October 24, 2018

TO: Arkansas Department of Environmental Quality
ATTN: C&H Draft Denial
5301 Northshore Drive
North Little Rock, AR 72118-5317

FROM: Arkansas Farm Bureau Federation
John Bailey, P.E.
Director, Environmental & Regulatory Affairs
P.O. Box 31
Little Rock, AR 72203

RE: Comments on permit 5264-W

To whom it may concern:

The Arkansas Farm Bureau Federation would like to offer the following comments opposing the denial of C&H Hog Farms's Regulation 5 permit. Our organization is a non-profit agriculture advocacy association with more than 190,000 members of whom 50,000 are directly engaged in agriculture production. Despite the fact there is no scientific evidence showing that C&H Hog Farms is causing an environmental impact, the Arkansas Department of Environmental Quality (ADEQ) has denied the owners of the farm a permit.

C&H Hog Farms is the most heavily scrutinized and monitored farm in the state. The Big Creek Research and Extension Team was originally created by then Governor Mike Beebe to evaluate the potential impact and sustainable management of the C&H Farms operation on the water quality of Big Creek. Several years later, the State of Arkansas funded a drilling study to evaluate the lithology/geology below the waste storage ponds at C&H Hog Farms and to assess potential subsurface impact from the waste storage ponds. Most recently, current Governor Asa Hutchinson created the Beautiful Buffalo River Action Committee and authorized the development of a Watershed Management Plan for the Buffalo River Watershed that would evaluate the tributaries to determine which would need the most attention. Despite conclusions of these state-funded independent third-party analyses showing C&H Hog Farms is having no impact, ADEQ ignored the science and denied the issuance of a Regulation 5 permit to C&H Hog Farms.

In addition to ignoring the science, the ADEQ chose the most intentionally difficult path for C&H Hog Farms to obtain permit coverage. The ADEQ has the authority to either require a work plan which would provide additional testing or sampling prior to issuance of the permit or include a schedule of compliance in the permit outlining what actions are necessary to maintain coverage. In either case, a timeline is set to allow the applicant a reasonable timeframe to provide any missing information before compliance actions

are taken. Because C&H Hog Farms has already been constructed and has operated for over five years without a single violation, a work plan or schedule of compliance would have been the reasonable approach. However, rather than using one of these approaches, the Department instead chose to immediately deny the permit and put the owners' livelihood in jeopardy.

The owners of C&H attempted to comply with ADEQ's request for additional information as is documented by emails between ADEQ and C&H, the conclusion of which ADEQ stated to C&H that the necessary information had been submitted only to deny C&H's permit for "technical deficiencies." These deficiencies were not identified in any detail until 10 days after in the "Blanz memo". In an attempt to comply or resolve the confusion regarding what, specifically, was deficient, the owners met with ADEQ at their offices a few days after being denied a permit. The Department, referring to a 422-page document, told C&H that when they read this then they would talk to them. Even then the list was not detailed or complete as evidenced by the addition of two new "deficiencies", one of which is unaddressable. It is noteworthy that according to ADEQ's website out of 2,422 agricultural permit applications submitted, including dozens of farms in the Buffalo River watershed, only one permit application has ever been denied.

Farm Bureau's focus is to ensure that sound science drives the production practices of our farmers and ranchers and to ensure that regulatory controls being applied to farmers and ranchers employ the same science. The justifications outlined in the Statement of Basis denying C&H Hog Farms a permit to operate, at a minimum, should result in additional permit conditions (i.e. installing synthetic liners), not denial of the permit. The Arkansas Farm Bureau would like to offer the following comments and ask that the ADEQ issue the February 15, 2017 draft Regulation 5 permit.

Animal Waste Management Field Hand Handbook

The ADEQ cites "requirements" of the Animal Waste Management Field Handbook (AWMFH) as justification for denial of the permit. However, the AWMFH does not provide requirements but instead planning considerations. These considerations are to be used by farmers and professional engineers to minimize costs while protecting water quality. In no case does the AWMFH ever recommend that a farm not be built, but instead recommends appropriate construction considerations as you will see below. C&H's engineer has stated that he reviewed these considerations and he is comfortable with his design as a professional.

The ADEQ goes on to say "[t]he list below is not intended to reflect all requirements of the AWMFH and it is not intended to reflect all factors that may have been considered by ADEQ during the review of the application." This sentence should be revised by removing the word 'not' to provide clarity. Farm Bureau believes that ADEQ as a state agency should be obligated to provide the applicant all reasons for denial. Doing so prevents the ADEQ from continuing to move the goal posts and bankrupting C&H Hog Farms through never-ending engineering and attorney fees.

The following reasons were provided as rational for denial of the permit:

- *Groundwater Assessment: A groundwater flow direction study to determine the directional flow(s) from any waste storage ponds (Citation APC&EC Regulation 5.402, AWMFH 651.0703(b)).*

The AWMFH 651.0703(b) states "A desirable site for a waste storage pond or treatment lagoon is in an area where groundwater is not flowing away from the site toward a well, spring, or important underground water supply." A site investigation provided by C&H Hog Farms to ADEQ on December 6, 2017 states that all wells located near the lagoons have either been properly closed or are a significant distance away. The results from this site investigation are considered protective in accordance with table 10-4 of the AWMFH. Currently the BCRET is sampling all known streams and springs (including interceptor trenches) near and around the lagoons and has found no impacts. The February 15, 2017, draft permit proposed continued monitoring which included an evaluation of any statistically significant increases within the measured points. Lastly, there is no underground water supply in the area. Therefore, if all of the reasons for needing directional groundwater flow have already been addressed, then the 'requirement' is unnecessary and should be removed.

- *Geologic Assessments: A complete geologic investigation, including but not limited to:*
    - *Borings within the pool areas to ascertain the groundwater elevation is not within 5 feet of invert of the ponds (Citation: APC&EC Regulation 5.402, AWMFH 651, Table 10-4);*
    - *Borings within the pool areas to ascertain the foundation of earth-filled structures ("For structures with a pool area, use at least five test holes or pits or one per 10,000 square feet of pool area, whichever is greater." (Citation APC&EC Regulation 5.402, AWMFH 651.0703(b)(4)); and*
    - *Borings within the pool areas to rule out the presence of large voids in karst (Citation: APC&EC Regulation 5.402, AWMFH 651, Table 10-4).*
- *Berm Integrity Assessment: Borings are required in the embankment centerline of the berms as part of the detailed geologic investigation. (Citation APC&EC Regulation 5.402, AWMFH 651.0704(b)(4)).*

As stated in the AWMFH 651.704(b), "The purpose of a detailed geologic investigation is to determine geologic conditions at a site that will affect or be affected by design, construction, and operation of an animal waste management system component.", meaning all of the assessments listed above would only result in considering the need to revise construction requirements, <u>not preclude them from building an animal waste storage system</u>. In this case, C&H Hog Farms has already been constructed and has been in operation for 5 years with no violations or impacts to water quality. Table 10-4 in the AWMFH evaluates the risk vs. vulnerability of the site to determine the appropriate pond construction recommendations. The farm already meets the recommendations in place by the AWMFH. C&H Hog Farms has submitted documentation demonstrating they are not in a 'very high' risk area, and information contained in the drill study as well as the drilling reports from the two onsite drinking water wells do not indicate they are located in a 'very high' vulnerability area. Also, it should be noted that even if C&H Hog Farms were found to be in a 'very high' risk or vulnerability area, the recommendation in Table 10-4 in the AWMFH recommends other storage alternatives or to properly seal wells and reevaluate vulnerability. It does not

preclude C&H Hog Farms from operating. It should be noted that C&H in fact paid to have an abandoned house well (cistern) properly closed when identified by ADEQ during the "response to comments" before ADEQ denied the permit. C&H Hog Farms has also proposed and received approval to install a synthetic liner in both lagoons. In instances where Table 10-4 indicates a synthetic liner is required, the table also says "*(or properly seal well and reevaluate vulnerability) No additional site characterization required." Although these investigations may not have been performed with the original application, additional investigation by BCRET, ADEQ, Harbor Environmental and Safety, and FTN & Associates should be sufficient to show the intent of the recommendations has been met and there is not a justifiable reason for denial on this basis. Therefore, we recommend any requirement for geologic assessment and berm integrity be removed from the statement of basis and reason for denial.

