# EPA Science Advisory Board Peer Review
# on
# EPA Office of Research and Development Draft Report,
# *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*
# *(External Review Draft, EPA/600/R-15/047, June 2015)*

## Additional Preliminary Individual Comments from Members of the EPA Science Advisory Board (SAB) Hydraulic Fracturing Research Advisory Panel

**U.S. EPA Science Advisory Board**
**1200 Pennsylvania Ave., N.W.**
**Washington, D.C. 20460**

**October 29, 2015**

## TABLE OF CONTENTS

**Additional Preliminary Individual Comments to Charge Questions from Members of SAB Hydraulic Fracturing Research Advisory Panel:**

## Charge Question 1: Goals, Background and History of the Assessment

The goal of the assessment was to review, analyze and synthesize available data and information concerning the potential impacts of hydraulic fracturing on drinking water resources in the United States, including identifying factors affecting the frequency and severity of any potential impacts. In Chapter 1 of the assessment, are the goals, background, scope, approach, and intended use of this assessment clearly articulated? In Chapters 2 and 3, are the descriptions of hydraulic fracturing and drinking water resources clear and informative as background material? Are there topics that should be added to Chapters 2 and 3 to provide needed background for the assessment?

### Comments from Dr. Elizabeth W. Boyer

Chapter 1 provides a detailed overview of the goals, background, scope, approach, and intended use of this EPA assessment report. The statement of goals should be made more explicit and clarified, and used consistently throughout the document. Here is how the objectives are currently worded -- embedded in the last sentence of the background section, in Chapter 1-1 (p 1-1). "In this report, we review and synthesize scientific literature, including the publications resulting from the EPA's research and information provided by stakeholders, to assess the potential for hydraulic fracturing for oil and gas to change the quality or quantity of drinking water resources. This report also identifies factors affecting the frequency or severity of any potential impacts." From my perspective, the review, synthesis, and analysis of scientific literature and information provided by stakeholders should be stated as part of the approach, not the goal. Further, the use of EPA sponsored research projects, technical input from agencies, industries, NGOs and other stakeholders can be highlighted as part of the approach. The goals of the assessment seem to be: 1) To assess the potential for hydraulic fracturing for oil and gas to change the quality or quantity of drinking water resources; and 2) To identify factors affecting the frequency or severity of any potential impacts. (to water resources).

Numerous public commenters were concerned with the narrow scope of the report. The report does note that the assessment does not discuss the potential impacts of the HF process on other water uses (e.g., agriculture or industry), other aspects of the environment (e.g., seismicity, air quality, or ecosystems). However, I suggest that EPA further acknowledge the deliberate aim to stay focused on drinking water resources, yet emphasizing that they recognize the need for additional assessment. Further research and assessment needs include: 1) detailed case studies, for example those that were proposed in the research plan yet not completed); 2) studies of impacts of the HF process on human health, ecosystem health, and aquatic life. Documenting future needs for these will help to further address limitations of the current report and identifying future directions for synthesis and assessment by EPA or other agencies.

In Chapters 2 and 3, the description of hydraulic fracturing and drinking water resources are clear and informative as background material.

One public commenter had issue with the EPA conclusion (on page 3-11) that "the colocation of hydraulic fracturing activities with surface and ground water increases the potential for impacts to current and future drinking water resources." The commenter states that "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…. " I agree that this conclusion should be carefully reworded.

