Halliburton Energy Services, Inc.

Attached please find comments on behalf of Halliburton Energy Services, Inc. regarding the Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities.

MANKO | GOLD | KATCHER | FOX LLP
AN ENVIRONMENTAL AND ENERGY LAW PRACTICE

Todd D. Kantorczyk
484-430-2359
tkantorczyk@mgkflaw.com

Admitted in PA, DC and NY

401 CITY AVENUE, SUITE 500
BALA CYNWYD, PA 19004
TEL: 484-430-5700
FAX: 484-430-5711
WWW.MGKFLAW.COM

PHILADELPHIA, PA
*CHERRY HILL, NJ
by appointment only

*Partner responsible – Bruce S. Katcher

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Via Electronic Submission
Pamela Bush, Esquire
Commission Secretary and Assistant General Counsel
Delaware River Basin Commission
P.O. Box 7360
25 State Police Drive
West Trenton, NJ 08628-0360

Re: Halliburton Energy Services, Inc. - Comments on Proposed Amendments to the Administrative Manual and Special Regulations Regarding Hydraulic Fracturing Activities

Dear Ms. Bush:

On January 8, 2018, the Delaware River Basin Commission ("DRBC") published for public notice and comment a proposed set of regulations entitled *Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities* ("Special Regulations"). The proposed Special Regulations, if finalized, will prohibit in the Delaware River Basin "high volume hydraulic fracturing" ("HVHF") as that term is defined in the proposed Special Regulations. The proposed decision to ban HVHF within the Delaware River Basin is a radical departure from the DRBC's previous approach to crafting a regulatory program that would allow HVHF operations in the Delaware River Basin through use of the DRBC's project review program. The public notice pertaining to the proposed Special Regulations included background information that describes the DRBC's reasons for the abrupt about-face in the approach for addressing HVHF contemplated by the Special Regulations (the "Background Document").

The purpose of this letter is to provide the DRBC with comments on behalf of Halliburton Energy Services, Inc. ("HESI") regarding the proposed Special Regulations. As a general matter, HESI stands with and supports the comments submitted by the American Petroleum Institute and the Marcellus Shale Coalition, which both object to the proposed prohibition of HVHF activities within the Delaware River Basin as an unprecedented effort to single out the oil and natural gas industry based upon an unsupported determination that HVHF "poses significant, immediate and long-term risks to the development, conservation, utilization, management and preservation of the water resources of the Delaware River Basin …." More specifically, HESI believes that the DRBC has inappropriately justified its proposal to ban an entire industry from the Delaware River Basin by relying upon questionable interpretations of HVHF studies published by other regulatory agencies and an incorrect characterization of the uncertainty and potential risks associated with the use of hydraulic fracturing chemical additives.

HESI is a leading provider of services to the oil and gas industry and is the global leader with respect to hydraulic fracturing services. HESI helped pioneer the use of hydraulic fracturing in the 1940s and has provided hydraulic fracturing services in a wide variety of geographic settings and formations for approximately 70 years. During this time period, HESI has employed hydraulic fracturing technology at many hundreds of thousands of wells and has been responsible for numerous innovations in the field of hydraulic fracturing. For example, HESI spent $329 million on research and development in 2016 alone, including millions of dollars on developing fluid additives to enhance the production of new and existing oil and gas wells. These innovations have helped fuel job growth and have enhanced the nation's energy security, while achieving continuous environmental improvements. The ability to effectively and efficiently tap into large amounts of natural gas in shale formations in the Appalachian Basin and elsewhere in the United States has contributed to stable domestic natural gas prices and significant utilization of natural gas for electric power generation in lieu of coal.

In addition to innovations that increase natural gas production and allow natural gas wells to function on a more efficient basis, HESI has devoted substantial resources to developing hydraulic fracturing technologies with important direct environmental benefits. For example, HESI has developed a hydraulic fracturing fluid system comprised of materials sourced entirely from the food industry. In addition, HESI has engineered a process that uses ultraviolet light to control the growth of bacteria in hydraulic fracturing fluids, allowing customers to minimize the use of chemical biocides. HESI has also developed fluid systems that facilitate the use of produced water rather than relying solely on fresh water as the base fluid for hydraulic fracturing. This wealth of experience makes HESI particularly well positioned to understand the natural gas production industry and to offer comments regarding the proposed Special Regulations, particularly as they relate to hydraulic fracturing stimulation practices.

1. The DRBC Incorrectly Interprets Hydraulic Fracturing Studies Published by Other Regulatory Agencies

In 2011, the DRBC indicated that it was prepared to move forward with regulations that would allow for HVHF to occur within the Delaware River Basin, subject to stringent standards enforced through the DRBC's project review program. However, such regulations were never finalized. Instead of moving forward with this approach, the DRBC is now proposing to prohibit HVHF operations within the Delaware River Basin, citing primarily three HVHF studies that have been published by regulatory agencies since 2011: (1) the *Final Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program*, published by the New York State Department of Environmental Conservation in May 2015 (the "Final SGEIS"); (2) the United States Environmental Protection Agency's study entitled *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Sources in the United States*, published in 2016 (the "EPA HF Study"); and (3) a 2016 study from the Susquehanna River Basin Commission entitled *Water Use Associated with*

Natural Gas Development: An Assessment of Activities Managed by the Susquehanna River Basin Commission (the "SRBC Water Use Study"). A fair and objective reading of these studies, however, does not provide a case for singling out the oil and gas industry as posing unacceptable risks to surface and groundwater supplies in the Delaware River Basin as the Special Regulations conclude.

HESI has previously detailed many of the shortcomings of the Final SGEIS and the EPA HF Study in other comments submitted during the drafting of these documents, and they will not be repeated here.[1] Even setting aside these shortcomings, the key studies relied upon by DRBC do not say what DRBC suggests that they say. For example, for all its reliance on the EPA HF Study, the Background Document fails to recognize that while the EPA HF Study noted a potential for some impact to drinking water sources caused by hydraulic fracturing, EPA confirmed that the overall incidence of actual impacts is low. This confirmed risk profile for HVHF operations is no different than the risk profile for other industries that the DRBC has allowed to take place within the Basin, including chemical and pharmaceutical manufacturing, wastewater treatment plants, and power plants.

Similarly, the Background Document cites the SRBC Water Use Study multiple times to argue that the volume of water required for use in HVHF operations and the amount of water that is "removed from the water cycle" as a result poses unacceptable risks to groundwater levels, surface water levels and stream flows in the Delaware River Basin. Once again, however, the Background Document fails to recognize the most important conclusion from the SRBC Water Use Study, namely that "[t]o date the Commission's monitoring programs have not detected discernable impacts on the quality of the Basin's water resources as a result of natural gas development…."[2] Moreover, concerns over potential impacts to the resources of the Susquehanna River Basin relating to the timing and location of water withdrawals have been and will continue to be adequately addressed through the SRBC's regulatory program, which includes low flow protection measures and other protective operative conditions.[3] The SRBC's experience and data indicate that the DRBC should continue with the efforts it had taken through 2011 to establish a regulatory program that utilizes DRBC's project review program to enforce standards that would allow for HVHF operations in the Delaware River Basin. Instead, however, the DRBC has incorrectly and inappropriately "cherry-picked" certain statements, as opposed to conclusions, contained in the Final SGEIS and the EPA HF Study (both of which are flawed) and the SRBC Water Use Study to support its arbitrary decision to prohibit HVHF operations in the Delaware River Basin.

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[1] For the DRBC's reference, HESI's comments on the EPA HF Study and the Final SGEIS are attached to this submission.

[2] SRBC Water Use Study, p.69

[3] *Id.* p. 68.

2. Extensive Information Regarding Hydraulic Fracturing Fluids is Readily Available and Promotes the Protection of Surface and Groundwater Resources

The Background Document prepared by the DRBC dedicates a section of that document to the use of chemical additives during the hydraulic fracturing process and how the DRBC believes such use justifies the prohibition of hydraulic fracturing activities in the Delaware River Basin. Rather than providing an in-depth risk assessment of these chemical additives to support its position, however, the DRBC instead cites general operational concerns over "spills" that are equally applicable to other chemical based industries currently operating within the Delaware River Basin. The DRBC's purported justification for banning HVHF in the Delaware River Basin based on concerns about "spills" and chemical usage, however, simply does not stand up under scrutiny. Virtually any type of human activity, ranging from chemical manufacturing to home improvements, involves the possibility of that chemicals may be spilled. If the litmus test for deciding whether a particular industry or activity should be allowed to exist in the Delaware River Basin is the possibility of "spills," virtually nothing would be permissible in the Delaware River Basin. Homes could not receive heating oil deliveries, individuals could not fuel their automobiles, farmers could not apply fertilizer to their fields, manufacturers could not lubricate their equipment or paint their products, and restaurants could not use deep fryers. Obviously, such a construction of DRBC's authority is absurd. And yet the oil and gas industry is being disparately treated apparently on such a basis.

Perhaps recognizing that these common operational concerns are not themselves sufficient to justify singling out the oil and gas industry for banishment, the DRBC ominously declares in this section of the Background Document that in some cases information about hydraulic fracturing chemicals "is considered Confidential Business Information and not disclosed by the fracturing operator." The claim that the identities of certain chemicals used in HVHF may be protected as trade secrets or CBI from general disclosure to the public, however, does little to advance DRBC's empty rationale. While the DRBC is correct that some chemical information qualifies as confidential business information ("CBI") under state laws, the implication that the treatment of such information as CBI prevents the oil and gas industry, regulators, and the public from accurately assessing any risks to surface and groundwater resources posed by these chemicals is simply incorrect. To the contrary, a framework of comprehensive chemical disclosure laws at the state and federal level, in combination with additional voluntary efforts by companies that go beyond existing legal requirements, means that an extensive amount of chemical information is readily available that is more than sufficient to demonstrate that any risks attributable the use of chemicals in hydraulic fracturing operations are quantifiable and low.[4]

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[4] If public disclosure of CBI or trade secrets is the predicate for doing business in the Delaware River Basin, as opposed to a defensible assessment of risk to surface and groundwater supplies, then the DRBC would need to ban the sale of Coca Cola and WD-40.

In Pennsylvania, for example, well operators are required under comprehensive revisions to the Pennsylvania Oil and Gas Act adopted in 2012 (commonly referred to as Act 13)[5] to post chemical-specific information regarding the constituents in the hydraulic fracturing fluid used to stimulate an unconventional well on a chemical disclosure registry.[6] To date, the chemical disclosure registry used for Pennsylvania HVHF wells is the FracFocus registry managed by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission. This information is publicly available on a well-by-well basis.[7] Although the precise identity or concentration of a chemical that qualifies as CBI does not need to be posted, Act 13 expressly provides that the chemical family or similar description associated with that CBI chemical must be posted.[8] Moreover, in accordance with Act 13, the Pennsylvania Department of Environmental Protection ("PADEP") has implemented a process by which service providers, like HESI, must provide PADEP with a coded list of all chemicals intentionally added to the hydraulic fracturing fluid for a well by name and chemical abstract service number, even if the service provider considers that information to qualify as CBI.[9] In this way, PADEP knows exactly what chemical additives are being used to stimulate a given well.

In addition to the detailed information available through FracFocus, each chemical additive used in hydraulic fracturing fluids must have a chemical safety data sheet ("SDS") in accordance with the requirements of the Hazard Communication Standard ("HCS") developed by the Occupational Safety and Health Administration.[10] The HCS is a broad set of regulatory requirements that applies across multiple industries and serves as a cornerstone for chemical disclosure. SDSs, which contain information pertinent to human health and environmental risks, are available to the public and are even posted on the web sites of certain chemical companies and service providers.[11] Even when the identity of a particular chemical ingredient or concentration in a chemical additive is protected as a trade secret, the SDS must provide information "concerning the properties and effects" of the chemical.[12] It is telling that DRBC's Background Document fails to acknowledge, much less utilize, any of these extensive sources of information regarding chemical additives used in HVHF operations in a section of the Background Document that purportedly serves to support a conclusion that the use of these chemicals in the Delaware River Basin poses such an unreasonable risk to surface and groundwater resources that HVHF should be categorically prohibited.

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[5] 58 Pa. Cons. Stat. Ann. §2301, et seq.

[6] *See* 58 Pa. Cons. Stat. Ann. § 3222.1(b)(2).

[7] FracFocus can be accessed at http://fracfocus.org. FracFocus currently includes lists of chemicals used in hydraulic fracturing operations for nearly 5,000 wells in Pennsylvania dating back to 2008. The site also contains a variety of general information about chemicals that are commonly used in hydraulic fracturing fluids.

[8] *Id.* § 3222.1(b)(3).

[9] *See* Pennsylvania Department of Environmental Protection Form 8000-FM-OOGM0132, *Registration of Trade Secret-Confidential Proprietary Stimulation Fluid Chemical Information*.

[10] 29 C.F.R. § 1910.1200(g)(2).

[11] *See, e.g.,* http://www.halliburton.com/en-US/tools-resources/safety/material-safety-data-sheet-search.page?node-id=hfci4043.

[12] *Id.* § 1910.1200(i)(1)(ii).

In addition to failing to provide a detailed review of available information about hydraulic fracturing chemical additives, the foregoing section of the Background Document mischaracterizes the statements on chemical risks set out in the EPA HF Study. The EPA HF Study states that while chemical additives generally make up the smallest portion of the overall composition of hydraulic fracturing fluids, they have the "greatest potential to impact the quality of drinking water resources compared to proppant and base fluids."[13] This conclusion, while worded suggestively, is not necessarily inaccurate on its face considering that proppants and base fluid are for the most part sand and water, respectively. The DRBC Background Document, however, inappropriately takes this statement a step further and asserts that chemical additives "pose a ***comparatively high risk*** to ground and surface water quality relative to proppants and base fluids." (emphasis added).[14] The phrase "comparatively high risk" is not used anywhere in the EPA HF Study and incorrectly implies that some type of objective risk analysis for hydraulic fracturing chemical additives has been performed by EPA or the DRBC. The decision to use this awkward sentence structure reflects a fundamental misunderstanding of the risk profile for hydraulic fracturing chemical additives and fails to support a decision to treat the oil and gas industry differently than other industries that use chemicals in the Delaware River Basin.

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In sum, HESI believes that the DRBC's proposal to prohibit HVHF operations in the Delaware River Basin is an extreme overreaction based upon either a misunderstanding or a misinterpretation of the most current and accurate information about the level of risk to surface water and groundwater sources from HVHF operations. This is not to say that HVHF should not be regulated. Protective regulations are important for both the oil and gas industry and the public. However, the proposed solution selected by DRBC – banning HVHF – is misguided and outside the bounds of DRBC's authority, particularly given the fact that the DRBC is treating no other activity in the same manner. Based upon HESI's experience in oil and gas plays throughout the United States and around the world, scientifically-based regulatory programs—akin to the program the DRBC had begun to develop as of 2011—are effective in allowing the public to reap the benefits of HVHF operations while simultaneously protecting surface and groundwater resources. Accordingly, HESI urges the DRBC to revisit its proposed prohibition of HVHF operations in the Delaware River Basin, treat the oil and gas industry like other industries currently in operation in the Delaware River Basin, and renew its efforts to develop a regulatory framework that will allow HVHF operations in the Delaware River Basin through use of the DRBC's project review program.

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[13] EPA HF Study 2016, Exec. Sum., p.16

[14] DRBC Background Document, p. 8

We very much appreciate the opportunity to provide these comments on behalf of HESI regarding the Proposed Special Regulations and would welcome the opportunity to discuss with the Commissioners and/or the DRBC staff opportunities to revise the Proposed Special Regulations to allow HVHF operations within the Basin.

Respectfully submitted,

Todd D. Kantorczyk
For MANKO, GOLD, KATCHER & FOX, LLP

TDK/tdk/10671-00022

cc: David Martin, Esquire
Michael M. Meloy, Esquire

Comments of Halliburton Energy Services Inc.
on EPA's Draft Assessment of the Potential Impacts of
Hydraulic Fracturing for Oil and Gas on Drinking Water Resources

Submitted by: **August 28, 2015**

Stuart H. Kemp
Senior Director, Health, Safety and Environmental
Law Practice Group
Halliburton Energy Services, Inc.
Building 4, 13th Floor
2107 CityWest Boulevard
Houston, TX 77042-3021

I. Introduction

Halliburton Energy Services, Inc. ("HESI") is a leading provider of services to the oil and gas industry and is a global leader with respect to hydraulic fracturing ("HF") services. HESI helped pioneer the use of HF in the 1940s and has been hydraulically fracturing wells in a wide variety of geographic settings and formations for over 60 years. During this time period, HESI has hydraulically fractured hundreds of thousands of wells, including both vertical and horizontal wells. At the same time, HESI has been at the forefront of industry innovations that have facilitated significant advances in oil and gas development. HESI has conducted extensive research and introduced new HF technologies that have increased oil and natural gas production and enhanced the efficiency of production.

HESI also has devoted substantial resources to developing HF technologies with important environmental benefits, such as (i) an HF fluid system that utilizes materials sourced from the food industry, (ii) HF additives that enhance the reuse of produced water as the base fluid for HF operations to reduce the volume of fresh water needed to perform the HF and to minimize disposal of waters from completion and/or production of the well, and (iii) a treatment system that uses ultraviolet light in lieu of conventional chemical biocides to control the growth of bacteria in fluids used during HF operations. In addition, HESI is an industry leader in fracture mapping using microseismic technology.

As an industry leader in HF activities, HESI is vitally interested in ensuring that the U.S. Environmental Protection Agency ("EPA") *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources* ("Study" or "Draft Assessment") has a sound scientific and technical basis. HESI has previously submitted comments on both the Agency's Study Plan and Progress Report and provided extensive information in response to the request for information EPA issued to a number of service companies as well as the November 2013 request for information to the general public. In addition, HESI representatives have participated in several of the Agency's technical workshops relating to the Study.

HESI has drawn on its wealth of experience and technical expertise to develop the following comments about the Draft Assessment. HESI requests that these comments be included in the administrative record for the Study.

II. Executive Summary

HESI recognizes that the Draft Assessment represents a significant undertaking by EPA. HESI appreciates the effort that the Agency has put into understanding the HF process and preparing the Draft Assessment.

HESI agrees with one of the major findings of the Draft Assessment, *i.e.*, that there is no evidence that HF operations have had widespread, systemic impacts on drinking water resources. HESI and others in the industry – not to mention state regulators – have maintained for years that there is no evidence that drinking water resources have been impacted by fracturing fluids. Moreover, this conclusion is certainly what HESI would have expected based not only on its decades of experience in undertaking HF operations but also on the research conducted by its consultant Gradient Corporation and others. For example, surface water and groundwater sampling from a number of basins around the country by the U.S. Geological Survey and others do not show any significant impact on water quality associated with HF activities. Gradient's work demonstrates that this is to be expected because:

- Fracturing fluids will not migrate upward any significant distance through the rock layers – many of them relatively impermeable – that lie between the production zone and the base of protected drinking water resources;
- As confirmed by extensive microseismic data, the vertical growth of the fractures created during the HF process is limited by a variety of factors, resulting in a general consensus that individual fractures will not reach drinking water sources;
- The same data show that natural faults will not provide a migration pathway for fracturing fluids; and
- Spills of HF fluids or flowback fluids potentially containing HF chemicals occur infrequently and when they do occur they are not expected to pose significant human health risks.

While finding that there is no evidence of widespread impacts on drinking water resources due to HF operations, the Draft Assessment also concludes that there are "potential mechanisms by which hydraulic fracturing could affect drinking water resources" and that there are specific instances where one or more of these mechanisms have led to contamination of drinking water wells and other impacts on drinking water resources.[1] However, HESI believes that the draft report overstates the potential for impacts via these mechanisms – or "vulnerabilities" as the Draft Assessment also describes them.

This is evident, for example, in EPA's discussion of the potential for impacts related to spills. In suggesting that the frequency of HF-related spills could range anywhere from 0.4 spills per 100 wells up to 12.2 spills, EPA seriously misrepresents the potential for spills of HF fluids. In fact, the state databases EPA reviewed provide strong evidence that the rate of spills of HF fluids is only about one in 100 wells. The Draft Assessment also overstates the potential for migration of fluids from these rare spill events and fails to acknowledge that the dilution and attenuation associated with such spills means that if and when HF chemicals in the spilled fluid reached a drinking water source they would not pose a significant risk to human health.

The overstatement of potential impacts is also evident in the Draft Assessment's discussion of possible subsurface migration pathways. The work of a variety of researchers – including not just Gradient but also others, such as the team from the Lawrence Berkeley National Laboratory ("LBNL") working for EPA – has shown that several of these pathways are highly unlikely or even implausible, particularly with respect to the migration of fracturing fluids. Indeed, there is no evidence of the migration of fracturing fluids into drinking water resources via any subsurface pathway. Thus, the potential for migration of fracturing fluids (and even methane) via (i) flow of fluids out of the production zone, (ii) fracture growth out of the

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[1] U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, at ES-23, External Review Draft (June 2015) ("Draft Assessment"), available at http://www2.epa.gov/hfstudy.

target formation, or (iii) the intersection of induced fractures with existing faults should be heavily discounted if not dismissed altogether. Moreover, the examples of impacts associated with another potential mechanism – failure of well casing or cement – generally involve methane, not HF fluids, reflecting the fact that methane is more mobile in the subsurface and HF fluids are not likely to migrate upward to reach drinking water aquifers even when wellbore integrity is compromised. Thus, the "potential mechanisms by which [HF] could affect drinking water sources" are not nearly as numerous as the Draft Assessment suggests.

Several factors further contribute to this overstatement of "vulnerabilities." First, the Draft Assessment does not clearly distinguish potential impacts that are directly related to HF operations from impacts that are more closely associated with other aspects of the process of constructing a well and producing oil and/or gas from it. HESI has expressed its concerns about this issue previously, noting the problem in its 2010 comments on EPA's study design and in its 2013 comments on the Progress Report. One example is the Agency's decision to lump spills of produced water – which is generated by all oil and gas wells regardless of whether they are hydraulically fractured and which consists of naturally-occurring formation water and is therefore not directly related to HF operations – together with spills of flowback, which contains some level of fracturing fluids. If EPA's goal is to "contribute[ ] to the understanding of the potential impacts of *hydraulic fracturing* on drinking water resources,"[2] the Agency is not advancing the ball by conflating impacts related to the HF process with impacts that have nothing to do with HF chemicals and are not a product of the HF process.

A second factor contributing to the overstatement of "vulnerabilities" is EPA's overly broad definition of drinking water resources. The Agency's definition is so broad it could apply to any surface water body or any groundwater regardless of whether the surface water or groundwater could realistically serve as a source of drinking water any time in the foreseeable future. Adopting such a broad definition may result in the study assessing potential resource impacts that pose no real risk to human health.

Another factor is the failure of the Draft Assessment to place these "vulnerabilities" in a more appropriate context by acknowledging that state regulatory programs are in place to address these issues. For example, state regulators have long had requirements in place regarding casing and cementing of wells and related measures to ensure well integrity, and these programs are continuing to evolve. Finally, EPA should acknowledge the extent to which members of the public are exposed to many of the chemicals at issue on a routine basis with no apparent health concerns. As a result of these and other factors, the Draft Assessment overstates the extent and significance of many of the "vulnerabilities" it identifies. A more realistic view of these "vulnerabilities" would lead to the conclusion that the absence of evidence in this case really does mean an absence of widespread impacts.

The Draft Assessment further undermines – without justification − its finding of no evidence of widespread HF impacts by asserting there exists insufficient data to properly assess the impacts of HF chemicals on drinking water resources and a lack of relevant water quality data. EPA suggests that this purported lack of information could mean that there are widespread impacts to drinking water resources that simply haven't been identified yet. However, these

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[2] *Id*. at ES-24 (emphasis added).

alleged "data gaps" are likewise overstated. For example, in assessing the hazards of chemicals used in HF operations, EPA chose to use data sources that resulted in the Agency being able to assess the toxicity of a limited number of chemicals. However, additional sources of reliable data that would be suitable for this type of assessment are readily available. Moreover, a growing body of surface and groundwater quality data already exist which demonstrate that HF operations have not impacted drinking water resources to any significant extent. Therefore, the Draft Assessment misstates the degree of uncertainty surrounding assessments of potential HF impacts.

In short, HESI believes that EPA is absolutely correct in concluding that there is no evidence that HF operations have had a widespread, systemic effect on drinking water sources. Moreover, based on extensive evidence and its own decades of experience, HESI believes that there is no evidence of such impacts because they have not in fact occurred. While there is potential for impacts to occur through some mechanisms such as surface spills, the Draft Assessment overstates their scope and significance. Accordingly, in finalizing the Assessment EPA should take steps to clarify the mechanisms by which HF operations themselves – as opposed to other aspects of oil and gas operations – have the potential to impact drinking water resources, to more accurately describe the potential for these mechanisms to lead to impacts and to put these purported "vulnerabilities" in a more appropriate context. As it stands, the Draft Assessment risks contributing to the confusion and misinformation that has characterized much of the public discourse concerning hydraulic fracturing.

III. The Conclusion That HF Has Not Had Widespread Impacts On Drinking Water Resources Is Well Supported

HESI agrees with the conclusion set forth in the Draft Assessment that there is no evidence of widespread, systemic impacts on drinking water resources in the United States from HF operations.[3] In fact, federal and state regulators for years have stated that there is no confirmed evidence that HF operations have resulted in any contamination of drinking water with fracturing fluids.

- As EPA knows, its 2004 study of allegations of contamination from hydraulic fracturing of coalbed methane ("CBM") wells "did not find confirmed evidence that drinking water wells have been contaminated by hydraulic fracturing fluid injection into CBM wells."[4]

- Former EPA Administrator Lisa Jackson stated in testimony before the House Committee on Oversight and Government Reform that she was "not aware of any water contamination associated with the recent drilling" in the Marcellus Shale.[5]

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[3] *Id*. at ES-6.

[4] U.S. EPA, *Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs*, ES-1 (2004), available at http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm.

[5] *Pain at the Pump: Policies that Suppress Production of Oil and Gas*, Hearing Before the H. Comm. on Oversight & Gov't Reform, Rep. No. 112-54, 87 (May 24, 2011), available at http://www.gpo.gov/fdsys/pkg/CHRG-112hhrg70675/pdf/CHRG-112hhrg70675.pdf.

- U.S. Department of Energy Secretary Ernest Moniz made remarks to the press on August 1, 2013 that, "to my knowledge, I still have not seen any evidence of fracking per se contaminating groundwater."[6]

- In 2012, regulators from a number of states – including Arkansas, Colorado, Louisiana, North Dakota, Ohio, Oklahoma, Pennsylvania and Texas – confirmed to the U.S. Government Accountability Office that, based on state investigations, the hydraulic fracturing process had not been identified as a cause of groundwater contamination in their states.[7]

- In 2009, regulatory officials from 15 states likewise confirmed that they were unaware of any contamination of drinking water aquifers in their states as a result of HF operations.[8]

- In 1998 the U.S. Ground Water Protection Council surveyed 25 state agencies responsible for oil and gas development and found that there was not a single substantiated claim of contamination of drinking water supplies attributable to hydraulic fracturing.[9]

- The Interstate Oil and Gas Compact Commission ("IOGCC") surveyed its state regulatory agency members in 2002 and found that nearly one million wells had been hydraulically fractured over the course of several decades but again found no evidence of substantiated claims of contamination of drinking water supplies due to hydraulic fracturing.[10]

In the face of this long line of declarations from regulatory officials, the Draft Assessment cites only a handful of examples of impacts to drinking water resources, all of which involve well integrity issues or surface spills.

It comes as no surprise to HESI that there is no evidence of widespread impacts to drinking water resources resulting from HF operations because there have been no such impacts. This conclusion is consistent with HESI's general experience as a global leader and innovator in HF services, as well as HESI's understanding of existing research conducted on the risks and impacts associated with HF.

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[6] *See* http://thehill.com/blogs/e2-wire/e2-wire/315009-energy-secretary-natural-gas-helps-battle-climate-change-for-now.

[7] U.S. GAO, *Information on Shale Resources, Development and Environmental and Public Health Risks*, 49 (Sept. 2012), available at http://www.gao.gov/assets/650/647791.pdf.

[8] New York State Department of Environmental Conservation, *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program*, 6-47 (2011), available at http://www.dec.ny.gov/energy/75370.html.

[9] Ground Water Protection Council, *Survey Results on Inventory and Extent of Hydraulic Fracturing in Coalbed Methane Wells in the Producing States* (1998), available at http://energyindepth.org/docs/pdf/hydraulic-fracturing-inventory.pdf.

[10] IOGCC, *States Experience with Hydraulic Fracturing: A Survey of the Interstate Oil and Gas Compact Commission* (2002), available at http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Interstae_Oil_Gas_Compact_Commission_States_Experience_w_Hydraulic_Fracturing_2002.pdf.

For example, Gradient has undertaken a detailed analysis of the use of HF fluids and their potential impact on drinking water. Gradient's 2013 *National Human Health Risk Evaluation*, which was cited in the Draft Assessment, demonstrates that subsurface migration from tight formations through induced fractures, existing faults or formations is not a concern.[11] As discussed in the *National Human Health Risk Evaluation* and as further elaborated in two peer-reviewed papers (also cited in the Draft Assessment),[12] Gradient determined that once the fracturing fluids are pumped into a tight formation, it is simply not plausible that the fluids would migrate upwards from the target formation through several thousand feet of rock to contaminate drinking water aquifers.[13] Accordingly, the report concludes that the fluids pumped into a target formation as part of the HF process do not present a risk to human health.[14] In addition, as discussed in greater detail below, Gradient's research found that surface spills are not expected to result in significant human health impacts.

A number of other studies likewise support the conclusion that HF has not led to impacts on drinking water resources:

- A U.S. Geological Survey ("USGS") analysis of 21 private drinking water wells in northeastern Pennsylvania where homeowners suspected that their well water was contaminated by flowback fluids indicated that in fact none of the wells was contaminated by flowback fluid associated with HF operations.[15]

- A group of USGS scientists who evaluated national USGS surface water data in an attempt to detect trends in surface water quality in regions of oil and gas development found no consistent trends in water quality in areas with increasing unconventional oil and gas development.[16]

- USGS researchers studying water quality in the Monongahela River Basin where shale gas exploration has occurred for eight years compared recent water samples with historical samples and found no significant difference in groundwater quality.[17]

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[11] Gradient, *National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives* (May 1, 2013) ("NHHRE"), available at http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=53a41a78-c06c-4695-a7be-84225aa7230f.

[12] Flewelling, SA; Sharma, M., "Constraints on upward migration of hydraulic fracturing fluid and brine," *Ground Water* 52: 9-19 (2014), available at http://dx.doi.org/10.1111/gwat.12095; Flewelling, SA; Tymchak, MP; Warpinski, N., "Hydraulic fracture height limits and fault interactions in tight oil and gas formations," *Geophys Res Lett* 40: 3602-3606 (2013), available at http://dx.doi.org/10.1002/grl.50707.

[13] NHHRE at ES-4.

[14] *Id*. at ES-5.

[15] Reilly *et al*., "Identification of local groundwater pollution in northeastern Pennsylvania," *Environ Earth Sci* (Jan. 3, 2015), available at http://link.springer.com/article/10.1007%2Fs12665-014-3968-0#.

[16] Bowen *et al*., "Assessment of Surface Water Chloride and Conductivity Trends in Areas of Unconventional Oil and Gas Development - Why Existing National Datasets Can't Tell Us What We Would Like to Know," *Water Resources Research* (Jan. 30, 2015), available at http://onlinelibrary.wiley.com/doi/10.1002/2014WR016382/abstract.