- *Pond Construction Quality Assurance: The record included one recompacted permeability test. That single test is insufficient to determine liner integrity. The necessary soil investigations including, but not limited to, percentage of fines and soil permeability evaluations, have not been performed at this facility in accordance with AWMFH 651 Table 10-4 and Appendix 10D. (Citation: APC&EC Regulation 5.402, AWMFH 651, Table 10-4 and Appendix 10D and 10E).*

The requirement for additional recompacted permeability tests in not dependent on a site investigation. A review of previously approved applications has shown in the past that one test has been acceptable; therefore, listing additional permeability tests as reason for denial is arbitrary and capricious. As previously stated, C&H Hog Farms has proposed and received approval to install a synthetic liner in both lagoons. No additional compaction test is necessary when installing synthetic liners. In addition, the ADEQ references Appendix 10E as a citation. Appendix 10E only discusses proper installation of synthetic liners but provides no reason why it is included. For the reasons stated above, the requirement for additional recompacted permeability tests is not a reason for denial. The ADEQ should at the most require either additional testing or installation of the synthetic liner, not denial of the permit.

- *Assessment of High-Risk Areas of Land Application Sites: A field assessment for all land application sites including all of the characteristics listed in AWMFH 651.0504 (a)-(n), and the resulting field management plans (Citation: APC&EC Regulation 5.402, AWMFH 651.0504(a)-(n) and Table 5-3).*

Typical assessment of the land application sites for permitting purposes is done through the use of NRCS's Web Soil Survey. Based upon this assessment tool, and AWMFH recommendations, most land applications sites (fields) are acceptable without restriction and the remaining land application sites are acceptable with restrictions. At no time is a recommendation of no land application assigned to any field. Even so, C&H's NMP writer(s) walked every field in an effort to ground truth the web soil survey information. As a result, setbacks and buffers were increased resulting in a reduction of allowable land application acres from the original permit submission.

- *Pond Levee Integrity and Assessment Requirements: An adequate Operations and Maintenance Plan for the pond levee, including an inspection schedule and plan document, was not included in the record. An adequate plan should at a minimum include:*

- *Whether the inspections are internal or independently performed by a third party;*
- *The specific checklist of items for the inspection to cover;*
- *Recordkeeping requirements;*
- *Frequency of inspections; and*
- *How the inspection results will be reviewed and/or audited.*

(Citation: AWMFH 651.1302(d); Natural Resources Conservation Service Operation and Maintenance, Waste Storage Facility, Code 313).

- *Emergency Response Preparedness: An emergency action plan regarding potential consequences of failure of the waste impoundment embankments or accidental release (Citation: APC&EC Regulation 5.402, AWMFH 651.0204(a)-(b)).*

The final items are simply paperwork requirements and had the ADEQ simply requested the information instead of denying the permit, C&H Hog Farms would have happily provided the information when requested.

Deficiencies in the Geological Investigation

The purpose of the Geological Investigation was to evaluate a specific location based on claims by environmental groups, who opposed C&H Hog Farms. The environmental groups claimed that Electrical Resistivity Imaging showed that C&H Hog Farms's holding ponds were leaking. Despite the fact the Big Creek Research and Extension Team presented scientific evidence at an APC&EC meeting stating the contrary, the ADEQ mandated that the owners of C&H Hog Farms allow the drilling to take place or be forced to shut down. The drilling study was completed and a final report was prepared by Harbor Environmental and Safety which concluded there was no evidence of the ponds leaking, reaching the same conclusion that was presented to the ADEQ originally by the BCRET. The Department should have used the final drill report to demonstrate compliance with the AWMFH requirements that are stated as the reasons for denial.

Karst

Although ADEQ spends a significant amount of time in the statement of basis discussing karst, Arkansas Farm Bureau has never argued that karst was not present. However, Regulation 5 does not preclude C&H Hog Farms from obtaining an operating permit. Even Regulation 22 for Solid Waste Management does not preclude the issuance of a landfill permit coverage in karst terrain. The ADEQ should not be allowed to retroactively review a permit that has been previously approved for construction and operation with no gap in coverage without proper cause. If through monitoring it is determined that additional requirements are necessary, the Department may include additional requirements in an effort to protect water quality.

In addition, a study was conducted by the U.S. Geological Survey in cooperation with the Natural Resources Conservation Service, the University of Arkansas, and the Arkansas Department of Environmental Quality to examine swine waste storage lagoons in a mantled karst terrane (Appendix A). The Study evaluated potential leakage from existing holding ponds and a settling basin as well as a newly

constructed Anaerobic lagoon at the University of Arkansas' Savoy Experimental Watershed. The Savoy Swine Facility is a demonstration farm that provides a long term model for environmental management. The study points out that the "Savoy Swine Facility is located within the Springfield Plateau, which is underline by nearly flat lying Mississippian-age cherty limestones and limestones" and has "[k]arst features such as springs, sinkholes, losing streams, caves, and conduits…in the study area."

Water quality samples were collected from several sampling locations which included wells, springs, seeps, and an interceptor trench. The study concluded that "very little leakage from the waste holding ponds and settling basin occurs" and goes on to say the reason for minimal leakage is due to the high solids content in the animal waste which provided a seal significantly reducing seepage. The study concludes with "[b]ased on these results, the swine waste lagoon…is minimally affecting the ground-water quality of the area."

303(d) List

The data used for the assessment of Big Creek was obtained from eight (8) different monitoring locations over a 5-mile stretch. Typically, when assessing streams, the Department has only had one set of data available to it from a single monitoring station to review. This results in all data being used for assessment purposes. In the case of Big Creek, the Department reviewed data from multiple monitoring locations up and down Big Creek. However, the Department's current assessment methodology practice is to use the highest value of a data set and throw out all other data. This practice does not provide an accurate representation of what is actually occurring in the stream and represents only the worst case scenario. For example, in 2016 the Department identified eight single instances where the E-coli criteria were exceeded during the primary contact season. Although additional data was provided with all eight of the afore mentioned exceedances, only the highest test result was used. However, the accompanying data for five of the exceedances shows a significant decrease over the values used for assessment purposes, with the remaining three reporting similar numbers. Farm Bureau recommends that an appropriate average, such as the commonly recognized standard methodology of geometric mean, be used for assessing E-coli on a segment.

This practice is especially concerning when considering the fact that, half of the data collected in 2016 resulting in Big Creek exceeding the assessment standard was collected by a group that has publically stated their goal is to shut down C&H Hog Farms. These groups know how many samples need to be submitted to cause a stream to be listed and can systematically collect numerous samples at a specific time and location only to submit the highest values knowing that the Department will use those and discard the remaining values. This is intentionally subverting scientific process and protocols.

In addition to utilizing all data submitted for assessment purposes, Farm Bureau recommends the Department reconsider its evaluation of Big Creek as single segment. Upon closer review, the data shows that most of the exceedances of the E-coli criteria occurred upstream of the confluence of Dry Creek. Again, using the 2016 data, six of the eight exceedances of the E-coli criteria occurred upstream of the confluence with Dry Creek. Of the two remaining exceedances, a review of the data shows that on one

date the upstream value exceeded the criteria, but the higher downstream value was utilized instead. The second date curiously did not have an upstream value submitted. Based on a more thorough evaluation of the data and the numerous monitoring locations, Big Creek should be divided into reaches or segments delineated by the confluence with major tributaries, as is common practice when assessing other waterbodies, rather than treating Big Creek as a single unit. Farm Bureau believes the most practical way is for the Department to assess Big Creek by upper, middle, and lower segments. The head waters of Big Creek to the confluence of Dry Creek as the upper segment, Dry Creek to Left Fork Big Creek as the middle segment and, Left Fork Big Creek to the Buffalo River is the lower segment.

A review of the continuous Dissolved Oxygen (DO) provided by the Department showed all data and exceedance of the criteria were from 2013. This is **prior to C&H Hog Farms applying a single drop of waste**. What was not clear is if the Department continues to measure DO on Big Creek. If the 303(d) list is finalized with Big Creek being impaired for DO, Farm Bureau requests the Department continue monitoring if there is any chance of Big Creek being delisted.