## Charge Question 2: Water Acquisition Step in the Hydraulic Fracturing Water Cycle

The scope of the assessment was defined by the hydraulic fracturing water cycle, which includes a series of activities involving water that support hydraulic fracturing. The first step in the hydraulic fracturing water cycle is water acquisition: the withdrawal of ground or surface water needed for hydraulic fracturing fluids. This is addressed in Chapter 4.

a. Does the assessment accurately and clearly summarize the available information concerning the sources and quantities of water used in hydraulic fracturing?
b. Are the quantities of water used and consumed in hydraulic fracturing accurately characterized with respect to total water use and consumption at appropriate temporal and spatial scales?
c. Are the major findings concerning water acquisition fully supported by the information and data presented in the assessment? Do these major findings identify the potential impacts to drinking water resources due to this step of the hydraulic fracturing water cycle? Are there other major findings that have not been brought forward? Are the factors affecting the frequency and severity of any impacts described to the extent possible and fully supported?
d. Are the uncertainties, assumptions, and limitations concerning water acquisition fully and clearly described?
e. What additional information, background, or context should be added, or research gaps should be assessed to better characterize any potential impacts to drinking water resources from this stage of the hydraulic fracturing water cycle? Are there relevant literature or data sources that should be added in this section of the report?

### Comments from Dr. Elizabeth W. Boyer

Chapter 4 focuses on water acquisition: the withdrawal of surface and ground water needed to support the hydraulic fracturing process. The goals of the chapter were clearly stated… considering potential effects of water acquisition for hydraulic fracturing on quality and quantity of drinking waters, and to identify factors that affect the frequency or severity of impacts. Though outside of the scope of these goals, a number of the public commenters raised concerns about the need to consider impacts of water use for fracking on aquatic life and ecosystem services in addition to the drinking water resources, that EPA should further acknowledge in terms of future research needs.

To achieve their goals, EPA reviewed publicly available data on sources of water used for HF from surface water, ground water, and reused wastewaters (section 4.2). Overall, I this portion of the assessment was relatively clear and concise summarizing the surface and ground water sources using the limited data and case studies available. The graphics were informative.

Considering accuracy, some prose in this EPA report, as well as numerous public commenters and committee panel members all noted the gaps in the data available to assess water use, and

there were numerous concerns expressed with heavy reliance on the industry supported frack focus database.

EPA considered the amount of water used per well (Section 4.3); and cumulative water use and consumption estimates at national, state, and county scales (Section 4.4). (EPA concluded that cumulative water use nationally for HF is at least 44 BG/year; Median water use for a well is approximately 1.5 MG.). Some reviewers noted the inaccurate use of the term cumulative suggesting that it be replaced with the term total use throughout the chapter.

EPA considered water use for HF in 15 individual states where hydraulic fracturing currently occurs and consider the potential for hydraulic fracturing water withdrawals to affect water quantity and quality in localities within those states (Section 4.5). They present results mostly at state and county level due to the availability of data at those scales (and representing heterogeneity – where states and localities often differ in industry activity, formation type, and water availability, all of which affect potential impacts). They use statistics to extrapolate results nationally.

There were several very useful case studies presented in the report, presented to illustrate how water withdrawals may affect short- and long-term water availability in areas experiencing high rates of hydraulic fracturing. The study found that water imbalances from HF operations have not occurred in either the Susquehanna River basin (page 4-35, box 4-5), or the upper Colorado River basin (page 4-31, box 4-4). These studies demonstrated that many local factors and local heterogeneity explain whether water imbalances occur. A limitation was that with only a few river basins under study, the role of factors such as climate, geology, water management, and water sources could not be fully explored.

The report noted that the potential for impacts on drinking water resources greatest in areas with high HF water use, low water availability and frequent drought. For example, the report documented some areas where it is problematic. In a study in southern Texas, there is a lot of demand from the dense array of natural gas wells tapping the Eagle Ford Shale, and there isn't much of a water supply available. Groundwater use there is causing change in water storage and drawdown of the local water table. There were some particularly useful public comments from hydrogeologist Bridget Scanlon toward clarifying that section.

Several of the public comments expressed concern with surface waters taken from small rivers or streams. In such cases the timing with relation to flow conditions is important, and withdrawals during low flow periods resulting in dewatering and severe impacts on small streams and aquatic life. It should be more clearly noted that the stresses on water resources are expected to be local and temporary, and not to understate the potential for localized problems. More attention needs to be given to describing the potential impacts on water resources at "hot spots" in space (e.g., headwater streams) and time (low flow conditions, seasonally).