[17] Chambers *et al*., *Water Quality of Groundwater and Stream Base Flow in the Marcellus Shale Gas Field of the Monongahela River Basin, West Virginia*, 2011–12, USGS Report 2014-5233 (Apr. 2015), available at http://pubs.usgs.gov/sir/2014/5233/. Researchers also analyzed groundwater methane concentrations in northeastern Pennsylvania and found no relationship between methane concentrations in drinking water wells and proximity to

- Another paper recently published by USGS researchers found that water samples collected from 30 randomly distributed domestic wells in 2013 in the area of the Bakken Formation in Montana and North Dakota gave no indication that energy development activities affected groundwater quality.[18]

- USGS published a report in January 2013 regarding the results of an analysis of water samples from 127 drinking water wells representing the western third of the Fayetteville Shale.[19] The study used two comparative analysis methods to identify potential impacts to water quality from gas production activities in the area and found no evidence of migration of gas production fluids into the shallow groundwater.[20]

- Researchers from the National Energy Technology Laboratory ("NETL") published a paper and report regarding a study of HF operations at a Marcellus Shale well site in Greene County, Pennsylvania.[21] The researchers took samples from Upper Devonian/Lower Mississippian wells at depths of up to about 4,400 feet below ground surface both before and up to 14 months after fracturing of the deeper Marcellus (at depths of about 8,000 feet). The study found no compelling evidence that the shallower wells – which were still about 4,000 feet below drinking water aquifers – were affected by any upward migrating fluids from the Marcellus over the study period.[22] Indeed, the researchers found that there was no evidence of migration of gas from the Marcellus to the shallower wells over the 14 months.[23]

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natural gas wells. Siegel et. al, (Mar. 2015) Methane Concentrations in Water Wells Unrelated to Proximity to Existing Oil and Gas Wells in Northeastern Pennsylvania, *Environ. Sci. Technol*, available at http://pubs.acs.org/doi/abs/10.1021/es505775c.

[18] McMahon *et al*., Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota, *Groundwater* Vol. 53 (2015), available at http://www.ncbi.nlm.nih.gov/pubmed/25392910.

[19] Kresse, *et al*., *Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-Production Area, North-Central Arkansas*, U.S. Geological Survey Scientific Investigations Report 2012-5273 (Jan. 2013), available at http://pubs.usgs.gov/sir/2012/5273/sir2012-5273.pdf.

[20] *Id*. at 28.

[21] U.S. Department of Energy, National Energy Technology Laboratory, *An Evaluation of Fracture Growth and Gas/Fluid Migration as Horizontal Marcellus Shale Gas Wells are Hydraulically Fractured in Greene County, Pennsylvania*, NETL-TRS-3-2014 (Sept. 15, 2014) ("NETL Study"), available at http://www.netl.doe.gov/File%20Library/Research/onsite%20research/publications/NETL-TRS-3-2014_Greene-County-Site_20140915.pdf.

[22] Kohl, *et al*., "Strontium Isotopes Test Long-Term Zonal Isolation of Injected and Marcellus Formation Water after Hydraulic Fracturing," *Environ. Sci. Technol.* 48, 9867-9873 (July 2014), available at http://pubs.acs.org/doi/abs/10.1021/es501099k.

[23] Sharma *et al*., "Assessing changes in gas migration pathways at a hydraulic fracturing site: Example from Greene County, Pennsylvania, USA," *Appl. Geochem* (2014), available at http://dx.doi.org/10.1016/j.apgeochem.2014.07.018. Another recently released study of the presence of methane in 113 drinking water wells in Pennsylvania and Texas reached essentially the same conclusion, with the authors finding that "our data do not suggest that horizontal drilling or hydraulic fracturing has provided a conduit to connect deep Marcellus or Barnett Formations directly to surface aquifers." Darrah *et al*., "Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales," *Proceedings of the National Academy of Sciences* (2014), available at http://www.pnas.org/content/111/39/14076.abstract.

- The Susquehanna River Basin Commission issued its Data Report of Baseline Conditions for 2010-2013 in June 2015, which reported on monitoring of small, headwater streams that would potentially be impacted by unconventional natural gas drilling. The report found that conductance and turbidity had not changed over the monitored years, there was no correlation between well pad density and stream temperature or well distance and biotic integrity, and very few water samples exceeded water quality levels or levels of concern.[24]

These research findings are consistent with actual HF operational data. For example, an October 2012 report regarding HF operations in the Inglewood Oil Field in the Baldwin Hills area of Los Angeles County showed that, based on actual monitoring results, the groundwater quality in the area was not affected by HF activities.[25] Moreover, microseismic monitoring showed that most of the induced fractures were contained within the target formation, and that the few fractures that were outside the target formation did not contain any proppant and therefore would have closed back up once the HF operation was completed.[26]

In light of the above, there is a general consensus among regulations and experts that the risk of contamination of drinking water by HF chemicals through subsurface migration of fluids from the target formation is not, in fact, significant. This emerging consensus is reflected in a report issued by Resources for the Future setting forth the results of a survey of 215 experts from state and federal regulatory agencies, academia, non-governmental organizations and industry regarding the "priority environmental risks related to shale gas development."[27] The experts were asked to identify priorities from among 264 potential "risk pathways" for both routine operations and accidents. The report states that "almost every priority routine pathway that garnered broad attention from experts has to do with risks present in most drilling operations or with the disposal of waste produced by fracturing, not with the actual hydraulic fracturing process itself."[28] The report further states that with respect to "pathways involved with the fracturing process and its effect on groundwater, only the flowback of reservoir fluids breaks any groups' top 20 most selected pathways."[29] As for accidents, the report indicates that all groups (regulators, academia, non-governmental organizations ("NGOs") and industry) shared the same top two priorities, *i.e.*, casing failure and cementing failure.[30] In short, those most knowledgeable about the actual risks posed by shale development – including those affiliated with NGOs – do not view the HF process itself as a primary concern.

This consensus was noted in the July 2014 Maryland Department of the Environment ("MDE") and Department of Natural Resources ("DNR") Marcellus Shale Safe Drilling Initiative's report on best practices, which found that "[t]he available scientific evidence

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[24] Susquehanna River Basin Commission, *Data Report of Baseline Conditions for 2010 — 2013*, Pub. No. 297 (June 2015), available at http://www.srbc.net/pubinfo/techdocs/publications/techreports.htm.

[25] Cardno Entrix, *Hydraulic Fracturing Study: PXP Inglewood Oil Field* (Oct. 2012) ("Inglewood Study"), available at http://www.inglewoodoilfield.com/fracturing-study/.

[26] *Id*.

[27] Resources for the Future, *Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development* (Feb. 2013), at 1, available at http://www.rff.org/research/publications/pathways-dialogue-what-experts-say-about-environmental-risks-shale-gas.

[28] *Id*. at 26.

[29] *Id*.

[30] *Id*. at 36.

indicates that the possibility that fracturing fluids would migrate upward through the overlying rock formations to reach drinking water is extremely remote."[31] The report cites the consensus reached by geologists from MDE, DNR, and USGS that "it is unlikely that fractures induced in the Marcellus shale in Maryland would continue to propagate to any great distance in an upward direction after the hydraulic fracturing pressure is released to form a pathway for the migration of methane or fracking fluid" and lists several bases for the consensus.[32]

In addition, the California Council on Science and Technology, LBNL and the Pacific Institute issued a study conducted for the U.S. Bureau of Land Management regarding the use of HF and other well stimulation technologies in California.[33] The study found that where the target formation is more than 2,000 feet below the overlying aquifers, the creation of migration pathways as a result of HF operations seems unlikely.[34] The report noted that most studies comparing baseline trends to post-stimulation measurements have not found any statistically significant changes in water quality in nearby drinking water wells.[35] The study concludes that the primary impacts to California's environment from well stimulation activities will be indirect impacts due to increases in oil and gas production, not impacts due to well stimulation itself.[36] Other governmental studies across the world likewise continue to conclude that the HF process poses little risk to human health or the environment.[37]

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[31] Maryland Department of the Environment and Maryland Department of Natural Resources, *Marcellus Shale Safe Drilling Initiative Study Part II Interim Final Best Practices*, C-33 (July 2014) available at http://www.mde.state.md.us/programs/land/mining/marcellus/pages/index.aspx.

[32] *Id*. at C-88-91. In January 2015, the Maryland Department of the Environment and Department of Natural Resources followed the report with a joint Risk Assessment for Unconventional Gas Well Development in the state that concluded that the risks of impact to groundwater from saline intrusion during drilling of vertical and lateral wellbore or due to casing and cement failure to be low. The assessment stated that "the best practices for casing and cement reduce the risk of casing and cement failures." In addition, based on a literature review and the best management practices available, the risk of impact to groundwater through fracturing fluids and mobilized substances through faults and old wells was also found to be low. Maryland Department of the Environment and Maryland Department of Natural Resources, *Assessment of Risks from Unconventional Gas Well Development in the Marcellus Shale of Western Maryland*, Appx. H (Jan. 20, 2015), available at http://www.mde.state.md.us/programs/Land/mining/marcellus/Pages/Risk_Assessment.aspx.

[33] California Council of Science and Technology *et al*., *Advanced Well Stimulation Technologies in California: An Independent Review of Scientific and Technical Information*, 234-37 (Aug. 28, 2014) ("CCST California Study"), available at http://ccst.us/projects/fracking_public/BLM.php/.

[34] *Id*. at 36.

[35] *Id*. at 233.

[36] *Id*. at 42.

[37] See, e.g., United Kingdom Parliament, House of Commons, Energy and Climate Change Committee, *Fifth Report: Shale Gas* (May 10, 2011), available at http://www.parliament.uk/business/publications/committees/recent-reports/cmenergy-795-5th-rpt1/; (hydraulic fracturing itself does not pose a direct risk to water aquifers, provided that the well casing is intact before this commences); The Royal Society, Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, 33 (June 2012), available at http://royalsociety.org/policy/projects/shale-gas-extraction/report/; Government of New Zealand Taranaki Regional Council, *Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region* (May 2012), available at http://www.trc.govt.nz/hydraulic-fracturing/; Government of New Zealand, Parliamentary Commissioner for the Environment, *Evaluating the environmental impacts of fracking in New Zealand: An interim report* (Nov. 2012), available at http://www.pce.parliament.nz/publications/all-publications/evaluating-the-environmental-impacts-of-fracking-in-new-zealand-an-interim-report/; AMEC Environment & Infrastructure UK Limited, Department of Energy and Climate Change, *Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing*, 96 (Dec. 2013), available at

Thus, there is ample support for the conclusion that HF operations have not had any meaningful impact on drinking water resources. In fact, to the extent that any such impacts have occurred they have been very infrequent and have resulted from particular incidents involving surface spills or well integrity issues that have led to highly localized effects.

IV. A Number of the "Vulnerabilities" Are Overstated

The other major finding of the Draft Assessment is that, despite the lack of evidence of widespread impacts to drinking water resources due to HF operations, there are mechanisms by which HF operations have the potential to impact drinking water resources and that there are specific instances where one or more of these mechanisms have led to contamination of drinking water wells and other impacts.[38] However, the Draft Assessment overstates many of the "vulnerabilities" it identifies with respect to HF. In particular, the spill rates identified by EPA as being related to HF operations are overstated and not put in the proper context. In addition, the Draft Assessment exaggerates the potential for exposure associated with many of the subsurface pathways identified by EPA.

A. The Potential For Spills of HF Fluids to Affect Drinking Water Resources Is Much Lower Than Is Suggested by the Draft Assessment

1. The Identified Spill Rates Are Inaccurate and Misleading

One of the primary mechanisms identified by EPA by which HF activities can affect drinking water is through spills of fluids used in HF operations. While spills of HF-related fluids certainly can occur on well pads, the spill rates identified by EPA in the Draft Assessment are substantially overstated. In particular, EPA states that estimated spill rates in Pennsylvania are between 0.4-12.2 spills for every 100 wells.[39] This range is highly misleading for several reasons.

The upper end of this range − 12.2 spills for every 100 wells − comes from a study by Rahm *et al*. that used the Pennsylvania Department of Environmental Protection ("PADEP") environmental violation database as a source.[40] However, the Rahm study included spills involving a variety of well pad activities, including spills related to activities such as site preparation and construction, well drilling and post-completion activities. For purposes of the Draft Assessment, EPA's focus should be on spills that are related to the HF process. Because the primary concern with respect to the HF process is the chemicals involved, EPA should focus on spills involving the chemicals used in HF fluids. This would include spills of HF additives, HF fluid mixtures, or flowback (which might contain some residual HF chemicals).

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https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/273997/DECC_SEA_Environmental_Report.pdf; Cape Breton University, *Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing*, 178 (Aug. 28, 2014), available at http://energy.novascotia.ca/oil-and-gas/onshore/hydraulic-fracturing-review ("it is recognized that the risk to water quality from shale gas operations is more related to operational practices (*e.g.*, chemical handling, waste management) rather than the fracturing and extraction process.").

[38] Draft Assessment at ES-6.

[39] *Id*. at ES-11, 5-49.

[40] *Id*. at 5-49.

Gradient has recently undertaken a detailed analysis of the same PADEP database used by Rahm *et al*. However, Gradient took its analysis a step further than Rahm and separated out spills involving HF chemicals. Gradient concluded that the spill rate for HF fluids and additives was 1 in 100 wells, or 1%.[41] This is comparable to the 1% spill rate that EPA found for Colorado.[42] Gradient also considered spills of flowback and found that the spill rate for any fluid potentially containing HF chemicals – HF additives, HF fluids or flowback – is about 2.3%, which is still far less than 12.2%.

EPA's own spill database supports the conclusion that spill rates involving HF chemicals are low. The Draft Assessment states that out of 24,000 spills whose source can be determined, there were 151 spills of chemicals, additives, or fracturing fluid.[43] The supplemental Spills Report shows that out of the 24,000, there were 88 spills from sources that should not be considered HF-related for purposes of the Draft Assessment − frac water, hydrocarbons, equipment fluids and "unknown."[44] Finally, there were 225 spills of flowback and produced water. Produced water also should not be considered HF-related; it does not contain HF chemicals and in fact is found at wellsites that do not have HF operations. A review of state enforcement records for some of the spills from the EPA database shows that these spills occurred after HF operations were completed and involved produced water spills unrelated to HF operations:

- EPA line no. 316 (Centre County, Rush Township; 3/18/2010; Violation ID 584008; Enforcement ID 256480) – The Comments section in the PADEP enforcement database states that "Well drilling was completed on 4/19/2009. Fracing was completed on 8/24/2009. Well is completed and not yet in production. Site ID is still in place, no well tag in place. The site is permanently stabilized. Two pits containing production fluids and precipitation remain on site. The front most pit had overtopped slightly. The fluids from the pit have only traveled about 3' across the ground

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[41] Flewelling *et al*., "Evaluation of Human Health Risks via Drinking Water for Aboveground Spills of Hydraulic Fracturing Fluids," (in prep) (2015), ("Flewelling *et al*. 2015"). EPA also cites to Gradient's 2013 *National Human Health Risk Evaluation* for its identified spill rate of 3.3 spills for every 100 wells. Draft Assessment at 5-49. In the 2013 report, Gradient used the number of spills reflected in the PADEP violations database from 2009-2012 compared to the number of wells installed in the Marcellus Shale in Pennsylvania during that time. Gradient noted that "[t]his spill frequency is likely a conservative (upper estimate) interpretation of the data, as it includes all spills in the PADEP database, even though some materials spilled were not identified as HF or flowback fluids (*e.g.*, hydraulic oil)." NHHRE at ES-8. However, the more recent Flewelling *et al*. report refined this analysis as described above and has determined that the proper spill rate for Pennsylvania is approximately 1%.

[42] EPA's Spill Report indicates that this 1% rate is for "HF-related" spills, although it is not clear exactly what this encompasses. If this rate includes only HF fluids and additives, it is consistent with the Pennsylvania spill rate. If the Colorado rate cited by EPA covers more types of fluids, then the actual spill rate for HF fluids and additives in Colorado would be lower than 1%.

[43] Draft Assessment at 5-42.

[44] EPA, *Review of State and Industry Spill Data: Characterization of Hydraulic Fracturing-Related Spill*, 14, Table 4 (May 2015) ("EPA Spill Report"). Spills of water to be used in an HF operation would not include HF chemicals and would not have any impact on human health. Spills of "hydrocarbons" likely involve spills of oil and would not be directly related to HF operations. "Equipment fluids" such as hydraulic fluids, while potentially related to HF in the sense that they could come from equipment used in the HF process, do not involve HF fluids and are not really the focus of concern. These types of leaks and spills occur in virtually all industrial operations. In any event, they are generally small and confined to the well pad.

surface." Thus, this spill took place over six months after HF operations had ended and involved produced water.

- EPA line no. 369 (Lycoming County, Penn Township; 4/02/2012; Violation ID 636114; Enforcement ID 282356) – The Comments section for this spill refers to "Control of produced fluids."
- EPA line no. 358 (Sullivan County, Fox Township; 11/21/2011; Violation ID 628404; Enforcement ID 278999) – The Comment section for this spill stated that "On the side of the wells near the fill slope high conductivity puddles occur. Sample analysis 2371 165 shows that this is production water on the pad approximately 1 month after fracing completed."

Assuming that half the spills in this category of 225 spills are flowback and half are produced water,[45] that would leave approximately 113 spills of flowback that are actually related to HF operations. Therefore, out of the 24,000 spills in EPA's database whose source or type could be determined, only 264 are HF-related in the sense that they could involve the chemicals used in HF. Thus, the state data indicate that the spill rate for fluids that may contain HF chemicals may be in the range of 1-2% but in any event all available data – including EPA's own database – show that spills involving HF chemicals are certainly far less common than the 12.2% suggested as a possibility by EPA.

2. The Draft Assessment Fails to Put Spills That Do Occur in the Proper Perspective

In addition to overstating the potential for HF-related spills, EPA's discussion of spills in the Draft Assessment fails to put these spills in the proper perspective, given that spills do not pose a significant risk to human health from a drinking water resources perspective. At the outset, EPA should acknowledge that a significant portion of spills do not pose any threat to human health or the environment because they are contained and/or remediated upon occurrence.[46] Containment measures are standard industry practice and are typically required by state regulations. As noted in Gradient's 2013 *National Human Health Risk Evaluation*, spills associated with exploration and production ("E&P") operations would typically be contained within required measures such as containment berms and protective barriers and would only run off the wellpad in limited instances.[47]

In addition, EPA mischaracterizes significant aspects of chemical fate and transport such as co-solvency and log K_{ow} values and fails to consider other key factors affecting fate and transport such as the small volumes and diluted chemical concentrations associated with HF spills. For example, as Gradient notes, EPA claims that co-solvency could enhance migration, but EPA's cited references all acknowledge that co-solvent concentrations must be very high for

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[45] A 50% figure is conservative. Gradient's analysis of the PADEP database showed that out of a total of 209 spills of flowback and brine or produced fluid, 87 (41%) were spills of flowback.

[46] Gradient's analysis of the PADEP database showed that, of the 54 spills of HF additives of HF fluid for which sufficient information was available, only five (11%) were not at least partially contained and/or remediated and 24 (55%) were fully contained.

[47] NHRRE at 8, 20, *supra* note 11; Flewelling *et al.* 2015, *supra* note 41.

this to occur. Co-solvent concentrations in HF fluids are far too low to enhance migration of HF chemicals via co-solvency.[48]

Moreover, EPA says a bias toward high K_{ow} values indicates that HF chemicals would be a long-term source of impacts to drinking water resources, but its method for estimating K_{ow} values is flawed. In EPISuite log K_{ow} values are estimated using a program called K_{ow}WIN. However, as Gradient notes the regression relationships used by K_{ow}WIN were developed over a limited range of log K_{ow} values (*i.e.,* -4.2 to 8.2), but the EPA study used K_{ow}WIN to estimate log K_{ow} values well outside of this range (*i.e.*, -23.2 to 22.6). Hence, many of the log K_{ow} values estimated by EPA are unreliable.[49] For example, all 20 of the chemicals the Draft Assessment identified as having the highest mobility and 16 out of 20 chemicals identified as having lowest mobility had estimated log K_{ow} values outside the range where K_{ow}WIN can be reliably used.[50] Moreover, prior reviews of K_{ow}WIN by EPA's Science Advisory Board ("SAB") had warned EPA that log K_{ow} values predicted by K_{ow}WIN outside the range for which the model was validated are uncertain and of limited utility.[51] EPA should have heeded the SAB's advice and not relied on model predictions from K_{ow}WIN that were beyond the range of the validated model.

EPA also fails to consider the effects of small spill volumes and chemical concentrations on chemical fate and transport. Instead, EPA assumes that any spill, regardless of volume and the concentrations of chemicals present, could be a potential concern for drinking water quality. This assumption is unsubstantiated and at odds with the fact that HF fluids are generally dilute solutions and spills tend to be small in volume.[52] In fact, EPA itself reports that a majority of HF-related spills resulted in a release of 1,000 gallons or less.[53] Dilute solutions of chemicals migrate very differently from pure-phase chemicals. Even using the unreliable high K_{ow} values described above, given the generally small volumes associated with HF-related spills, a high K_{ow} would mean that a significant quantity of chemical would partition to organic carbon in shallow soils and migration would be slow. This would mean that HF chemicals may never reach downgradient receptors at concentrations of consequence. Other fate and transport processes, such as degradation, would also further reduce the potential for migration of chemicals at concentrations potentially relevant to human health. For example, a recent study demonstrated that most HF-related compounds would degrade to concentrations below EPA MCL drinking water standards before reaching the edge of typical well pads.[54] Without considering concentrations and spill volumes, EPA has no basis for suggesting that spills could create an adverse effect on drinking water resources.

While HESI understands that EPA does not intend to undertake a formal risk assessment, an effort to take account of volume, concentration and basic fate and transport characteristics such as dilution would put spill data in a more appropriate context. Gradient's 2013 *National*

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[48] *See attached* Gradient Corp., *Comments on EPA Study "Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources"*, at 2.2.3 (Aug. 28, 2015) ("Gradient Comments").

[49] *See attached* Gradient Comments at 2.1.

[50] Draft Assessment, Tables 5-7, 5-8.

[51] *See attached* Gradient Comments at 2.1.

[52] NHHRE at 45, *supra* note 11; Flewelling *et al*. 2015, *supra* note 41.

[53] EPA Spill Report at 11, *supra* note 44.

[54] *See attached* Gradient Comments at 2.2.2 (citing Rogers *et al*., 2015).

Human Health Risk Evaluation report and the new Flewelling *et al.* paper described above both used available data to develop a distribution of potential spill volumes. Taking into account the initial concentrations of chemical constituents in the spilled fluids and using conservative assumptions regarding distance to drinking water resources and other parameters, Gradient considered the effects of dilution in the course of fluid migration to characterize potential concentrations of HF- and flowback-related constituents in surface and subsurface drinking water in the event of an HF-related spill. These studies both found that HF-related spills do not present a significant risk to human health via impacts on drinking water resources. An analysis such as the 2013 study undertaken by Gradient – even using a subset of chemicals − is well within the scope of EPA's study and would demonstrate that the potential for impacts to drinking water is low.

Finally, EPA would put the risk associated with surface spills in a more appropriate context by acknowledging that spills accompany virtually all types of industrial activity. By recognizing the potential for spills and taking steps to minimize their frequency and manage their consequences, the oil and gas industry has limited the potential for HF-related spills to affect drinking water resources.

B. The Draft Assessment Overstates the Potential for Exposure Associated With a Number of the Subsurface Pathways

Surface spills is not the only area where the Draft Assessment casts the potential for HF-related impacts in an overly negative light. The Draft Assessment also concludes that there are a number of potential subsurface pathways for impacts on drinking water. The report states that "the potential for these pathways to exist or form has been investigated through modeling studies that simulate subsurface responses to [HF], and demonstrated via case studies and other monitoring efforts" and that "the development of some of these pathways – and fluid movement along them – has been documented."[55] However, the Draft Assessment overstates the potential for impacts to drinking water resources associated with these subsurface pathways in a number of significant respects.[56]

First, the potential for migration of fluids via a number of the pathways identified by EPA is very low. One prominent example of this is the potential for migration "out of the production zone via flow through the formation."[57] The Draft Assessment acknowledges that in deep, low permeability formations where the substantial majority of HF operations occur, this is considered an unlikely pathway.[58] Yet "unlikely" suggests some reasonable possibility that this type of migration might actually occur and misrepresents the consensus of the scientific community. In fact, the only source cited in the Draft Assessment as suggesting that this may be a viable pathway under any conditions is the paper by Myers. However, as the Draft Assessment recognizes[59] and as discussed further in the attached Gradient Comments,[60] Myers' analysis has

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[55] Draft Assessment at 6-51.

[56] *See attached* Gradient Comments at 3.3.1.

[57] Draft Assessment at 6-31.

[58] *Id*.

[59] Myers, T., "Potential contaminant pathways from hydraulically fractured shale to aquifer," *Ground Water* 50:872-882 (2012), available at http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.2012.00933.x/abstract.

been widely criticized within the scientific community as overly simplistic and lacking grounding in actual subsurface conditions.[61] As stated by Saiers and Barth, "Myers' modeling framework neglects critical hydrologic processes, misrepresents physical conditions that drive groundwater flow, and is underpinned by simplifications that are too severe and unnecessary."[62]

The Draft Assessment cites Myers' responses to these criticisms, but these responses also do not stand up to scrutiny:

- Myers claims that these many criticisms do not prove his hypothesis wrong but instead highlight the need for complex three-dimensional modeling and collection of data. However, the LBNL team has undertaken exactly the kind of modeling described by Myers, and their results provide no support for Myers' thesis. Moreover, as discussed above, significant data have been collected since Myers' paper was written – including the data collected by NETL at its Greene County test site – and these data likewise do not support Myers' position.

- Myers questions the ability of the Marcellus Shale to imbibe all the fluid pumped into it as part of HF operations, but as Gradient demonstrates, the available pore space far exceeds the HF fluid volumes.[63]

- Myers claims that migration of fluids into overlying formations may be facilitated by existing faults or by induced fractures growing out of the production zone. However, as discussed below, neither of these mechanisms provides the basis for the type of upward fluid migration suggested by Myers.

Therefore, Myers' paper does not provide a credible basis for concluding that migration through the formation is a plausible pathway.

In fact, there are a number of significant constraints on fluid movement that – particularly when considered in combination – lead to the conclusion that migration of fluids from even a moderately deep, tight formation to reach drinking water resources is extremely unlikely:

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[60] The Gradient Comments, *attached*, provide a number of specific examples of statements in the Draft Assessment concerning subsurface migration that are incorrect.

[61] *See, e.g.,* Flewelling, S.A. and Sharma, M., "Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine," *Ground Water* (2013), doi:10.1111/gwat.12095 (open access); Saiers, J.E. and Barth, F., "Potential Contaminant Pathways from Hydraulically Fractured Shale Aquifers," 50: 826-828, *Ground Water* (2012), doi: 10.1111/j.1745-6584.2012.00990.x; Cohen, H.A., Paratt, T. and Andrews, C.B., "Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers," 51: 317-319, *Ground Water* (2013), doi: 10.1111/gwat.12015; Carter, *et al.*, "Technical Rebuttal to Article Claiming a Link between Hydraulic Fracturing and Groundwater Contamination" (2013); R.D. Vidic, S. L. Brantley, J. M. Vandenbossche, D. Yoxtheimer, and J. D. Abad, "Impact of Shale Gas Development on Regional Water Quality," 340 (6134), 1235009, *Science* (May 17, 2013), doi: 10.1126/science.1235009; Engelder, T. *et al.*, "The fate of residual treatment water in gas shale," *Journal of Unconventional Oil and Gas Resources*, 7: 33-40 (2014); Dusseault, M., *et al.* "Seepage pathway assessment for natural gas to shallow groundwater during stimulation, production and after abandonment," Environmental *Geosciences* 21 (2014) 107-126.

[62] Saiers and Barth, *supra* note 61.

[63] *See attached* Gradient Comments at 3.3.1.

- Upward migration of HF fluid and brine through the rock layers above the fractures is controlled by pre-existing hydraulic gradients and bedrock permeability. These layers are typically dominated by shales, siltstones, and other mudstones that have inherently low permeability.[64]

- The upward head gradients that would be necessary to push fluids toward the surface are found only where the permeabilities of the rock are very low, ensuring that any upward movement will be minimal.[65]

- The hydraulic head that would be necessary to lift the fracturing fluid to the surface cannot be sustained, with leak-off limiting the pressures created during the HF process and the remaining pressure dissipating once the HF operation is completed.[66]

- The pressures created by the HF process are too short-term and too localized to create the pressure that would be needed to overcome the effects of density stratification and the low permeabilities of intervening layers to reach drinking water resources.[67]

- The capillary seals which have prevented the leakage of oil or gas from the target formation for tens of millions of years will continue to operate.[68]

- Production of gas from a formation will tend to drive fluids into – rather than out of – the formation.[69]

- Gas shales have very low water saturation, and the permeability of any rock decreases by orders of magnitude as water saturation decreases.[70]

- In the case of dry gas shales, imbibition will effectively sequester the fracturing fluids in the shale.[71]

Given the above, there is a sound technical basis for concluding that migration along this pathway is not just unlikely, but highly unlikely if not implausible. EPA should clarify that fluid migration to drinking water sources via this pathway has never been documented and, at least in the case of deep, tight formations, is a remote possibility at best.[72]

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[64] Flewelling and Sharma, *supra* note 61; Saiers and Barth, *supra* note 61; Carter, *supra* note 61.

[65] Flewelling and Sharma, *supra* note 61.

[66] Dusseault, *supra* note 61; *See* ICF International, LLC, *Technical Assistance for the Draft Supplemental Generic EIS: Oil, Gas and Solution Mining Regulatory Program*, 21 (Aug. 7, 2009), available at http://www.nyserda.ny.gov/Cleantech-and-Innovation/Environment/Environmental-Research-and-Development-Technical-Reports/Natural-Gas-Enviromental-Impact.

[67] Flewelling and Sharma, *supra* note 61.

[68] Engelder, *supra* note 61; Carter, *supra* note 61.

[69] Engelder, *supra* note 61. This same phenomenon applies to oil shales.

[70] Engelder, *supra* note 61; Carter, *supra* note 61; Vidic, *supra* note 61.

[71] Engelder, *supra* note 61; Saiers and Barth, *supra* note 61; Carter, *supra* note 61.

[72] Gradient has demonstrated that if fracturing fluids were able to migrate from a deep, tight formation to reach an overlying drinking water aquifer, the concentrations of the chemical constituents would be so low that they would not give rise to any human health concerns. NHHRE at ES-5, *supra* note 11.

A second potential migration pathway addressed in the Draft Assessment is fracture growth out of the production zone. While induced fractures have been documented to extend beyond the production zone in some cases, hydrogeologic principles and modelling indicate – and extensive evidence confirms – that it is extremely unlikely that induced fractures would reach drinking water resources. As the Draft Assessment notes, it is generally recognized that vertical fracture growth is constrained by a number of factors, including the layered nature of the rock overlying production zones and the stress contrasts between the layers as well as the tendency for higher permeability layers to act as "thief zones."[73] Fracture height growth is also limited by fluid volumes and pumping rates used during HF operations, with the Agency's own research concluding that unless unrealistically high pumping rates and pressures are used, induced fractures are unlikely to extend into drinking water resources.[74] Several other factors are also important:

- In shales and other tight formations, HF tends to create fracture networks rather than a single planar fracture, thereby limiting the height of any single fracture.[75]
- Leakoff of fluid into the formation will limit the amount of fluid available to "drive" the height of a given fracture.[76]
- It is well recognized that at depths shallower than about 2,000 feet below ground surface ("bgs") induced fractures tend to be oriented horizontally rather than vertically, meaning that if an induced fracture did propagate upward a significant distance from a deeper formation it would still not be likely to reach a drinking water source because once the fracture started to reach shallower depths its vertical progress would be reduced and any remaining propagation would tend to be in a more horizontal direction.[77]

Extensive data bear out these conclusions. As noted in the Draft Assessment, the large microseismic database cited in a number of papers[78] demonstrates that most fractures are of limited height, with a median fracture height of less than 250 feet. The maximum fracture height was 1,930 feet, but in all cases there were at least 1,500 feet – and generally more than 3,000 feet – between the top of the fracture and the base of any drinking water aquifer.[79] One of the factors contributing to this separation is that the taller fractures generally occurred at greater depths while the few fractures in the database that were shallower than 2,000 feet bgs showed essentially no height growth.[80] As noted in the Draft Assessment, the research undertaken by

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[73] Draft Assessment at 6-39.

[74] *Id.*

[75] NHRRE at 37, *supra* note 11.

[76] *Id*.

[77] Flewelling *et al*., "Hydraulic fracture height limits and fault interactions in tight oil and gas formations," *Geophys Res Lett*, 40: 3602-3606 (2013), available at http://dx.doi.org/10.1002/grl.50707.

[78] Draft Assessment at 6-38 (citing Fisher and Warpinski, 2012; Davies *et al*., 2012; Flewelling *et al*., 2013). This database includes over 12,000 HF stages from basins across North America.

