE EDITOR OF SALUD OCUPACIONAL with B. Castleman, J Dement, AL Frank, H Frumkin, F Giannasi, M Gochfeld, BD Goldstein, P Grandjean, M Greenberg, J LaDou, RA Lemen, BS Levy, C Maltoni, M McDiarmid, EK Silbergeld, A Thebaud-Mony, AC Upton, and DH Wegman. Int J Occup Environ Health, 4(2): 131-3, 1998.

OPEN LETTER TO THE GREENOCK TELEGRAPH, GREENOCK, SCOTLAND. [editorial] with B Fowler, J LaDou, AM Osoria, M Paul, and SH Swan. Int J Occup Environ Health, 4(3): 204-5, 1998.

CHRONIC MYELOGENOUS LEUKEMIA DUE TO SKIN ABSORPTION OF BENZENE AS A CONTAMINANT IN OTHER SOLVENTS, A REPORT OF TWO CASES, with David Brenner and Jonas Kalnas. Eur J. Oncol, 4(5): 603-5, 1999.

BOOK REVIEW. AMIANTE LE DOSSIER de l'AIR CONTAMINE, by Francois Malye. Int J Occup Environ Health, 5(1): 76-7, 1999.

SYMPOSIUM: DBCP-INDUCED STERILITY AND REDUCED FERTILITY AMONG MEN IN DEVELOPING COUNTRIES: A CASE STUDY OF THE EXPORT OF A KNOWN HAZARD with Barry S. Levy, Jeffrey L. Levin. Int J Occup Environ Health, 5(2): 115-122, 1999.

SCIENTIFIC METHODOLOGY AND THE ADMISSIBILITY OF EXPERT TESTIMONY. SECOND ANNUAL APPELLATE JUDGES AND LAWYERS SYMPOSIUM, MAY 13-15, 1999. KS J Law & Public Policy, IX(I): 56-74, Fall 1999.

THE TOXICOLOGY OF 1,2-DIBROMO-3-CHLOROPROPANE (DPCP): A BRIEF REVIEW. Int J Occup Environ Health 1999; 5: 122-6.

DERMAL ABSORPTION OF BENZENE: IMPLICATIONS FOR WORK PRACTICES AND REGULATIONS with Jonas Kalnas. Int J Occup Environ Health, 6: 114-21, 2000.

LETTER TO THE EDITOR: BENZENE AND MULTIPLE MYELOMA: APPRAISAL OF THE SCIENTIFIC EVIDENCE with Nachman Brautbar, Myron Mehlman, and Joseph LaDou. Blood, 95(9): 2995, 2000.

THE HALOGENS, Chapter 48, in PATTY'S TOXICOLOGY, 5th Edition, v. 3, E. Bingham, Ed. New York: John Wiley & Sons, 2001; 731-825.

CURRENT ISSUES IN WATERBORNE INDUSTRIAL TOXIC CHEMICAL EXPOSURE. Eur J Oncol 2001; 6 (1): 19-21.

METALWORKING FLUIDS: SAFETY AND HEALTH – BEST PRACTICES MANUAL, contributing Public Representative member of OSHA Metalworking Fluids Standard Advisory Committee. October 2001.

TOXIC TORTS IN THE TRANSPORTATION INDUSTRY. Clin Occup Environ Med 3; 189-202, 2003.

WATER POLLUTION – Chapter 42 with Tushar Kant Joshi. Current Diagnosis and Treatment in Occupational & Environmental Medicine, 4th ed., Joseph LaDou, ed. New York: McGraw Hill: 2006; 730-748.

AMERICAN COLLEGE OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE (ACOEM): A PROFESSIONAL ASSOCIATION IN SERVICE TO INDUSTRY with Josaph LaDou, David Egilman, Arthur Frank, Sharon Kramer. Int J Occup Environ Health, 13(4): 404-426, Oct/Dec 2007.

TEACHING VIDEOTAPES:

"Chemical Safety", produced by Hewlett Packard.

"Primary Management of the Acutely Self - Poisoned Adult", produced by the Network for Continuing Medical Education.

"Occupational Diseases: Steps for Positive Action", produced by the Network for Continuing Medical Education.

"Management of the Acutely Poisoned Patient", produced by BioScience Laboratories, Van Nuys, California.

"The Six Big Ones", in cooperation with Xerox Microelectronics Center, November, 1981.

A Needle in a Haystack. The role of the laboratory in the management of the poisoned patient. BioScience Laboratories, 1982.

"Definitive Management of Poisoning", BioScience Laboratories, Van Nuys, California, October, 1982.

"ZAP: Human Electrocution - What Happens and How to Prevent It", in cooperation with Motorola BiPolar Division, Mesa, Arizona, 1982.

"Diagnosis and Management of Substance Abuse Disorders." NCME, NY, 1983.

PUBLISHED BIBLIOGRAPHIES:

With B.J. Croall, M.A.

THE HEMATOLOGIC EFFECTS OF TRIAZINES, October, 1978.

BENZIDINE AND HAIR DYES, April, 1978.

HEMATOLOGIC EFFECTS OF EXPOSURE TO PESTICIDES, February, 1978.

TOXICITY OF CYCLONITE, August, 1978.

ALPHA METHYLDOPA, February, 1978.

SUGGESTED TITLES FOR AN INDUSTRIAL TOXICOLOGY LIBRARY, June, 1977.

PAINT REMOVERS AND CARBON MONOXIDE INTOXICATION, April, 1977.

EXPOSURE TO SULFURIC ACID, October, 1977.

CONTACT DERMATITIS, December, 1977.

ANTICONVULSANTS, January, 1976.

ANALYTICAL ASPECTS OF LEAD INTOXICATIONS, October, 1976.

STANDARD INTERNATIONAL (SI) UNITS, June, 1979.

PENTAZOCINE ADDITION, April, 1981.

TOXICITY OF THALLIUM, June, 1982.

OCCUPATIONAL ASTHMA, September, 1982.

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