There are several places in this chapter where a time or units need to be clarified.

A further discussion of key data limitations – such as the need for specific local data useful for modeling; and needs for better regional data from state/national (USGS) water use statistics reporting are needed and may help the states and federal agencies to understand what is needed for continued assessment. For example, how should USGS track county-level "mining" and other categories of water use, to best facilitate understanding of the role of water use for HF compared to other water uses? There are challenges with regard to the way the use categories are defined, the reliability of the information reported by the states, and consistency of reporting. Similarly, a further description of how the FracFocus database should be impoved, or how such information could be acquired operationally by state or federal agencies, would add to the utility of this section.

Relevant new reference: The Depths of Hydraulic Fracturing and Accompanying Water Use Across the United States. RB Jackson, ER Lowry, A Pickle, M Kang, D DiGiulio, and K Zhao. Environmental Science & Technology; 2015, 49, 8969−8976. DOI: 10.1021/acs.est.5b01228.

**Comments from Dr. Katherine Bennett Ensor**

I became aware of this recently published paper today. It is not referenced in the current version of the report, but does address issues.

Zacariah L. Hildenbrand, Doug D. CarltonJr., Brian E. Fontenot, Jesse M. Meik, Jayme L. Walton, Josh T. Taylor, Jonathan B. Thacker, Stephanie Korlie, C. Phillip Shelor, Drew Henderson, Akinde F. Kadjo, Corey E. Roelke, Paul F. Hudak, Taylour Burton, Hanadi S. Rifai, and Kevin A. Schug, A Comprehensive Analysis of Groundwater Quality in The Barnett Shale Region, *Environ. Sci. Technol.*, 2015, *49* (13), pp 8254–8262, DOI: 10.1021/acs.est.5b01526, Publication Date (Web): June 26, 2015

## Charge Question 4: Well Injection Step in the Hydraulic Fracturing Water Cycle

The third step in the hydraulic fracturing water cycle is well injection: the injection of hydraulic fracturing fluids into the well to create new fractures and dilate existing fractures, fracture the geologic formation and to address connection to natural fractures. This is addressed in Chapter 6.

a. Does the assessment clearly and accurately summarize the available information concerning well injection, including well construction and well integrity issues and the movement of hydraulic fracturing fluids, gases, and other materials in the subsurface?
b. Are the major findings concerning well injection fully supported by the information and data presented in the assessment? Do these major findings identify the potential impacts to drinking water resources due to this step of the hydraulic fracturing water cycle? Are there other major findings that have not been brought forward? Are the factors affecting the frequency and severity of any impacts described to the extent possible and fully supported?
c. Are the uncertainties, assumptions, and limitations concerning well injection fully and clearly described?
d. What additional information, background, or context should be added, or research gaps should be assessed, to better characterize any potential impacts to drinking water resources from this phase of the hydraulic fracturing water cycle? Are there relevant literature or data sources that should be added in this section of the report?

### Comments from Dr. Elizabeth W. Boyer

Many of the public commenters had issue with the fact that the case studies of Dimock, PA; Pavillion, WY, and Parker County, TX were not included in any depth in the report. This leads to animosity against the EPA and gives the appearance of a lack of credibility of the report. I suggest that these studies be described in some detail in the report, reviewing what happened in these areas and what is known; articulating the role of state agencies in addition to EPA in these areas, and so forth.