[79] The Draft Assessment asserts that fracture volume can be larger than the volume of fracturing fluid used and that fluid volume alone should not be used to estimate fracture height. Draft Assessment at 6-31. However, Flewelling *et al*., 2013, stated only that maximum fracture heights are bounded by fluid volume and their analysis is confirmed by actual microseismic data.

[80] NHHRE at 37, *supra* note 11.

NETL at the Greene County site is consistent with the microseismic database. The study undertaken of HF operations in the Inglewood Oil Field in California is likewise consistent with these data. There HESI found that, after completing the well treatments, the actual distances from the tops of the created hydraulic fractures to the discontinuous groundwater bodies was approximately 7,700 feet. The study concludes that the fracture height growth in the Inglewood field is limited by the physical properties of the multiple layered formations. In addition, all microseismic events during the fracturing treatment occurred within 20 feet of the top of the shale.[81]

Even if an induced fracture did reach a drinking water aquifer and was propped along its entire length so as to create a permeable pathway, the work conducted for EPA by Reagan *et al.*, shows that as long as production is occurring any migration of fluid or even methane up the fracture would be minimal. Thus, as with migration through the formation, EPA should recognize that migration of fluids to drinking water resources via induced fractures is highly unlikely and has not been documented.

This same conclusion applies to the potential for migration via individual fractures intersecting with existing geologic features such as faults.[82] The LBNL team undertook extensive modelling of a highly unlikely scenario – pumping of fracturing fluid directly into a fault – and concluded that even under these extreme conditions the shear rupture of faults associated with an HF operation extended only up to 660 feet (200 meters). The LBNL team concluded that it is very unlikely that activation of a fault as a result of an HF operation at great depth could create a new flow path through fault ruptures that could reach shallow groundwater resources.[83] Prior work by the LBNL team and Flewelling *et al*. likewise demonstrated that the extent of fault activation during HF operations is limited.[84] As a result, the potential for fluid migration via this pathway can also be heavily discounted.

In short, contrary to the impression created by some of the statements in the Draft Assessment, the potential for migration of fluids to drinking water via a number of the subsurface pathways identified in the Draft Assessment is extremely low. This is particularly true with respect to the potential for migration of liquids such as fracturing fluid. It is well known that gases such as methane are more mobile in the subsurface than liquids and are more likely to migrate upward. EPA itself acknowledges that "density driven fluid buoyancy" is a

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[81] Halliburton Energy Services, Inc., *Inglewood Oil Field Hydraulic Fracturing Report* (July 2012), available at http://www.inglewoodoilfield.com/fracturing-study/.

[82] The Draft Assessment states that this pathway "has been recognized as a potential contamination hazard for several decades." Draft Assessment at 6-48. However, the Harrison paper cited as support for this statement does not even discuss HF. *See attached* Gradient Comments at Table 3.1.

[83] Rutqvist, J. *et al.*, "Modeling of fault activation and seismicity by injection directly into a fault zone associated with hydraulic fracturing of shale-gas reservoirs," 127: 377-386, *Journal of Petroleum Science and Engineering* (2015).

[84] *Id*.; Flewelling *et al*. 2013, *supra* note 77. The microseismic database which Fisher and Warpinski, Flewelling and others have used in their analyses shows recorded microseismic events that represent the combined extent of induced fractures and fault activation. Therefore, the analysis undertaken by Flewelling *et al*. actually applies to fault activation as well. The Draft Assessment suggests that fault activation may not be so localized, citing Skoumal *et al*. Draft Assessment at 6-36. However, as Gradient points out in the attached Comments, this is an apples and oranges comparison. *See attached* Gradient Comments at 3.3.1.

factor in fluid migration.[85] Methane is less dense than the fluids in the formation and buoyancy effects may contribute to upward migration of methane. However, fracturing fluids are comparable in density to, if not more dense than, formation waters, and therefore the upward migration of fracturing fluids would require a "driving" force in order to overcome the natural effects of stratification. Such a driving force would normally be absent once the HF operation is complete and the pressure is relieved. As a result, fracturing fluids are unlikely to migrate upward even if there is a preferential pathway that would allow the fluids to pass through low permeability layers.

This is borne out by examples EPA cites of documented instances of migration occurring via the identified pathways. With the possible exception of the Killdeer well blowout, the few examples cited in the Draft Assessment involving subsurface migration – such as Mamm Creek Field, the Raton Basin retrospective study and the Bainbridge, Ohio incident – all involve alleged migration of methane. EPA has not cited any confirmed instances of migration of fracturing fluids via these subsurface pathways and has not shown that these pathways have been documented for fracturing fluids or even that they represent plausible pathways for fracturing fluid migration.

In light of this and given that public concerns primarily center around the chemicals in fracturing fluids and the public perception that drinking water supplies have been contaminated with these chemicals as the result of the migration of fracturing fluids, EPA needs to be much more precise with its conclusions in this portion of the Draft Assessment. In particular, EPA should avoid using "fluids" in its technical sense to cover both liquids and gases given that this use of the term will easily confuse the public. At a minimum, EPA needs to clarify its conclusion to distinguish between migration of gases and migration of fracturing fluids while acknowledging that many of these pathways have not been documented as pathways for the migration of fracturing fluids.

Finally, the Draft Assessment states that separation distance between the production zone and drinking water resources is one of the most important factors affecting the possibility of migration, suggesting that shallower HF operations somehow present a greater threat to drinking water resources.[86] For example, the Draft Assessment concludes that for 20% of wells, the separation distance between the production zone and overlying drinking water resources is less than 2,000 feet, suggesting that in these cases drinking water resources are at greater risk.[87]

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[85] Draft Assessment at 6-27.

[86] Draft Assessment at 6-32. EPA appears to use differing factors to calculate these separation distances rather than a common approach. At various points throughout the chapter, EPA discusses separation distances between oil and gas reservoirs and drinking water aquifers, production zones and groundwater resources, and fractures and drinking water resources. EPA then states that it "identified an estimated 4,600 wells that were located in areas with less than 2,000 ft (610 m) of vertical separation between the fractures and the base of protected ground water resources." *Id*. However, EPA fails to clarify exactly how it is calculating these vertical separation distances. Without an ability to review EPA's calculations or know exactly what EPA is referring to when it discusses "separation distances," there is a risk that EPA may be overstating the potential for limited separation distances. EPA should adopt a consistent approach and clarify this information to more fully communicate its findings.

[87] *Id*. at 6-32. The 20% figure may be an overestimate. As EPA's Well File Review notes, some operators reported a depth to the base of ground water resources without indicating whether these resources were protected, yet EPA treated these as protected water resources. EPA, *Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design and Construction*, 23 (May 2015) ("Well File Review"). However, given that

However, this suggestion is misplaced for several reasons. First, as Gradient notes, other factors discussed above play a greater role than separation distance in constraining upward migration.[88] Even if separation distances are smaller for these wells than for other wells, it is still highly likely that multiple layers of lower permeability rock would lie between the production zone and the base of protected drinking water resources. In addition, it is unlikely that induced fractures would reach these resources given the tendency of fractures to assume a horizontal orientation at depths of less than 2,000 feet. Therefore migration of fluids from the production zone to these resources is still very unlikely.

In addition, the Draft Assessment fails to adequately note the distinction between HF of shales and other tight formations, which typically involves a horizontal wellbore thousands of feet below the surface, and HF of coalbed methane ("CBM") wells, which typically involves a shallower vertical well and the use of much lower amounts of water and chemicals.[89] The Draft Assessment mentions that fracturing of CBM wells typically occurs at much shallower depths than shale gas plays, but does not explain how the much smaller volume of HF fluids used in CBM wells affects EPA's findings with respect to separation distances and potential exposure pathways. As recent studies have noted, these same distinctions – shallower HF operations with much less use of water and chemicals – would also apply to much of the HF activity in California, which has not resulted in any known contamination of drinking water by HF fluids.[90]

The Draft Assessment also states that in some cases, HF operations take place in formations that contain drinking water resources. However, the Draft Assessment itself finds that only a very small percentage of HF activities (0.4%) fall in this category,[91] and even in those cases there have been no reported instances in which HF operations have resulted in the contamination of actual drinking water with fracturing fluids.[92] Moreover, the Draft Assessment fails to note that water in formations that contain commercial quantities of oil or gas are unlikely to be used as sources of drinking water even if the water has manageable TDS levels.[93]

V. Various Factors Contribute to an Overly Pessimistic View of "Vulnerabilities" Associated With HF Operations

A number of factors contribute to EPA's overstatement of the extent to which drinking water resources might be vulnerable to impacts associated with HF operations. These factors include a failure to clearly communicate the difference between issues that are directly related to the HF process itself versus oil and gas operations generally and an overly broad definition of

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ground water resources were reported to be as deep as 8,000 feet, *id*. at 40, it seems highly likely that some of the ground water resources reported by operators were not in fact protected resources. In addition, the Well File Review report suggests that in over 90% of cases the depth to the base of protected groundwater resources is less than 2,000 feet. *Id*. at 40, Figure 16.

[88] *See attached* Gradient Comments at 3.2.1.

[89] The differences between unconventional HF and HF of CBM wells, specifically the use of lower water volumes and chemicals, should also be more clearly explained at the outset in Chapter 2 of the Draft Assessment to provide readers with this frame of reference as it reads through the Study report. *See* Draft Assessment at 2-4.

[90] CCST California Study, *supra* note 33.

[91] Draft Assessment at 6-34.

[92] Gradient notes in the attached Comments that it is unlikely that formations containing commercial quantities of oil or gas would be used as sources of potable water. *See attached* Gradient Comments at 3.1.

[93] *See attached* Gradient Comments at 3.1.

drinking water resources. The Draft Assessment also fails to acknowledge that many of the identified vulnerabilities are already addressed through state regulation. Finally, the Draft Assessment does not put HF chemical information in the proper context because it fails to acknowledge that many HF chemicals are already pervasive in the environment or are commonly used in a variety of products to which people are routinely exposed with no apparent health concerns.

A. The Draft Assessment Should Distinguish Between What Is Directly Related to the Process of HF and What Is Incidental or Not Related

One of HESI's concerns is that the Draft Assessment does not clearly distinguish activities and potential impacts that are directly related to HF operations from other aspects of oil and gas operations. This confusion takes numerous forms. For example:

- In the discussion of spills in Chapters 5 and 7, the Draft Assessment fails to distinguish between spills of flowback, which are related to HF, and spills of produced water, which is a typical byproduct of oil and gas production operations irrespective of whether a well has been hydraulically fractured.[94] As discussed above, EPA then used these spill numbers to discuss spill rates, resulting in a discussion of spill rates that substantially overstates the rate of spills that involve HF fluids. As a result, the Draft Assessment conveys an erroneous impression to members of the public and regulators that spills involving HF chemicals occur far more often than they actually do, which could lead to exaggerated concerns on the part of those living near well pads.

- In Chapter 8, the Draft Assessment discusses waste practices that are not related to HF and are instead related to oil and gas activities generally and are regulated wholly separate from well pad activities. These include operations at Centralized Waste Treatment facilities and Publicly Owned Treatment Works. In addition, waste management practices such as the use of injection wells and road spreading are typically regulated under oil and gas regulatory programs but are separate from oil and gas *exploration and production* ("E&P") requirements. EPA should acknowledge that these activities are typically regulated separately from HF in particular, and oil and gas E&P in general, to avoid confusion by future users of the Study report.

- As discussed above, the draft Assessment's example incidents in Bainbridge, Ohio and the Mamm Creek gas field in Colorado were not specifically related to HF operations. Both incidents involved inadequate cement and demonstrate that "construction issues, sustained casing pressure, and the presence of natural faults and fractures can work together to create pathways for fluids to migrate toward drinking water resources."[95] EPA should acknowledge that well construction issues such as cement placement and casing pressure are not directly related to the process of HF.

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[94] *See, e.g.*, Draft Assessment at 5-48, 7-30 - 7-31.

[95] *Id*. at ES-15.

As a result of this lack of clarity, the Draft Assessment appears to ascribe to HF operations potential impacts that are at best only indirectly related, thereby significantly overstating the potential impacts of HF.

HESI understands that EPA intends to cover the larger scope of activities involving water supporting the practice of HF and did not intend to limit the Study to the discrete act of HF performed downhole. Nevertheless, public discussions about HF and E&P operations in general will not be advanced by confusion about causes and effects; too much of the public debate regarding HF has already been characterized by misunderstandings spawned by simple but avoidable confusion over what "fracing" means. HESI is able to distinguish between what is discretely related to the HF process versus what is ancillary to the HF process and more closely related to oil and gas development generally. However, many readers or users of the Draft Assessment may not be able to easily discern these differences. For example, the average public reader or even some regulators may have difficulty understanding whether an impact or issue described in the Draft Assessment could be addressed through regulation of the HF process itself or whether it should be addressed through regulation of some activity ancillary to the HF process. Given that a stated goal of the Study is that it "contribute[ ] to the understanding of the potential impacts of *hydraulic fracturing* on drinking water sources and the factors that may influence those impacts" and to "facilitate and inform dialogue among interested stakeholders,"[96] it is incumbent on EPA to explain more clearly the sources of the "vulnerabilities" it identifies and in particular to articulate clearly which impacts it believes are directly associated with the HF process and which impacts are included only because they occur at wells that happen to have been hydraulically fractured.

HESI therefore recommends that the Draft Assessment identify which of its research questions are directly related to the process of HF and distinguish those research questions that are related to activities that are incidental to HF or related to oil and gas operations generally. The chart below demonstrates which research questions are directly related to HF or at least incidentally related to HF operations:

Research Question	**Relation to HF Process**
Water Acquisition	
What are the types of water used for hydraulic fracturing?	Incidental to HF
How much water is used per well?	Incidental to HF
How might cumulative water withdrawals for hydraulic fracturing affect drinking water quantity?	Incidental to HF
What are the possible impacts of water withdrawals for hydraulic fracturing on water	Incidental to HF

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[96] *Id*. at ES-24 (emphasis added).

quality?	
Chemical Mixing	
What is currently known about the frequency, severity, and causes of spills of hydraulic fracturing fluids and additives?	Directly related to HF (although as discussed above this section improperly includes spills unrelated to HF)
What are the identities and volumes of chemicals used in hydraulic fracturing fluids, and how might this composition vary at a given site and across the country?	Directly related to HF
What are the chemical, physical, and toxicological properties of hydraulic fracturing chemical additives?	Directly related to HF
If spills occur, how might hydraulic fracturing chemical additives contaminate drinking water resources?	Directly related to HF (although as discussed above this section improperly includes spills unrelated to HF)
Well Injection	
How effective are current well construction practices at containing fluids—both liquids and gases—before, during, and after fracturing?	Incidental to HF
Can subsurface migration of fluids—both liquids and gases—to drinking water resources occur, and what local geologic or artificial features might allow this?	Some aspects directly related to HF; some aspects incidental to HF
Flowback and Produced Water	
What is currently known about the frequency, severity, and causes of spills of flowback and produced water?	Flowback is incidental to HF; produced water is unrelated to HF
What is the composition of hydraulic fracturing flowback and produced water, and what factors might influence this composition?	Flowback is incidental to HF; produced water is unrelated to HF
What are the chemical, physical, and toxicological properties of hydraulic fracturing flowback and produced water constituents?	Flowback is incidental to HF; produced water is unrelated to HF
If spills occur, how might hydraulic fracturing flowback and produced water contaminate	Flowback is incidental to HF; produced water

drinking water resources?	is unrelated to HF
Wastewater Management and Waste Disposal	
What are the common treatment and disposal methods for hydraulic fracturing wastewater, and where are these methods practiced?	Flowback is incidental to HF; produced water is unrelated to HF
How effective are conventional POTWs and commercial treatment systems in removing organic and inorganic contaminants of concern in hydraulic fracturing wastewater?	Flowback is incidental to HF; produced water is unrelated to HF
What are the potential impacts from surface water disposal of treated hydraulic fracturing wastewater on drinking water treatment facilities?	Flowback is incidental to HF; produced water is unrelated to HF

These distinctions should be included where the research questions are described throughout the Executive Summary, in Chapter 1 on pages 1-9 through 1-11 and at the end of each chapter. This will allow the Study to be better understood and more effectively used by the public, researchers and regulators in addressing any risks and impacts identified in the Study or conducting further research.

B. The Definition of Drinking Water Resources Used in the Draft Assessment Is Overly Broad

The Draft Assessment also overstates the potential impacts of HF by adopting an overly expansive definition of drinking water resources. EPA defines "drinking water resources" as "any body of ground water or surface water that now serves, or in the future could serve, as a source of drinking water for public or private use."[97] This definition is overly vague and broad in that it could theoretically encompass anything from freshwater to groundwater to brackish water and even saltwater. EPA does not provide any additional clarification of the phrase "could serve as a source of drinking water." Therefore it is unclear exactly what resources EPA is using to assess impacts and vulnerabilities, potentially overstating any findings.

EPA should have adopted a definition of "drinking water resources" that better focused the assessment on threats to resources that are actually used for drinking or that could reasonably be used as a source of potable water and that could be used in future regulatory and research efforts. For example, EPA could have chosen to use a definition with which it has substantial experience, *i.e.*, its existing regulatory definition of "underground source of drinking water" which covers an aquifer or its portion: (1) which supplies any public water system; or (2) which contains a sufficient quantity of ground water to supply a public water system and (i) currently supplies drinking water for human consumption, or (ii) contains fewer than 10,000 mg/l total

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[97] *Id*. at ES-3.

dissolved solids.[98] This definition is broad and covers sources not currently used for drinking water, including those that would require significant treatment, and therefore is conservative in its protectiveness. At the same time, this definition attempts to distinguish groundwater that could not reasonably be expected to be used for drinking water purposes.

Alternatively, EPA could have used the definition of "usable water" set forth by the Bureau of Land Management in its recently promulgated HF regulations:

> Generally those waters containing up to 10,000 parts per million (ppm) of total dissolved solids. Usable water includes, but is not limited to: (i) Underground water that meets the definition of ''underground source of drinking water'' as defined at 40 C.F.R. 144.3; (ii) Underground sources of drinking water under the law of the State (for Federal lands) or tribe (for Indian lands); and (iii) Water in zones designated by the State (for Federal lands) or tribe (for Indian lands) as requiring isolation or protection from hydraulic fracturing operations.[99]

This definition likewise demonstrates a conservative approach to protecting drinking water resources and is specifically intended for application to HF operations. Regulators and researchers could also easily follow this approach for future endeavors.

Either of the above definitions would have provided greater clarity and certainty for future users of the Study report. Instead, EPA used the broad and vague definition cited above, which could encompass almost any source of water.[100] As a result, the Draft Assessment may encompass impacts on resources that cannot reasonably be expected to serve as sources of drinking water at any time in the foreseeable future and thus overstates impacts from HF.

C. EPA Should Acknowledge That Many of the Identified "Vulnerabilities" Are Addressed by State Regulation

One of the other ways in which the Draft Assessment contributes to an overly pessimistic view of the "vulnerabilities" it identifies is through its approach to state regulations that are applicable to HF operations and other aspects of oil and gas production. Despite the fact that states have been regulating E&P operations – including HF activities – for decades, the Draft Assessment makes very little mention of existing state regulatory programs. Yet state regulatory programs address many of the alleged "vulnerabilities" that EPA identifies, and they continue to evolve to respond to concerns as state regulators apply expertise gained over the course of many years. While HESI understands that the Draft Assessment is not intended to be a formal risk assessment or to include a detailed evaluation of the effectiveness of state oil and gas regulations, the Draft Assessment – and its readers – would undoubtedly benefit from at least some acknowledgement of the existence of state regulatory programs and the role they play in minimizing any risks that may be associated with the identified "vulnerabilities."

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[98] 40 CFR § 144.3.

[99] 80 Fed. Reg. 16,217-16,218 (Mar. 26, 2015).

[100] *See attached* Gradient Comments at 3.1.

There are a number of examples of areas covered in the Draft Assessment that are regulated by the states, in many cases extensively so. One prominent example is the regulation of well construction, including requirements for casing and cementing of wells. Well integrity is an area that has been regulated by the states for many years. In recent years oil and gas states have increasingly been adopting regulations strengthening requirements for ensuring that wells that undergo HF operations are cased and cemented in a manner that provides good zonal isolation. In fact, as the Ground Water Protection Council ("GWPC") has noted,

> Between 2009 and 2013, a number of states amended well integrity standards, particularly those states where shale development is prevalent. . . . [S]everal states (e.g., Ohio, Texas, Pennsylvania, Arkansas, Wyoming, North Dakota, West Virginia, and Colorado) have updated rules, and, the number of states requiring cement evaluation logs or other approved methods under specifically defined circumstances has risen from 9 to 14, a 65% increase.[101]

Moreover, by 2013 essentially all oil and gas states required that surface casing be cemented to the surface and nearly all states required that surface casing be set below the deepest protected groundwater zone.[102]

Most of the 2009-2013 well integrity rulemakings cited by GWPC – including those in Ohio, Texas, Pennsylvania, Wyoming, North Dakota and West Virginia – occurred shortly before the cut-off date for EPA's information requests in connection with the study (September 2010) or came after that date. Moreover, states have continued to strengthen their regulations concerning well integrity for wells undergoing HF since the time period addressed in GWPC's report (cutoff date of July 1, 2013). For example, since that time, Alaska, California, Illinois, Mississippi and Nebraska have all adopted new regulatory requirements relating to well integrity. As a result, the already high percentage of fully cemented surface casings reported by EPA in 2009-2010 (93%)[103] is undoubtedly even higher today. The Draft Assessment should at least acknowledge these and other steps that states have taken to provide further assurance of well integrity.

Another "vulnerability" that is being addressed by the states is "frac hits." States have adopted a variety of approaches for responding to concerns regarding the potential for induced fractures to create connections to existing wellbores. For example, the Colorado Oil & Gas Conservation Commission adopted a statewide policy requiring that all Applications for Permit to Drill include an Offset Well Evaluation to determine if wells within 1,500 feet of a well to be hydraulically fractured have adequate zonal isolation.[104] The Pennsylvania Department of

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[101] Ground Water Protection Council, *State Oil & Gas Regulations Designed to Protect Water Resources*, 34 (2015 ed.), available at http://www.gwpc.org/sites/default/files/state_oil_and_gas_regulations_designed_to_protect_water_resources_0.pdf.

[102] *Id*. at 35.

[103] Draft Assessment at 6-8.

[104] COGCC, *Interim Statewide Horizontal Offset Well Policy* (February 10, 2014), available at http://cogcc.state.co.us/forms/instructions/Form_2_Attachment_Guidance_PDFs/Offset_Well_Evaluation_20141015.pdf.

Environmental Protection is preparing to amend its regulations applicable to horizontal wells to require that, at least 30 days prior to commencement of drilling, operators identify all active, inactive, orphaned and abandoned wells within 1,000 feet of the vertical wellbore and within 1,000 feet of the entire length of the lateral as well as a plan for monitoring the wells.[105] Again, EPA should at least acknowledge in the Draft Assessment that state regulators are already taking steps to address this "vulnerability."

State regulations also address spill containment standards to prevent spills as well as spill response requirements in the event that spills do occur. For example, the Texas Railroad Commission requires oil and gas facilities to have spill containment measures in place and establishes standards for spill reporting, delineating and remediation.[106] These types of measures help minimize any potential for adverse impacts to drinking water resources as a result of spills.

In sum, the Draft Assessment would place a number of the "vulnerabilities" it identifies in a more appropriate context if it acknowledged that these issues are being addressed by state regulators. This state-based approach makes good sense in light of EPA's recognition that many of the vulnerabilities it identifies vary in significance depending on the region of the country a well is located in.

D. The Draft Assessment Fails to Put Chemical Information in the Proper Context

The Draft Assessment also overstates the significance of the "vulnerabilities" identified by EPA by failing to put its discussion of chemical exposure in the proper context. In its extensive discussion of HF chemicals, the Draft Assessment fails to note that individuals are routinely exposed to many of the identified HF chemicals through other sources. Many of the HF chemicals identified in the Draft Assessment are pervasive throughout the home, workplace and other environments as ingredients in commonly used products and substances. These include foods and household products such as cosmetics, shampoo and cleaning products.

For example, as Gradient points out, the Draft Assessment identifies acrylamide as a high hazard compound, but individuals are already exposed to this chemical on a routine basis due to its presence at high concentrations in food such as french fries.[107] Moreover, a number of the HF compounds have been determined to be "Generally Recognized as Safe" by the U.S. Food and Drug Administration, including hydrochloric acid, citric acid, hydrogen peroxide, acetic acid, calcium chloride, ammonium chloride, and sucrose when used in certain concentrations (which are higher than the concentrations of these chemicals in fracturing fluids to which members of the public might ever be exposed).[108] Other HF constituents are considered by EPA to be inert compounds of "minimal risk" to human health (*e.g.*, glycerine and sodium benzoate), are found in common household/personal care products (*e.g.*, cellulose and propylene glycol), and/or are

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[105] *See* Proposed § 78a.52a (March 9, 2015 draft), available at http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_technical_advisory_board_(TAB)/18260.

[106] *See* 16 Tex. Admin. Code §§ 3.8, 3.20, 3.91.

[107] *See attached* Gradient Comments at 4.3.

[108] *Id.*

naturally occurring in the environment (*e.g.*, sodium chloride and fatty acids).[109] Some of the more common applications of HF chemicals are laid out in the chart below.[110]

Compound Used in HF	**Common Application**
Acids	Swimming pool cleaner
Glutaraldehyde	Disinfectant; sterilizer for medical and dental equipment
Sodium Chloride	Table salt
N, n-Dimethyl formamide	Used in pharmaceuticals, acrylic fibers and plastics
Borate salts	Used in laundry detergents, hand soaps and cosmetics
Polyacrylamide	Water treatment, soil conditioner
Petroleum distillates	Make-up remover, laxatives, and candy
Guar gum	Thickener used in cosmetics, baked goods, ice cream, toothpaste, sauces, and salad dressing
Citric Acid	Food additive; food and beverages; lemon juice
Potassium chloride	Low sodium table salt substitute
Ammonium bisulfite	Cosmetics, food and beverage processing, water treatment
Sodium or potassium carbonate	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Drinking water filtration, play sand
Ethylene glycol	Automotive antifreeze, household cleansers, deicing, and caulk
Isopropanol	Glass cleaner, antiperspirant, and hair color

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[109] *Id.*

[110] Energy in Depth, A Fluid Situation: Typical Solution Used in Hydraulic Fracturing, available at http://www.energyindepth.org/frac-fluid.pdf.

In failing to acknowledge the commonplace presence of many of the chemicals used in HF, the Draft Assessment risks misleading users of the Study report who may assume that people would only be exposed to these chemicals through the practice of HF. The final Study report should put its HF chemical information in the proper context by acknowledging that many of these chemicals are already present in the environment in various forms and concentrations.

Finally, even if EPA chooses not to undertake a formal risk assessment, some assessment of chemical exposure that takes into account concentrations at which these chemicals are used in HF operations and the concentrations at which they might appear in drinking water sources in the event of a spill would allow EPA to better convey the potential for HF to result in meaningful impacts on drinking water resources. This approach was used in the Gradient 2013 analysis described above regarding spills, where Gradient used the concentrations of HF chemicals in its probabilistic analysis to determine that spills of HF fluid do not pose a risk to human health or the environment from a drinking water resource standpoint.

Instead, EPA uses a flawed hazard ranking approach to provide exposure estimates. As described by Gradient, the qualitative hazard ranking approach used by EPA (the "MCDA" approach) evaluates only a small fraction of identified chemicals and has numerous underlying flaws that make the results highly unreliable, rendering it impossible to draw any meaningful conclusions.[111] This is because EPA unnecessarily limited its toxicity data (when other reliable sources were available) and used inappropriate scores for chemical occurrence, physicochemical properties, and toxicity in the MCDA framework. In addition, EPA's reliance on EPISuite-predicted physicochemical properties suffers from the shortcomings of the model predictions, and EPA's substitution of use frequency for exposure concentrations is inappropriate. Thus, many aspects of EPA's approach for estimating exposure are flawed, further contributing to the unreliable nature of the MCDA analysis.

EPA should at the very least acknowledge that it has not properly taken HF chemical concentrations into account when assessing potential impacts from HF-related spills. Without some statement to this effect, users of the Study report may assume that the Draft Assessment is referring to the potential for exposure to HF chemicals at the concentrations at which they are found in additives.

VI. EPA Overstates the Uncertainty Regarding Its Finding Concerning Lack of Widespread Impacts

While concluding that there is no evidence of widespread impacts to drinking water resources associated with HF operations, EPA qualifies its conclusion by stating that the lack of evidence of such impacts could be due to "other limiting factors" such as a lack of data concerning water quality and the "inaccessibility of some information on HF activities and potential impacts."[112] EPA thus uses this alleged uncertainty to suggest that the impacts of HF on drinking water resources may be more significant than many years of evidence would indicate.

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[111] *See attached* Gradient Comments at 4.4.

[112] Draft Assessment at 10-1.

However, the lack of data is not nearly as extensive or as significant as EPA suggests. There are many additional resources regarding the physiochemical properties and toxicity of chemicals used in HF operations EPA could have consulted or at least acknowledged to allow for further review. HESI provides examples of these resources below. Although there are many instances in which EPA overstates the extent of data gaps, we focus on three areas in particular: (i) the toxicity and physicochemical properties of chemicals, (ii) information withheld under trade secret or confidential business information ("CBI") claims, and (iii) water quality data.

A. Physicochemical Properties and Toxicity

In Chapters 5 and 9 of the Draft Assessment, EPA explains that it had limited data with which to examine the toxicity and physicochemical properties of chemicals used in HF operations, and that this lack of data hampered its ability to assess the potential impacts of those chemicals.[113] However, there are readily available sources of this information that EPA did not consult or chose not to use. For physicochemical properties, EPA relied solely on the EPISuite database, which did not have physicochemical property data for over half of the HF chemicals identified by EPA because it is only capable of estimating properties for organic chemicals with recognizable structures.[114] EPA could have also consulted the following resources for physicochemical properties: EPA pesticide registration documents, the EPA High Production Volume Information System ("HPVIS"), and the Regulation on Registration, Evaluation, Authorization, and Restriction of Chemicals ("REACH"). These sources contain data that are reliable and appropriate for use in this context.[115]

As for toxicity, EPA consulted a variety of resources that met stringent selection criteria, including EPA's IRIS, HHBP, and PPRTV databases, ASTDR MRLs, the California Toxicity Criteria database and CICAD.[116] Many additional resources were not used because they did not meet EPA's stringent selection criteria. However, by essentially taking the position that toxicity can only be assessed using reference values that are the product of the Agency's own lengthy process or a comparable process, EPA is being unduly restrictive and ignoring a host of reliable data that could be used to provide relevant information concerning the toxicity of a much wider range of substances. These sources include QSAR approaches and the ACToR database, which the Agency itself acknowledges it could have used.[117] In addition, EPA could have used data collected by the European Chemicals Agency ("ECHA") under REACH or the Organization for Economic Co-operation and Development ("OECD") Screening Information Data Set ("SIDS") toxicity profiles. Finally, as a fallback, EPA could have used drinking water maximum contaminant levels, which are set by EPA to be protective of human health. As Gradient points out in the attached Comments, EPA could have established a tiered system whereby its preferred

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[113] *Id*. at 5-73, 9-36 - 9-38.

[114] Moreover, as Gradient explains in its attached Comments, EPA misused EPI Suite by seeking to use the model to evaluate chemicals with very high or low mobility despite previous warnings by the SAB about using the model outside the range for which it has been validated. *See attached* Gradient Comments at 2.1 (citing US EPA. 2007a).

[115] *Id*.

[116] Draft Assessment at 9-6.

[117] *Id*. at 9-5, 9-9.

databases would have occupied the first tier and these other resources could have been placed in a second tier to be used only if relevant data were not available from first tier sources.[118]

Gradient's *National Human Health Risk Evaluation*[119] demonstrates that relevant data are available to assess the toxicity of most chemicals used in HF operations. Gradient was able to identify established oral toxicity factors or find data from publicly available databases that allowed it to calculate (using EPA methodologies) a chronic reference dose for over 85% of the chemicals used in the HF fluid systems it evaluated. In addition, Gradient was able to identify regulatory determinations concerning several other compounds that allowed it to conclude that these compounds pose a low hazard.

EPA could have consulted these additional resources. Had it done so, the Draft Assessment would have presented a much more comprehensive picture of the physiochemical properties and toxicity of the chemicals on its list. Because it chose not to do so, EPA's analysis of the physicochemical and toxicological properties was based on such limited data that its value for researchers, regulators and the public is questionable.

