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Arkansas Department of Environmental Quality
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Regarding: Support for a "Permanent Moratorium" on medium and large swine concentrated animal feeding operations (CAFOs) in the Buffalo National River watershed

To whom it may concern:

Please let your records reflect that I am wholeheartedly in favor of making the conditions of the moratorium permanent, thereby prohibiting the siting and operation of medium and large swine CAFOs in the Buffalo National River watershed.

Given that reports in the press have indicated that certain members of the Arkansas Pollution Control and Ecology Commission and others may be considering the results of the Big Creek Research Extension Team (BCRET) report in their decision to make the moratorium "permanent", I have taken efforts to review the BCRET report entitled Monitoring the Sustainable Management of Nutrients on C&H Farm in Big Creek Watershed Final Report. In my opinion as a scientist and having read other criticisms of the BCRET study and its methods and conclusions, the BCRET study generally lacks sufficient technical breadth to be used as a decision-making tool for determining the release of nutrient contaminants from C&H Farm to Big Creek.

While the BCRET study design, methods, uncertainty analysis, and conclusions may be faulted, at least one result of the study is clearly appreciated. This clear result from the BCRET study is that nitrate concentrations in Big Creek surface water downstream of C&H Farm (sampling location BC7) were consistently about double the nitrate concentration upstream of the C&H Farm (sampling location BC6) over the 5 years of the study. This result strongly implies that C&H Farm and its operations resulted in substantial increases in nitrate loading to Big Creek over the study period. If for no other reason, this result is sufficient to prohibit medium and large swine CAFOs from being sited and operated in the Buffalo National River watershed.

I present some additional technical criticisms of the study and its methods and conclusions below.

The authors of the report are presumed to be those listed on page 9 of the document and described as the "Big Creek Science Team". It is not clear to the reader whether the Big Creek Science Team is the same as BCRET or a subset of individuals making up BCRET. I also note that this report was published in 2019 but is undated and would suggest that it should be dated on the front cover. This would help readers to understand the context for conclusions referring to "the present time" (Executive Summary, 20). Should it undergo further revision, I would ask that some system be used to track the revision number of the report. In my comments, I henceforth refer to the report as BCRET (2019).

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Before making any criticisms of BCRET (2019), I acknowledge the practical and budgetary limitations on the design and conduct of the study and credit BCRET for the time and effort spent over its years of the study. I also note, however, that the practical and budgetary limitations of the study and their impacts on the scientific certainty of its conclusions are not acknowledged in BCRET (2019). Furthermore, important portions of the BCRET investigation are subject to considerable uncertainty, variability, and potential bias. The degree of confidence that can be placed in the conclusions of BCRET (2019) is rightfully placed within the context of the considerable uncertainty and variability of the investigation results. For example, the report lacks even the most basic discussion of the uncertainty associated with surface water, soil, and groundwater sampling methods, analytical uncertainty associated with reporting of nutrient concentrations below the laboratory reporting limits, and the variability of parameters used to model loading of nutrients to Big Creek.

For a study of the magnitude of BCRET (2019), it is typical to establish and clearly explain data quality objectives (DQOs) for environmental sampling, laboratory analyses, and data handling as a part of the quality assurance and quality control processes of the study. DQOs are designed to ensure that study conclusions rely on high quality data and procedures. When DQOs are not met, the quality of the study and its conclusions suffer. For this reason, it is important to establish DQOs and discuss whether they are met, particularly if the study results are to be used in environmental decision-making. BCRET (2019) is silent on whether DQOs are even established or met. The apparent omission of this discussion from the report is an important factor in whether environmental decision-makers can confidently rely on the results and conclusions of BCRET (2019).

Further, BCRET (2019) presents little sensitivity analysis to provide a possible range of modeling outcomes that could be used to bound estimates of nutrient loading and nutrient runoff. A sensitivity analysis of the most important modeling parameters would provide readers a better understanding of the uncertainty and variability associated with modeled estimates of nutrient runoff and the degree of confidence that should be placed on these estimates.