## Charge Question 5: Flowback and Produced Water Step in the Hydraulic Fracturing Water Cycle

The fourth step in the hydraulic fracturing water cycle focuses on flowback and produced water: the return of injected fluid and water produced from the formation to the surface and subsequent transport for reuse, treatment, or disposal. This is addressed in Chapter 7.

a. Does the assessment clearly and accurately summarize the available information concerning the composition, volume, and management of flowback and produced waters?
b. Are the major findings concerning flowback and produced water fully supported by the information and data presented in the assessment? Do these major findings identify the potential impacts to drinking water resources due to this step of the hydraulic fracturing water cycle? Are there other major findings that have not been brought forward? Are the factors affecting the frequency and severity of any impacts described to the extent possible and fully supported?
c. Are the uncertainties, assumptions, and limitations concerning flowback and produced water fully and clearly described?
d. What additional information, background, or context should be added, or research gaps should be assessed, to better characterize any potential impacts to drinking water resources from this phase of the hydraulic fracturing water cycle? Are there relevant literature or data sources that should be added in this section of the report?

### Comments from Dr. Elizabeth W. Boyer

Relevant new reference: The Depths of Hydraulic Fracturing and Accompanying Water Use

Across the United States. RB Jackson, ER Lowry, A Pickle, M Kang, D DiGiulio, and K Zhao. Environmental Science & Technology; 2015, 49, 8969−8976. DOI: 10.1021/acs.est.5b01228.

## Charge Question 7: Chemicals Used or Present in Hydraulic Fracturing Fluids

The assessment used available information and data to identify chemicals used in hydraulic fracturing fluids and/or present in flowback and produced waters. Known physicochemical and toxicological properties of those chemicals were compiled and summarized. This is addressed in Chapter 9.

a. Does the assessment present a clear and accurate characterization of the available chemical and toxicological information, including potential exposure frequency, duration, and level?
b. Does the assessment clearly identify and describe the constituents of concern that potentially impact drinking water resources?
c. Are the major findings fully supported by the information and data presented in the assessment? Are there other major findings that have not been brought forward? Are the factors affecting the frequency and severity of any impacts described to the extent possible and fully supported?
d. Are the uncertainties, assumptions, and limitations concerning chemical and toxicological properties fully and clearly described?
e. What additional information, background, or context should be added, or research gaps should be assessed, to better characterize chemical and toxicological information in this assessment? Are there relevant literature or data sources that should be added in this section of the report?

### Comments from Dr. Elaine M. Faustman

"The purpose of this assessment[1], entitled *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, was to synthesize available scientific literature and data on the potential for hydraulic fracturing for oil and gas to change the quality or quantity of drinking water resources, and to identify factors affecting the frequency or severity of any potential changes."

Overall the document provides an extraordinarily clear and detailed assessment of the processes involved in Hydraulic fracturing, where these activities take place and how the process may differ by location. It provides a very clear inside view of how these activities impact the amount and source of water and how hydraulic fracturing activities link with the overall cycle of water use. In this context the document is excellent and provides an extraordinary resource.

However it is the opinion of this reviewer that the document doses not adequately address the factors affecting the frequency or severity of any potential health impacts. Thus the full purpose of report was not met by specific chapters of this document. In particular this purpose was not

met in Chapter 9 "Identification and Hazard Evaluation of Chemicals across the Hydraulic Fracturing Water Cycle".

This is reflected in multiple ways that I will delineate below but does include:

1. Disconnect from what the public comments are requesting for impact information
2. Evaluate appropriate tools for the majority of the data. Provide additional assessment methods that use tools that evaluate more of the available data rather than focus on data that fits into the specific Decision tool chosen for this analysis. Focus on other decision models that can use the data that was available and include these assessments as well.
3. Inconsistent application and inclusion of peered and non-peered review data between chapters

Specifc Charge Questions:

1. The assessment used available information and data to identify chemicals used in hydraulic fracturing fluids and/or present in flow back and produced waters. Known physicochemical and toxicological properties of those chemicals were compiled and summarized. This is addressed in Chapter 9.
    a. Does the assessment present a clear and accurate characterization of the available chemical and toxicological information concerning chemicals used in hydraulic fracturing?
    b. Does the assessment clearly identify and describe the constituents of concern that potentially impact drinking water resources?
    c. Are the major findings fully supported by the information and data presented in the assessment? Are there other major findings that have not been brought forward? Are the factors affecting the frequency or severity of any impacts described to the extent possible and fully supported?
    d. Are the uncertainties, assumptions, and limitations concerning chemical and toxicological properties fully and clearly described?
    e. What additional information, background, or context should be added, or research gaps should be assessed, to better characterize chemical and toxicological information in this assessment? Are there relevant literature or data sources that should be added in this section of the report?