B. Trade Secret/CBI Information

Although EPA states several times throughout the Draft Assessment that the withholding of the identities of certain chemicals from public disclosure as trade secrets or CBI limited the Agency's ability to fully analyze the chemicals used in HF operations, HESI believes that EPA's statements are misleading.[120] For example, throughout the draft report, EPA cites data limitations by saying that "approximately 70% of the disclosures in the FracFocus database contain at least one CBI chemical."[121] Only in *one* instance does the Draft Assessment also note that "[a]pproximately 11% of all ingredients were reported to FracFocus as CBI," meaning that almost 90% of HF chemicals are fully disclosed.[122] The first statement, which is repeated on six occasions in absence of the second statement, is misleading by itself.

Moreover, EPA had full access to trade secret and CBI information provided by nine service companies, including HESI, and is therefore aware of the identities of these CBI chemicals. EPA even performed a physicochemical analysis of these chemicals, finding that:

> The values of the physicochemical properties of known and CBI chemicals are similar, covering similar ranges centered on similar values, suggesting that even though these chemicals are not publicly known, their physicochemical properties are not appreciably different from the known chemicals. This means that their fate and transport would not be appreciably different than the chemicals that are publicly known.[123]

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[118] *See attached* Gradient Comments at 4.2.
[119] NHHRE, *supra* note 11.
[120] *Id*. at ES-22, 5-15, 5-26, 5-73, 9-4, 9-38, 10-18.
[121] *Id*. at 5-73.
[122] *See id*. at 5-15, 5-73, 9-4.
[123] *Id*. at 5-54.

EPA certainly had few if any constraints on its ability to analyze the chemicals − including trade secret chemicals – used in HF operations, and the analysis it did perform provided evidence that, on the whole, the relatively limited number of chemicals whose identities are not publicly disclosed do not differ in significant respects from the vast majority of chemicals whose identities are public.[124] Accordingly, in the final report EPA should eliminate or at least qualify its statements concerning CBI claims as a limiting factor in assessing the hazards of chemicals used in HF operations.

In addition, by presenting CBI claims only as limitations on the ability to assess the impacts of HF operations, EPA implies that these CBI claims are somehow inappropriate. Therefore, EPA should provide more context for its discussion of CBI claims by providing a summary on the purpose and use of CBI and trade secret claims. Trade secret protection is a concept that dates back at least two centuries. The purpose of protecting trade secrets is to foster innovation, and countries in all corners of the globe today recognize the critical role that trade secrets play in creating incentives for innovative efforts in a variety of fields that over the years have resulted in a wide range of benefits for people around the world. In the U.S., a wide range of laws – from provisions in federal laws such as the Emergency Planning and Community Right-To-Know Act and the Freedom of Information Act that exempt trade secrets from public disclosure requirements to the widespread adoption of the Uniform Trade Secrets Act at the state level – attest to the high degree of consensus that trade secrets are worth protecting. Trade secret protection enables companies like HESI continue to develop new and innovative products used in drilling, casing, cementing and stimulating shale gas wells and other types of wells that provide significant environmental and economic benefits. Not only have these innovations helped fuel job growth and contributed to the nation's energy security, but they have done so while achieving continual environmental improvements.

In seeking trade secret protection, companies who perform HF are not requesting unique treatment from regulators. Trade secret protection is common and has been historically provided for a variety of products and technologies; indeed, the trade secret protections of the federal Toxic Substances and Control Act apply to all chemical substances. For example, the formulas of many products that people routinely eat, drink, and use in their homes – including the identities of key ingredients – are protected as trade secrets. This includes products such as Coca-Cola[125] and Dr. Pepper, KFC's fried chicken, Bush's baked beans, McDonald's special sauce, designer perfume fragrances, mosquito repellents, and household products such as WD-40. The makers of these products are afforded trade secret protection so that their valuable recipes and formulas are not disclosed to the public and their competitors, while at the same time the public knows enough details about the make-up of the product to assess its function, characteristics and health effects as necessary. Given the lack of any significant risk associated with the use of HF chemicals and the benefits they provide, there is no basis for granting trade

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[124] It has been suggested by some that the industry uses CBI or trade secret claims to somehow cover up the use of particularly dangerous chemicals, a claim that is based on a fundamental misunderstanding of the role CBI and trade secret claims play. EPA's analysis certainly provides no support for this conspiracy theory.

[125] There is a popular misconception that all of the ingredients of Coke are listed on the product label. In fact, a glance at the label on a Coke will quickly show that one of the listed ingredients is "natural flavorings." Exactly what these flavorings are is a trade secret that is closely guarded by the Coca-Cola Company, which keeps the formula locked in a vault. *See Coca-Cola Bottling Co. v. Coca-Cola Co.*, 107 F.R.D. 288 (D. Del. 1985).

secrets for HF chemicals any less protection than the trade secret protection enjoyed by a wide range of other industries.

Unless EPA provides an understanding of the context of the purpose and use of CBI and trade secret claims and the fact that these types of claims are not unique to the oil and gas industry rather than only citing to perceived data limitations presented by these claims, readers of the Study report may come away with the erroneous impression that these claims are unnecessary and problematic.

C. Existing Water Quality Data Corroborate the Lack of Widespread Impacts

Another factor identified by the Draft Assessment as potentially contributing to a failure to identify impacts to drinking water resources associated with HF operations is a lack of pre- and post-fracturing data on the quality of drinking water resources in areas where unconventional oil and gas development is taking place. However, there is a significant and growing body of data concerning surface and groundwater quality in these areas which indicates that such impacts are not occurring. For example, as discussed above, regional water quality studies undertaken by USGS and others covering portions of the Marcellus, Fayetteville and Bakken have shown no significant differences in groundwater quality in those areas over time. Moreover, a group of USGS scientists who evaluated national USGS surface water data found no consistent trends in surface water quality in areas with increasing unconventional oil and gas development.[126] Supplementing these studies are site-specific studies such as those conducted by NETL in Greene County, Pennsylvania and HESI in the Inglewood Oil Field in California which confirm that there is no evidence of upward migration of fracturing fluids or methane through overlying formations in connection with HF operations.[127] Thus, there are more data than suggested in the Draft Assessment to support a finding that HF operations have not resulted in widespread impacts to drinking water resources.

VII. HESI Has Identified Other Deficiencies in the Report

The Draft Assessment also contains several other deficiencies that either risk misleading users of the Study report or omit pertinent information. These problems are set forth below by chapter.

A. Chapter 3

In Chapter 3, EPA concludes that "the colocation of hydraulic fracturing activities with surface and ground water increases the potential for impacts to current and future drinking water resources."[128] By using the term "colocation," EPA risks giving a false impression to users of the Study report that there is little protection if HF occurs at a wellsite that is in close proximity to surface or ground water. This would be an inaccurate impression for several reasons. First, wells are generally set back from surface water resources – particularly those used by public water systems – in accordance with state and local regulations. In addition, most HF activities

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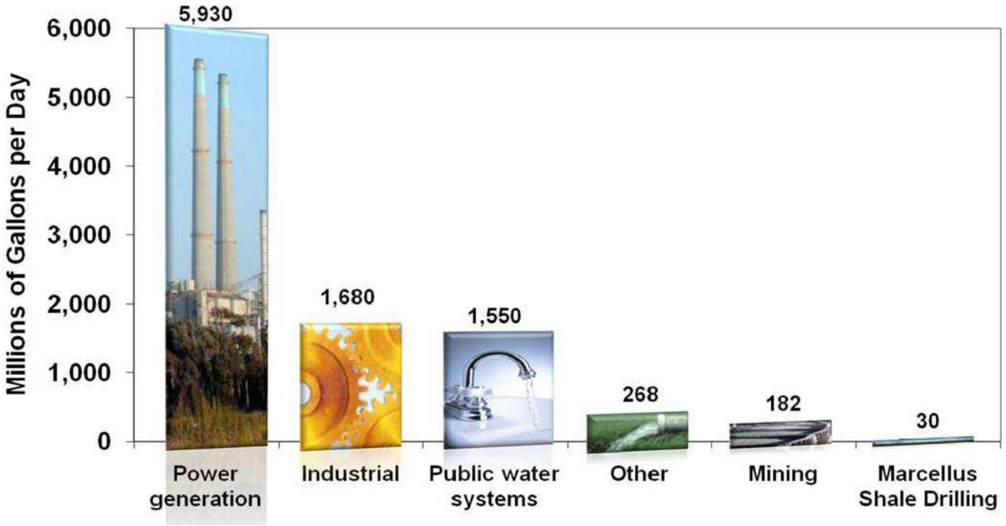
[126] Bowen *et al.* 2015, *supra* note 16.
[127] NETL Study, *supra* note 21; Inglewood Study, *supra* note 25.
[128] Draft Assessment at 3-3; *See also* Draft Assessment at 3-11.

occur well below drinking water aquifers and wells have zonal isolation as required by state regulations to protect any aquifers through which the wells are drilled.

Moreover, to the extent proximity to drinking water resources increases the potential for impacts, that potential is not significant. This is because, as discussed above, there is no significant risk to human health from surface spills associated with HF activities. In addition, as discussed above, there is no evidence of impacts to underground aquifers from HF activities. Even in the case of the Killdeer blowout, any impacts to groundwater appear to be limited to the area of the wellpad and did not extend to surface water.[129] HESI recommends that EPA clarify its conclusion in Chapter 3 and acknowledge that protections are in place to prevent impacts to surface or ground water even where HF activities occur in close proximity to those sources of water.

B. Chapter 4

In the discussion of water usage in Chapter 4, EPA should put HF water usage in its proper context by comparing the amount of the water used in HF operations with the amount of water dedicated to other uses. As EPA well knows, the amount of water used in hydraulically fracturing a horizontal well pales in comparison to amounts used for power generation, agriculture and industrial uses as well as amounts used in public water systems. A sample comparison for the Marcellus Shale is provided in the chart below:[130]



Inclusion of this information would provide users of the Study report with a frame of reference for the amount of water used in HF activities.

C. Chapter 5

The discussion of trends in chemical use in HF operations notes that industry is working on strategies to reduce the number and volume of chemicals used and to identify safer chemicals.

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[129] *Id*. at 5-12.

[130] USGS, Pennsylvania Water Consumption. The estimated Marcellus Shale Drilling water use the amount expected at peak drilling rate of 3,000 wells per year.

HESI has been very active in both of these areas. For example, HESI has developed its own Chemistry Scoring Index ("CSI") as a mechanism for promoting safer chemical use in HF operations by providing a basis upon which to take hazards into account in the selection of chemicals. HESI developed the tool "to address the lack of a suitable system for evaluating and comparing the potential HSE hazards of products used in the oil and gas industry."[131] The CSI allows HESI to consider the relative hazards associated with the products it uses in its HF and other operations. By assessing the intrinsic health, safety and environmental hazards of the chemicals in a product and considering the concentrations of those chemicals in the product, the CSI can be used to generate a score for a product that can then be compared to the scores for similar types of products (i.e., the score for a surfactant can be compared to the scores for other surfactants). Products with a lower CSI score within a product group are considered to have a lower intrinsic hazard compared to other products within the same use group. This serves as "a powerful tool to evaluate relative product hazards; to review and assess product portfolios; and to aid in the formulation of products."[132] With the help of this tool, HESI has introduced a number of products that have lower CSI scores for potential use under a variety of conditions.

In addition, HESI has developed several products that achieve reductions in the number and volume of chemicals used in HF and HF-related operations. For example, HESI has developed CleanStim®, which is an HF fluid made entirely of ingredients sourced from the food industry that provides exceptional fracturing and environmental performance as compared to traditional formulations. The ADP™ Advanced Dry Polymer Blender enables mixing of any of HESI's fracturing fluids using a dry polymer, which eliminates the need for liquid gel concentrates and results in the use of less petrochemical materials and reduced vehicle miles travelled transporting liquid gelled material. During 2012, the use of ADP blenders and associated dry gel removed over 30 million gallons of hydro-treated light petroleum distillates from HF fluid in North America. In addition, HESI has developed the CleanStream® service for controlling bacteria growth through the use of ultraviolet light rather than chemical biocides.

Another concern with respect to Chapter 5 is the discussion of storage and spill containment practices and requirements.[133] EPA should note that containment practices and requirements are not unique to the oil and gas industry, but are instead used by a wide range of industries.

D. Chapters 7 and 8

In Chapters 7 and 8, EPA identifies unpermitted or illegal discharges of wastewater as a vulnerability in terms of potential impacts to drinking water resources.[134] However, HESI believes that it is inappropriate to call out specific illegal actions as a vulnerability. Any illegal action could constitute a vulnerability, which is why those activities are prohibited. Without some evidence that there are pervasive illegal or unpermitted discharges of wastewater occurring

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[131] Verslyke, Tim, *et al*., "The Chemistry Scoring Index (CSI): A Hazard-Based Scoring and Ranking Tool for Chemicals and Products Used in the Oil and Gas Industry," 6, 3993-94, *Sustainability* (2014), (DOI:10.3390/su6073993).

[132] *Id*.

[133] Draft Assessment at 5-30 - 5-42.

[134] *See e.g., id*. at 8-20.

and that these illegal actions are affecting drinking water resources, it is misleading for EPA to discuss these activities as a potential vulnerability to drinking water resources.

E. Chapter 9

EPA relies on a list of HF chemicals from the "Colborn *et al*. 2011" paper in compiling its list of chemicals used in HF operations.[135] The Colborn paper itself states that "[f]or most products, we cannot definitively say whether they were used during drilling or during fracking."[136] In other words, the paper acknowledges that its list of chemicals may have included chemicals used in aspects of well pad operations other than HF. EPA has a number of more reliable sources on which it can and has relied on in identifying chemicals used in HF operations and does not need to rely on the information from the Colborn paper. Moreover, reliance on this potentially inaccurate chemical information only serves to undermine the validity of the Draft Assessment. EPA should remove this reference and information provided by this paper from the Draft Assessment.

HESI believes that FracFocus provides the best indication of chemicals currently being used in HF operations. This is because the FracFocus registry is incorporated into the HF chemical disclosure programs in 23 states and has been proposed or considered for use in two other states;[137] these states accounted for over 90% of U.S. onshore oil production in 2013 and over 80% of onshore gas production in 2012. FracFocus currently has disclosures regarding the chemical make-up of HF fluids used in over 99,000 HF operations in over 25 states, including hundreds of reports on HF operations in the three principal oil and gas states that do not currently use FracFocus as part of their chemical disclosure programs (*i.e.*, Arkansas, New Mexico and Wyoming). HESI recommends that EPA consider FracFocus as the primary resource for HF chemicals currently in use and acknowledge it as such for the benefit of future users of the Study report.

VIII. Conclusion

HESI appreciates the effort that EPA has put into the Study, and agrees with the major finding in the Draft Assessment that there is no evidence of widespread, systemic impacts. This conclusion finds ample support in the public statements of federal and state regulators over the course of a number of years, as well as the work of numerous researchers (including LBNL). At the same time, the Draft Assessment significantly overstates the potential for impacts through various mechanisms or pathways (the "vulnerabilities"). The Draft Assessment also overstates the extent to which data gaps, which could be filled with existing and available resources, purportedly limit the Agency's ability to reach more definitive conclusions. There is more than sufficient information available to conclude that the absence of evidence of widespread impacts is simply a confirmation of the fact that such impacts have not occurred.

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[135] *Id*. at 9-41.

[136] Colborn *et al*., "Natural gas operations from a public health perspective." *Hum Ecol Risk Assess* 17: 1039-1056. (2011).

[137] Alabama, Alaska, California, Colorado, Idaho, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Montana, Nebraska, Nevada, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Utah and West Virginia have included FracFocus in their chemical disclosure requirements; Maryland has proposed to do so and Virginia is considering doing so.

In order to address these overstatements and other deficiencies, in finalizing the Draft Assessment EPA should:

- Clarify which potential impacts are directly related to HF operations and which are not;
- Revise its definition of “drinking water resources” so that it covers only underground sources of drinking water as defined under the Safe Drinking Water Act and any similar water bodies currently available for drinking water use;
- Provide better context for its assessment of potential impacts by acknowledging the role of state regulatory programs in addressing the “vulnerabilities” identified and by recognizing that many of the chemicals at issue are commonly used in other types of products;
- Refine its discussion of spill rates to reflect the spill rate for fluids containing HF chemicals of about 1-2%;
- Review its discussion of chemical fate and transport mechanisms, including consideration of spill volumes and chemical concentrations;
- Recognize that several of the subsurface pathways analyzed are highly unlikely, particularly with respect to migration of fracturing fluids;
- Qualify its statements regarding the limitations presented by trade secret and confidential business information claims;
- Replace use of the term “fluids” with “liquids and gases” to avoid public confusion; and
- Reassess its approach to hazard assessment and exposure, taking into account the extensive data available concerning physiochemical properties and toxicity and taking steps to incorporate chemical concentrations in its assessment.

Addressing these issues will result in a final report that more effectively contributes to the understanding of the potential impacts of HF rather than contributing to the misunderstandings that often characterize public dialogue regarding HF operations.

ATTACHMENT

Comments on EPA Study "Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources"

Prepared for
Halliburton Energy Services, Inc.
P.O. Box 42806
Houston, TX 77242-2806

August 28, 2015

GRADIENT

www.gradientcorp.com
20 University Road
Cambridge, MA 02138
617-395-5000

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1 Introduction

The United States Environmental Protection Agency (EPA) released a draft of its study on the "Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources" (Study) in June 2015 (US EPA, 2015a). The purpose of the EPA Study is to evaluate the potential relationship between hydraulic fracturing (HF) and drinking water resources, including potential effects of spills or releases of HF and flowback fluids. The technical comments provided in this report address the parts of the EPA Study that relate to EPA's analysis of chemical fate and transport for HF-related compounds, the potential impacts of spills of HF and flowback fluids, the potential for fluids[1] to migrate upward through stimulated fractures and faults, and the potential hazards of identified chemicals. In reviewing the sections of the EPA Study that are relevant to these topics, it is clear that a number of technical flaws exist and that future drafts of EPA's study should address these shortcomings. The key issues are outlined below and discussed in more detail in subsequent sections.

1.1 Chemical Fate and Transport and Potential Impacts of Spills

The EPA Study broadly characterizes processes that control chemical fate and transport and discusses how these processes could potentially affect the migration of spilled HF-related materials. However, the Study's characterization of chemical fate and transport is flawed. In particular, the analysis of physicochemical properties in the EPA Study is inherently unable to evaluate the majority of identified compounds, due to methodological limitations, and is inappropriate for evaluating chemicals with high or low mobility. For example, the EPA Study relies on a software package to estimate physicochemical properties that is only capable of estimating properties for organic chemicals with identifiable chemical structures. The methodology is inherently unable to evaluate inorganic chemicals and chemicals with complex structures (*e.g.*, some polymers, surfactants). For the organic chemicals that the model could evaluate, the EPA Study used the model to predict chemical properties substantially beyond the range in which the model is reliable. EPA should instead use other readily available information on physicochemical properties for both inorganic and organic chemicals, so that it can improve the reliability of its chemical property data and evaluate a broader range of identified compounds.

The EPA Study has also mischaracterized the key factors that control chemical migration and potential impacts, such as the importance of chemical concentrations and spill volumes. Many of the dominant transport processes (*e.g.*, adsorption, chemical/microbial reactions, effects of chemical mixtures and co-solvency) are dependent on chemical concentrations, such that the failure to characterize chemical concentrations severely hinders EPA's ability to evaluate the potential impacts of spills and releases on drinking water. The EPA Study also makes misleading statements about the role of other factors, such as log K_{ow} values, surfactants, and co-solvents, and also mischaracterizes many of the references it cites. For example, the EPA Study states that co-solvency could increase the mobility of some chemicals and cites several studies to support this assertion (*e.g.*, Corseuil *et al.*, 2004; Powers *et al.*, 2001); however, these references actually demonstrate that co-solvent concentrations in HF fluid are too low to have a mobilizing effect on other chemicals. EPA should correct these mischaracterizations and other shortcomings in its discussion of chemical transport.

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[1] The term "fluids" refers broadly to both liquids and gasses throughout this report.

In addition to mischaracterizing the factors that control what happens when a spill occurs, the EPA Study also mischaracterizes the frequency with which spills occur. The EPA Study fails to identify an appropriate spill rate for Pennsylvania, overstates the spill rate in Colorado, and fails to state that the spill rates for the two states with available data (Colorado and Pennsylvania) are consistent with one another. The EPA Study places too much emphasis on the range of spill rates previously estimated for Pennsylvania, without critically reviewing them or identifying the correct spill rate for HF-related fluids. EPA should consider the work of Flewelling *et al*. (In Preparation), which shows that the correct spill rate for HF-related spills in Pennsylvania is 1%. EPA also used a methodology that artificially biased the spill rate high for Colorado. The EPA Study should correct these issues and also state that the spill rate for Pennsylvania is consistent with the spill rate EPA determined for Colorado (*i.e.*, approximately 1-2%), suggesting that there is likely a common HF-related spill rate for the industry or nation as a whole.

Finally, the EPA Study fails to reach any conclusions about the potential impacts of spills. EPA's primary finding is too general and could have been reached without doing any analysis, as exemplified by the following statement: "[t]he EPA analysis demonstrates that spills of chemicals, additives, and fracturing fluids do occur at well sites and reach both soil and surface water receptors" (US EPA, 2015a, p. 5-47). EPA should instead use the available information to undertake an analysis that can reach more meaningful conclusions, such as characterizing spill rates, spill volumes, and chemical concentrations, so that the potential for changes to drinking water quality can be put into perspective.

1.2 Potential Migration of Fluids Through Overlying Formations, Stimulated Fractures, and Faults

The EPA Study overstates the potential for the migration of fluids through formations overlying targeted rocks to drinking water resources. EPA's evaluation of the potential effects of HF on drinking water resources is inherently dependent on the definition of underground sources of drinking water, yet the EPA Study uses multiple definitions that are inconsistent and, in some cases, overly broad. In addition, the EPA Study misidentifies the vertical separation distance between HF stimulations and overlying drinking water resources as the dominant factor controlling the possibility of upward fluid migration; the dominant factors are, in fact, the controls on upward fracture growth and the capacity of rocks to store and transmit fluid. The EPA Study also mischaracterizes the potential for fluids to migrate upward through stimulated fractures and faults throughout its Study, in many cases relying on a single flawed study (Myers, 2012) that has been rejected by the scientific community to allege that HF fluid could potentially migrate upward to drinking water resources. In many other cases, the EPA Study mischaracterizes the references it cites or ignores other studies when it alleges that fluids could potentially migrate upward through stimulated fractures or faults.

The central focus of the EPA Study is the relationship between HF and drinking water resources, but the Study's descriptions of these resources are vague and inconsistent. The EPA Study initially proposes a definition that is so broad that it could include any water on Earth. Later in the Study, EPA appears to use the narrower definition of an underground source of drinking water, as described in the Safe Drinking Water Act (SDWA). Yet, in other places, the Study declines to adopt a definition of drinking water resources at all. The use of multiple terms and definitions is confusing, and EPA should instead use terminology that is consistent with the SDWA throughout the Study. In addition, the EPA Study conveys an erroneous impression that, in some limited cases, HF operations are occurring in formations that serve as drinking water supplies. For multiple reasons (*i.e.*, high treatment requirements and the limited water supply potential of hydrocarbon reservoirs), commercially viable hydrocarbon deposits are not suitable for drinking water development, and the EPA Study should clearly state this fact.

The EPA Study identifies the vertical separation distance between groundwater resources and the shallowest HF operations as one of the most important variables controlling the possibility of upward fluid migration. However, the references cited by EPA state that separation distance plays a secondary role; prior studies have clearly identified the constraints on upward fracture growth and the capacity of rocks to store and transmit fluids as the most important factors. Moreover, the method used in the EPA Study to estimate separation distance is unreliable and not reproducible. The EPA Study utilized data in its calculations that were apparently not intended for this purpose and does not provide any quality control in regards to the accuracy or representativeness of its calculations. The underlying data used to calculate separation distance were not even included in the EPA Study, so it is impossible to evaluate whether EPA's calculations are correct and reproducible.

The EPA Study makes a number of flawed assertions that suggest there is potential for upward migration of fluids through overlying formations. However, these assertions often rely on a single flawed study, *i.e.*, Myers (2012). The Myers (2012) study has been rejected by the scientific community, as demonstrated by multiple peer-reviewed comments and studies criticizing virtually all aspects of its analysis. Although the EPA Study points out some of these criticisms, it gives the false impression that Myers's work might still be valid by citing his rebuttal to some of these criticisms. However, Myers' rebuttals are as deeply flawed as his original work. The EPA Study should not rely on the article by Myers or any of his subsequent rebuttals to criticisms of his study.

The EPA Study repeatedly mischaracterizes other studies to support flawed statements about potential upward fracture growth and fluid migration. This misuse of the scientific literature is pervasive and includes multiple issues, such as the maximum extent of fracture growth, pressure diffusion and fluid migration, and the hydraulic properties of rocks. The EPA Study also overstates the degree of existing uncertainty regarding the maximum possible extent of upward fracture growth, contradicting several studies that have clearly demonstrated overarching limitations with extensive monitoring of fracture growth throughout the major basins in the US. The entire discussion of upward fluid migration and fracture growth should be closely reviewed and edited to ensure that the EPA Study is factually correct and appropriately characterizes cited work.

1.3 Analysis of Potential Hazards

EPA's analysis of the potential hazards posed by HF chemicals is also flawed in several respects. EPA developed its list of HF chemicals using some unreliable sources and the list is outdated. For example, the EPA Study relies on chemical lists developed by Colborn *et al*. (2011), even though Colborn *et al*. (2011) stated that they could not definitively determine whether the chemicals they identified were even used in HF. Furthermore, Colborn *et al*. (2011) compiled chemicals that are generally used on a wellpad, but not necessarily associated with HF or flowback fluids. EPA lists over 50 chemicals solely on the basis of the work of Colborn *et al*. (2011), even though these chemicals were neither reported as HF-related by the service companies that EPA contacted, nor included in the more reliable sources used in generating the EPA list. EPA's list of chemicals is also outdated (*i.e.*, largely from data collected 6-10 years ago) and does not reflect the evolving nature of HF technology. Although some of the chemicals compiled from sources 6-10 years ago are still in use currently, the generally outdated nature of this list as a whole is clearly demonstrated by the fact that the majority of chemicals listed in the EPA Study were not found in disclosures to the FracFocus database during 2011-2013. The high degree of inconsistency between EPA's list of HF chemicals and the chemicals reported to FracFocus clearly indicates that the list of HF chemicals identified by EPA is not adequately reflective of current HF fluid compositions.

In addition, the EPA Study utilizes a very limited source of toxicity data and fails to use other sources that would have enabled toxicity evaluation of a majority of HF chemicals identified by EPA. The data sources utilized by EPA only included a small set of regulatory agency databases that yielded data for 60 of the 1,173 chemicals identified by EPA. The EPA Study should have used a tiered approach for identifying toxicity data. For example, data sources currently utilized by EPA should have been placed in a higher-tier category with other data sources included in a lower-tier category, to be considered if reference values are not available from higher-tier sources. This approach would have allowed EPA to evaluate toxicity for the majority of identified chemicals.

The EPA study also places too much emphasis on hazard analysis, does not address exposure directly, and fails to place the HF compounds in proper perspective by discussing other common uses of compounds. The EPA Study acknowledges the importance of exposure and had all the necessary information to better characterize potential exposures, yet did not undertake such an analysis. EPA instead relied on crude surrogates for exposure (*e.g.*, frequency of use and physicochemical properties of chemicals) that are not appropriate. In addition, other common sources of exposure to the HF chemicals identified by EPA should be discussed, to put the potential exposures related to HF into proper perspective. Many of the compounds identified by EPA are present in high concentrations in foods and consumer products, while many other compounds have already been characterized as having low potential hazards.

The only mechanism through which EPA attempts to take exposure into account is a qualitative Multi-Criteria Decision Analysis (MCDA). However, this approach has a number of fundamental flaws and yields no meaningful conclusions. EPA's MCDA approach only evaluates an extremely small subset (3-5%)[2] of the compounds it identifies as being associated with HF, without evaluating the representativeness of this chemical subset. In addition, EPA's approach for estimating exposure to HF chemicals relies on occurrence frequency and qualitative chemical fate and transport assessments, both of which are inappropriate surrogates for exposure. While we understand that EPA's report is not a formal risk assessment of HF fluids, a more robust evaluation was feasible given that all the necessary information for a risk analysis was available to EPA.

1.4 Overall Conclusions

Overall, the sections of the EPA Study relating to the topics above have unnecessary limitations, contain avoidable flaws, and repeatedly mischaracterize the cited literature. The EPA Study also fails to reach meaningful conclusions on these topics, in part due to the shortcomings and mischaracterizations discussed in the detailed technical comments below. The recommendations in this report would help ensure that EPA's analyses and findings appropriately characterize current HF operations and scientific state of knowledge on potential chemical migration and allow for more meaningful conclusions about the potential impacts of HF on drinking water.

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[2] EPA evaluated a total of 60 compounds: 37 HF chemicals and 23 flowback/produced water compounds.

2 EPA's analysis of potential spills of HF fluid and chemical transport processes is severely limited, contains avoidable flaws, and fails to reach any meaningful conclusions.

EPA evaluated factors that control the transport of chemicals potentially associated with spills of HF fluid and attempted to characterize the frequency at which spills of HF fluid might occur. However, the EPA Study is unable to evaluate the majority of identified chemicals, due to the limitations of the resources that EPA relied on to estimate chemical properties. EPA's methods for estimating chemical properties are also not appropriate for evaluating chemicals with high or low mobility, even though EPA used them precisely for that purpose. In addition, the EPA Study has included flawed discussions regarding the role of some transport processes (*e.g.*, surfactants, solvents, the effect of K_{ow} values) that overstate the potential for chemicals to migrate from a spill to a potential drinking water resource. The EPA Study also fails to identify the correct spill rate for HF-related fluids in Pennsylvania or to state that the two states with spill data available (Pennsylvania and Colorado) have consistent spill rates (*i.e.*, approximately 1%). Thus, a spill rate of 1% for HF-related fluids is likely applicable to the country as a whole. Lastly, the EPA Study fails to reach any meaningful conclusions about the potential effects of HF-related spills on drinking water resources. Overall, these deficiencies have resulted in the EPA Study overstating the potential for impacts from spills.

2.1 EPA's analysis of physicochemical properties is unnecessarily limited and inappropriate for evaluating chemicals with high or low mobility.

The EPA Study attempted to identify or estimate physicochemical properties for 1,075 chemicals that EPA identified as being potentially present in HF fluid. However, in estimating physicochemical properties, EPA solely relied on EPI Suite, a software package that is only capable of estimating the properties of organic chemicals with identifiable chemical structures. EPI Suite is unable to estimate the properties of inorganic chemicals and organic chemicals with complex or varying structures (*e.g.*, some surfactants and polymers), severely limiting its utility. As a result, the methodology in the EPA Study is unable to evaluate physicochemical properties for approximately 58% of the 1,075 chemicals alleged to be associated with HF.

Moreover, physicochemical properties predicted by EPI Suite are unreliable for evaluating chemicals with either very high or low mobility. However, EPA used the model exactly for this purpose. For example, one of the chemical properties estimated with this software is the logarithm of the octanol-water partitioning coefficient (log K_{ow}), which is a measure of how readily a given chemical partitions between water and organic matter. In EPI Suite, log K_{ow} values are estimated using a program called KOWWIN, a regression analysis that has been validated using measured log K_{ow} values and chemical structural characteristics. The regression relationships used by KOWWIN were developed over a limited range of log K_{ow} values (*i.e.*, -4.2 to 8.2), but the EPA Study used KOWWIN to estimate log K_{ow} values well outside of this range (*i.e.*, -23.2 to 22.6; see Figure 2.1).