In addition, the most basic descriptive statistics used in scientific studies are not presented in summary tables of analytical results. For example, Table 1 of BCRET (2019) presents only the median concentrations or values for the analytes. The minimum detected concentrations, maximum detected concentrations, arithmetic mean concentrations, geometric mean concentrations, standard error of the mean, or number of samples analyzed are not presented in Table 1. By presenting only the median concentration, the reader might be tempted to ignore the considerable variability in concentration data from the pond sampling. The report provides no justification for why the median concentration versus the arithmetic mean, geometric mean, or other representation of central tendency is more representative for field loading calculations for nutrients. I would also suggest that the representative nutrient concentration used to calculate field loading of nutrients be clearly identified in Table 1.

The report does not clearly state the party or parties responsible for the collection of samples (i.e., pond samples) and data reporting (i.e., gallons of slurry used on the fields). For example, in the section of the report entitled "Composition and Land Application of Holding Pond Slurry", it states

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> To help guide adaptive manure management decisions, samples of manure slurry from the C&H ponds are collected periodically over the 5-year monitoring for analysis.
>
> And
>
> The distribution of chemical constituents with lagoon depth is given in Figure 2. This information was shared with C&H's owners as part of the adaptive manure management discussions.

I take this to mean that it is possible that the landowner, and not BCRET, may have performed the unsupervised sampling of the holding ponds containing the slurry. This should be acknowledged as a possible source of uncertainty and bias. This is potentially important when the landowner might collect potentially unrepresentative samples of the ponds. BCRET (2019) embeds a standard operating procedure for sampling liquid manure ("Sampling Liquid Manure" by Karl VanDevender) within the body of the report. This embedded procedure acknowledges the difficulty of obtaining representative pond slurry samples, stating

> This stratification affects the manure nutrient concentrations in the storage facility. The nitrogen and potassium will be more concentrated in the top liquid, while the phosphorus will be more concentrated in the settled solids. This stratification of nutrient concentrations increases the challenge of getting samples that represent what will be applied to a particular field.

It should also be stated whether BCRET made efforts to verify that the reported gallons of "slurry applied" by the landowner are accurate. If BCRET made no attempt to identify the accuracy of these data, it should be stated.

In summary, for the sake of transparency and as an indicator of the degree of confidence that should be placed in field nutrient loading calculations, BCRET (2019) should provide typical descriptive statistics for nutrient concentrations such that the reader can appreciate the amount of variability in the pond sample results. Furthermore, BCRET (2019) should acknowledge the analysis of nutrient field loading is dependent on slurry application data reported by the landowner. If the landowner performed the pond sampling, this too should be stated as a potential source of uncertainty and bias in BCRET (2019). To the extent that other calculations (such as annual loss of phosphorus and nitrogen in surface runoff from Fields 1, 12, and 5a) rely on these data, the uncertainty associated with the use of these data in other calculations should be stated.

BCRET (2019) also does not discuss the analytical uncertainty associated with the measurement of nutrient constituents in groundwater and surface water. In "Table 2. Minimum detection limits for each chemical and biological constituent." presents method detection limits and reporting limits for "Dissolved P", "Total P", "Nitrate-N", and "Total N". As defined in Table 2,

> The Minimum detection limit of an analyte is the value, which can be measured and reported with 99% confidence that the analyte concentration is greater than zero.
>
> And
>
> The Reporting limit is the least (non-zero) calibrated standard used in analysis, or as defined by method for total suspended solids.

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Table 2 lists the minimum detection limit and reporting limit for dissolved P as 0.002 mg/L and 0.010 mg/L, respectively. It is customary to flag reported concentrations with a data qualifier (such as "J") to indicate when an analytical result is below the reporting limit. Analytical results below the reporting limit are considered to be estimates and are therefore less certain than results reported above the reporting limit. As such, there is less confidence that the reported concentration is accurate when the result is below the reporting limit. In general practice, no concentration is listed below the minimum detection limit and instead, the result is given as the method detection limit with the less than ("<") symbol in front of the method detection limit (i.e., <0.002 mg/L).