Based on the comments above and a review of the data, it is clear that C&H Hog Farms is not contributing to the impairment of Big Creek. It should also be noted that according to the ADEQ website there are 119 TMDL's issued for the state of Arkansas with hundreds of facilities operating under discharge and non-discharge permits that contribute or are the cause for impairment. **None of those TMDL's require that a facility's permit be denied or terminated**. In addition to the TMDL's there are even more streams listed as impaired. Once again, the ADEQ is not proposing to deny of those permits. Even if C&H was contributing to the impairment, it is not reason to deny the permit.

Nitrates

In the statement of basis, the ADEQ discusses nitrate-N by saying "In addition to this proposed listing of Big Creek and the Buffalo River as impaired waterbodies, the Big Creek Research Extension Team (BCRET) has documented an increase in nitrate-N near the facility. In the April 1 to June 30, 2018 Quarterly Report, BCRET presented data that documents a statistically significant increase of nitrate-N in the ephemeral stream (BC4) and the house well (W1) since 2014. (BCRET April-June 2018, Figure 24). Increased nitrate-N in both the ephemeral stream and the house well suggest that these systems may be hydrologically connected to areas where farm activities take place." However, ADEQ fails to provide all of the information stated in the BCRET April 1 to June 30, 2018 report.

The report states "This analysis indicates a statistically significant increase in Nitrate-N concentrations in ephemeral stream and well samples over the monitoring period (Figure 19). Additionally, there has been a gradual increase in geomean nitrate concentrations of well samples each water year of site monitoring (i.e., April 1 to March 31; Figure 24). In contrast, concentrations of chloride, a conservative element that can move freely through the soil without chemical, physical, or biological modification, did not exhibit any statistically significant change over the monitoring period in ephemeral stream and well samples (i.e., April 2015 to April 2018; Figure 22)."

The report goes on to say, "The chloride concentration and electrical conductivity of slurry in holding ponds 1 and 2 is appreciably greater than that measured upstream of the C&H Farm in Big Creek (i.e., BC6), which represents background concentrations not impacted by farm operations (see Table 9). Given chloride and electrical conductivity can be considered as conservative tracers of water flow, the lack of any increasing trend in these analyses for well (W1), trench (T1 and T2), or ephemeral stream (BC4) samples, suggests that elevated nitrate-N concentrations in well and ephemeral stream samples may be influenced ***by sources other than the holding ponds*** [emphasis added] (i.e., sources that have low chloride and electrical conductivity values)."

First, the word statistically significant increase doesn't mean that nitrates are significantly increasing at some order of magnitude, it means that nitrates are increasing but it is not due to sampling error even if the increase is less than the sampling error of the test. For example, you can have a statistically significant increase from 0.01 mg/L to 0.011 mg/L even with a sampling error of +/- 0.005 mg/L and not be due to rounding either. The definition of the statement does not represent magnitude of increase, all that can be said with any certainty is that Nitrates are increasing over the sampling period. These concentrations are extremely low from the outset. Some have described Big Creek's water quality as "excellent, very high, and even pristine." While there may be an increase, 10% of a very small number is still a very small number. Two things that are certain concerning the nitrates issue; 1) the nitrates are increasing very slowly; and 2) it cannot be said that nitrates only started increasing when the farm was built. Because the nitrates are increasing at such a slow rate it is conceivable that nitrates have been increasing in the groundwater long before C&H was built.

The second part to BCRET's statement is the key "concentrations of chloride, a conservative element that can move freely through the soil without chemical, physical, or biological modification, did not exhibit any statistically significant change over the monitoring period". Meaning the argument that the increase in nitrates is a result of the C&H Hog Farms operation is weak, if not all together false. Nitrates cannot be considered in a vacuum. They must be evaluated in context with all other data, i.e. chlorides.

Taking the nitrate conversation a little further, the BCRET also looked into the impacts of nutrient concentrations on Big Creek as well (Appendix B). The report concluded that, "[t]he evaluation of flow-adjusted concentrations over time showed that nutrients in Big Creek were not increasing over the short duration of monitoring for which concentration and discharge data were available (May 2014 through April 201). At this point in time, it is evident that nutrient concentrations in Big Creek have not increased at the monitored site."

What is clear is that ADEQ's statement that monitoring data from C&H Hog Farms collected by BCRET "suggest that these systems may be hydrologically connected" is without merit.

Soil Test Phosphorus

Although the Arkansas 303(d) list does not list Big Creek or the Buffalo River as impaired, the ADEQ stated a reason for denial is "Arkansas scientists agree that there is no agronomic reason or need for [Soils Test Phosphorus] to be greater than about 50 ppm (Mehlich-3 extraction). As of the C&H Hog Farms,

Inc. 2017 Annual Report, soil test phosphorus for all fields receiving waste were greater than 50 ppm." The ADEQ does not regulate or permit based on agronomic uptake but instead uses the P-index to assess phosphorus runoff risk. Is the Department arguing to limit all STP for poultry, dairy, and swine to 50 ppm, and devastate agriculture in Arkansas, or is it ADEQ's plan to be arbitrary and capricious by applying this requirement only to C&H Hog Farms? Is the Department also prepared to limit land applications of waste water treatment plant biosolids and sludges to 50 ppm STP?

Conclusion

As stated in the opening remarks, the ADEQ continues to ignore independent third-party scientific groups that were created and paid for using taxpayer money to evaluate the impacts of the hog farm on Big Creek, that have repeatedly stated C&H Hog Farms is not impacting Big Creek. The direct measurements of Big Creek, surrounding ditches, springs, the house well, and interceptor trenches shows that C&H Hog Farms is not having an impact on water quality. There is no evidence the previously approved construction plans are inadequate and require additional testing and review. Therefore, it is recommended the ADEQ issue the original draft Regulation 5 permit to C&H Hog Farms, without changes.

Attachment:

Appendix A
Appendix B

Appendix A

Ground-Water Quality Near a Swine Waste Lagoon in a Mantled Karst Terrane in Northwestern Arkansas

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ABSTRACT

Livestock production is generally the predominant agricultural practice in mantled karst terranes because the thin, rocky soils associated with carbonate bedrock are not conducive to crop production. Unfortunately, livestock production in karst areas can create environmental problems because of rapid, focused flow through soil and regolith. A study was conducted by the U.S. Geological Survey in cooperation with the Natural Resources Conservation Service National Water Management Center, the University of Arkansas, and the Arkansas Department of Environmental Quality to examine a swine waste storage lagoon in a mantled karst terrane at the University of Arkansas' Savoy Experimental Watershed to evaluate the effects of a swine waste lagoon on ground-water quality. The Savoy Experimental Watershed is a long-term, multidisciplinary research site, which is approximately 1,250 hectares and encompasses parts of six drainage basins. An anaerobic swine waste lagoon was constructed at the Savoy Swine Facility in compliance with U.S. Department of Agriculture Natural Resources Conservation Service Conservation Waste Storage Practice Standard no. 313 in one of the drainage basins. An inventory of springs, seeps, sinkholes, and losing streams was conducted in the basin where the waste lagoon was constructed. Based on the inventory, nine shallow monitoring wells were augered to refusal in the regolith. Shallow ground-water from wells, springs, and an interceptor trench was sampled and analyzed for nutrients, major cations, and major anions during high-flow and low-flow conditions. Results from ground-water sampling indicate concentrations of chloride and nitrate were higher than concentrations from non-agricultural land-use areas in the Ozarks, but were comparable to concentrations near the site prior to the construction of the swine facility. A sample collected from an interceptor trench indicated that nutrients are able to pass through the clay liner. The results of an electromagnetic geophysical survey indicated that there were no preferred flow paths from the swine waste storage lagoon. Based on these results, it appears that the swine waste lagoon built using the Natural Resources Conservation Service Conservation Practice no. 313 is minimally affecting the ground-water quality of the area.

INTRODUCTION

Animal production in northwestern Arkansas is the predominant agricultural practice because the thin, rocky soils are unsuitable for sustainable crop production. Nationally, Arkansas ranks 2nd in broiler production, 16th in cattle, and 17th in swine production (U.S. Department of Agriculture, 2003). Animal waste generated from these agricultural operations typically is applied to local pastures, often in excess of nutrient requirements. These excess nutrients have little opportunity for natural attenuation in a mantled karst setting because of thin soils and underlying karst geology that allow rapid, focused flow resulting in contaminated ground and surface waters. Adamski (1987) compared nutrient concentrations in springs in an intensely farmed area with a minimally affected forested area and reported that the areas of intense livestock production had elevated concentrations of nitrate and chloride.