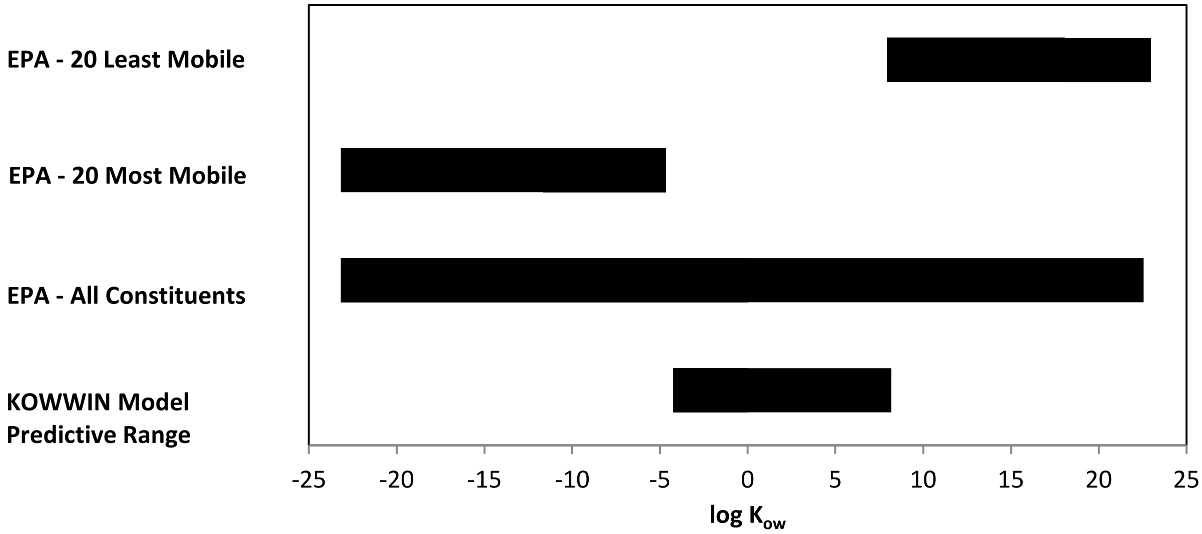

Figure 2.1 Comparison of K_{ow} Ranges for the KOWWIN Model to Predicted Values That EPA Used in Its Study

Hence, many of the log K_{ow} values estimated by EPA are unreliable. For example, all 20 of the chemicals the EPA Study identified as having the highest mobility (US EPA, 2015a, Table 5-7) and nearly all (*i.e.*, 16 of 20) of the chemicals identified as having the lowest mobility (US EPA, 2015a, Table 5-8) had estimated log K_{ow} values outside the range where KOWWIN can be reliably used (see Figure 2.1). Prior reviews of KOWWIN by the EPA Science Advisory Board (SAB) had warned EPA that log K_{ow} values predicted by KOWWIN outside the range for which the model was validated are uncertain and of limited utility:

> First, for chemicals similar to those for which modules to estimate chemical properties were developed, the algorithms that support the calculations are scientifically defensible and appropriate for Agency regulatory screening applications…[F]or chemicals whose structures and/or properties are outside the domain used in module development, scientific uncertainty may limit the utility of this software. In such cases, the Agency uses other methodologies to evaluate chemical properties. (US EPA, 2007a, p. 2)

EPA should have heeded the SAB's advice and not relied on model predictions from KOWWIN that were beyond the range of the validated model.

EPA should, instead, use other readily available information on physicochemical properties for both inorganic and organic chemicals. For example, EPA has previously evaluated physicochemical properties for metal ions and oxy-ions as part of its soil screening-level guidance (US EPA, 1996). EPA should have utilized this information to assess the mobility of inorganic constituents. EPA should also have utilized measured K_{ow} data submitted to EPA as part of other programs and by other state, federal, and international agencies (*e.g.*, EPA pesticide registration documents, EPA High Production Volume Information System [HPVIS], and the Registration, Evaluation, Authorisation and Restriction of Chemical [REACH] regulation). For example, as shown in Table 2.1, several chemicals that are typical components of HF fluids (Gradient, 2013) and are also identified in EPA's list of chemicals have measured log K_{ow} values available from sources not considered by EPA. Some of these measured values are substantially different from the log K_{ow} values predicted by EPA, further demonstrating the unreliable nature of the EPA analysis. By using these alternative sources of information, EPA can identify log K_{ow}

values for a wider range of chemicals and the log K_{ow} values identified at the high and low ends of the spectrum would be more reliable.

Table 2.1 Comparison of Available log K_{ow} Values for Selected Chemicals Used in Typical HF Fluids to Estimated log K_{ow} Values Listed in the EPA Study

Chemical Name	CAS RN	EPA (EPI Suite) log K_{ow}	Experimental log K_{ow}	Experimental log K_{ow} Source
Phosphonic acid, [[(phosphonomethyl)imino]bis [2,1-ethanediylnitrilobis(methylene)]]tetrakis-	15827-60-8	-9.72	-3.4	ECHA (2015a)
N-(3-Chloroallyl)hexaminium chloride	4080-31-3	-5.92	-0.1	EPA (1995)
Triethylenetetramine	112-24-3	-2.65	-1.4	OECD (1998)
Tetrakis(hydroxymethyl)phosphonium sulfate	55566-30-8	-5.03	-9.8	IPCS (2000)
Fatty acids, C18-unsaturated, dimers	61788-89-4	14.6	1-2.5	Pine Chemical Association, Inc. (2004)

Notes:
ECHA = European Chemicals Agency; EPA = United States Environmental Protection Agency; HF = Hydraulic Fracturing; IPCS = International Programme on Chemical Safety; log K_{ow} = Octanol-Water Partitioning Coefficient; OECD = Organisation for Economic Co-operation and Development.

2.2 EPA has mischaracterized key factors that control chemical migration.

2.2.1 Chemical concentrations are critically important factors for transport analyses, but EPA fails to adequately discuss and utilize chemical concentration data.

EPA's discussion of chemical migration mischaracterizes the key factors that control this process. As discussed below, the EPA analysis never accounts for concentrations of chemicals in solution and their effect on transport or their potential to affect drinking water resources and makes incorrect and misleading statements about the effects of chemical mixtures, co-solvency, and equilibrium partitioning.

EPA never discusses how the concentrations of chemicals in solution affect their subsequent transport or potential to affect drinking water resources. HF fluids are generally dilute solutions and spills tend to be small (Gradient, 2013; Flewelling *et al*., In Preparation). Dilute solutions of chemicals migrate very differently from pure-phase chemicals, and EPA needs to acknowledge these differences. For example, a spill of a pure solvent might migrate as a non-aqueous phase liquid (NAPL), be characterized by complex multi-phase transport processes, and have the potential to impact relatively larger volumes of water than a spill of a dilute solution. Conversely, dilute solutions, such as HF fluids, would migrate in the dissolved phase if released and, hence, are not subject to the complex multi-phase transport behavior of NAPLs. Moreover, dominant transport processes (*e.g.*, adsorption, chemical/microbial reactions, effects of chemical mixtures, and co-solvency) are dependent on chemical concentrations, again pointing to the importance of characterizing concentrations. Although spills of HF additives could occur, the volumes of such spills are inherently limited due to the modular nature of additive packaging (*e.g.*, buckets, barrels, totes). For example, a review of spill data in Pennsylvania from 2009-2013 indicates that spills of fluids that may have been HF additives were infrequent and had small spill volumes ranging only from 1 quart to 33 gallons. EPA needs to account for these important factors when assessing whether compounds in HF fluids could potentially migrate and reach drinking water resources at concentrations high enough to adversely affect human health. Without considering concentrations and spill volumes, EPA has no way of knowing whether spills are expected to create an adverse effect on drinking water resources.

In addition to failing to discuss or account for chemical concentrations, the EPA study includes tables that incorrectly state the concentrations of chemicals potentially present in HF fluids. EPA has incorrectly used the concentrations of chemicals in HF additives (*i.e.*, the HF additive products prior to being mixed and diluted into HF fluid) to represent the much lower concentrations of these chemicals in the mixed HF fluid. For example, EPA lists the chemicals reported to FracFocus that were used in 10% or more of gas (US EPA, 2015a, Table C-1) and oil (US EPA, 2015a, Table C-2) wells. In the last column of each of these tables, EPA lists the alleged median[3] concentration of each of the identified chemicals, but has incorrectly listed the concentration of these chemicals in the additive products rather than the actual diluted concentration of each chemical in HF fluid. Thus, the listed concentrations of chemicals in Tables C-1 and C-2 of the EPA Study (US EPA, 2015a) grossly overstate the concentrations of these chemicals in HF fluid. Moreover, apart from relying on FracFocus, EPA could have also used data submitted by service companies to calculate the concentrations of chemicals used in HF fluid, as a check of the values reported in Table C-1 and C-2 of the EPA Study (US EPA, 2015a). EPA needs to correct the errors in Tables C-1 and C-2 of the EPA Study (US EPA, 2015a) and make sure that the calculated concentrations from FracFocus compare reasonably to HF fluid formulations submitted to EPA by service companies. As discussed above, these concentrations should also be considered in EPA's discussion of chemical migration.

2.2.2 The EPA study mischaracterizes the roles of surfactants and log K_{ow} values in chemical transport.

EPA mischaracterizes the role that surfactants play in chemical transport. EPA alleges that surfactants can mobilize other chemicals (US EPA, 2015a, p. 5-64), but fails to discuss the importance of surfactant concentration on its potential to mobilize other constituents (*e.g.*, Edward *et al*., 1991; Li and Logan, 1999; Pennell *et al*., 1993). Moreover, EPA also alleges that surfactants can mobilize bacteria but fails again to discuss the importance of several factors, including the surfactant concentration. In all cases, EPA assumes that the presence of surfactants in solution will increase the migration potential of other constituents, but fails to acknowledge the full set of fate and transport processes that would control whether surfactants could contribute to a potential impact at a drinking water resource.

EPA also mischaracterizes the significance of the log K_{ow} values it estimates. EPA states that its prediction of physicochemical properties shows that the log K_{ow} values for chemicals used in HF fluids are biased greater than zero, which EPA interprets as suggesting that most HF chemicals would be a long-term source of impacts to drinking water (US EPA, 2015a, p. 5-55). However, as discussed previously, EPA's methodology for estimating K_{ow} values was not appropriate for chemicals with very high or low mobility. Furthermore, its interpretation ignores several important factors that control the potential for spilled chemicals to affect drinking water, including the concentration of constituents in the spilled material, the size of the spill, and the nature of transport for highly sorptive chemicals. As discussed previously, the concentrations of chemicals in HF fluids were available to EPA from FracFocus and information submitted to EPA by service companies. Moreover, given the generally small volumes associated with HF-related spills – *e.g.*, a median spill volume of 150 gallons (Flewelling *et al*., In Preparation) to 420 gallons (US EPA, 2015a) – a high K_{ow} would mean that a significant quantity of chemical would partition to organic carbon in shallow soils, and migration would be slow, meaning that such chemicals may never reach downgradient receptors at concentrations of consequence. Other fate

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[3] Concentrations in FracFocus are reported as ranges. The median concentration value reported by EPA (the so-called median maximum) is the median of the maximum reported value of each concentration range in FracFocus.

and transport processes, such as degradation, would also further reduce the potential for chemicals to migrate at concentrations potentially relevant to human health. For example, a recent study demonstrated that most HF-related compounds would degrade to concentrations below maximum contaminant levels (MCLs) before reaching the edge of typical well pads (Rogers *et al.*, 2015). Thus, claims in the EPA Study that chemicals with high log K_{ow} values would serve as a long-term source of impacts to drinking water overstate the potential for the generally small spills of HF-related fluids (in the unlikely event that a spill occurs) to impact drinking water.

2.2.3 The EPA study makes flawed statements about co-solvency that do not apply to HF fluids.

EPA claims that co-solvency (*e.g.*, *via* the presence of methanol or ethanol) could enhance the mobility of some chemicals but fails to state that solvents must be present at very high concentrations (*e.g.*, present at >10% by volume) for co-solvency effects to be manifested. Because the total amount of chemicals in HF fluid typically makes up less than 1% of the solution (with solvents representing only a fraction of that), co-solvency is not even relevant with regard to chemical transport potentially related to HF. Although spills of more concentrated additives could potentially occur, as discussed previously, the modular nature of additive packaging leads to limited additive spill volumes that would not be expected to have an effect on drinking water quality or enhance the mobility of other chemicals due to co-solvency effects.

The references that EPA cites to support its claims that co-solvency could potentially enhance the mobility of HF constituents very clearly state that solvent concentrations must be very high (*e.g.*, >10% by volume) in order for co-solvency effects to occur and that, in any event, co-solvency may play only a minor role in HF constituents' mobility. For example, the following two statements are from the references that EPA cited:

- "Results indicate that cosolvency would be significant only for high aqueous ethanol concentrations (higher than 10%). Under these conditions, cosolvency may be critical only in cases of large gasohol spills [(*i.e.*, those with approximately 24% ethanol by volume)] or in simultaneous releases of neat ethanol and other fuels" (Corseuil *et al*., 2004).
- "Ethanol can increase the aqueous concentration of BTEX compounds due to a cosolvent effect, and it can inhibit BTEX biodegradation by preferentially consuming electron acceptors and nutrients. Our review illustrates that cosolvent effects should be minor at the ethanol concentrations expected from gasohol spills" (Powers *et al*., 2001).

These references clearly support the conclusion that HF additive concentrations are far too low to enhance the transport of HF-related chemicals *via* co-solvency.

EPA also mischaracterizes two of the studies it cites to support its claims about co-solvency – Rasa *et al*. (2013) and Corseuil *et al*. (2011). The study by Rasa *et al*. (2013) did not evaluate the potential effects of co-solvency whatsoever. Rasa *et al*. (2013) evaluated biodegradation and microbial growth within BToX[4] and BToX plus ethanol plumes when the constituents were present in the dissolved phase below their solubility limits. The study by Corseuil *et al*. (2011) also did not evaluate co-solvency. Corseuil *et al*. (2011) found that the groundwater plume associated with a spill of Brazilian gasoline containing 24% ethanol initially experienced lower than expected degradation rates, but the effect was short-lived.

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[4] BToX stands for benzene, toluene, and o-xylene.

It is unclear why the EPA Study focuses on co-solvency when the references cited by EPA indicate that this process is not even relevant for HF fluids, due to the low concentration of additives (of which solvents are only a fraction). EPA should remove the discussion of co-solvency, because it is not relevant to HF chemical transport.

2.3 EPA's analysis of potential spills fails to identify the most appropriate spill rate for Pennsylvania and fails to acknowledge that available state data are consistent.

The EPA study includes a lengthy discussion of spill rates in Pennsylvania and implies that the rates vary depending on the methods used, but fails to undertake any analysis of its own or to critically evaluate previously developed rates to identify the most appropriate value. A rigorous analysis of the Pennsylvania violations database indicates that the spill rate for HF fluid is approximately 1% (Flewelling *et al.*, In Preparation). The other rates reported in the EPA study suffer from problems in the underlying methodology that either over- or under-represented the number of spills in the state, as discussed below. Additionally, EPA's analysis of the spill rate in Colorado is biased high. These shortcomings give the impression that there is more uncertainty surrounding spill rates and overstates the rate at which spills of HF-related and flowback fluids occur.

The discussion of spill rates for Pennsylvania in the EPA Study is summarized in Box 5-14 at the end of Section 5.7 (along with other places in the Study) and concludes that spill rates vary, depending on the data analysis method used (US EPA, 2015a). After reviewing the methodologies in the cited studies, however, it is clear that the HF fluid spill rates reported for Pennsylvania by EPA are not appropriate. The spill rate reported in Brantley *et al*. (2014) – 0.4% – is an underestimate. As discussed in the EPA Study, Brantley *et al*. (2014) only considered spills with volumes greater than 400 gallons, which inappropriately excludes small spills. Because the median spill volume in Pennsylvania is about 150 gallons (Flewelling *et al*., In Preparation), the imposition of a 400-gallon minimum for consideration of spills in the Brantley *et al*. (2014) analysis inherently ignores the majority of HF-related spills that occur in the state. At the other extreme, the EPA study cites Rahm *et al*. (2015) to allege that the HF fluid spill rate could be as high as 12.2%, but fails to state that this rate is for potential spills of all fluid types during all unconventional oil and gas activities, not just HF. Rahm *et al*. (2015) lumped together spills from all oil- and gas-related activities in Pennsylvania, including spills potentially associated with site preparation and construction, drilling, completion, and post-completion activities. Thus, the spill rate reported by Rahm *et al*. (2015) is for the oil and gas industry as a whole and greatly overestimates the spill rate for HF activities.[5] Using a method similar to Rahm *et al*. (2015) for identifying spills and screening out duplicates from the Pennsylvania violations database, Flewelling *et al*. (In Preparation) found a similar overall spill rate for all unconventional oil and gas development activities in Pennsylvania. However, when spills were parsed by their source, Flewelling *et al*. (In Preparation) found that HF-related spills represented only a small fraction of all spills and had an overall spill rate of 1%. Flewelling *et al*. (In Preparation) similarly found that the spill rate for flowback fluid was 1.3%. If one were to lump spills of HF-related and flowback fluid spills into a single category, the spill rate for these two fluid categories would be 2.3%. Thus, while about 12% of wells might have a spill during the course of all oil and gas development activities, only about 1% of wells have a spill of an HF-related fluid, whereas another 1.3% of wells have a spill of flowback fluid.

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[5] The EPA Study also cites a spill rate of 3.3% from Gradient (2013). The Gradient (2013) analysis includes spills of all types of liquids (HF fluid, flowback, equipment fluids, *etc.*) at well pads that reported spill volumes. The Gradient analysis therefore includes some fluids that are unrelated to HF, but also restricted its analysis to spills that reported volumes.

EPA also presented the results of its analysis of the spill rate for HF-related fluids in Colorado. However, the method that EPA used to calculate an average spill rate for Colorado caused the result to be biased high. The EPA Study states that HF-related spill rates in Colorado were calculated for the following three periods:

- January 2006 to April 2012 (spill rate of 1.1%);
- January 2011 to April 2012 (spill rate of 1.4%); and
- September 2009 to October 2010 (spill rate of 1.4%).

EPA then averaged the spill rates from these three periods to come up with an overall spill rate for the state. This averaging approach is not statistically sound. The period of January 2006 to April 2012 obviously includes the latter two periods. Thus, by EPA including the latter two periods in the average, it is inappropriately giving additional weight to the spill rates in the later two periods and biasing the spill rate toward those two periods. Because those latter two spill rates are higher than for the entire period evaluated, EPA is therefore artificially and inappropriately biasing the spill rate high. EPA should instead use the spill rate from January 2006 to April 2012 and not average it with the other two periods, which are simply subsets of the time interval from January 2006 to April 2012. In addition, there is a general lack of clarity regarding the description of EPA's methodology for identifying spills from data that EPA obtained from the Colorado Oil and Gas Conservation Commission (COGCC) (*e.g.*, see US EPA, 2015b, p. 7). The description provided by EPA does not clearly state the key words used to search the COGCC data, making it difficult to reproduce EPA's results. EPA should review these issues to make sure its methodology and calculations are clearly articulated and accurate.

Overall, HF-related and flowback fluid spill rates are available for two states (Pennsylvania and Colorado), and the spill rates for both states are consistent (*i.e.*, approximately 1-2%). Despite significant differences in topography, climate, and targeted formations between these states, the consistency in the spill rate for HF fluid in these two states suggests that a spill rate of about 1-2% is likely appropriate for the industry or nation as a whole, contrary to statements made in the EPA Study.

2.4 EPA fails to reach any meaningful conclusions regarding the potential impacts of spills.

The so-called findings and conclusions in the sections of the EPA Study related to spills (*e.g*., Sections 5.7, 5.8, 7.7, and 7.8; US EPA, 2015a) are obvious and could have been reached without doing any analysis. For example, the report states on page 5-47: "The EPA analysis demonstrates that spills of chemicals, additives, and fracturing fluids do occur at well sites and reach both soil and surface water receptors" (US EPA, 2015a). This statement would be true of any human activity in which fluids are handled and provides no new insight from the analyses undertaken by EPA or other relevant literature.

EPA should have instead focused on more clearly presenting available data on potential spill rates and spill volumes – *i.e.*, the two factors that largely control the potential for impacts arising from spills of HF fluid. In addition, EPA should have used spill rate data, concentrations of HF and flowback/produced water constituents, and hydrologic data to quantify a range of exposure concentrations in drinking water resources. Gradient (2013) and Flewelling *et al*. (In Preparation) previously used available data to characterize potential concentrations of HF- and flowback-related constituents in drinking water resources. These analyses should be carefully reviewed, and EPA should present some analysis or summary of potential exposure concentrations in its report.

3 Potential Fracture Growth and Upward Fluid Migration

The EPA Study discusses the potential for fractures to grow upward from targeted formations and for fluids to migrate upward through stimulated fractures and faults to overlying drinking water resources. However, the discussion lacks a clear definition of which water resources EPA considers to be potential sources of drinking water. The EPA Study provides several definitions that are inconsistent with one another, but, in other sections, declines to provide a definition at all. EPA also implies that some limited HF stimulations might be occurring in formations that serve as drinking water supplies, while failing to acknowledge that rocks in the vicinity of commercially viable hydrocarbon deposits are not practical targets for water resource development, due to naturally poor water quality and limited water quantity/yield.

The discussion in the EPA Study of the factors that control the potential for fluids to migrate upward through stimulated fractures and faults also contains a number of flaws. For example, the EPA Study states that the vertical separation distance between targeted rocks and overlying drinking water resources is one of the most important factors controlling the potential for upward fluid migration, even though current research indicates that other factors are more important than separation distance (*e.g.*, limits to fracture growth and the physical properties of rocks). Moreover, EPA did not specifically request data from operators to calculate separation distance and did not provide sufficient information to determine whether it calculated this quantity correctly. Additionally, the EPA study makes flawed assertions about potential upward fluid migration and repeatedly mischaracterizes cited studies. For example, the EPA Study relies on a single flawed study (Myers, 2012) to allege that fluids could potentially migrate upward, even though Myers's work is contradicted by numerous other studies, including recent work done by Lawrence Berkeley National Laboratory (LBNL) (*e.g.*, Reagan *et al*., 2015) in cooperation with EPA, among others. Numerous other studies are repeatedly mischaracterized throughout the discussion of upward fracture growth and fluid migration in the EPA Study. Lastly, the EPA Study makes several vague statements that imply that hydraulic fractures may have created pathways for upward fluid migration and that HF fluid might have affected drinking water resources, without providing a single example in which this has occurred. Overall, the deficiencies in EPA's discussion of potential upward fracture growth and fluid migration are pervasive and have led EPA to overstate potential impacts to drinking water.

3.1 The EPA Study expands the definition of "underground sources of drinking water" without any credible rationale and incorrectly assumes that hydrocarbon deposits are viable sources of drinking water.

The central focus of the EPA Study is on the potential impacts of HF on drinking water resources, but the study is vague and inconsistent in describing those resources. The EPA Study initially defines drinking water resources broadly by stating:

> In this assessment, drinking water resources are defined broadly as any body of ground water or surface water that now serves, or in the future could serve, as a source of drinking water for public or private use. Drinking water resources provide not only water

> that individuals actually drink but also water used for many additional purposes such as cooking and bathing. Our definition of drinking water resources includes both fresh and non-fresh bodies of water. (US EPA, 2015a, p. 3-1)

This definition is so broad that it could potentially include any water on Earth. However, in other sections, the EPA Study seems to use the narrower definition of an underground source of drinking water (USDW) from the SDWA, and in still other sections declines to adopt a definition of drinking water resources at all. The following two quotations from the EPA Study are examples of these issues:

- "Evidence we examined suggests that some hydraulic fracturing for oil and gas occurs within formations where the ground water has a salinity of less than 10,000 mg/L TDS. By definition, this results in the introduction of fracturing fluids into formations that meet the Safe Drinking Water Act (SDWA) salinity-based definition of a source of drinking water and the broader definition of a drinking water resource developed for this assessment" (US EPA, 2015a, p. 6-53).
- "This report does not use a single definition for protected ground water resources and relies solely on information provided to the EPA by well operators" (US EPA, 2015c, p. 76).

The use of multiple terms and definitions in the EPA Study is confusing; one of the definitions (*i.e.*, US EPA, 2015a, p. 3-1; 2015c, p. 76) used by EPA conflicts with the definition of an USDW in the SDWA and, as evidenced above, in one instance EPA declines to provide a definition at all. EPA should use terminology that is consistent throughout the report and with the SDWA.

In addition, EPA suggests that, in some limited cases, HF operations are occurring in formations that serve as drinking water supplies. However, this conveys an erroneous impression given that for a number of reasons formations with commercially viable quantities of oil and gas would not generally be used as sources of drinking water. For example, it would make no sense for a community water system (CWS) to install drinking water production wells in hydrocarbon-rich rocks, because the CWS would incur significant costs in removing the hydrocarbons from the water and treating the water to meet national drinking water standards prior to distribution. Clearly, this is a case in which developing the hydrocarbon resources in such a rock would be more practical than developing the water resources. Moreover, the water present in hydrocarbon deposits is not generally a replenishable resource. Targeted hydrocarbon deposits are millions to hundreds of millions years old (Law and Spencer, 1998), and the water contained within them is typically of comparable age. The recharge rate of water to hydrocarbon deposits is so low as to be negligible over timescales relevant to humans. Thus, the water in hydrocarbon deposits would, in effect, be permanently removed if it were ever developed for drinking water purposes. Furthermore, most hydrocarbon-bearing rocks and the surrounding strata are highly compacted and have limited water saturation, meaning that they do not store a significant amount of water for drinking water supply purposes and have a limited capacity to yield water to a drinking water production well (*i.e.*, further limiting supply potential). These distinctions are important, because HF operations are occurring in commercially viable hydrocarbon deposits that are not practical targets for water resource development. Thus, even though HF might occur in some rocks containing water that meets the SDWA definition of an USDW this does not mean that the targeted rocks are, or would be in the future, a practical target for drinking water development. The EPA Study should clearly state this fact.

3.2 The EPA method for estimating separation distance is unreliable, and its interpretation of the importance of separation distance is flawed.

The method used in the EPA study to estimate the vertical separation distance (*i.e.*, the distance between the deepest drinking water resource and shallowest HF stage at a given well) is not reproducible and relies on data that were not intended to be used for this purpose. Moreover, EPA acknowledges that it has no way of ensuring quality control over the data it used in its calculations and admits that the data might not be consistent with other sources of information. In addition, the EPA study incorrectly states that separation distance is one of the most important factors affecting the possibility of upward fluid migration and mischaracterizes the studies that it uses to support this presumption.

3.2.1 The EPA Study did not request appropriate information to estimate vertical separation distance and did not provide enough information to determine if its calculations are correct.

From reviewing the information request that EPA sent to operators, it is clear that EPA did not request information that could be used to calculate vertical separation distance. Thus, the data that EPA used to estimate vertical separation distance were not appropriate for the purpose. For example, EPA relies on the depth to a "protected ground water resource" provided by operators to calculate separation distance, but does not provide information to describe what this term means from a technical standpoint, how it differs across states or regions (basins or plays), or whether it is an appropriate metric that can be used to determine the maximum depth of drinking water resources. In fact, EPA explicitly declines to define the term "protected ground water resource" in its report regarding data submitted by operators, stating that "[t]his report does not use a single definition for protected ground water resources and relies solely on information provided to the EPA by well operators" (US EPA, 2015c, p. 76). Compounding this lack of clarity is the fact that only a small percentage of the wells used by EPA to calculate vertical separation distance had site-specific data to determine the depth to protected groundwater resources (*e.g.*, well logs). For the vast majority of wells, the data source used to estimate the depth of "protected groundwater resources" was "well authorization documentation" (US EPA, 2015c, p. 76). EPA provides no description of how the depth to protected groundwater resources was determined (either by EPA or the operator) from well authorization documentation or any other submitted records and whether depths to protected groundwater can be independently verified by examples from literature, local sample results, or well logs. In fact, EPA states that:

> No attempt was made to independently and systematically verify the data supplied by the operators, including depths to protected ground water resources. Consequently, the EPA Study results, which include comparisons of operator-reported protected ground water resources to well construction characteristics (Section 4.3.2), are of the same quality as the supplied data. Other sources, such as state oil and gas agencies, may identify different values for the data elements used in this study, which would affect the results presented in this report. (US EPA, 2015c, p. 55)

Thus, EPA has no way of knowing whether the depths to protected groundwater that it uses in its calculation of vertical separation distance are appropriate, and apparently has no intention of undertaking any quality control of its calculations. The approach used in the EPA Study is haphazard and does not constitute good science. Instead, EPA should use a technically sound and reproducible method to identify the depth to protected groundwater resources or exclude the calculation from the Study.

In addition to using inappropriate information, the EPA Study did not provide enough information to determine whether it calculated vertical separation distance correctly based on the information it did use. The EPA Study stated that "separation distance was estimated by subtracting the depth of the operator-reported protected ground water resources from the measured depth of the point of shallowest hydraulic fracturing" (US EPA, 2015c, p. 42), but did not include the underlying data used in these calculations in its report. Thus, there is no way to determine whether EPA's calculations are correct and reproducible.

3.2.1 The EPA Study mischaracterizes the importance of vertical separation distance on the potential for fluids to migrate upward.

EPA states that separation distance is "one of the most important factors affecting the possibility of fluid migration between these formations" (US EPA, 2015a), citing the work of Reagan *et al*. (2015) and Jackson *et al*. (2013) to support this assertion. However, EPA's statement is too narrowly focused on separation distance and does not acknowledge other factors that are more important controls on potential upward fluid migration. For example, Reagan *et al*. (2015) (*i.e.*, one of the references EPA cites to support its statement) state that the permeability and storage volume of a conductive pathway are the most important factors controlling potential upward migration of natural gas, with separation distance playing only a secondary role. Other work has shown that separation distance is essentially irrelevant for deep shales, because hydraulic fractures cannot grow far enough upward to reach drinking water resources from these deep formations, whereas, at shallower depths, the naturally occurring stresses cause hydraulic fractures to turn and go horizontal, thereby sharply reducing the potential for upward fracture growth to shallower depths (Fisher and Warpinski, 2011; Flewelling *et al*., 2013). Thus, it is the physical properties of rocks and natural changes of stress with depth that are the most important controls on the potential for upward fluid migration. The other paper cited in the EPA Study, Jackson *et al*. (2013), did not include any analyses related to the importance of separation distance on upward fluid migration. Hence, the Jackson *et al*. (2013) paper is not even relevant. It appears that the EPA Study is singling out vertical separation distance as an important factor for the possibility of upward fluid migration without any basis for making this assertion. EPA should remove this statement from the Study or provide a technically sound rationale, with appropriate supporting references, for why it thinks that separation distance is important.

3.3 The EPA Study makes flawed assertions about potential upward fluid migration and repeatedly mischaracterizes cited studies.

3.3.1 EPA's assertions that fluids could potentially migrate upward through stimulated fractures and faults are flawed.

EPA makes a number of assertions that suggest there is potential for upward migration of fluids through overlying formations. However, these assertions often rely on a single flawed study – *i.e.*, Myers (2012). The EPA Study repeatedly cites Myers (2012) to claim that HF could drive fluids upward through a pre-existing fault or stimulated fractures to drinking water resources over timescales of less than 1 year (*e.g.*, US EPA, 2015a, pp. 6-35–6-36, 6-50). The Myers study has been rejected by the scientific community because of numerous fundamental shortcomings, omissions, and oversimplifications in the modeling assumptions and framework. Specifically, the model used by Myers (2012) included the unrealistic presence of a single, high-permeability vertical fault zone between the Marcellus Shale and the surface; included boundary conditions that artificially induced vertical fluid flow through the modeled fault; used a deeply flawed approach for modeling HF fluid injection and flowback; and failed to account for multiphase flow and density gradients in subsurface fluids (*e.g.*, Saiers and Barth, 2012; Cohen *et al*., 2013; Carter *et al*., 2013). Additionally, the modeling assumptions and framework, and the conclusions in the Myers study are contradicted by work done at LBNL under contract by EPA (*e.g.*, Rutqvist *et al*., 2013, 2015; Kim and Moridis, 2015) and by many other studies (*e.g.*, Engelder, 2012; Flewelling *et al*., 2013; Flewelling and Sharma, 2014a; Cai and Ofterdinger, 2014; Darrah *et al*., 2014; Engelder *et al*., 2014; Hammack *et al*., 2014; Kohl *et al*., 2014). The Myers (2012) study is not a credible analysis and should not be relied upon in the EPA Study.