From Table 1 in the Appendix H of BCRET (2019), it is apparent that many dissolved phosphorus results are reported below the reporting limit of 0.010 mg/L. In the case of water samples collected from September 12, 2013 to July 31, 2014, fully 45% of all dissolved phosphorus results reported are below the reporting limit of 0.010 mg/L, qualifying them as estimated values. Nowhere in BCRET (2019) is the uncertainty of the analytical results discussed. The lack of attention given to this uncertainty may lead the reader to believe that the reported concentrations, and the conclusions reached by using these results, are more reliable than they actually are. While it is often the case that numerical estimates of concentrations reported below the reporting limit are used in an evaluation, the use of these data is also qualified to reflect lesser confidence in the results.

Also, for 16 analyses listed in Table 1, dissolved P concentrations of 0.001 mg/L are reported. As defined in BCRET (2019), this concentration is below the minimum detection limit of 0.002 mg/L and should be reported as "<0.002 mg/L" unless the minimum detection limit is 0.001 mg/L.

A key process undertaken by the BCRET for its evaluation of trends in water quality was the log-transformation and smoothing of data using LOESS. General assumptions regarding the transformation of data (log transformation) and proportion of data sampled (0.5) are used by BCRET in the analysis. I question whether the authors performed any distribution tests and seeing none, accepted a log distribution as the default for data transformation. Further, the use of a default value for the sampling proportion (0.5) in the absence of some additional justification appears unwarranted. I would like to see alternative trend analysis performed using a range of accepted procedures to examine the sensitivity of the evaluated trends to the type of data transformation and smoothing performed. Absent sensitivity analysis by the authors, I believe it would be appropriate to have the trend analysis peer reviewed by a statistician not affiliated with the University of Arkansas or USGS.

In perhaps the single admission of the uncertainty of the data analysis presented in the report, BCRET states that

> Ideally, long-term, water-quality trend analysis by WRTDS should include more than 200 water samples collected over 20 years.

The authors do point out that they use only use data for 5 years of sampling, suggesting that the WRTDS for Big Creek water quality data is less than ideal and qualifies the WRTDS analysis as being subject to considerable uncertainty.

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Assuming that data quality objectives for surface water sampling and analysis of nitrate are met, I am confident that one conclusion presented in BCRET (2019) is supported by the investigation. The BCRET (2019) report clearly shows that nitrate-N concentrations in water samples collected from Big Creek are higher in the sampling station downstream from the C&H farm, providing evidence that C&H farm operations contributed to increased nitrate concentrations in Big Creek. I am mystified by the need to state that "the relationship between upstream and downstream [nitrate-N] concentrations is unchanged over time" as if some change is to be expected. Given the high water solubility of nitrate, I doubt that ongoing yearly application of similar amounts of nitrate to fields and the leaking of wastes from the ponds would lead to ever-increasing amounts of nitrate in Big Creek. Rather, the constant application of slurry to the fields and leakage from the ponds causes ongoing, relatively similar nitrate increases in Big Creek, as shown in the report. Moreover, there is considerable doubt as to whether the Big Creek study design would even allow such a trend to be detected.

I also disagree with the conclusion that the impact to Big Creek is "limited", as though a portion of the Buffalo National River watershed that Big Creek comprises should be considered directly comparable to the Upper Illinois and Upper White River watersheds. Such a comparison requires the reader to conclude that the Upper Illinois and White River watersheds are similar to the Buffalo National River watershed and of equal conservation and cultural value to the Buffalo National River. It could just as easily be stated that the impact to the Big Creek watershed is similar to the impact of watersheds that do not have national river status. Given its status as our first national river, the reduction of nutrients flowing into the Buffalo National River should remain our high goal. With this in mind, the Arkansas Department of Environmental Quality (ADEQ) should aim higher for protection of the Buffalo National River and its watershed, not forgetting that it is a one-of-a-kind natural gem of the Natural State and thus deserves our best efforts to protect its water quality.

Respectfully submitted,

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