One potential source of ground-water contamination is from animal waste stored in anaerobic lagoons generated from confined animal feeding operations. These lagoon structures are designed to store animal waste for a specified time period until the waste is ready to be applied as liquid fertilizer to adjacent pastures or cropland. If not properly located, designed, constructed, and maintained, animal waste lagoons can adversely affect water quality through the introduction of excess nutrients and bacteria (Ham and DeSutter, 2000).

The Natural Resources Conservation Service (NRCS) has developed several Best Management Practices (BMPs) to reduce this risk of ground-water contamination. Waste Storage Practice no. 313 was created to allow producers to safely and effectively store animal waste while protecting ground-water resources in environmentally sensitive areas across a variety of hydrogeological environments (Natural Resources Conservation Service, 2003). Ideally, these structures are located in areas with thick soils, over deep or confined aquifers, and away from domestic water supplies. When this is not possible, the NRCS provides options that allow an additional measure of safety such as an impermeable geosynthetic membrane liner or a compacted liner constructed from native soil with a specific permeability.

This BMP has been successful in protecting ground-water resources in other hydrogeologic settings, (David Moffit, Natural Resources Conservation Service, oral commun., 2004) but its effectiveness has not been evaluated in areas with thin soils such as a mantled karst setting. To address this need, the U.S. Geological Survey in cooperation with the Natural Resources Conservation Service National Water Management Center, the University of Arkansas, and the Arkansas Department of Environmental Quality designed a study to determine the effectiveness of Waste Storage Practice no. 313 for storing swine waste in a mantled karst setting. The purpose of this report is to describe ground-water quality near the swine waste lagoon.

STUDY AREA

The Savoy Swine Facility is located within the Savoy Experimental Watershed (SEW) in northern Washington County in northwestern Arkansas (fig. 1). The SEW serves as a long-term, multi-disciplinary research site to examine water-quality problems associated with livestock production in a mantled karst setting. The SEW offers a unique opportunity to test and evaluate the environmental effects of different animal agricultural practices. In 2002 the University of Arkansas constructed the Savoy Swine Facility to improve planned large-scale swine production. The Savoy Swine Facility is managed as a demonstration farm to provide a long-term model for environmentally friendly management of animal nutrition, animal waste and odors (Maxwell and others, 2003).

The Savoy Swine Facility is located within the Springfield Plateau (Fenneman, 1938), which is underlain by nearly flat lying Mississippian-age cherty limestones and limestones. These sedimentary sequences have been incised by streams to form dendritic drainages and rolling hills. Karst features such as springs, sinkholes, losing streams, caves, and conduits are present in the study area (Little, 1999).

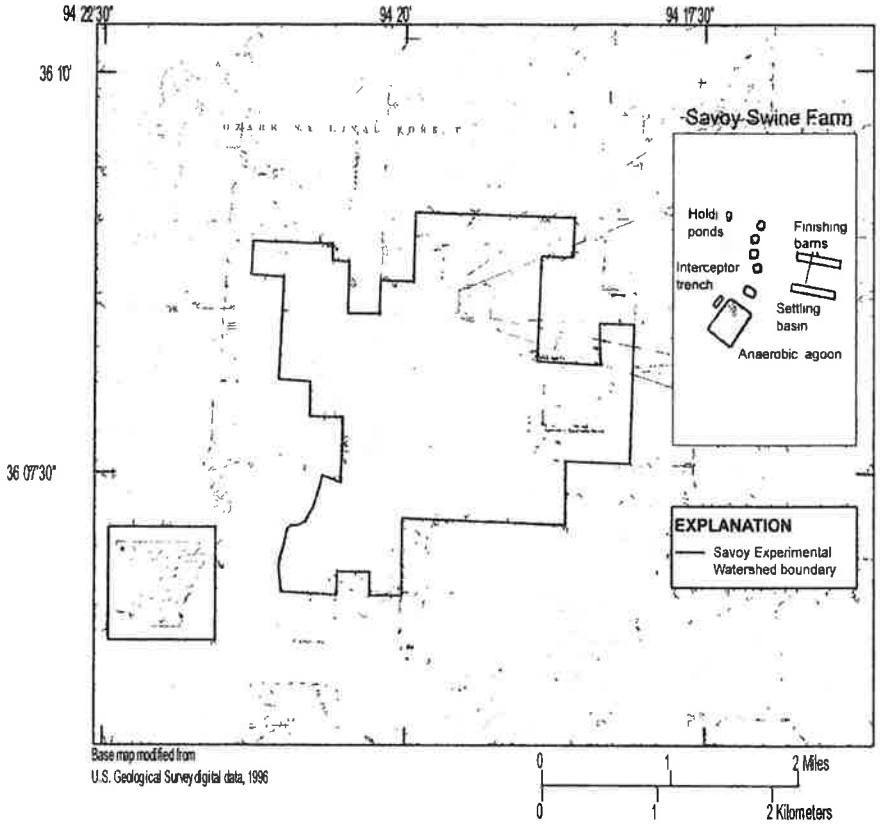

Figure 1. Location of the Savoy Swine Farm and diagram of waste storage infrastructure within the Savoy Experimental Watershed.

The major geologic units present in the study area are the Chattanooga Shale, the St. Joe Limestone Member of the Boone Formation, and the Boone Formation. The Chattanooga Shale is a black, Devonian-age shale that is approximately 45 feet thick within the SEW (Little, 1999) that unconformably underlies the St. Joe Limestone Member. The Chattanooga Shale acts as a regional confining unit where it is present in the Ozarks separating groundwater flow between the Mississippian-age limestones which compose the Springfield Plateau aquifer and the underlying Ordovician-age dolomites and sandstones which compose the Ozark aquifer (Imes and Emmett, 1994). The St. Joe Limestone Member, which is part of the Boone Formation is a relatively pure limestone, is conformably overlain by cherty limestone. The Boone Formation consists of Mississippian-age cherty limestones and is thickest beneath the uplands throughout the study area. The bedrock in the study area is overlain by regolith that is the weathering product of the cherty limestone of the Boone Formation that creates the mantled karst topography. The soils formed from the regolith are composed of silt loams and the associated subsoils are silty clay loam or cherty silt loam (Harper and others, 1969).

The waste storage infrastructure at the Savoy Swine Facility was constructed in compliance with Waste Storage Practice no. 313 (Natural Resources Conservation Service, 2003). Because the swine facility was constructed over an unconfined limestone aquifer, more stringent design options were considered for the waste lagoon. The most economical solution was to construct a compacted clay liner from sieved native soil with a target coefficient of permeability of 1.0×10^{-7} centimeters per second (Stan Rose, Natural Resources Conservation Service, oral commun., 2004). Because of budget constraints during the construction, the Savoy Swine Facility is only able to house half the animals it was initially designed for. As a result the waste storage

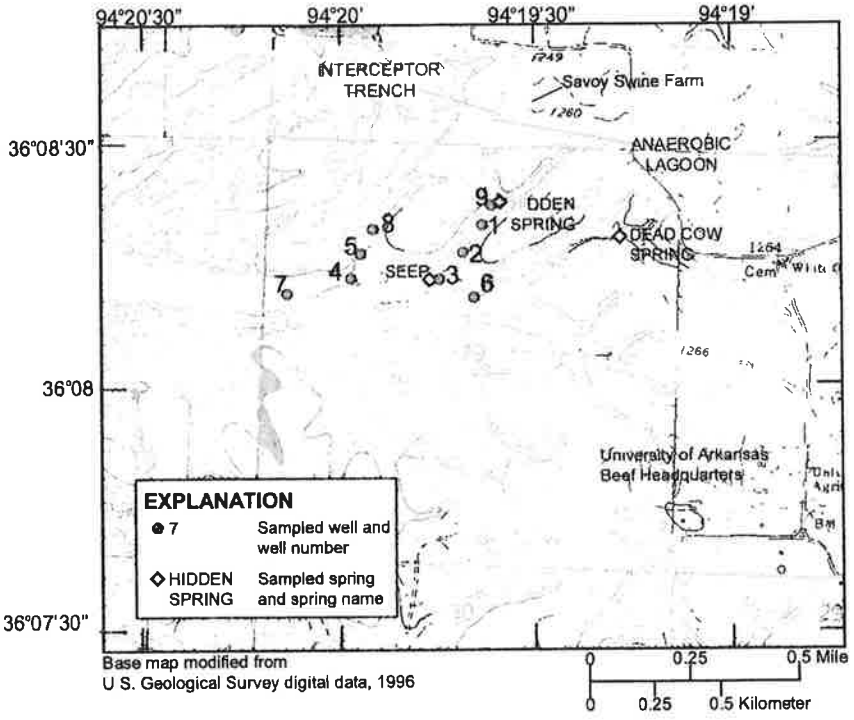

Figure 2. Location of water-quality sampling points within study area.

infrastructure is substantially oversized with respect to the number of animals served (Karl VanDevender, University of Arkansas, oral commun., 2004). The Savoy Swine Farm has a unique project-specific design constructed with four holding ponds each designed to store animal waste for a set of animals with a specific diet (fig. 1).