Despite the clearly articulated criticisms of Myers (2012), the EPA Study gives the impression that Myers' work still has credibility by highlighting his rebuttals to others' criticisms at the end of Section 6.3.2.1 (US EPA, 2015a). Similar to Myers's original study, his responses to criticisms by others are deeply flawed. For example, Saiers and Barth (2012) pointed out that Myers did not consider that imbibition of HF fluid into the targeted rocks would sequester the injected HF fluid and not allow for upward HF fluid migration. Myers responded by speculating that more HF fluid is injected than could be sequestered by the formation, but his speculation is wrong. It is easy to show that there is more than enough pore space in targeted rocks to potentially trap all injected HF fluid. For example, if one conservatively assumes that stimulated fractures are contained within a 15-m-thick interval of the Marcellus Shale, the well lateral is 1,000 m long (*i.e.*, relatively short), the horizontal extent of the fracture network is 500 m (250 m on each side of the well lateral), and the porosity of the Marcellus is 0.06 (*i.e.*, at the low end of measured values; Bruner and Smosna, 2011), there would be 450,000 m^3 of pore space available. The largest HF stimulations are, at most, 41,000 m^3 (Gallegos and Varela, 2015), indicating that only 9% of available porosity would need to be filled to sequester the very largest of HF stimulations. Typical HF stimulations use much smaller fluid volumes and would represent an insignificant fraction of the available pore space in the shale. Moreover, recent experiments have shown that the driving forces for imbibition can trap all injected HF fluids in a matter of hours (Engelder *et al*., 2014). Thus, there is a large excess of pore space and a large driving force for sequestering HF fluid, in direct contradiction to the speculation by Myers (2012).

The EPA Study also cites Myers's speculation that HF fluid migration to shallower formations may be facilitated by "out-of-zone" fractures. However, Myers did not undertake any analysis of hydraulic fracture growth, so it is inappropriate for the EPA Study to cite Myers on this matter. Moreover, as discussed later in this section of the present report, there are well-established bounds on potential upward fracture growth and it is not physically plausible for stimulated fractures to grow upward from the Marcellus Shale to shallow drinking water resources (Flewelling *et al*., 2013; Rutqvist *et al*., 2015; Kim and Moridis, 2015). Every other rebuttal by Myers that we have reviewed is similarly flawed. Thus, contrary to Myers's rebuttals to various criticisms, his original modeling and hypotheses are wrong, and the EPA Study should not rely on Myers (2012) or any of his subsequent rebuttals to criticisms of his study.

EPA repeatedly mischaracterizes other cited studies to support flawed statements about fracture growth and upward fluid migration. As one example, the EPA Study (US EPA, 2015a, p. 6-41) incorrectly implies that the LBNL study by Reagan *et al*. (2015) showed that significant upward gas flux through fractures and faults could occur during shut-in. However, the study by Reagan *et al*. (2015) found that upward gas flux through a fracture or fault extending from a targeted gas shale to a shallow drinking water aquifer was insignificant, even if such a pathway were to exist and even during the shut-in period when a well is not producing. Other studies have evaluated the possibility of such a pathway occurring and have found that it is physically implausible (Rutqvist *et al*., 2013; Flewelling *et al*., 2013; Rutqvist *et al*., 2015; Kim and Moridis, 2015). Thus, contrary to statements in the EPA Study, there is no basis for EPA to claim that upward gas flux through stimulated fractures or faults would be significant. There is even less potential for upward liquid migration, due to its higher density (*i.e.*, lack of buoyancy) and under-saturated conditions in tight gas deposits (Engelder *et al*., 2014; Reagan *et al*., 2015).

As another example, the following quote from the EPA Study demonstrates one of several major conceptual problems with the reasoning in the EPA Study:

> Some researchers have also suggested that pressure perturbations due to hydraulic fracturing operations are localized to the immediate vicinity of the fractures, due to the very low permeabilities of shale formations (Flewelling and Sharma, 2014). However, there are emerging studies indicating that pressure impacts of hydraulic fracturing

> operations may extend farther than the immediate vicinity and may create risk of induced seismicity (Skoumal et al., 2015). (US EPA, 2015a, p. 6-36)

EPA is making an apples and oranges comparison in these statements. Flewelling and Sharma (2014a) calculated pressure diffusion through unstimulated, low permeability rock beyond the stimulated fracture network. The purpose of that calculation was to demonstrate that pressures applied during HF are not capable of extending far above stimulated fractures and, hence, are unable to drive brine or HF fluid to the shallow depths where drinking water resources occur. The quotation above from the EPA Study is attempting to compare the calculations in Flewelling and Sharma (2014a) for pressure diffusion through an unstimulated rock to an altogether different setting – pressure diffusion in a stimulated fracture network (*i.e.*, the alleged cause of seismicity in Skoumal *et al.*, 2015). However, this comparison is not appropriate, because it is well known that pressure diffuses several orders of magnitude more rapidly through a stimulated fracture network than through unstimulated rock (Shapiro and Dinske, 2009). Moreover, the reference to Skoumal *et al*. (2015) within a discussion of potential upward fluid migration is misleading, because Skoumal *et al*. (2015) studied a stimulated seismic event far below an HF operation. Although Skoumal *et al*. (2015) speculated that the stimulated seismicity might have been due to pressure diffusion, it is also possible that the seismicity could have been associated with the altered stress field arising from inflation of the stimulated rocks (*e.g.*, *via* poroelastic coupling, as discussed by Segall, 1989). If the cause was the latter (*i.e.*, altered stress), the Skoumal *et al*. (2015) paper would have nothing to do with pressure diffusion. Thus, the EPA study has made an invalid comparison of these two studies, has insufficient information to attribute findings in Skoumal *et al*. (2015) to pressure diffusion or stress alteration, and has cited Skoumal *et al*. (2015) even though it is not relevant for upward fluid migration. EPA should remove these statements, because they are inappropriate and unrelated. There are numerous other instances in the EPA Study in which EPA has mischaracterized the studies it cites, as shown in Table 3.1. Note that the comments in Table 3.1 address a number of key issues but do not address all the points on which we disagree with the opinions or statements in the EPA study. The entire discussion of upward fluid migration and fracture growth should be closely reviewed and edited to ensure that the EPA Study is factually correct and appropriately characterizes the cited studies.

Although EPA ultimately concludes that stimulated fractures are unlikely to extend upward to drinking water resources, EPA implies that there is more uncertainty around the limits to fracture growth than is actually the case. For example, Fisher and Warpinksi (2011) and Flewelling *et al*. (2013) presented extensive data compilations (>12,000 HF stages throughout North America) that showed there are limits to upward fracture growth and that fractures are not capable of growing upward to drinking water resources – a conclusion that is consistent with detailed modeling studies by LBNL (*e.g.*, Rutqvist *et al*., 2013, 2015; Kim and Moridis, 2015). Specifically, Rutqvist *et al*. (2013, 2015) found that the likelihood of HF creating flow paths that could reach shallow aquifers was remote, with the vast majority of stimulated fractures extending 10-20 m vertically, and rarely would fractures extend up to 100 m or more vertically. Numerical modeling work by Kim and Moridis (2015) also found that vertical fracture growth due to HF was limited and in agreement with observations of the vertical extent of stimulated fracture networks in the field. The combination of extensive fracture monitoring data throughout the US with these detailed numerical modeling studies provides a high degree of certainty for characterizing maximum potential upward fracture growth. The language in the EPA Study should reflect this fact.

Table 3.1 Examples of Flawed or Misleading Statements in the EPA Study Regarding Upward Fluid Migration and Fracture Growth

Flawed or Misleading Statement Made in the EPA Study	Comment on EPA Statement
"The volume of fluid injected is typically monitored to provide information on the volume and extent of fractures created (Flewelling et al., 2013)" (US EPA, 2015a, p. 6-31).	Injected HF fluid volume is not the only variable monitored to estimate the volume and extent of fracturing (Economides and Nolte, 2000). Furthermore, the EPA Study incorrectly cites Flewelling *et al*. (2013) to support its statement here. Flewelling *et al*. (2013) never discuss the use of HF fluid volume as a monitoring tool. They demonstrated, with an extensive fracture monitoring dataset for virtually all major basins in North America, that the upper bound fracture height is limited by injected volume, but that upper bound heights are rarely achieved.
"However, numerical investigations have found that reservoir gas flows into the fractures immediately after they open from hydraulic fracturing, and injection pressurizes both gas and water within the fracture to induce further fracture propagation (Kim and Moridis, 2015). Therefore, the fracture volume can be larger than the injected fluid volume. As a result, simple estimation of fracture volume based on the amount of injected fluid may underestimate the growth of the vertical fractures, and additional information is needed to accurately predict the extent of fracture growth" (US EPA, 2015a, p. 6-31).	In making this statement, EPA is apparently ignoring the massive microseismic data compilation presented by Flewelling *et al*. (2013) that clearly shows that the upper bound on potential fracture height is limited by injected HF fluid volume. Although the modeling done by Kim and Moridis (2015) is rigorous and valid, hypothetical modeling results should not be used to supplant measurements of actual fracture growth. The empirical data presented by Flewelling *et al*. (2013) clearly shows that maximum possible fracture heights are limited by HF fluid volume, and EPA needs to clearly acknowledge this fact.
"Potential fluid migration via natural fault or fracture zones in conjunction with hydraulic fracturing has been recognized as a potential contamination hazard for several decades (Harrison, 1983)" (US EPA, 2015a, p. 6-48).	EPA's statement is incorrect. Harrison (1983) never evaluated or considered HF. In fact, the words "hydraulic fracturing" do not appear in the article by Harrison (1983). EPA should remove this statement.
"At a site in Ohio, Skoumal et al. (2015) found that hydraulic fracturing induced a rupture along a pre-existing fault approximately 0.6 miles (1 km) from the hydraulic fracturing operation" (US EPA, 2015a, p. 6-49).	This quote from the EPA Study refers to Skoumal *et al*. (2015) in a discussion of vertical fracture growth, but fails to state that Skoumal *et al*. (2015) observed fault stimulation far *below* the targeted rocks. The cause of the seismic events that Skoumal *et al*. (2015) investigated is unclear and could have been due to pressure diffusion or stress perturbation associated with inflation of the stimulated rock volume (*i.e.*, no pressure diffusion required). The Skoumal *et al*. (2015) study is relevant for potential seismic stimulation, but is not an example of upward fracture growth above the hydraulically fractured formation. Thus, it is not appropriate for EPA to include this reference in its discussion of potential vertical fracture growth.

Flawed or Misleading Statement Made in the EPA Study	Comment on EPA Statement
"Using a new monitoring method known as tomographic fracturing imaging, Lacazette and Geiser (2013) also found vertical hydraulic fracturing fluid movement from a production well into a natural fracture network for distances of up to 0.6 miles (1 km). However, Davies et al. (2013) questioned whether this technique actually measures hydraulic fracturing fluid movement" (US EPA, 2015a, pp. 6-49 to 6-50).	EPA's statement here is incorrect. Lacazette and Geiser (2013) found 1 km fracture stimulation in the horizontal direction, not vertical, as pointed out by Flewelling and Sharma (2014b). Moreover, Lacazette and Geiser (2013, as cited in Flewelling and Sharma, 2014b) clearly stated that their monitoring provided evidence of pressure propagation or elastic deformation at horizontal distances exceeding 1 km. This does not mean that fluid migrated that far; the extents of pressure propagation and elastic deformation extend beyond the migrating fluid itself.
"Myers (2012a, 2012b) found that a highly conductive fault could result in rapid (<1 year) fluid migration from a deep shale zone to the surface (as described in Section 6.3.2.1). Other researchers reject the notion that open, permeable faults would coexist with hydrocarbon accumulation (Flewelling et al., 2013), although it is unclear whether the existence of faults in low permeability reservoirs would affect the accumulation of hydrocarbons because, under natural conditions, the flow of gas may be limited due to capillary tension" (US EPA, 2015a, p. 6-50).	EPA's statement about it being unclear whether faults can co-exist with hydrocarbons due to capillary tension is unsupported and should be removed. The high capillary tension needed to trap gas occurs in fine-grained materials (*e.g.*, clays and shales), which are synonymous with low permeability (Horseman *et al*., 1996). Thus, by saying that capillary tension traps gas, EPA is effectively stating that the rocks have low permeability and is making a statement that is in agreement with Flewelling *et al*. (2013). Furthermore, published studies by LBNL agree with the statements by Flewelling *et al*. (2013) that permeable faults cannot co-exist with commercially viable hydrocarbon accumulations (Rutqvist *et al*., 2015). Additionally, as discussed earlier in these comments, the Myers (2012) study is not a credible analysis and should not be relied upon by EPA.
"Results from another recent modeling study suggest that, under specific circumstances, interaction with a conductive fault could result in fluid migration to the surface only on longer (ca. 1,000 year) time scales (Gassiat et al., 2013)" (US EPA, 2015a, p. 6-50).	The study by Gassiat *et al*. (2013) was criticized by Flewelling and Sharma (2015) for containing many of the same fundamental flaws as Myers (2012). The modeling scenario used by Gassiat *et al*. (2013) cannot physically occur in nature and the model that they used lacks critical fluid transport processes (*e.g.*, multiphase flow) that cause the results of Gassiat *et al*. (2013) to be unreliable. EPA should review the critique by Flewelling and Sharma (2015) and include a discussion of the numerous problems with the analysis conducted by Gassiat *et al*. (2013).
"Ideally, data from ground water monitoring are needed to complement theories and modeling on potential pathways and fluid migration" (US EPA, 2015a, p. 6-56).	EPA is ignoring the extensive pre-drill datasets from Pennsylvania and other data compilations (*e.g.*, Anning and Flynn, 2014; Olmstead *et al*., 2013; Kresse *et al*., 2012; Reilly *et al*., 2015) that corroborate theoretical and modeling work related to the potential for HF to affect drinking water resources (*e.g.*, Gradient, 2013; Flewelling *et al*., In Preparation). EPA should acknowledge that there is surface water and groundwater quality data available to evaluate theories and modeling on potential fluid migration.

Notes:
EPA = United States Environmental Protection Agency; HF = Hydraulic Fracturing; LBNL = Lawrence Berkeley National Laboratory.

3.3.2 EPA implies that stimulated fractures may have created pathways for HF fluids and natural gas to migrate upward, but does not provide a single example in which this has occurred.

The EPA Study makes several general statements about potential pathways for fluid migration and fluid movement along these pathways, as illustrated in the following examples:

- "The potential for these pathways to exist or form has been investigated through modeling studies that simulate subsurface responses to hydraulic fracturing, and demonstrated via case studies and other monitoring efforts. In addition, the development of some of these pathways – and fluid movement along them – has been documented" (US EPA, 2015a, p. 6-51).
- "Fluids can migrate from the wellbore and surrounding subsurface formations due to inadequate casing or cement, and via natural and man-made faults, fractures, and offset wells or mines (see Text Box 6-5)" (US EPA, 2015a, p. 6-57).
- "To prevent fluid migration through the wellbore or through subsurface pathways, wells must have adequate casing and cement, and induced fractures must not intersect existing fractures or permeable zones that lead to drinking water resources" (US EPA, 2015a, p. 6-57).

In these statements EPA is not clear about the pathways to which it is referring or whether the alleged "documented" pathways involve HF fluids (typically liquids) or methane (a gas). In other sections, EPA is more specific, asserting that HF fluids may have affected drinking water resources – *e.g.*, "Evidence shows that the quality of drinking water resources may have been affected by hydraulic fracturing fluids escaping the wellbore and surrounding formation in certain areas, although conclusive evidence is currently limited" (US EPA, 2015a, p. 6-57).

However, the examples that EPA cites (*i.e.*, Mamm Creek, Raton) generally involve gas, not HF fluid. The only example potentially involving HF fluid is the Killdeer, North Dakota case study, but the potential impacts in that case are highly localized, and it is uncertain whether there is any potential for impacts to drinking water associated with that event. Based on these examples, there is no evidence that induced fractures have contributed to the migration of liquids or gases.

Some may cite a paper by Llewellyn *et al*. (2015) as an alleged example in which HF fluid might have migrated to drinking water wells. However, we caution EPA that the Llewellyn *et al*. (2015) analysis does not actually provide evidence of such fluid migration and, in fact, contains several fundamental flaws. For example, Llewellyn *et al*. (2015) assert that the presence of undifferentiated hydrocarbons (UCM) and/or 2-n-Butoxyethanol (2-BE) in domestic well samples is associated with drilling or HF fluids and has caused the foaming observed at several domestic wells. 2-BE was detected at sub-nanogram-per-liter concentrations in only one of the three domestic wells investigated in the study, essentially ruling it out as the cause of foaming. Moreover, the attempt by Llewellyn *et al.* (2015) to associate the UCM in the water samples from the domestic wells with drilling, HF, or flowback fluids is deeply flawed. Because the chemical compositions of these three fluid types are distinct, they are expected to have different UCMs, especially after reactive transport over kilometer-scale distances underground. Furthermore, Llewellyn *et al*. (2015) did not characterize the UCM in drilling or HF fluids, and, hence, the authors have no means for attributing the UCM observed in the domestic wells to these fluids. Finally, the chloride-to-bromide ratios in the domestic well water samples are consistent with road salt, thereby ruling out flowback/brine as the source of impacts at the domestic wells. Thus, the alleged evidence that Llewellyn *et al*. (2015) present to support their claims that HF fluids might have migrated upward is not evidence at all. In addition to the problems with their data analysis, Llewellyn *et al*. (2015)

also provide no reasonable transport process for how both liquids and gasses reached the domestic wells at concentrations that would cause foaming. Thus, the analysis by Llewellyn *et al*. (2015) is flawed and should not be misconstrued as an example in which HF fluid potentially migrated upward to drinking water wells.

In summary, the EPA Study should clearly state that there is no evidence that induced fractures have contributed to fluid migration to shallow depths or that HF fluids have affected drinking water resources, consistent with prior theoretical and modeling studies.

4 Hazard Evaluation

EPA undertook an analysis of potential hazards of HF-related chemicals and presented a crude approach for screening potential for adverse effects using an MCDA. However, EPA's analysis relies on a chemical list that was developed using some unreliable sources and does not appear to adequately reflect the chemicals currently used in HF operations. Moreover, EPA's analysis of chemical toxicity relied on an extremely limited list of sources for identifying toxicity data that allowed EPA to analyze only a small percentage (3-5%) of identified compounds. EPA should have utilized a broader range of publicly available, reliable sources of toxicity data that would have enabled it to evaluate a majority of identified chemicals. The EPA Study also places too much emphasis on hazard analysis, does not address exposure directly, and fails to place the HF compounds in proper perspective by discussing other common uses of these compounds. These shortcomings were avoidable, because EPA had the data needed to calculate concentrations of constituents in HF fluid, and there is readily available information on the common uses for many of the chemicals that EPA identified. Furthermore, EPA's MCDA analysis has a number of fundamental flaws, including the use of inappropriate proxies for exposure and the extremely small subset of chemicals for which it was able to identify toxicity data. These shortcomings severely compromise the representativeness of EPA's MCDA analysis and therefore make it difficult for EPA to draw meaningful conclusions from its MCDA analysis.

4.1 EPA's list of HF chemicals was developed using some unreliable sources and is outdated.

EPA generated a list of 1,173 chemicals identified as being used in HF fluid and/or detected in flowback or produced water. Of these, 1,076 chemicals were identified as being used in HF fluids. This list was generated based on a variety of existing chemical lists, some of which are not reliable sources of chemicals ever used in the HF process. EPA should not have considered chemical lists developed by unreliable sources (*e.g.*, The Endocrine Disruption Exchange [TEDX]; Colborn *et al.*, 2011). For example, Colborn *et al*. (2011) explicitly state that "[f]or most products, we cannot definitively say whether they were used during drilling or during fracking." Colborn *et al*. (2011) also considered other chemicals present on the well pad and not just those specifically present in HF fluids or flowback water. Thus, the use of such information does not accurately reflect the substances used for HF processes. Colborn *et al*., (2011) also used unreliable information sources, such as documents detailing the Crosby well spill in Wyoming (Terracon, 2007, as cited in Colborn *et al*., 2011) and pit solid samples drawn from 6 evaporation pits in New Mexico (no reference provided), or no information source at all, to generate their list. EPA lists over 50 chemicals (US EPA, 2015a, Appendix A Table A-2) solely on the basis of the work of Colborn *et al*. (2011), even though these chemicals were neither reported as HF-related by the service companies that EPA contacted, nor included in the more reliable sources used to generate the EPA list. These compounds should be removed from EPA's list and not considered in its assessment.

EPA also appears to have included chemicals in its list without considering whether they would reasonably be associated with HF. For example, the EPA Study lists Aroclor 1248 – a polychlorinated biphenyl (PCB) mixture – as a constituent detected in flowback. HF activities should not be assumed as the source of this chemical. Manufacturing of PCBs was banned in the US in 1979, so there is no logical reason why HF would be a potential source of this constituent. In fact, the reference that reported a detection of Aroclor 1248 states that "[o]nly one PCB (Aroclor 1248) was detected in all the [flowback] samples analyzed. This result should be considered an anomaly" (Hayes, 2009). EPA should carefully review its compiled list of chemicals to ensure that the list does not erroneously include chemicals that are unrelated to HF.

EPA's list of chemicals is also outdated and does not reflect the evolving nature of HF. The EPA Study largely relies on data that were collected 6-10 years ago (*i.e.*, from 2005-2009). The HF process, along with the chemicals involved, has evolved over this period as a result of various factors, including ongoing research and development, conversion to more efficient fluids, and the application of different fluid systems in different plays, as well as an increasing trend to move to "greener" (*i.e.*, less hazardous to human health and the environment) HF fluids. Regarding the latter point, Halliburton developed a chemical toxicity scoring system that is used during additive product development and by companies when selecting which HF additives to use, with the aim of moving Halliburton's additive portfolio toward less-hazardous alternatives (Verslycke *et al*., 2014). This system, called the Chemistry Scoring Index (CSI), comprehensively scores and ranks hazards to human health, safety, and the environment for products used in oil and gas operations. The CSI is a powerful tool for evaluating relative product hazards (for materials in similar use groups) that has been implemented on a global scale to review and assess product portfolios and to aid in the formulation of new and existing products. The CSI allows Halliburton to qualitatively compare product- or individual component-specific hazards and rank their products in order to identify those chemicals for which alternative, less-hazardous substances may be viable in some situations.

Further illustrating the dated nature of the EPA list is the fact that only slightly more than half of EPA's HF chemicals were found in the FracFocus database. The EPA report uses information from the FracFocus database from over 35,000 well disclosures during the period of January 2011 to February 2013 (US EPA, 2015a,d). These data from the FracFocus database are significantly more recent than the EPA Study's other major sources, which were predominantly from 2005-2010. Although some of the chemicals compiled from 2005-2010 are still in use, the high degree of inconsistency between EPA's list of HF chemicals and the chemicals reported to FracFocus clearly indicates that the list of HF chemicals identified by EPA is not adequately reflective of the composition of current HF fluids.

4.2 EPA identifies – yet fails to consider – other sources of toxicity data that would have enabled toxicity evaluation of a majority of HF chemicals identified by EPA.

EPA asserts that there are "major knowledge gaps… regarding the toxicity of most chemicals used in hydraulic fracturing fluids or detected in flowback/produced water" (US EPA, 2015a, p. 9-35). This assertion is not true. Alternative toxicity data sources were identified in EPA's report but not actually utilized in the toxicity assessment, and there are also other reliable, publicly available toxicity data for many of the chemicals on EPA's list. Additionally, EPA appears to have excluded several existing reference values (RfVs) from the regulatory agency databases considered in its analysis. EPA should review its analysis to ensure that it identifies all relevant toxicity data from the sources that it currently utilizes and modify its approach to consider a broader range of data sources so that it can evaluate more of the identified chemicals.

The EPA Study utilized a limited set of data sources for evaluating chemical toxicity, *i.e.*, EPA's Integrated Risk Information System (IRIS), Human Health Benchmarks for Pesticides (HHBP), Provisional Peer-Reviewed Toxicity Values (PPRTV); Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs); State of California Toxicity Criteria Database; and Concise International Chemical Assessment Documents (CICAD). EPA's approach of solely considering toxicity factors presented in certain regulatory agency databases is inappropriate and self-limiting. The processes used in generating RfVs listed in IRIS or PPRTV, for example, are lengthy, and the hurdles in this process inherently limit the number of chemicals for which reference doses (RfDs) can be developed. EPA should therefore acknowledge these limitations and utilize other publicly available, reliable toxicity data to increase the robustness and applicability of its assessment. For example, EPA could use a two-tiered approach for compiling toxicity data in which the current sources utilized by EPA could be used preferentially as "higher-tier" sources and other "lower-tier" data sources could be used when higher tier data are unavailable. Using this approach, EPA could have considered many more data sources, such as the following:

- **REACH Dossiers:** The data-rich dossiers submitted to the European Chemicals Agency (ECHA) in the European Union (EU) under the REACH regulation contain toxicity data for many chemicals in EU commerce.
- **OECD SIDS Toxicity Profiles:** The Organization for Economic Co-operation and Development (OECD) Screening Information Data Set (SIDS) toxicity profiles contain toxicity data for a much larger portfolio of substances than the sources considered by EPA alone and contain Klimisch[6] scores to assess the reliability of these data.
- **EPA's ACToR Database:** The EPA Study identifies the Aggregated Computational Toxicology Resource (ACTor) database as a source of toxicity data for approximately 500 chemicals on EPA's HF and flowback/produced water lists but does not use these data in its assessment.
- **EPA MCLs:** Although MCLs are based on both toxicity and the constraints of available treatment technologies, they are federally enforceable drinking water standards that are considered by EPA to be protective of human health. MCLs are established by considering concentrations that are health-protective over a lifetime of exposure, but, in some cases, they may be modified to a concentration that is achievable with currently available technology (US EPA, 2009a, 2012). MCLs could be used when other sources of information are unavailable, such as for chromium and the sum of nitrate and nitrite.
- **EPA RSLs:** Regional screening levels (RSLs) are available for several chemicals for which no other reference values are established (*e.g.*, chloromethane, 1,2,4-trimethylbenzene). Although these levels are not federally enforceable, they are stringent, risk-based values based on cancer and non-cancer effects for a combination of exposure pathways (*e.g.*, oral, dermal, and inhalation) in a particular medium (*e.g.*, tap water).

Considering toxicity data from the identified regulatory databases above in a "lower-tier" approach would have enabled the assessment of more than 50% of the chemicals on EPA's HF and flowback/produced water lists.

In addition to these other sources of information, in the absence of chemical-specific data, a read-across approach is increasingly used in regulatory and industrial settings for the purposes of toxicity hazard and risk assessment (ECHA, 2015b; United Nations, 2013). The use of surrogate or analog substances for read-across toxicity data increases the number of substances whose toxicity can be evaluated and for which RfVs can be derived.

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[6] The Klimisch scoring system is a method of systematically assessing the quality of toxicology studies, as proposed by H.J. Klimisch and colleagues (Klimisch *et al*., 1997). Primarily conducted for hazard and risk assessment purposes, this scoring system presents definitions for the reliability, relevance, and adequacy of data in order to harmonize data evaluation processes worldwide. As described by Klimisch *et al*. (1997), reliability is differentiated into four categories: 1) reliable without restriction, 2) reliable with restrictions, 3) not reliable, and 4) not assignable.

The EPA Study also excluded reference values for a number of substances that have existing toxicity values from the list of sources it relied upon. For example, diethanolamine has an RfD from PPRTV, and fluoride has a reference value listed in the California Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database (US EPA, 2015e). A closer analysis of the substances listed in Table 1 of Appendix A of the EPA Study (US EPA, 2015a) reveals that such toxicity values were excluded for at least eight substances (*i.e.*, 1,3,5-trimethylbenzene, diethanolamine, hydrogen fluoride, isopropanol, p-xylene, zinc carbonate, zinc chloride, and zinc oxide). In other cases, such as for the isomers of xylene, the EPA Study only included a reference value for "xylenes" (as a mixture; CAS RN 1330-20-7), although EPA guidance states that the same toxicity value can be used for all xylene isomers (US EPA, 2015f). The same issue occurs for zinc compounds: the toxicity value from the source relied upon by EPA is for "zinc and zinc compounds" (US EPA, 2005). The EPA study used this toxicity value for zinc but did not apply it to the other four zinc compounds it identified in its list of HF chemicals. Thus, there are more available toxicity reference values from even the stringent set of databases EPA utilized, but the EPA Study failed to include them. These omissions should be reviewed by EPA, and the Agency should ensure that it utilized all available sources to the extent possible. Overall, it is possible for the EPA Study to characterize toxicity for a much broader range of identified chemicals from multiple data sources, and EPA should consider these additional data in its analysis.

4.3 The EPA study places too much emphasis on hazard analysis, does not address exposure directly, and fails to place the HF compounds in proper perspective by discussing other common uses of compounds.

EPA acknowledges the importance of exposure in chemical hazard evaluation:

> When considering the hazard evaluation of chemicals in drinking water, it is important to remember that toxicity is contingent upon exposure. All chemicals, including pure water, may be toxic if they are ingested in large enough quantities. Therefore, in addition to data on health effects, hazard evaluations must also consider data on potential chemical exposure." (US EPA, 2015a, p. 9-16)

However, EPA makes no attempt to quantify exposures directly. Instead, EPA uses chemical occurrence and physicochemical property data as metrics to estimate a "likelihood that the chemical could reach and impact drinking water resources" (US EPA, 2015a, p. 9-16). Occurrence frequency is not a surrogate for exposure concentrations. For example, in using this approach, the frequent use of a substance in low concentrations would lead EPA to incorrectly assigning a high-exposure-related score in its ranking system whereas the infrequent use of a chemical in high concentrations would result in a low-exposure-related score (see Section 4.4 of these comments for additional discussion of EPA's ranking framework). Thus, there is no basis for assuming that the use frequency of chemicals has any relation to exposure concentrations. EPA's approach should have accounted for concentration in some fashion (*e.g.*, maximum concentration of a component in a HF fluid system); these data are available from the FracFocus database and from the information provided by the service companies to EPA. Other problems with EPA's use of occurrence frequency and qualitative physicochemical data as exposure proxies are discussed further in Section 4.4 of these comments.

In addition, other sources of exposure to the HF chemicals identified by EPA should be discussed, to put the potential exposures related to HF into proper perspective. Compounds that are commonly present or ubiquitous in the home, workplace, and environment should be identified, along with measured ranges of exposure concentrations for these compounds (*e.g.*, chemicals associated with food preparation, environmental sources). For example, the EPA Study identifies acrylamide as a high-hazard compound, but individuals are already exposed to this chemical on a routine basis due to its presence at high concentration in food (*e.g.*, French fries; US FDA, 2006a). Moreover, many of the HF compounds have been determined to be "Generally Recognized as Safe" (GRAS) by the United States Food and Drug Administration (FDA), including citric acid, acetic acid, calcium chloride, and ammonium chloride (US FDA, 2006b, 2009a,b). These substances have various safe-use threshold concentrations under GRAS and are contained in a variety of food and consumer products at similar concentrations to those found in HF fluids (see Table 4.1, below). Other HF components are considered inert compounds of "minimal risk" to human health (*e.g.*, glycerine and sodium benzoate; US EPA, 2009b), are found in common household/personal care products (*e.g.*, cellulose and propylene glycol; NLM, 2009; US EPA, 2007b), and/or are naturally occurring in the environment (*e.g.*, sodium chloride and fatty acids; Feldman, 2005; Rhodes, 2008).

Table 4.1 GRAS Substances Contained in Food and HF Fluids

Chemical	Example of Food Item	Max. Concentration in Food (mg/L or mg/kg)	Max. Concentration in HF Fluid (mg/L)[a]
Guar Gum	Yoghurt	20,000[b]	81
Acetic Acid	Vinegar	50,000[c]	4,304
Ammonium Chloride	Bread/Flour	2,500[d]	953

Notes:
GRAS = Generally Recognized as Safe; HF = Hydraulic Fracturing.
(a) Maximum concentration measured at the well-head from Gradient (2013).
(b) Mudgil *et al*. (2014).
(c) H.J. Heinz Co. (2015).
(d) Health Canada (2012).

A number of other HF constituents are non-hazardous polymers. These large molecules are made up of repeating chemical structural units and, because of their large size, have a low potential to cause adverse health effects, especially *via* oral or dermal routes. US EPA (2001) stated that "polymers with molecular weights greater than 400 generally are not absorbed through the intact skin and substances with molecular weights greater than 1,000 generally are not absorbed through the gastrointestinal (GI) tract. Chemicals not absorbed through the skin or GI tract generally are incapable of eliciting a toxic response. Therefore, there is no reasonable expectation of risk due to cumulative exposure." EPA should clearly identify the non-hazardous polymers in its list of HF related compounds to place the low risks associated with these compounds in proper perspective.