METHODS

A karst inventory was conducted in the area of the swine farm to gain a better understanding of the ground-water system prior to sampling point selection and well drilling. An inventory of springs, seeps, sinkholes, and losing and gaining reaches of streams was compiled. Nine shallow monitoring wells were augered to the depth of drilling refusal in the regolith. All wells were constructed with 2-inch polyvinyl chloride (PVC) casing and slotted PVC screen sections. A sand filter pack was installed surrounding the screened section with 2 feet of bentonite overlying the filter pack to prevent surface contamination. An interceptor trench was installed west of the anaerobic lagoon on the swine farm and was excavated with a backhoe to the bedrock surface to allow collection of lagoon leachate moving downgradient from the anaerobic lagoon after a storm event (fig. 1).

Sampling points consisted of monitoring wells, springs, seeps, and the interceptor trench. Water-quality samples were collected (fig. 2) during high-flow conditions in April 2004 and low-flow conditions in October 2004. The interceptor trench was sampled after one storm event on July 27, 2004. All samples were analyzed for nutrients including nitrate plus nitrite, ammonium, total Kjeldahl nitrogen, total phosphorus, and orthophosphate, major cations and major anions by the Arkansas Department of Environmental Quality (ADEQ) Water Quality Laboratory in Little Rock, Arkansas. Nitrate plus nitrite concentrations are reported as nitrate for this report because nitrate is the dominant form of nitrogen for this analyte. Fewer monitoring wells

were sampled during low-flow conditions because some of the wells were dry or did not yield water for sampling.

An electromagnetic geophysical survey was conducted near the waste storage infrastructure to determine any areas of preferential seepage from the lagoon and to assess the selection and placement of the sampling points. An EM-31 is a frequency domain electromagnetic instrument that is capable of determining subsurface conductivity (Geonics, 1984). Electromagnetic surveys have been successful in the past locating areas of preferred seepage from animal waste lagoons. Areas of lagoon seepage result in anomalously high subsurface conductivities compared to unaffected areas (Brune and Doolittle, 1990). Conductivity data were collected with a horizontal dipole instrument orientation providing an average depth of investigation of 6 meters. Global Positioning System (GPS) data and subsurface conductivity data were collected simultaneously. These data were plotted and contoured using the computer program Surfer (2002) for visual interpretation of results.

GROUND-WATER QUALITY

Concentrations of nitrate and chloride for both high-flow and low-flow sampling events were above background concentrations, but were low compared to other areas in the Ozarks affected by livestock production (table 1). Background concentrations for nitrate plus nitrite in forested, relatively pristine areas of the Ozarks are typically less than 0.5 milligrams per liter (mg/L) as nitrogen (N) and 5.0 mg/L for chloride (Steele, 1983). Data collected in this study indicate that local livestock production probably is affecting the ground-water quality of the area. Concentrations of nitrate ranged from 0.27 to 2.39 mg/L as N during high-flow conditions and 0.84 to 3.41 mg/L as N during low-flow conditions. Chloride concentrations ranged from 3.95 to 14.8 mg/L during high-flow conditions and 14.1 to 30.2 mg/L during low-flow conditions. Concentrations of both nitrate and chloride were higher during the low-flow sampling event probably because of mixing and dilution that occurs during high-flow conditions.

Table 1. Concentrations of nitrate and chloride for low-flow and high-flow sampling events

[Background concentrations of nitrate and chloride are from relatively pristine, forested areas of the Ozarks. Source sample collected from anaerobic lagoon]

Sampling point	High-flow sampling (concentrations in mg/L)			Low-flow sampling (concentrations in mg/L)			
	Date	Nitrate as N	Chloride	Date	Nitrate as N	Chloride	Ammonium as N
Well 1	4-12-04	1.08	14.8	-	-	-	-
Well 2	4-12-04	2.10	6.96	10-5-04	1.37	18.4	-
Well 3	4-12-04	1.23	9.97	10-5-04	1.07	18.9	-
Well 4	4-12-04	0.32	5.87	10-5-04	0.98	14.4	-
Well 5	4-12-04	0.46	3.95	-	-	-	-
Well 6	4-12-04	0.75	5.87	10-6-04	0.84	15.2	-
Well 7	4-12-04	0.27	3.95	10-6-04	0.99	14.1	-
Well 8	4-12-04	0.62	14.3	10-5-04	2.22	29.1	-
Well 9	4-12-04	1.99	12.9	-	-	-	-
Hidden Spring	4-12-04	2.39	11.5	10-5-04	3.41	30.2	-
Dead Cow Spring	-	-	-	10-5-04	2.59	19.8	-
Seep	4-12-04	1.32	8.90	10-5-04	1.15	16.0	-
Interceptor Trench	7-27-04	23.5	10.5	-	-	-	1.19
Anaerobic lagoon	6-13-05	-	-	6-13-05	0.44	462	40.0
Background [1]	-	0.5	5.0	-	-	-	-

[1] From Steele (1983)

These results were comparable to a previous study conducted prior to the construction of the Savoy Swine Facility. Little (1999) collected water-quality samples from springs, seeps, and wells proximal to the study area under high-flow and low-flow sampling conditions. Nitrate concentrations ranged from 0.06 to 4.64 mg/L as N and chloride concentrations ranged from 2.89 to 27.0 mg/L as N. The elevated concentrations suggest that the basin probably was affected by local livestock production prior to the construction of the Savoy Swine Facility. The highest concentrations of nitrate and chloride were detected near the University of Arkansas Beef Headquarters towards the eastern portion of the study area (fig. 2).

The results from the interceptor trench sample indicate that nitrogen is seeping through the anaerobic lagoon liner as ammonium with nitrification converting the ammonium into nitrate. The interceptor trench sample had concentrations of nitrate at 23.5 mg/L as N and ammonium concentrations at 1.19 mg/L as N. A water-quality sample was collected from the anaerobic lagoon on June 13, 2005. The form of nitrogen within the anaerobic lagoon is predominantly ammonium, with concentrations at 40.0 mg/L as N. Nitrate concentrations were 0.44 mg/L as N and chloride concentrations were 462 mg/L in the lagoon sample (table 1). The lagoon leachate is probably mixing with other waters resulting in lower concentrations of nitrate and chloride in downgradient sampled wells and springs. Based on these ground-water quality data, the swine waste lagoon built using the Natural Resources Conservation Practice no. 313 is minimally affecting the ground-water quality of the area.

ELECTROMAGNETIC GEOPHYSICAL SURVEY

The results of the EM-31 survey did not identify any areas of preferential seepage from the holding ponds, settling basin, or anaerobic lagoon. Subsurface conductivities ranged from 0.6 to 21.0 millimhos per meter. It appears that most of the leakage is from the anaerobic lagoon and the leachate is migrating from the source in a fairly uniform pattern (fig. 3). There is very little leakage from the waste holding ponds and settling basin. This is probably because the animal waste stored in both the holding ponds and settling basin contains a much higher proportion of solid animal waste compared to the anaerobic lagoon. The solid waste is able to create a seal that decreases liner permeability (Natural Resources Conservation Service, 2003). Based on the results of the EM-31 survey it appears that the oversizing of the waste storage infrastructure is having a negative impact on the effectiveness of the anaerobic lagoon.

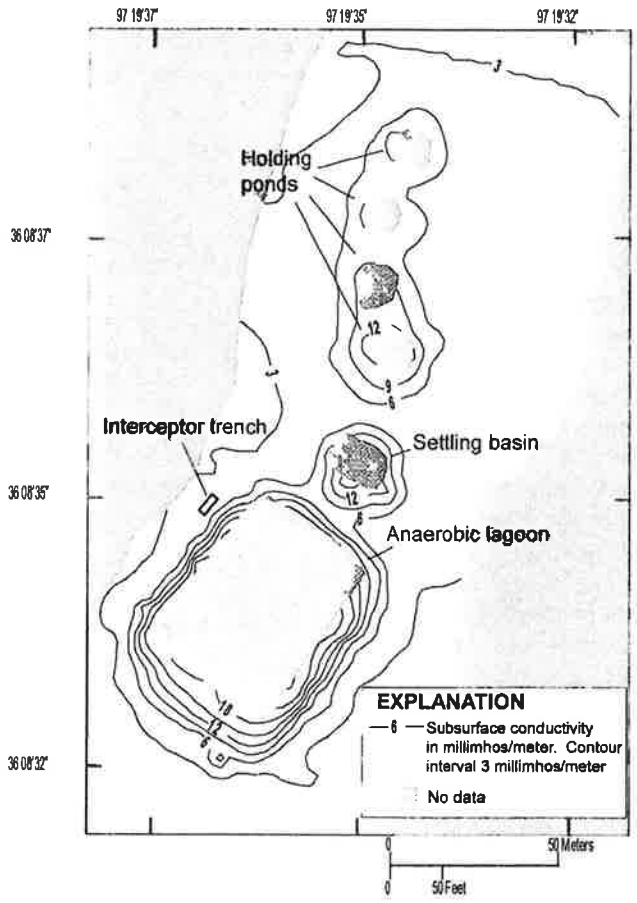

Figure 3. Results of EM-31 electromagnetic survey.

SUMMARY

A study was conducted to evaluate the effects of a swine waste lagoon on ground-water quality in a mantled karst terrane at the University of Arkansas' Savoy Experimental Watershed. An anaerobic swine waste lagoon was constructed at the Savoy Swine Facility in compliance with U.S. Department of Agriculture NRCS Conservation Waste Storage Practice Standard no. 313. An inventory of springs, seeps, and losing streams was conducted in the basin where the waste lagoon was constructed. Based on the inventory, sampling sites were selected and nine shallow monitoring wells were augered to the depth of drilling refusal in the regolith. Shallow ground-water from wells, springs and an interceptor trench was sampled for nutrients, major cations, and major anions during high-flow and low-flow conditions.

Data collected in this study indicate that the ground-water quality of the area is probably being affected by local livestock production. The concentrations of nitrate and chloride for both high-flow and low-flow sampling events were above background concentrations, but were low compared to other agriculturally affected areas in the Ozarks. Concentrations of nitrate plus nitrite ranged from 0.27 to 2.39 mg/L as N during high-flow conditions and 0.84 to 3.41 mg/L as N during low-flow conditions. Chloride concentrations ranged from 3.95 to 14.8 mg/L during high-flow conditions and 14.1 to 30.2 mg/L during low-flow conditions. Concentrations of both nitrate and chloride were higher during the low-flow sampling event probably because of mixing and dilution that occurs during high-flow conditions.

These results were comparable to a previous study conducted prior to the construction of the Savoy Swine Facility. Water-quality samples were collected from springs, seeps, and wells within near the study area under high-flow and low-flow sampling conditions. Nitrate concentrations ranged from 0.06 to 4.64 mg/L as N and chloride concentrations ranged from 2.89 to 27.0 mg/L. The elevated concentrations suggest that ground water in the basin has been affected by local livestock production prior to the construction of the Savoy Swine Facility.

A water-quality sample collected from an interceptor trench after a storm event on July 27, 2004 had concentrations of nitrate at 23.5 mg/L as N and dissolved ammonium concentrations at 1.19 mg/L as N. The results from the interceptor trench sample indicate that nitrogen is seeping through the anaerobic lagoon liner as ammonium with nitrification converting the ammonium into nitrate. The lagoon leachate probably is mixing with other waters resulting in lower concentrations of nitrate and chloride in downgradient sampled wells and springs.

The results of an electromagnetic geophysical survey identified no areas of preferred seepage from the holding ponds, settling basin, and anaerobic lagoon. Most of the leakage appears to be from the anaerobic lagoon and the leachate is migrating from the source in a fairly uniform pattern. Very little leakage from the waste holding ponds and settling basin occurs. This is probably because the animal waste stored in both the holding ponds and settling basin contains a much higher proportion of solid animal waste compared to the anaerobic lagoon. Based on these results, the swine waste lagoon built using the Natural Resources Conservation Service Conservation Practice no. 313 is minimally affecting the ground-water quality of the area.

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Appendix B

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA9537

Nutrient Concentrations in Big Creek Correlate to Regional Watershed Land Use

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In the Ozark Mountain karst region, nutrient concentrations in streams of the Buffalo, Upper Illinois and Upper White River watersheds increase as the percent of land in pasture and urban use increases. Averaged over the last three years, nutrient concentrations in Big Creek above and below the C&H Farm are similar to concentrations found in other watersheds where there is a similar amount of pasture and urban land use.

Background

Land use within watersheds influences the quantity and quality of water draining from a watershed. As land disturbance increases and use intensifies, there is a general increase in stormwater runoff and nutrient inputs that leads to a greater potential for nutrient discharge to receiving waters. For instance, with urban growth, more impervious surfaces increase the flashiness of runoff, stream flows and wastewater treatment discharge. Also, as areas of agricultural production grow, more fertilizer is applied to achieve optimum production. Thus, as the percent of a watershed drainage area in pasture, row crop or urban use increases, there is a general increase in nutrient concentrations in storm and base flows.

In this fact sheet, we show the effect of land use on nitrogen (N) and phosphorus (P) concentrations in streams of the Ozark Highlands and Boston Mountains, northwest Arkansas, by combining previously published data for the Upper Illinois River Watershed (Haggard et al., 2010), Upper White River Watershed (Giovannetti et al., 2013) and ongoing monitoring in the Buffalo River Watershed. The location of these watersheds is shown in Figure 1. The relationships between stream nutrient concentrations and land use for the region are used to determine if a permitted concentrated animal feeding operation (CAFO) in Big Creek Watershed, a sub-watershed of the Buffalo River Watershed, has affected stream water quality. Land use in these watersheds is given in Table 1.

Nitrate-N, total N, dissolved P and total P concentrations have been measured over varying periods during base flow at the outlet of sub-watersheds in the Big Creek (two sites, 2014 to 2017), Buffalo (20 sites, 1985 to 2017), Upper Illinois (29 sites, 2009) and Upper White River Watersheds (20 sites, 2005 to 2006) (Figure 1).

Data from Big Creek were paired with discharge available from a gaging station just downstream from the swine CAFO, where the USGS developed the rating curve; discharge information was only available from May 2014 through December 2017. The data were then used to look at changes in flow-adjusted nutrient concentrations[A] in Big Creek (White et al., 2004).

[A]Concentration is defined as the mass of a substance (M), such as a nutrient, over the volume of water (V) in which it is contained, or C = M/V. "**Flow-adjusted nutrient concentrations**" – when looking at how concentrations change over time in streams, we have to consider how concentrations might also change with stream flow (volume of water) and not just change in mass; nutrient concentrations often have some type of relation to flow, maybe increasing or even decreasing as stream flow increases. We have to flow-adjust concentrations so we can remove the variability in concentrations that flow might cause to see how things are changing over time.