In summary, the EPA Study uses an inappropriate method for evaluating exposure and should instead consider chemical concentrations explicitly, especially since this information is readily available from FracFocus and data on HF fluid chemicals submitted to EPA by service companies. Additionally, the EPA study needs to characterize exposures to identified HF chemicals from other common sources to put the potential HF-related exposures into context. EPA should also use guidance from appropriate agencies to flag chemicals that are known to have low toxicity (*e.g.*, FDA GRAS compounds, inert compounds of minimal risk, common personal care products, polymers with high molecular weight), because these compounds are highly unlikely to be drivers of potential human health risks.

4.4 The qualitative Multi-Criteria Decision Analysis (MCDA) has a number of fundamental flaws and yields no meaningful conclusions.

While we understand that EPA's report is not a formal risk assessment of HF fluids, a more robust evaluation of risk was feasible, because all the necessary information for a risk analysis was available to

EPA. Exposure estimates should have been quantified by coupling HF chemical concentration data in the FracFocus database and provided by service companies with exposure models. Toxicity data should have been estimated using data from all available sources, as discussed in Section 4.2 of these comments. Conducting such an assessment would have enabled a more meaningful analysis of potential exposures and risks to HF-related chemicals.

EPA instead developed and applied the MCDA framework to two lists of chemicals: HF fluid chemicals and those identified in flowback/produced water. However, in both cases, the lists were limited to chemicals for which RfVs were identified using the approved sources identified by EPA (*e.g.*, EPA IRIS and PPRTV, ATSDR). EPA assigned three scores to each chemical on these lists based on: 1) toxicity, 2) occurrence, and 3) qualitative physicochemical properties. These three scores were then normalized and summed to yield a total composite hazard score for each chemical on a scale of 0-3, with higher scores indicating chemicals predicted to be more likely to affect drinking water.

Overall, the qualitative hazard ranking approach used by EPA (*i.e.*, MCDA) has a number of fundamental flaws and does not yield any meaningful conclusions. EPA's MCDA approach only evaluates an extremely small subset (3-5%)[7] of the compounds it identifies as being associated with HF without evaluating the representativeness of this chemical subset. It is impossible for EPA to draw any meaningful conclusions from its analysis, because the vast majority of identified chemicals were not even evaluated. As discussed previously, the main reason why EPA evaluated such a short list of compounds is EPA's reliance on toxicity factors approved by federal agencies. This self-limiting approach has severely and unnecessarily restricted the utility of EPA's analysis, because toxicity data are available for more than 50% of compounds that EPA identified (see Section 4.2 of these comments). The use of these data in conjunction with data available from other reliable sources, as well as use of a read-across approach (discussed in Section 4.2 of these comments), would allow EPA to evaluate hazard for the majority of identified chemicals.

In addition, EPA's approach for estimating exposure for HF chemicals relies on occurrence frequency and qualitative chemical fate and transport assessment, both of which are inappropriate. EPA's assignment of equal scores to occurrence, physical/chemical properties, and toxicity in the MCDA framework is not valid, because occurrence and physical/chemical properties are both surrogates of exposure and should not be considered separately, but rather should be assigned a single score. Moreover, EPA's reliance on EPI Suite-predicted physical/chemical properties suffers from the shortcomings of the model predictions, discussed in Section 1.1 of these comments. Furthermore, as discussed in Section 4.3 of these comments, use frequency is not a good surrogate for exposure concentrations. Thus, every aspect of EPA's approach for estimating exposure is flawed, further contributing to the unreliable nature of the MCDA analysis.

In theory, the MCDA exercise should have provided a qualitative indication of relative hazards, but EPA's MCDA evaluates only a small fraction of identified chemicals and has numerous underlying flaws that make its results highly unreliable, making it impossible to draw any meaningful conclusions. Other approaches have been used to characterize potential exposure concentrations and the toxicity of HF- and flowback-related compounds (*e.g.*, Gradient, 2013; Flewelling *et al.*, In Preparation). EPA should review these other studies and adopt more appropriate assessment methods that would result in a more comprehensive evaluation and yield meaningful conclusions.

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[7] EPA evaluated a total of 60 compounds: 37 HF chemicals and 23 flowback/produced water compounds.

5 Conclusions

Overall, the analyses described in those sections of the EPA Study that relate to HF chemical fate and transport, potential impacts of spills, potential upward fluid migration, and hazard assessment impose unnecessary limitations, contain avoidable flaws, and repeatedly mischaracterize the literature cited therein. These shortcomings have resulted in the EPA Study overstating the potential for HF to affect drinking water resources. EPA should carefully consider the criticisms and recommendations throughout this report and make appropriate changes to its Study. These changes would help ensure that EPA's analyses and findings appropriately characterize current HF operations and the scientific state of knowledge on potential chemical migration and would allow for more meaningful conclusions about the potential impacts of HF on drinking water.

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COMMENTS

OF

HALLIBURTON ENERGY SERVICES, INC.

ON THE

REVISED DRAFT SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS AND SOLUTION MINING REGULATORY PROGRAM AND PROPOSED IMPLEMENTING REGULATIONS

WELL PERMIT ISSUANCE FOR HORIZONTAL DRILLING AND HIGH-VOLUME HYDRAULIC FRACTURING TO DEVELOP THE MARCELLUS SHALE AND OTHER LOW-PERMEABILITY GAS RESERVOIRS

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Prepared by:
Stuart Kemp
Assistant General Counsel
Halliburton Energy Services, Inc.
2107 CityWest Boulevard, Bldg. 2
Houston, TX 77042-3051

Of Counsel:
Ruth E. Leistensnider
Jean H. McCreary
Nixon Peabody LLP
677 Broadway, 10th Floor
Albany, New York 12207

INTRODUCTION

Halliburton Energy Services, Inc. ("HESI") submits these comments to the New York State Department of Environmental Conservation ("DEC" or "Department") on the "Revised 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" ("revised dSGEIS"), together with the proposed implementing regulations. HESI requests that these comments be made part of the record for the revised dSGEIS and the proposed implementing regulations.[1] The Department requested that comments on the revised dSGEIS be focused on changes from the 2009 draft SGEIS, and stated that comments previously submitted need not be resubmitted. HESI submitted comments on the 2009 draft SGEIS dated December 31, 2009, which it incorporates by reference into these comments.

HESI is a leading provider of services to the oil and gas industry and is the global leader with respect to hydraulic fracturing services. HESI helped pioneer the use of hydraulic fracturing in the 1940s and has provided hydraulic fracturing services in a wide variety of geographic settings and formations for over 60 years. During this time period, HESI has employed hydraulic fracturing technology at many hundreds of thousands of wells and has been responsible for numerous innovations in the field of hydraulic fracturing. In addition to innovations that increase natural gas production and enhance the efficiency of natural gas wells, HESI has devoted substantial resources to developing hydraulic fracturing technologies with important direct environmental benefits. For example, HESI is in the process of developing:

- Hydraulic fracturing additives that enhance the reuse of produced water as the base fluid for hydraulic fracturing to reduce the volume of fresh water needed to perform the hydraulic fracturing and to minimize disposal of waters from completion and/or production of the well;

- A proprietary method of on-site blending of gelling agents that can be transported to well sites in dry form so as to eliminate the need for the use of liquid gel concentrates and reduce the volume and weight of chemicals being transported across State and local roads or stored at the pad; and

- A suite of technologies, called the CleanSuite™ Technologies, that, among other things, utilize materials sourced from the food industry in hydraulic fracturing fluids and substitute ultra violet light in lieu of certain conventional chemical additive biocides as part of hydraulic fracturing operations.

This wealth of experience makes HESI particularly well positioned to understand the natural gas production industry and to offer comments on the revised dSGEIS, particularly

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[1] Comments on specific provisions of the Department's proposed implementing regulations not discussed in the text are contained in Exhibit A hereto.

relating to hydraulic fracturing stimulation practices. Additional information concerning HESI and its operations is included in Exhibit B to these comments.

HESI supports the policies of the State of New York which promote the development of the Marcellus Shale and other low permeability gas reservoirs. As expressed in New York's Energy Law, it is the energy policy of this State:

> To foster, encourage and promote the prudent development and wise use of all indigenous state energy resources including, but not limited to, on-shore oil and natural gas, off-shore oil and natural gas from Devonian shale formations[.]

Energy Law § 3-101(5). In addition, the Oil, Gas and Solution Mining Law provides that it is the policy of this State to "regulate the development, production and utilization of natural resources of oil and gas in this state in such a manner as will prevent waste" and to "provide for the operation and development of oil and gas properties in such a manner that a greater ultimate recovery of oil and gas may be had". Environmental Conservation Law ("ECL") § 23-0301.

These policies of the State are reflected in the *2009 State Energy Plan* (Dec. 2009), *available at* http://www.nysenergyplan.com/2009stateenergyplan.html ("State Energy Plan").[2] The State Energy Plan provides "the framework within which the State will reliably meet its future energy needs in a cost-effective and sustainable manner." State Energy Plan, Vol. I at xiii. The purpose of the State Energy Plan is to establish "policy objectives to guide state agencies and authorities as they address energy-related issues." *Id.* It also "sets forth strategies and recommendations to achieve these objectives." *Id.*

One of five fundamental strategies discussed in the State Energy Plan for achieving its goal is to support the development of in-State energy supplies. With regard to increasing New York's domestic energy production, the State Energy Plan specifically recommends that agencies "…encourage development of the Marcellus Shale natural gas formation with environmental safeguards that are protective of water supplies and natural resources…" (*id.* at xiii) and recommends that New York promote large scale development of new sources of natural gas – including the Marcellus Shale. *Id.*, Vol. II at 35. The State Energy Plan specifically notes that the Marcellus Shale "presents an opportunity for the State to unlock substantial economic value" and that "natural gas extraction would create jobs, create wealth for upstate land-owners, and increase State revenue from taxes and landowner leases and royalties." State Energy Plan, Vol. I at 56. As a result, the State Energy Plan emphasizes that the development of the Marcellus Shale could "spur economic development and job creation in economically depressed regions of the state" and lower the cost of energy for New Yorkers. *Id.*

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[2] The 2009 New York State Energy Plan was created pursuant to Executive Order No. 2, issued by then-Governor Paterson, directing the development, implementation and periodic review of a sensible comprehensive State-wide energy plan to enable the State to determine its future energy needs and facilitate a deliberate, efficient and cost-effective means of meeting those needs. The process encompassed many New York State agencies, the public and other stakeholders and a broad public participation process.

Based on the conclusions and recommendations of the State Energy Plan, it is clear that the State Energy Planning Board intends for the Department to encourage full scale development of the Marcellus Shale in order to increase the State's domestic energy production. The State Energy Plan reminds the Department to be protective of water supplies and natural resources as it drafts the SGEIS (*id*. at xv) and recommends that agencies "…reduce health and environmental risks associated with the production and use of energy" (*id.* at xiii).

It would contravene both the New York State Energy Law and the State Energy Plan for there to be any regulatory restrictions on natural gas production that are not demonstrably necessary to reducing potential risks or that are disproportional to anticipated environmental risks. Unfortunately, many of the requirements contained in the revised dSGEIS and the Department's proposed implementing regulations impose requirements that are unrelated or disproportional to anticipated risks. In particular, the revised dSGEIS acknowledges that many of the potential impacts to groundwater resources from high volume hydraulic fracturing that are the basis for numerous new and burdensome requirements imposed by the revised dSGEIS - including requirements related to the disclosure of formulae of hydraulic fracturing fluid additives - are not unique to high volume hydraulic fracturing, are not new, were fully assessed in the 1992 GEIS (Revised dSGEIS, Executive Summary, p. 10) and as to which there has been no demonstrated material risk over the long history of such operations.

Further, a number of requirements are disproportionate to the demonstrated actual potential for risk For example, as will be discussed in greater detail below, the *Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives* (Gradient Corporation, January 2012), ["*Human Health Risk Evaluation*"] a copy of which is attached as Exhibit C) contains a comprehensive analysis of the possible human health risks that might be associated with potential spills or leaks of fluids associated with the hydraulic fracturing process that might reach drinking water resources. Gradient's *Human Health Risk Evaluation* conservatively assessed a range of potential fluid spill scenarios ranging from sudden events to long term diffuse spills of chemicals at and around a well pad, and hypothetically assumed 100 percent of all released material reached both surface water bodies and drinking water/groundwater supplies (even though it is physically impossible for all material to simultaneously impact both resources) and eliminated any consideration of the beneficial effect that mitigation measures might have to prevent or reduce off-site migration of releases from a well pad. The *Human Health Risk Evaluation* also conservatively did not consider the Department-proposed setback requirements and mitigation measures, and does not appear to substantiate the need for such setbacks. Despite all of these overly conservative assumptions, the evaluation nevertheless concluded that the potential human health risks associated with exposure to hydraulic fracturing fluid and flowback constituents as a result of surface spills contaminating either surface water or groundwater "…are insignificant according to agency risk management guidelines (*i.e.*, Hazard Quotients and Hazard Indices less than a threshold value of 1.0 in the context of US EPA risk assessment guidelines)."

Despite the lack of a potential impact, the revised dSGEIS imposes multiple stringent setbacks, outright prohibitions, and other requirements which, contrary to New York's Energy Law and State Energy Plan, restrict the ability to develop the Marcellus Shale and other low permeability reservoirs to their fullest extent. The Gradient *Human Health Risk Assessment* analysis specifically demonstrated that the need for Department-proposed setback requirements

"…has not been established on the basis of any formal exposure and risk analysis, and that the appropriateness of the Department-proposed setback requirements should be reevaluated based on these findings."

Moreover, in addition to the risk analysis of surface spills, Gradient examined the possibility that constituents pumped into the Marcellus Shale during fracturing might migrate upward and impact shallow drinking water aquifers, as many regulatory requirements appear to center on addressing this potential exposure pathway. Gradient's *Human Health Risk Assessment* indicated that the thickness of the overlying confining rock layers, and the effective hydraulic isolation that these overlying layers have provided for millions of years will sequester fluid additives within the bedrock far below drinking water aquifers such that upward migration is physically implausible – a conclusion that Department also reached in its revised dSGEIS. Even if such a pathway were hypothetically assumed, the rate of migration would be such that the constituent dilution/attenuation would be significant (over a million-fold) and reduce the hydraulic fracturing ("HF") fluid constituent concentrations in a shallow drinking water aquifer to concentrations below health-based standards. In short, to the extent that regulatory requirements are aimed at addressing this potential risk scenario, they are vastly and demonstrably disproportionate to the actual risk and contravene State law and policy.

The revised dSGEIS documents potentially massive economic benefits that could result from exploration of the Marcellus Shale in Section 6.8. Further support for the potential economic benefits may be found in the report "The Economic Opportunities of Shale Energy Development" published by the Manhattan Institute's Center for Energy and Policy in May, 2011. The imposition of burdensome disclosure requirements and various other mitigation measures in the revised dSGEIS that are unjustified by any demonstrated risk could chill such substantial economic benefits which is unwarranted and contrary to New York law and policy. These concerns are more fully discussed in the comments of the Independent Oil and Gas Association of New York ("IOGA of NY"), which HESI supports to the extent they are not inconsistent with HESI's comments herein.

In its own comments, HESI will focus on specific aspects of the revised dSGEIS and proposed implementing regulations which directly impact HESI's operations as a service company or aspects of these documents as to which HESI anticipates that its customers (principally operators) would almost exclusively rely on HESI information to comply with requirements applicable to operators. HESI's comments are set forth below.

COMMENTS

I. General Comments on revised dSGEIS and Implementing Regulations

HESI supports the Department's definition of high-volume hydraulic fracturing which subjects to the requirements in the revised dSGEIS only hydraulic fracturing activities which utilize 300,000 gallons of water or more, and subjecting activities below that amount to the requirements contained in the 1992 GEIS. The level is appropriate, and HESI supports the concept. However, this definition should encompass only *fresh* water, not recycled water, in calculating the 300,000 gallon threshold to promote recycling of flowback and produced waters, which would reduce potential impacts from truck traffic and on water resources. Thus, the definition of high-volume hydraulic fracturing, and the applicability of the requirements of the revised dSGEIS, should be revised as follows: "'high-volume hydraulic fracturing'" shall mean the stimulation of a well using 300,000 gallons or more of <u>fresh</u> water as the primary carrier fluid in the hydraulic fracturing fluid." *See* Page 2-1 and Section 3.2.2.1, revised dSGEIS, proposed 6 NYCRR §§ 560.2(b)(8) and 750.3-2(b)(23).

HESI is also concerned with the Department's attribution, throughout the revised dSGEIS, to high volume hydraulic fracturing of impacts that are in fact not related to the hydraulic fracturing process. For instance, in Section 6.4 (and specifically at page 6-67), the revised dSGEIS characterizes impacts to ecosystems and wildlife, and more specifically, habitat fragmentation, to high volume hydraulic fracturing, in and of itself. However, such statements are inaccurate and unsubstantiated. To the extent that they exist at all, the potential impacts to habitat, including fragmentation, transfer of invasive species, and impacts on endangered and threatened species are *not* as a result of the act of high volume hydraulic fracturing; rather, the potential for such impacts may arise as a result of surface activities relating to the development of the natural gas itself regardless of whether high volume hydraulic fracturing is being performed beneath the surface. The final SGEIS should clearly differentiate between the potential for impacts from high volume hydraulic fracturing, and the potential for impacts from natural gas exploration activities in general. Doing so is critical to ensuring that, in accordance with New York's Energy Law and policy, any restrictions on activities are specific to, and commensurate with, the potential risk associated with the specific activity.

II *<u>Disclosure of Hydraulic Fracturing Fluid Constituents and Formulations</u>*

A. <u>MSDS Level Disclosure is Sufficient</u>

The 2009 dSGEIS required disclosure of the constituents of additives intended to be used in hydraulic fracturing fluids because of the potential for air emissions from surface impoundments used for flowback. The revised dSGEIS, however, acknowledges that industry will not use surface impoundments for flowback in New York. Revised dSGEIS, Section 1.1.1.1. Further, the Department acknowledges that the New York State Department of Health reviewed information on 322 unique chemicals present in 235 products proposed for hydraulic fracturing of shale formations in New York, categorized them into chemical classes, and "…did not identify any potential exposure situations that are qualitatively different from those addressed in the 1992 GEIS." Revised dSGEIS, p. 8-29.

The revised dSGEIS also acknowledges that "…adequate well design prevents contact between fracturing fluids and fresh ground water sources…" and that "…groundwater contamination by migration of fracturing fluid is not a reasonably foreseeable impact." Revised dSGEIS Section 8.2.1.1. Also, Chapters 6 and 7, and Appendix 11, further explain how a myriad of regulatory controls to be implemented by permit applicants will protect surface waters and mitigate adverse impacts if any spill occurs. Therefore, the principal rationale used in the 2011 revised dSGEIS for requiring disclosure of the constituents of additives is so that appropriate remediation measures can be taken in the event of a spill on the well pad. Revised dSGEIS, Section 7.1.3. For the reasons explained below, this rationale is flawed.

The revised dSGEIS (Section 8.2.1.1) and the EAF Addendum propose to require the disclosure (as part of the well permit application) of each additive (by product name, purpose/type and percent by weight of water, proppants and each additive as well as volume of each additive product) proposed to be used, together with the Material Safety Data Sheet ("MSDS") for each additive, unless a MSDS is already on file with the Department as a result of disclosures made as part of the preparation of the revised dSGEIS or in a previous well permit application. The revised dSGEIS is silent, however, as to what review the Department would undertake if a proposed additive has not previously been disclosed to the Department. Footnote 45 on page 5-41 of the revised dSGEIS, as well as proposed 6 NYCRR § 750.3-12(b)(6), suggests that the individual constituents of a "new" additive, as well as the precise formula for the "new" additive, would need to be disclosed to the Department. For the reasons set forth in Section II.C, *infra,* HESI strongly opposes this level of disclosure.

HESI supports the use of MSDS level disclosure for the additives proposed to be used for hydraulic fracturing. The Department's proposed disclosure of MSDSs (*i.e.*, its treatment of MSDSs as public information which is ineligible for exception from disclosure as trade secrets) provides workers, emergency responders and healthcare providers, and the interested public access to necessary information about the identities, properties and potential effects of chemical constituents within additives proposed to be used in high-volume hydraulic fracturing operations in New York. As discussed in HESI's December 31, 2009 comments on the 2009 dSGEIS, the MSDSs contain all the necessary information as to the response actions to be taken in the event of a spill or for the protection of workers (December 31, 2009 comments at pp. 59-64).

Briefly, the MSDSs provide a wide range of information that is intended to alert employees to the hazards of any chemical products used in a work place and to provide medical personnel with the key information needed to treat any employee who may have been exposed to a chemical product. MSDSs specifically contain information concerning the physical properties of the chemical product, the known hazards associated with the chemical product, measures to be taken in response to a release of the chemical product and relevant first aid information. However, while providing the requisite information needed to properly address the use of hazardous chemicals, the regulations of the Occupational Safety and Health Administration ("OSHA") do not require the complete disclosure of the identities of specific chemical constituents of or quantities of such chemical constituents. *See* 29 C.F.R. § 1910.1200(e).

Pursuant to OSHA 1910.1200(a)(2), the OSHA Hazard CommunicationStandard is intended to address comprehensively the issue of evaluating the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, and to preempt any legal requirements of a state, or political subdivision of a state, pertaining to this subject. Under section 18 of the Act, no state or political subdivision of a state may adopt or enforce, through any court or agency, any requirement relating to the issue addressed by this Federal standard, except pursuant to a Federally-approved state plan. 1910.1200(g)(2)(i)(C)(1). Under OSHA 1910.1200(g)(2)(i)(C) *et seq.*, an MSDS must include, among other things, the chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise 1% or greater of the composition (except that chemicals identified as carcinogens shall be listed if the concentrations are 0.1% or greater); the chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise less than 1% (0.1% for carcinogens) of the mixture; if there is evidence that the ingredient(s) could be released from the mixture in concentrations which would exceed an established OSHA permissible exposure limit or ACGIH Threshold Limit Value, or could present a health risk to employees; and the chemical and common name(s) of all ingredients which have been determined to present a physical hazard when present in the mixture. HESI submits that the existing OSHA disclosure regime is very comprehensive, widely-accepted, and commensurate with the potential risks involved.

In addition, the revised dSGEIS imposes robust additional regulatory controls regarding the transportation, storage and management of chemicals during transportation and at the well pad, including requirements for secondary containment, all of which will minimize the potential for spills of additives to the environment. These precautions are more than sufficient to minimize any potential impact from the release of any additive in the event of a spill. Thus, requiring MSDS disclosures adequately addresses any potential risks to human health and the environment that could arise from use of the additive in the hydraulic fracturing process while preserving, and not disproportionately impacting, the business interests of the innovators and inventors of new fluid system chemistries and deployment technologies.

HESI believes that the existing provisions of the OSHA Hazard Communication regulations represent the appropriate balance of disclosure and protection of trade secrets, while still promoting the Department's mission to protect human health and the environment. Given the OSHA chemical disclosure requirements – which, among other things, in practice require that companies provide MSDSs for all chemicals used at a well site – "full chemical disclosure" of chemical constituent formulations is unnecessary because existing federal and state requirements are more than sufficient to provide regulators with the information they need to address any incidents or potential releases of chemicals (*i.e.* additives) from well sites; the release of further information would be competitively harmful.

Furthermore, the potential risks to human health from the act of hydraulic fracturing are extremely low. In HESI's December 31, 2009 comments to the Department, it submitted a report prepared by its consultant, Gradient Corporation ("Gradient") (HESI December 31, 2009 comments, Appendix 6), which, *inter alia*, supported the conclusions reached by the Department's consultant, ICF International. ICF International assessed the risks to drinking water aquifers posed by subsurface migration of fracturing fluids from the Marcellus Shale, and concluded that contamination of drinking water sources would not occur from hydraulic fracturing.

At HESI's request, Gradient has prepared an updated, comprehensive risk analysis of the potential human health risks that might arise from spills or leaks of fluids associated with the hydraulic fracturing process in unconventional gas formations that might reach drinking water sources. *See Human Health Risk Evaluation*, Exhibit C. In this comprehensive analysis, Gradient evaluated a broad range of constituents, including not only those found in typical HESI HF fluid systems used in the Marcellus Shale formation, but also those used in other unconventional gas-bearing formations. In addition, to address possible spills of flowback fluids derived from the Marcellus Shale formation, Gradient evaluated constituents that have been measured in flowback samples from Pennsylvania and West Virginia as reported in the revised dSGEIS. Using established engineering and risk assessment methods, Gradient evaluated a range of conservative exposure scenarios and concluded that the potential human health risks were insignificant as defined by agency-based risk management guidelines (*i.e.*, chemical "Hazard Quotients" and summation "Hazard Indices" were all below the agency threshold value of 1.0).

Gradient's analysis was founded upon conservative exposure assumptions for a range of fluid spill scenarios. They evaluated both "sudden" spills that might occur over a short time period and "diffuse" spills that might be small in nature at any one time, but hypothetically occur over an extended time period. For each of these spill scenarios, Gradient assumed that 100 percent of the fluid (and constituents contained therein) hypothetically migrates to both a nearby surface water body and downward to an underlying drinking water aquifer. Gradient adopted this hypothetical outcome for the purposes of its analysis as a very conservative assumption, as it is of course not physically possible for 100 percent of a given spill to simultaneously impact both surface water and groundwater. Moreover, Gradient's evaluation implicitly ignored any possible mitigation measures that could prevent or reduce the off-site migration of surface releases from a well pad.

In order to estimate the possible human exposure to constituents released in these hypothetical spills, Gradient developed "dilution attenuation factors" ("DAFs") using established scientific methods and models. The DAFs account for the inherent dilution of the constituent concentrations that would occur as any spilled material migrates from the point of the spill, to the point at which drinking water is hypothetically consumed.

The dilution factors for the surface water and groundwater exposure pathways were applied to the full range of "wellhead" constituent concentrations in HF fluid and flowback to estimate the hypothetical concentration ranges for these constituents in drinking water. In order to assess the potential health implications of these hypothetical concentrations in drinking water, Gradient reviewed the scientific literature to develop "risk-based concentrations" ("RBCs") for all of the constituents evaluated. The ratio of the estimated constituent concentration in drinking water (the "exposure point concentration") to the constituent's RBC, represents a Hazard Quotient in human health risk assessment terminology. A Hazard Quotient less than a value of 1.0 indicates the exposure point concentration is less than the constituent RBC, or represents a condition generally accepted as posing no significant risk. Gradient's analysis indicated that HF and flowback constituent Hazard Quotients for all the exposure scenarios evaluated were less than 1.0. Moreover, for each of the typical HESI HF fluid systems, Gradient summed constituent Hazard Quotients to calculate the "Hazard Index" for possible cumulative health impacts of all constituents combined for each system. All Hazard Indices were similarly less than a value of 1.0. On the basis these results, Gradient indicated that the potential human health risks associated with exposure to HF and flowback constituents as a result of surface spills contaminating either surface water or groundwater are insignificant according to agency risk management guidelines (*i.e.*, Hazard Quotients and Hazard Indices less than a threshold value of 1.0 in the context of US EPA risk assessment guidelines). Furthermore, DEC-proposed setback requirements and mitigation measures were not considered in Gradient's analysis. Therefore, Gradient's analysis suggests that the need for these setbacks has not been established on the basis of a formal exposure and risk analysis and the appropriateness of the DEC-proposed setback requirements should be reevaluated based on these findings.

In addition to the risk analysis of surface spills, Gradient examined the possibility that constituents pumped into the Marcellus Shale during fracturing might migrate upward and impact shallow drinking water aquifers. Gradient's analysis indicated that the thickness of the overlying confining rock layers, and the effective hydraulic isolation that these overlying layers have provided for millions of years will sequester fluid additives within the bedrock far below drinking water aquifers such that upward migration is physically implausible—a conclusion also reached by DEC in its revised dSGEIS. Moreover, Gradient determined that even if such a pathway were hypothetically assumed, the rate of migration would be such that the constituent dilution/attenuation would be significant (over a million-fold), thereby reducing the HF fluid constituent concentrations in drinking water (*e.g.*, in a shallow aquifer), to concentrations well below health-based standards that would not pose a threat to human health.

B. Disclosure Should Not Be Required for Headworks Analysis

The revised dSGEIS provides that in order to dispose of flowback at a publicly owned treatment works ("POTW"), the POTW must have approval to treat the wastewater. In order to obtain that approval, the POTW must perform a headworks analysis. As part of that analysis, the revised dSGEIS requires that a complete list of all ingredients in each chemical additive to be used must be submitted to the POTW, along with aquatic toxicity data for each of the additives. Revised dSGEIS, p. 6-59.[3] The implementing regulations go further and require the disclosure of complete product formulas for all hydraulic fracturing fluid additives. Revised dSGEIS Appendix 22 also requires that the flowback water be characterized (analyzed to ensure no violation of the POTW's effluent limits or sludge disposal criteria, cause pass through of unpermitted substances, or inhibit the POTW's treatment processes) for all parameters of concern. HESI submits that the characterization of flowback water should be sufficient for purposes of performing the headworks analysis.

Specifically, the correlation between chemicals utilized in the hydraulic fracturing process (fluid systems) and the constituents contained in flowback is low. As the revised dSGEIS itself acknowledges, flowback from hydraulic fracturing in the Marcellus Shale will contain constituents which are not used in the additives themselves, but rather are naturally occurring in the formation. In addition, after a fluid has been mixed and pumped down the well bore, its component chemicals can interact with other fracturing fluids, with well construction materials such as cement, and with natural materials such as rock. The relationship between the concentrations of constituents in the fracture fluid additives and the concentrations of constituents in flowback is even more attenuated in light of the many chemical interactions that can occur between the mixing of additives at the surface as part of the hydraulic fracturing process and the pumping of flowback to the surface as well as the dilution of fracturing fluids in formation water. Therefore, requiring the disclosure of product formulas for each additive used at a particular well would provide little, if any, relevant information for the headworks analysis,

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[3] Very little aquatic toxicity data exists for the additives to be used. HESI suggests that the aquatic toxicity for the chemical constituents should be sufficient for purposes of this requirement. While not taking into account the synergistic effects of the constituents, aquatic toxicity at the chemical constituent level can be used as an indicator of the general toxicity of the additive.

and should not be required. Not only is such information not meaningfully related to the potential risk that serves as the rationale for the disclosure requirement, the lack of specific protections for proprietary information at all stages of this process imposes a disproportionate impact on the regulated community.[4]

Furthermore, requiring such an elaborate submission of information to the POTW should not be required because hydraulic fracturing fluid constituents will not impact POTWs. HESI included with its December 31, 2009 comments a report prepared by Gradient which analyzed the potential impacts of the discharge of fracturing fluid constituents to a POTW as part of flowback fluid disposal, focusing particularly on the potential for fracturing fluid constituents to cause an upset condition at a POTW through adverse impacts on the microorganisms used in secondary treatment of wastewater. *See* Gradient Corp., *Evaluation of Potential Impacts of Hydraulic Fracturing Flowback Fluid on Microbial Processes in Publicly-Owned Treatment Works* (Dec. 31, 2009) (included as Exhibit 11 to HESI's December 31, 2009 comments). Gradient has updated that report. *See* Gradient Corp., *Evaluation of Potential Impacts of Flowback Fluid Constituents from Hydraulic Fracturing on Treatment Processes in Publicly-Owned Treatment Works* (2012) ("2012 POTW Evaluation), a copy of which is attached as Exhibit D.

As discussed in the 2012 POTW Evaluation, Gradient evaluated the potential for flowback water recovered from the HF process in the Marcellus Shale to upset the treatment process at a POTW. Gradient's analysis focused on the organic constituents that may be found in flowback due to their use in HF fluids, as well as certain organic constituents that have been measured in flowback samples and that occur naturally in the Marcellus Shale.[5] Gradient concluded that the organic constituents in flowback fluids are unlikely to upset biological treatment processes within POTWs.