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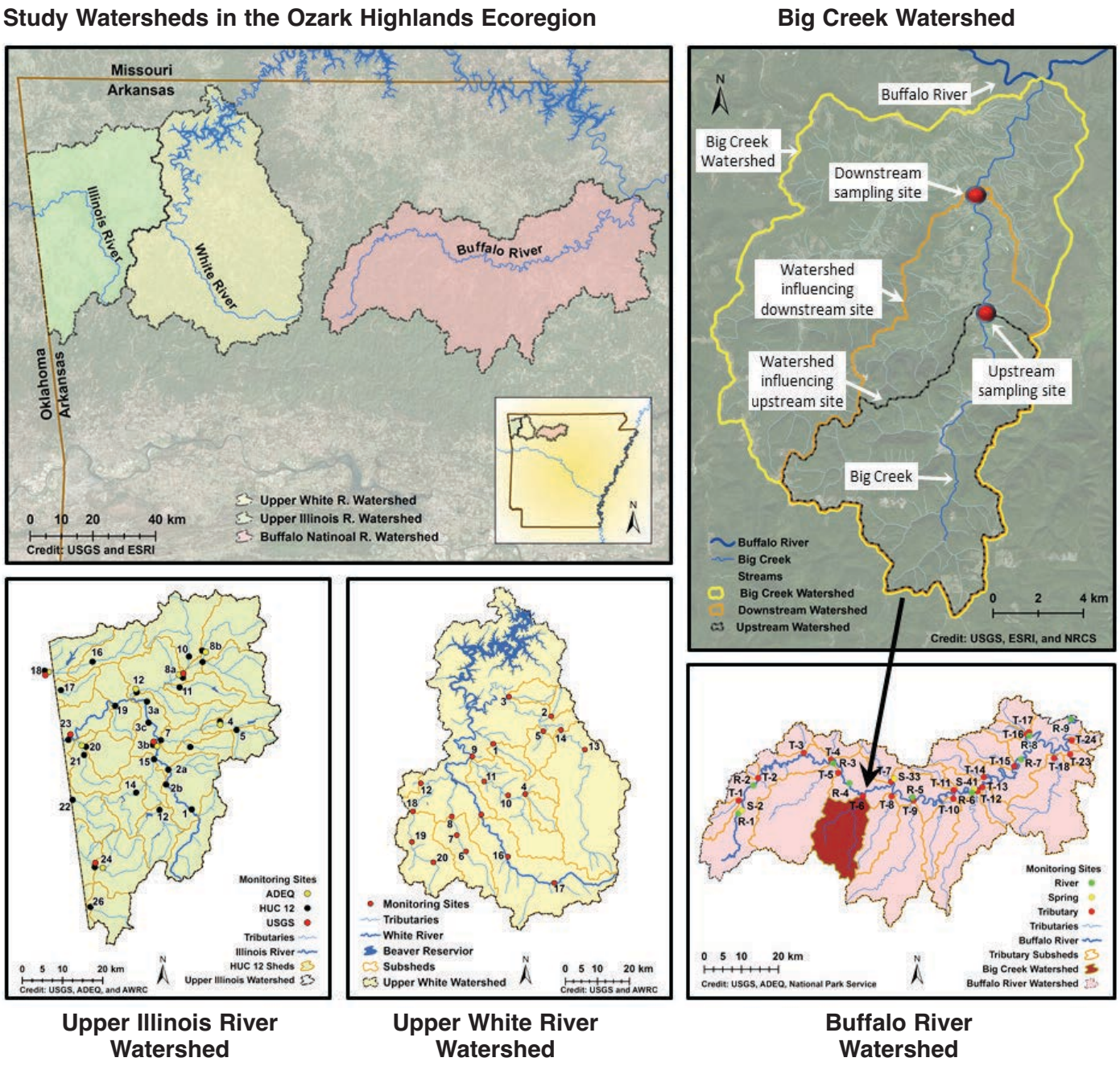

Figure 1. Location of the Big Creek, Buffalo River, Upper Illinois River and Upper White River watersheds in the Boston Mountains and Ozark Highlands ecoregion. *Information from U.S. Geological Survey (USGS), Environmental Systems Research Institute (ESRI) and National Aeronautics and Space Administration (NASA).*

Table 1. Percent of forest, pasture and urban land use in the Big Creek, Buffalo River, Upper Illinois and Upper White River watersheds.

Watershed	Forest	Pasture	Urban
	- % -		
Big Creek*			
Upstream	89.5	8.0	2.6
Downstream	79.5	17.0	3.5
Buffalo River	52 - 99	0 - 25	0 - 1
Upper White River	34 - 90	7 - 55	0 - 44
Upper Illinois River	2 - 70	27 - 69	3 - 61

*Up and downstream of CAFO operation and fields permitted to receive manure.

Putting Stream Nutrient Concentrations Into Context at Big Creek

Geometric mean concentrations[B] of stream P and N are related to the percent of watershed drainage area in pasture and urban land use for the Buffalo, Upper Illinois and Upper White River watersheds (R^2 of 0.56 to 0.81 where the number of observations is 71; Figure 2)[C]. The dashed lines on Figure 2 represent the upper and lower thresholds concentrations, where there is a 95 percent confidence that a stream draining a watershed with a specific percent pasture and urban land use will have a P and N concentration within those thresholds.

The relationship between land use and stream nutrient concentrations is not a model that can be used to predict concentration. Given the large variability observed in these relationships, they simply show trends between two variables, land use and stream nutrient concentrations. Continued monitoring of stream concentrations in Big Creek will continue to more reliably define trends.

As the percent pasture and urban land (i.e., land use intensity) increases, so does stream P and N concentrations (see Figure 2). The general increase in nutrient concentrations is consistent with the fact that fertilizer (as mineral and manure sources) is routinely applied to pastures to maintain forage production, as well as deposition of nutrients by grazing cattle.

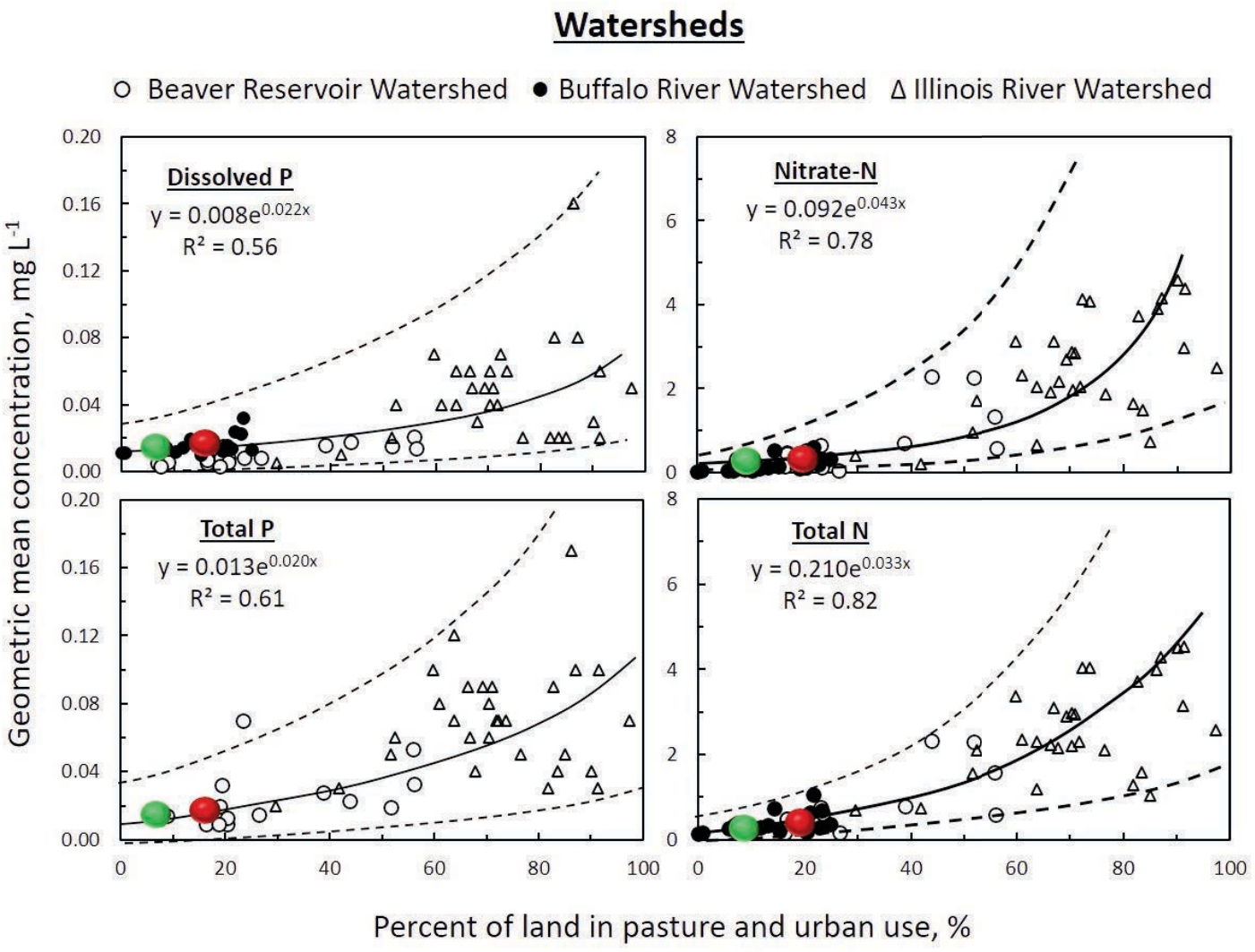

Figure 2. Relationship between land use and the geometric mean N and P concentrations (mg L^{-1}) in the Buffalo, Upper Illinois and Upper White River watersheds. Dashed lines represent the 95 percent confidence intervals for the estimated mean (solid line). Green points are geometric mean concentrations measured upstream of the CAFO on Big Creek and red points are geometric mean concentrations measured downstream of the CAFO on Big Creek.

[B]"**Geometric means**" – There are many ways to calculate the central or typical value of a data set, like the average or median. With water quality data, the geometric mean is often used because it minimizes the influence of really low or high values on the average.

[C]"**R^2**" is the **coefficient of determination** – the proportion of variance in the dependent variable (i.e., vertical axis) that is predictable from the independent variable (i.e., horizontal axis). The closer to 1 the value is, means less variability and the better the relationship between the two variables is.

In the Big Creek watershed, the percent of land influenced by human activities (i.e., pasture plus urban) doubles from ~10 percent to ~20 percent in the drainage area upstream and downstream of the CAFO. In Big Creek itself, upstream of the swine production CAFO, the geometric mean concentrations of dissolved P, total P, nitrate-N and total N during base flow were 0.009, 0.030, 0.10 and 0.20 mg L^{-1}, respectively, between September 2013 and December 2017. Directly downstream of the CAFO, the geometric mean concentrations in Big Creek during base flow over the same period were 0.011, 0.030, 0.25 and 0.37 mg L^{-1}, respectively.

Geometric mean nutrient concentrations in Big Creek above and below the swine production CAFO and its current potential sphere of influence from slurry applications are similar to or lower than concentrations measured in rivers draining other subwatersheds in the Upper Illinois and Upper White River watersheds with similar proportions of agricultural land use. (See Figure 2.)

Have Nutrient Concentrations Changed in the Short Term at Big Creek?

Long-term (e.g., decadal scale) water quality data are needed to reliably assess how stream nutrient concentrations have changed in response to watershed management and climate variations (Hirsch et al., 2015). The literature shows that stream nutrient concentrations can change relatively quickly in response to effluent management (e.g., Haggard, 2010; Scott et al., 2011), but seeing a response (i.e., decrease or increase in concentrations) from landscape management can take decades or more (Green et al., 2015; Sharpley et al., 2013). A myriad of factors may influence observed nutrient concentrations in streams, including discharge, biological processes and climactic conditions (i.e., drought and floods), and dominant transport pathways. Thus, we need to use caution when interpreting trends in water quality over databases that only cover a limited timeframe. Flow-adjusted concentrations showed no

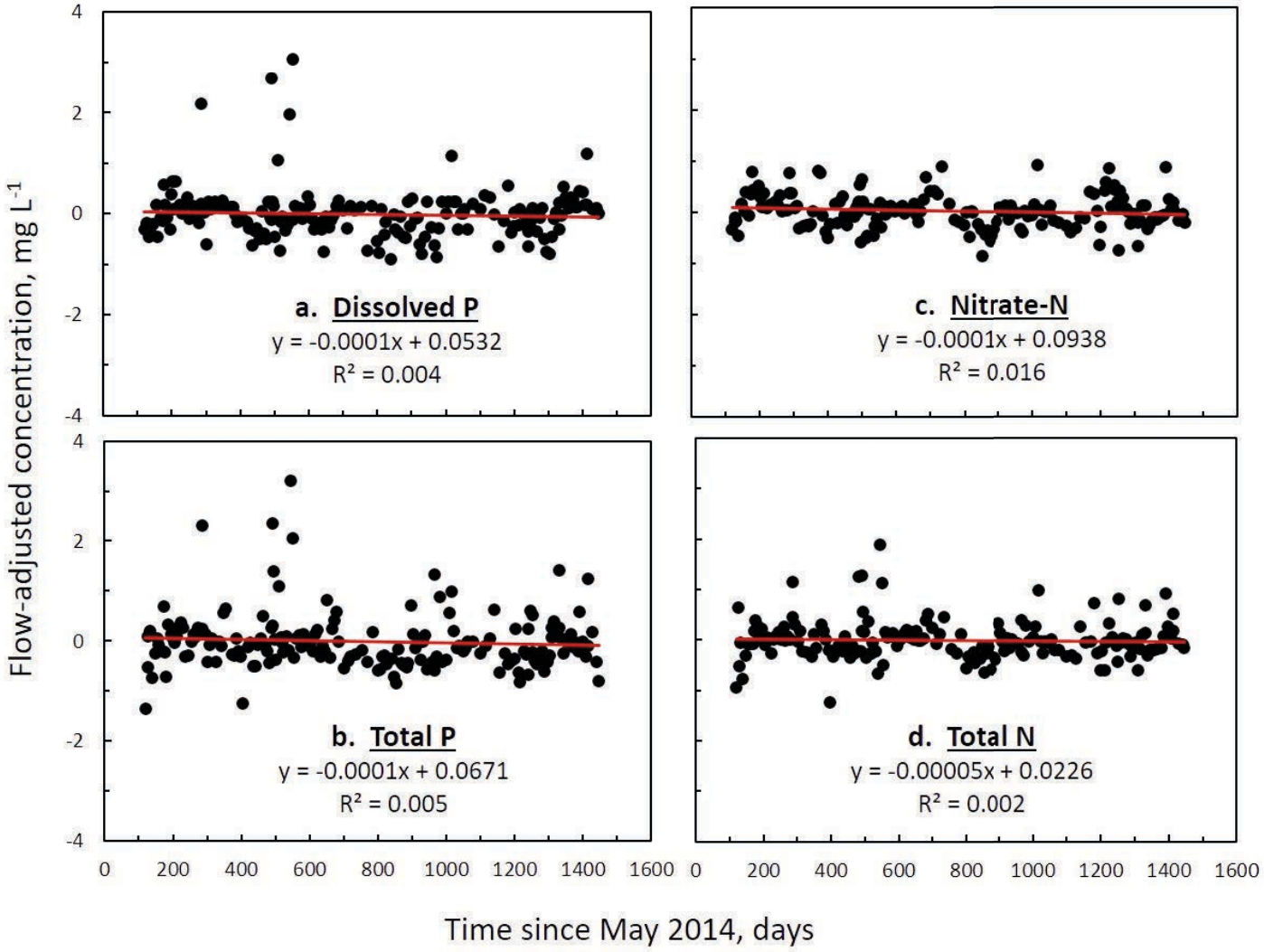

Figure 3. Change in flow-adjusted concentration of (a) dissolved P, (b) total P, (c) nitrate-N and (d) total N over time since May 2014, when monitoring in Big Creek started.

statistically significant increasing or decreasing trends in dissolved P, total P, nitrate-N and total N (R2 <0.016); where number of observations is 182) over the current monitoring period (Figure 3).

Summary

Nutrient concentrations at Big Creek upstream and downstream of the swine CAFO, and indeed most tributaries of the Buffalo River, are low relative to other watersheds in this ecoregion (Figure 2). This provides a starting point to build a framework to evaluate changes in nutrient concentrations of streams as a function of land use and management.

The evaluation of flow-adjusted concentrations over time showed that nutrients in Big Creek were not increasing over the short duration of monitoring for which concentration and discharge data were available (May 2014 through April 2017). At this point in time, it is evident that nutrient concentrations in Big Creek have not increased at the monitored site. However, flow and nutrient concentration data over a longer period are needed to reliably quantify water quality trends and characterize sources, and monitoring needs to continue for at least a decade to evaluate how discharge, season and time influence nutrient fluxes.

Stream nutrient concentration-land use relationships are not a predictive tool. However, use of these relationships provides a method to determine if nutrient concentrations in a given watershed are similar to observed nutrient concentration-land use gradients in other watersheds of the Ozark Highlands and Boston Mountains. Over time, tracking these relationships provides a mechanism to note and evaluate changes in nutrient concentrations.

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FSA9537-PD-3-2018N