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[4] To the extent the Department continues to require any level of disclosure in the final SGEIS, HESI notes that the revised dSGEIS states, at p. 6-59, that the POTW headworks analysis "may" include in the submission a "note" about whether "any confidentiality is allowed under State law based upon the existence of proprietary material[.]" This section should eliminate such ambiguity and explicitly confirm the protection of such proprietary information by the POTW or others who may have access to it as a result of the submissions required for the permit. Moreover, Appendix 22 of the revised dSGEIS, which contains the procedures by which POTWs can obtain approval to accept wastewater from high volume hydraulic fracturing activities, does not contain any reference whatsoever as to protection of proprietary information by the POTWs, the State, EPA or others involved in the approval process. Appendix 22 as contained in the 2009 dSGEIS did contain such a statement, and Appendix 22 in the 2011 revised dSGEIS should be revised to include procedures for protection for confidential information pursuant to the New York Public Officer's Law Sec. 89(5) and its federal analogue. Further, in addition to eliminating the requirement for disclosure of constituents of additives to POTWs by applicants and by POTWs seeking approval to accept flowback going beyond the characterization of the flowback, Section 6.1.8.1 of the revised dSGEIS should be revised to more explicitly protect trade secret information included in any submissions.

[5] Inorganic and conventional wastewater parameters were not the explicit focus of Gradient's analysis because such parameters have been routinely treated in POTWs for decades, and are commonly subject to effluent discharge limits to ensure that they do not upset treatment processes (which may in turn possibly require pretreatment in certain cases to achieve the discharge limits).

Gradient's analysis was founded upon several fundamental components: 1) Estimation of potential concentrations of constituents in flowback; 2) determination of "risk-based concentrations" ("RBCs") for these constituents that reflect the potential for a constituent to adversely affect the biological treatment stage in a POTW; and, 3) a comparison of the flowback constituent concentrations when diluted within the POTW treatment system to the RBCs for the various constituents in order to calculate a "Hazard Quotient" for each constituent (and then summing the Hazard Quotients to estimate a cumulative "Hazard Index").

Gradient adopted several quite conservative assumptions in its analysis. For example, for the flowback samples reported in the revised dSGEIS (samples from Marcellus flowback collected in Pennsylvania and West Virginia), Gradient used the maximum detected concentrations for all organic constituents detected in at least 3 samples. In addition, Gradient conservatively assumed that the constituents used in typical HESI HF fluid systems would be hypothetically found in flowback at 100 percent of their respective concentrations as pumped at the wellhead during the hydraulic fracturing process (no chemical breakdown or attenuation within the Marcellus formation).

In its determination of the risk-based constituent concentrations, Gradient adopted established procedures that included using measured constituent toxicity information where available, or using "Quantitative Structure-Activity Relationships" ("QSARs"), when measured data were unavailable. The use of QSARs in such instances is a practice routinely used by US EPA.[6]

Gradient found that Hazard Quotients for all organic flowback constituents were less than 1, indicating the flowback constituents within a POTW would be below their respective RBCs. Moreover when all Hazard Quotients were summed together to estimate the possible "cumulative" impact of all organic HF constituents combined, the resulting "Hazard Indices" were similarly less than a value of 1. On the basis of these results, Gradient concluded that organic constituents in flowback were unlikely to lead to upset conditions in POTW treatment processes. Using the conservative approaches outlined above, the results of Gradient's analysis indicate that the requirement for routine detailed headworks analysis proposed in the revised dSGEIS should be reconsidered with respect to organic constituents in flowback.

C. Complete Chemical Disclosure is not Warranted

The discussion in Sections II(A) and (B) above demonstrates that, from a scientific and legal perspective, disclosure of the constituents and formulae (the "complete product composition disclosure" referenced in footnote 45 on page 5-41 of the revised dSGEIS) is not warranted in order to protect the environment. MSDS level disclosure is sufficient to address potential impacts from spills, and OSHA regulations adequately provide for disclosure of trade

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[6] United States Environmental Protection Agency ("US EPA"). 2011. Methodology Document for the Ecological Structure-Activity Relationship Model ("ECOSAR") Class Program. Office of Pollution Prevention and Toxics. Washington DC. June 2011. http://www.epa.gov/oppt/newchems/tools/ecosartechfinal.pdf

secret information to health professionals under certain circumstances. 29 C.F.R. § 1910.1200(i). Characterization of flowback, as discussed in Section II(B), is sufficient for purposes of any headworks analysis or to determine the ability of the receiving waters to assimilate discharges. Thus, additional disclosure is not necessary or warranted, and is not driven by any valid risk scenario.

The revised dSGEIS and the Department's proposed implementing regulations from the Division of Mineral Resources suggest that the Department will afford trade secret protection to proprietary information, but the Division of Water's regulations are less clear. MSDS level disclosure to the Department of the identity of additives will allow regulators, remediation personnel, and health professionals who interact with the hydraulic fracturing process to make informed decisions and respond to potential risks. At the same time, HESI has invested extensively in the invention and development of proprietary constituents which it uses as part of the services it renders to well operators during the hydraulic fracturing process. HESI's ability to invest in innovation and continue developing cutting-edge technologies that potentially reduce the environmental impact of natural gas development operations hinges upon its being able to safeguard such trade secret information from disclosure to the public and to its competitors.

HESI is the global leader in well stimulation and related well services. The Company is able to remain the leader in well stimulation services because it offers its customers products and services that they cannot obtain from any other company. These products have gained a solid reputation in the industry for being the most environmentally safe and most effective products available, and they provide HESI's customers with better results than any other competing product on the market. HESI's proprietary additives and fluid systems are the result of years of extensive research, development testing, and application.

HESI has gone to great lengths to ensure that it is able to protect the fruits of the Company's research and development efforts. If the formulae (or, in some cases, even the identities of specific constituents that have never been previously utilized in this context) for these innovative products were to become available to other companies, HESI could lose its competitive advantage and its investment in innovation with respect to those companies not only in New York but throughout the world.

Protection of trade secrets is critical because it provides incentives for companies like HESI to continue to invest resources in research and development efforts that yield products that enhance oil and gas production. As demonstrated in HESI's December 31, 2009 Comments to the Department, the use of proprietary technologies increase well production by 20% or more as compared to conventional technologies, resulting in significant economic benefits for the State, among others. *See Analysis of Economic Impacts Resulting From Fracturing Stimulation "Advance Technology" Within the Marcellus Basin* (Exhibit 12 to December 31, 2009 comments). Innovation can also result in significant environmental benefits. For example, the Company's newest and most innovative formulations include fluid systems that contain ingredients sourced from the food industry and other systems that facilitate the recycling of flowback and produced water. Robust protection of HESI's proprietary technologies will ensure that these benefits continue to accrue in New York.

HESI also recognizes that under the Public Officers Law, it would have the ability to claim trade secret protection for product formula information, including specific constituent identities or concentrations, or both, where appropriate. Under the revised dSGEIS, the proposed implementing regulations and the Public Officer's Law, HESI would be required to submit the product formula information to the Department with a request that it be protected as a trade secret. Under this scenario, even where the Department makes an ultimate determination that the trade secret claim is valid, supporting documents and testimony from private companies will be provided to the Department to assist in determining the validity of the claim. While the concentration or other sensitive constituent information itself may be protected from public disclosure under the provisions of the Public Officer's Law, much of the supporting material backing up the claim may suddenly fall into the public domain. Any process which results in exposure of technical and otherwise private company information would be highly inappropriate and unnecessary.

HESI supports transparency and the Department's proposal to require MSDS level disclosure to the public. HESI has undertaken its own efforts to promote transparency, making readily available to the public on its website information regarding the makeup of fluids it uses in its hydraulic fracturing operations around the country[7] — as well as Material Safety Data Sheets for all of its additives. In fact, FracFocus is being widely used and has been adopted by a number of states as an appropriate mechanism for disclosure of information concerning the makeup of fluids used in fracturing individual oil and gas wells, and DEC should strongly consider the use of the current FracFocus form in New York.

In sum, HESI recognizes the importance of encouraging continued innovation in order to enhance recovery of oil and gas while minimizing any potential impacts associated with well development. However, by forcing service companies to submit the complete formulas for their products as a condition of their use in the State, DEC will be putting service companies that have made substantial investments in the development of innovative products in a difficult position. Such disclosure requirements create disincentives to the type of continued innovation that results in products that are more effective and that can offer significant environmental benefits. DEC should seek instead to encourage continued innovation by adopting disclosure provisions that will maintain incentives for companies such as HESI to invest in the development of products that will optimize production and further minimize the environmental "footprint" of shale gas development, resulting in benefits for the citizens of New York.

Accordingly, HESI proposes that the revised dSGEIS and implementing regulations be modified so that a complete product composition disclosure would not be required in the first instance with either a well permit, or for purposes of conducting a headworks analysis. Rather, HESI proposes that HESI and other service companies be required to provide the MSDSs to the Department with the well permit application, and, if appropriate, with a claim that complete product composition and/or disclosure of the identity of a particular constituent, beyond the

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[7] HESI's website includes a variety of information about fluid systems it typically uses in its hydraulic fracturing operations. See http://www.halliburton.com/public/projects/pubsdata/Hydraulic_Fracturing/fluids_disclosure.html.

chemical family of the constituent, constitutes a trade secret. Complete product composition disclosure should only be required in the event of a spill or other event which would necessitate additional information be disclosed for that limited purposes (and, again, subject to such information being otherwise not publicly made available). This approach strikes the appropriate balance between the need for all necessary disclosure, on the one hand, and sufficient protections of intellectual property and other proprietary information, on the other hand. This approach also minimizes the number of trade secret determinations the Department would need to address and ensures that service companies, vendors and operators would utilize the hydraulic fracturing materials and technologies which are in the best interests of the State of New York and most protective of human health and the environment.

D. Timing and Mechanics of Disclosure for the Well Permit

As currently written, the revised dSGEIS and proposed regulations require the disclosure of additives at the MSDS level with the well permit application, and prohibits the use, when actual drilling eventually occurs, of any hydraulic fracturing fluids that have not been disclosed in the application unless there has been prior Department approval. An applicant is also required to document, at the time of application, an “evaluation of available alternatives for the proposed additive products that are efficacious but which exhibit reduced aquatic toxicity and post less risk to water resources and the environment.” EAF Addendum, p.1 and revised dSGEIS, p. 8-30. These provisions pose obvious timing concerns given that at the time of application, an operator may not have determined which fluid system will be used or have selected the service company that will support the hydraulic fracturing process. Also the well-specific geology, and thus the specific formulation of the fluid system to be used in the hydraulic fracturing process, may only be fully known as the drilling and fracturing processes progress (a point in time that could be long after the application has been submitted, reviewed and approved by the Department).

Presumably (based on revised dSGEIS, Section 7.1.3, p. 8-31, and chapter 5), if the chemical constituents of a proposed additive have not previously been disclosed to the Department, another level of submission and review is required (but not defined). HESI supports disclosure with the application of the information contained in MSDSs because the MSDSs have sufficient information regarding the makeup of particular additives in the event of a spill or other potential exposure. However, the timing and mechanics of such disclosure should be implemented in a workable manner which does not restrict the flexibility that is needed to adjust the specific fluid system formulations to respond to conditions that may be encountered after the application or during drilling, completion and hydraulic fracturing, or that will preclude innovation and use of constantly evolving and more environmentally safe technologies that are identified between the time the application is submitted and when drilling/fracturing commences.

1. Substitution of hydraulic fracturing additives

As discussed in HESI’s December 31, 2009 comments, the requirement to disclose the proposed additives at the time of the well permit application is premature. The well operator may not have selected a service company at the time the permit application is submitted, or the service company may be changed after a well permit application has been submitted, and thereby change the additives proposed to be used at a particular well.

Furthermore, a decision regarding which additives to use for a given well may not be feasible until there is adequate information regarding the geology at the particular well site. This may not occur until after drilling has commenced. Even once a hydraulic fracturing operation has commenced, it is not unusual for information gained during the drilling process to result in the introduction of fracturing products that were not originally anticipated to be used and therefore would not have been included in the permit application for the job. The process must be nimble enough to enable appropriate changes to be made in response to conditions encountered in the field without cumbersome and time-consuming cycles of review.

Finally, upfront identification of the particular additives, and their accompanying MSDSs, could be misleading to the public and would likely be inaccurate by the time the hydraulic fracturing occurs. A well operator at the permit application stage may identify particular additive products which the public will assume are the additives that will ultimately be used. However, as discussed above, the additives may change in order to optimize the fracturing treatment or maximize the well production.

In sum, for all of the reasons set forth above, requiring disclosure with the well permit application does not best fill the needs of the Department, the industry or the public. It may be more appropriate to require the disclosure of additives (to the extent that they are known) at the time the pre-frac checklist is submitted (Appendix 20), and at completion.

Even if the Department will ultimately still require disclosure of the proposed additives at the time of the well permit application, it should allow the subsequent use of additives that were not identified in the application without requiring any further Department approval process (Appendix 10, Supplemental Permit Condition 43) if the proposed unidentified additives: (a) have already been reviewed and approved by the Department in other applications or are present on Tables 5.4 or 5.5; or (b) are identified to be within the same chemical family as additives the Department has already approved in other applications or Tables 5.4 or 5.5. This would be consistent with the review performed by the Department of the additives in Tables 5.4 and 5.5. The revised dSGEIS, in section 5.4.3.1, reviewed the impacts of the products in Tables 5.4 and 5.5 through a review of the chemical constituents (Table 5.7), grouped by chemical family (Table 5.8). In short, if the proposed additives to be used at a particular well have constituents which have already been reviewed by the Department, they should be presumed to be acceptable. This could be accomplished through a simple notification process whereby the well operator (or service company) informs the Department in advance of the change in additives to be used and no further review process is required.

In the event additives are to be used which were not identified in the application and which do not meet the above two criteria for presumptive approval, the Department should provide a streamlined process for the substitution of hydraulic fracturing fluids as outlined below.

2. The Department should provide a process for approval of new additives

The revised dSGEIS is silent as to what process the Department will use for approval of new additives that are neither on its approved list nor within the same chemical family as those chemicals on the approved list. A lengthy or cumbersome approval process, especially if required as part of a particular well permit application or in the interval between the submission of the well permit application and actual drilling/hydraulic fracturing, is not in the best interest of resource development in New York by discouraging the use of new and innovative products in New York, and resulting in the loss of production, economic and environmental benefits and potentially preclude the use in New York of the latest green innovations.

HESI's December 31, 2009 comments included an exhibit (Exhibit 12) demonstrating the increased production that could be achieved through the use of proprietary hydraulic fracturing additives. HESI submits that any process for the approval of new additives should be undertaken outside the context of an individual well permit application, in order to provide for flexibility in addressing the particular characteristics of an individual well, thereby providing increased production. This could be accomplished with a description of the chemical family associated with the chemicals in the additives. Chemical families contain elements or groups with similar characteristics, sometimes determined by number of electrons or chemical groups attached. Based on this structure, chemical compounds which are members of the chemical families will exhibit trends or similarities in physical and chemical properties and the biological activity (erg toxicity) of a chemical compounds. In the event the chemicals in the additives fall within the chemical families reviewed in Section 5.4.3.1 of the revised dSGEIS, there should be a presumption that such additive product may be used, and added to an "approved" additive product list. In every case, whether presumptively approved or triggering a streamlined supplemental review process, any disclosure of these constituents should be subject to strong protections for proprietary and confidential business information.

As noted previously, HESI understand the Department's perception that to protect human health and the environment it must be informed about the additives used in hydraulic fracturing operations and the requirement to submit MSDSs for its additives. HESI, however, invests substantial economic resources and efforts to innovate and develop its hydraulic fracturing fluid systems and the technologies that deploy these fluids, and to ensure that such systems are protective of human health and the environment and suitable for use in the hydraulic fracturing process. Consequently, HESI must – to protect its global intellectual property – treat such information as proprietary and valuable trade secrets and to seek the protection by the Department (and all states) of these interests. These highly valuable intellectual property rights would otherwise be jeopardized at a global level.

The revised dSGEIS (and other federal and State law provisions) expressly acknowledges the right to claim confidential business information and/or trade secret protections for the constituents of a particular additive. Revised dSGEIS, p. 8-31. Implementing a process for review and approval of new additives outside of the context of a particular well permit application will minimize delay, and ensure that such proprietary information is protected.

It is well-recognized that designing an effective hydraulic fracturing job requires a sophisticated understanding of the geologic, petrophysical and reservoir parameters of the hydrocarbon-bearing formation and its surrounding layers and the chemistry of the stimulation fluids themselves. In essence, implementing an effective hydraulic fracturing job requires the right "tools." HESI devotes substantial resources to understanding and improving the elements necessary to successfully stimulate a formation while ensuring the integrity of the production and water zones. To achieve these goals, HESI has developed a multitude of new fracturing fluids and technologies that will make hydraulic fracturing more effective and efficient, and that minimize potential environmental impacts. HESI has made a strong commitment toward reducing the environmental footprint of its hydraulic fracturing fluid systems while maintaining the effectiveness of the fluid systems. For example HESI is currently deploying its CleanStim™ technology, a fracturing fluid system comprised of materials sourced entirely from the food industry. Other technologies HESI has developed will reduce the volume of additives being transported to sites, and create more environmentally protective ways of storing and handling such materials at the well pad, or promote recycling and reuse of production and flowback waters.

Thus, in order to allow for regulatory flexibility and the selection of the appropriate additives at an individual well based upon the particular characteristics of the location, approval of new additives should be undertaken outside the context of an individual well permit application. The Department should provide for a process for approval of new additives, through submission of information with protection for trade secrets and confidential business information, separate and apart from a well permit application. This process should be defined for operators and service companies in order to provide reasonable timeframes for Department review. This will ensure that the appropriate "tools" are able to be brought to bear to maximize the production of a particular well with minimal delay. HESI strongly encourages DEC to engage in further discussions with stakeholders regarding the implementation of this review process in order to establish a process that is workable for all parties.

3. Evaluation of Alternative Additives

The revised dSGEIS (Appendix 6, p.1 and p. 8-30) requires an applicant to document that as part of the application process they have evaluated "…available alternatives for the proposed additive products that are efficacious but which exhibit reduced aquatic toxicity and pose less risk to water resources and the environment." The Department proposes that the applicant's evaluation must demonstrate that the evaluated alternatives are not "equally effective or feasible" including consideration of impacts if residues persist in the environment over time, and the comparative toxicity and mobility of the available alternatives. What constitutes an acceptable level of evaluation or demonstration is unclear, and is very open-ended. HESI believes that this process must be made workable for all parties involved and strongly encourages the Department to engage in further discussions with stakeholders regarding the implementation of any such requirements.

In its December 31, 2009 comments, HESI suggested a mechanism for substitution of additives through the use of a Chemistry Scoring Index ("CSI"). As described in HESI's 2009 comments, the CSI is a system for comparing the human health, physical and environmental hazards of different products within a usage group. Alpha Geoscience has prepared a review report of HESI's proposed CSI, and found that it had "merit in ranking chemicals on a comparative basis to evaluate potential hazard[.]" Since the time of HESI's initial comments, and subsequent meetings with the Department, HESI has refined the CSI, and prepared a manual for its use. The current CSI manual is included as Exhibit E hereto. Without precluding other means of performing the evaluation and demonstrating the effectiveness and feasibility of alternatives, HESI proposes that the Department specifically approve the use of the CSI as an acceptable means to evaluate the environmental attributes of alternative additives within the intent of this section.

4. The Department should allow an option for service companies, rather than well operators, to provide additive information

The revised dSGEIS and the EAF addendum provide that the well operator is required to submit information regarding the proposed additives to be used at a particular well. As discussed above, HESI considers many of its hydraulic fracturing fluid systems, the additives contained therein, and technologies that deploy these fluid systems to be proprietary information, and to protect its intellection property rights HESI may not disclose this proprietary information even to its customers, the well operators. In order to continue to protect this information, service companies should be included among the entities allowed by the revised dSGEIS and implementing regulations to provide this information to the Department, and that the EAF addendum and the regulations be revised accordingly to permit service companies to do so.

III <u>*Impacts from Air Emissions*</u>

The revised dSGEIS contains an evaluation of impacts from air emissions associated with natural gas exploration and production, as well as from high volume hydraulic fracturing. The revised dSGEIS requires the preparation of a Greenhouse Gas ("GHG") Mitigation Plan in Section 7.6, and a series of well pad mitigation requirements in Section 7.5. Both of these mitigation requirements are unworkable, as discussed more fully below.

A. <u>Greenhouse Gas Mitigation Plan</u>

Section 7.6.8 of the revised dSGEIS sets forth the requirements to be contained in a GHG Mitigation Plan. These requirements include a list of GHG related Best Management Practices ("BMPs"), a leak detection and repair program, use of EPA's Natural Gas STAR BMPs, use of reduced emission completions in certain circumstances, and other detailed requirements. Since the time the preliminary revised dSGEIS was released, however, EPA initiated a rulemaking to establish New York Performance Standards for the Oil and Natural Gas Sector. 76 FR 52737 (August 23, 2011). The public comment period on these proposed regulations closed November 30, 2011. 76 FR 66886 (October 28, 2011). Any requirements regarding the contents of a GHG Mitigation Plan should await completion of EPA's rulemaking, which is required to be finalized by February 28, 2012, and should not include any requirements not included in EPA's final regulations.

B. <u>Well Pad Mitigation</u>

Section 7.5 of the revised dSGEIS contains a series of well pad mitigation requirements, based upon an analysis of air quality impacts contained in Section 6.5 of the revised dSGEIS which revealed the potential to exceed short term ambient air quality standards. One of the mitigation requirements included is a requirement that completion engines be limited to Tier 2 or newer, and that particulate traps and Selective Catalytic Reduction controls be added to all completion engines, regardless of Tier. The mandate that a particular tier of engine be used, and that controls be added to these engines, is preempted by Clean Air Act Section 209(e). These requirements are also onerous, unwarranted, and out of keeping with the objectives of the 2009

Energy Plan in that the requirements are not demonstrably necessary or proportionate to the potential environmental risks involved.

1. The air emissions modeling is flawed

The Department's proposed well pad mitigation requirements are not supported by appropriate air modeling. As set forth in the analysis prepared by Gradient, the air modeling undertaken by the Department is flawed in a number of key respects and should not serve as the basis for any regulatory requirements. *See* Gradient Corp., *Critique of the Air Impact Analysis Performed As Part of the Revised Draft Supplemental Generic Environmental Impact Statement for Hydraulic Fracturing* (2012) ("Air Critique"). A copy of the Air Critique is attached as Exhibit F. Among the significant flaws in DEC's modeling approach noted by Gradient are the following:

- DEC has proposed to regulate short-term emissions from completion engines that it typically does not regulate and modeled air emissions impacts associated with these short-term sources to assess compliance with National Ambient Air Quality Standards. The inclusion of short-term emissions from completion engines is inconsistent with Department policy[8] and guidance from the U.S. Environmental Protection Agency.

- The air dispersion modeling methods used by the Department in its analysis significantly over predict ground level concentrations of $PM_{2.5}$ and NO_x. For example, DEC's modeling incorrectly accounts for plume buoyancy effects. In its preliminary modeling, DEC failed to model the buoyancy effects of these combined plumes correctly, resulting in an overestimation of NO_2 concentrations by a factor of three. In its refined modeling, DEC failed to merge the plumes from the stacks on multiple completion engines in close proximity to each other and instead modeled each source individually. DEC's modeling of each source individually also does not properly account for buoyancy effects and, likewise, leads to overestimated NO_2 and PM concentrations. In addition, DEC's method of accounting for plume downwash effects may greatly mischaracterize actual flow patterns in a way that may further overestimate emissions.

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[8] Commissioner's Policy CP-33 "Assessing and Mitigating Impacts of Fine Particulate Matter Emissions". This policy does not require modeling mobiles sources to determine $PM_{2.5}$ air quality impacts where the annual potential to emit PM_{10} is less than 15 tons. It is important to note that CP-33 was prepared to comply with the State Environmental Quality Review Act ("SEQR"). Therefore, since the Department did not require the modeling of mobile sources to demonstrate compliance with SEQR for $PM_{2.5}$, the Department should not need to model short-term emissions from drilling and completion engines to comply with SEQR for high volume hydraulic fracturing.

- DEC's approach to the speciation of NO_x results in substantial uncertainty regarding NO_2 concentrations and is overly conservative. The Department's analysis assumes that NO_x emitted by a source reacts instantaneously and completely with ozone to form NO_2, which is highly unlikely.

- The Department's modeling of short-term air emissions is extremely unrealistic because it combines "worst-case" maximum load engine emissions with "worst-case" meteorological conditions, both of which will occur at most for a very limited number of hours per year. In addition, the Department does not use the most appropriate methodology for adding engine emissions to background levels.

In addition to these critical modeling flaws, Gradient's report demonstrates that the add-on controls for completion engines proposed by DEC as mitigation measures are, in fact, not feasible. DEC's feasibility analysis for the proposed control technologies is based on on-highway vehicle engines. Non-road engines such as completion engines are significantly different from on-highway engines, particularly with respect to size and the range of engine loads during typical operations, and the same control technologies for NO_x and PM cannot be used for these two categories of engines.

2. The level of emissions assumed from hydraulic fracturing equipment is overestimated

HESI submits that DEC overestimated the emissions of NOx from hydraulic fracturing equipment in the modeling. The NOx emissions used in the DEC modeling were based on the completion engines running at 100% load the entire time period during the fracturing operation. HESI has worked with the engine manufacturer to review detailed engine information for the duty cycle of a completion engine running in a Marcellus specific completion. Based on the unusual duty cycle for completion engines (differring from the standard duty cycle used to generate emissions profiles resulting in an emission factor for an engine), the load factors were used to identify the emissions at particular operating points based on horsepower and rpm on the engine performance curve. The calculated number was 11,636 grams of NOx per engine in a 4 hour stage, 19.5 percent, significantly less than the completions number used in the modeling (59,725 grams of NOx per engine per 4 hour run time). If the NOx emissions are indeed overestimated by up to 80%, this would indicate the modeled numbers should be reduced to levels not requiring additional control measures.

3. The imposition of add-on controls is preempted

The Clean Air Act Amendments of 1990 created a scheme for the regulation of emissions from nonroad sources such as lawnmowers, bulldozers, locomotives, and marine vessels. The 1990 amendments regarding nonroad sources "reflect the basic structure of the Clean Air Act ("CAA"), which makes the States and the Federal Government partners in the struggle against air pollution, but sought to avoid an anarchic patchwork of federal and state regulatory programs." *Pacific Merchant Shipping Ass'n v. Goldstene*, 517 F.3d 1108, 1110 (9th Cir. 2008) (internal quotations omitted). Accordingly, the 1990 amendments gave the federal government the authority to establish “standards applicable to emissions from . . . new nonroad engines and new nonroad vehicles.” CAA § 213(a)(3), 42 U.S.C. § 7547(a)(3). At the same time, the statute expressly preempts all states from regulating emissions from new engines smaller than 175 horsepower that are used in construction or farm equipment or vehicles, and new locomotive engines. CAA § 209(e)(1), 42 U.S.C. § 7543(e)(1).

For other nonroad engines beyond those expressly reserved to the federal government, CAA § 209(e)(2) allows California to seek authorization from the EPA to adopt “standards and other requirements relating to the control of emissions.” CAA § 209(e)(2)(A), 42 U.S.C. § 7543(e)(2)(A). States other than California may adopt and enforce “standards relating to control of emissions from nonroad vehicles or engines [other than those expressly preempted under § 209(e)(1)],” only upon certain requirements. That is, (1) the State must provide notice to EPA; (2) the “standards and implementation and enforcement [must be] identical, for the period concerned, to the [EPA authorized] California standards; and (3) California and the regulating State must adopt such standards “at least 2 years before commencement of the period for which the standards take effect.” CAA § 209(e)(2)(B).

Both the federal courts and EPA itself have construed the obvious intent of CAA § 209(e)(2) to provide for implied preemption of state regulations purporting to establish standards or requirements applicable to nonroad engines and vehicles. This is because the CAA permits only California to seek authorization to adopt such regulations, and other states are merely allowed to opt in to the California rules. *See Pacific Merchant Shipping Ass’n v. Goldstene*, 517 F.3d at 1113; *Engine Mfrs. Ass’n. v. EPA*, 88 F.3d 1075, 1087 (D.C. Cir. 1996); 40 C.F.R. Part 89, Appendix A to Subpart A. As stated by the D.C. Circuit, “[t]he California authorization provision assumes the existence of a category of sources that are subject to preemption. . . . states must be preempted from adopting any regulation for which California could receive authorization.” *Engine Mfrs. Ass’n. v. EPA*, 88 F.3d 1075, 1087-1088 (D.C. Cir. 1996) (citations omitted). In addition, the United States Supreme Court has held that “standards” within the purview of Title II of the CAA (applying to mobile sources, such as drilling and completion engines) include “numerical emissions levels with which vehicles or engines must comply, or emission-control technology with which they must be equipped.” *Engine Mfrs Ass’n v. South Coast Air Quality Mgmt. Dist.*, 541 U.S. 246, 253 (2004) (citations omitted).

At least one court has found that time of use restrictions and fleet composition requirements were preempted by the CAA. In *Engine Mfrs. Ass’n, et al. v. Huston, et al.*, (190 F. Supp. 2d 922 (W.D. Tx 2001), the court held that rules adopted by the Texas Natural Resource Conservation Commission (“TNRCC”) which prohibited the operation of certain construction equipment in the morning from June through September in the Dallas – Fort Worth area constituted a “standard or other requirement relating to the control of emissions”, and therefore, was preempted by the Clean Air Act. The court also found the TNRCC’s rules, which required that, by December 31, 2007, 100% of the fleet engines must consist of Tier 2 engines, to be similarly preempted.

Clearly, the Department’s mandate for the use of Tier 2 engines, and that that all completion engines be equipped with particulate traps and SCR is preempted under the CAA as a standard or requirement relating to the control of emissions from nonroad engines. This is consistent with EPA’s position contained in 40 CFR Part 89, Appendix A to Subpart A (“EPA believes that states are precluded from requiring retrofitting of used nonroad engines except that states are permitted to adopt and enforce any such retrofitting requirements identical to California requirements which have been authorized by EPA under section 209 of the Clean Air Act.”). Since California has not adopted any requirement for the use of add-on controls, the mitigation requirements in the revised dSGEIS which mandate the use of add-on controls are clearly preempted.

4. Add-on controls are not available or feasible

The comments submitted by the Truck and Engine Manufacturers Association, which HESI support, demonstrates both that the requirement for add-on controls is preempted, but also that add-on controls, especially for the completion engines, are simply not available. Furthermore, even if controls were available, the requirement for add-on controls is simply not feasible. Completion engines are highly engineered pieces of equipment. Add-on controls are not just bolt-on solutions, but rather would require extensive engineering and design, and will need to meet road weight limits and other safety regulations. This could lead to increased truck traffic, increased wear and tear on the roads, and increased air emissions from the increased truck traffic.

IV *Flowback Water Management*

Section 5.12 of the revised dSGEIS contains a discussion of flowback water treatment, recycling and reuse technologies. Section 7.1 discusses a number of requirements for management of flowback, including a fluids disposal plan, a waste disposal tracking form, and requirements that POTWs must meet in order to obtain approval for the disposal of flowback water. However, none of the requirements in Section 7.1 appear designed to encourage recycling. The Department should consider mitigation measures which are designed to encourage recycling of flowback water, so as to minimize the amount of fresh water used in hydraulic fracturing.

CONCLUSION

HESI appreciates the opportunity to submit these comments on the revised dSGEIS and proposed implementing regulations. HESI stands willing to continue to work with Department staff to achieve a workable solution which allows for the most efficient, environmentally friendly and productive exploration of the Marcellus and Utica Shale formations while protecting proprietary information and technology. However the Department proceeds, HESI will adhere to the final SGEIS and implementing regulations, and will continue to cooperate with the Department. However, the final form of the SGEIS and implementing regulations will impact the way that HESI is able to conduct business in the State of New York and how HESI serves its clients’ needs while protecting its proprietary assets. Certainly, the availability to operators in New York of HESI’s most innovative technologies will hinge on the ability to ensure protection of trade secrets.

HESI encourages the Department to consider the purpose and objectives of the disclosure of hydraulic fracturing fluids. If the purpose is to foster public disclosure about the identities of ingredients in hydraulic fracturing treatments and minimize trade secret claims, and to promote the most efficient and environmentally sound methods for hydraulic fracturing in the State of

New York, the Department should adopt a final SGEIS and implementing regulations in a manner that allows vendors, service providers, and operators to report on chemicals and constituents contained in hydraulic fracturing treatments, but not require disclosure of proprietary information in the absence of a showing of need for the information.