There are many major findings that have not been adequately brought forward. This reviewer was not in agreement with how this "Identification and Hazard Evaluation of Chemicals across the Hydraulic Fracturing Water Cycle was presented and analyzed. Note that this reviewer combined responses across some of the charge question subsets.

Detailed comments for Chapter 9:

Section 9.1 introduction provides some details on what process was used to evaluate potential impacts on drinking water resources. Although the overall document emphasizes that this document does not include a risk assessment this section would be the place to clearly delineate what is a risk assessment. Add a few more specific definitions here to help general reader and stakeholders who still think this is the anticipated outcome.

Good emphasis on missing data in Page 9-2 lines 3 to 11 and the potential for missing potential health impacts.

Section 9.2 Identification of chemicals… through Section 9.3 Summary of toxicological and physiochemical property data…

These sections clearly present a process that EPA used to identify 1, 173 chemicals and this is available in the Appendices A and B. A summary figure 9-1 summarizes a part of this process and information.

This reviewer feels that this assessment process was not adequate and was not consistent with the other chapters in how peer reviewed versus non-peer viewed information was used. For example in Chapter

Why wasn't a general vulnerability analysis conducted where each of the 1,173 chemicals were assessed if any peer –reviewed article identified these chemicals as potential toxicants. Since this was not a risk assessment it appears that to set the context for needed follow-up that this initial vulnerability analysis is needed for each of these identified chemicals. This is a straight-forward and well accepted approach for initial scoping of potential for impacts during hazard evaluations. Requiring that a specific RfV or OSF be required seems to be a very high initial hurdle in this process.

Use of FracFocus as key check point for inclusion of health information in further analysis also should be discussed and questioned. Note that is not a peer reviewed database but a "..national hydraulic fracturing registry for oil and gas well operators to disclose information about hydraulic fracturing well locations and water and chemical use during hydraulic fracturing operations developed by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission " See page 4-5 and Text Box 4-1 on page 4-15. These section goes on to discuss that it is largely voluntary and emphasized only a few regions of the US were included in this assessment (lines 5- 8, page 4-15). This text states that : "Estimates based on the EPA's FracFocus project database likely form an incomplete picture of hydraulic fracturing water use because most states with data in the project data base (14 out of 20) did not require discloser to RacFocus during the time period analyzed." This should not be used to set the potential exposure considerations for Chapter nine assessments.

Chapter 4 also provides important considerations lost in the assessments conducted in Chapter 9. For example, page 4-16 discusses the potential for drinking water impacts such as "For instance, in the absence of controls surface water withdrawls can lower water levels and alter stream flows, potentially decreasing a stream's capacity to dilute contaminants… further more ground

water withdrawals exceeding natural recharge rates may lower the water level in aquifers, potentially mobilizing contaminants or allowing the infiltration of lower-quality water from the land surface or adjacent formations.."

This information or at least possibilities need to be discussed in the context of Chapter 9 as well.

Handling confidential information—missing in discussion of approaches and context for Chapter 9

Without revealing exact compounds has EPA reviewed their CBI data to see some statistics of potential hazard? For example, does EPA have number of known carcinogens, reproductive or potentially toxic chemicals that are a part of the CBI data for fracking related products? EPA could still do an assessment of total chemicals of concern that are present in CBI data without specific chemical info. Could a figure like 9-2 or review of broader data sets be done? This would help open this door without giving away business secrets. It also would go towards a more transparent process to know that hazards are being considered as part of our PMN process.

Inconsistent application of peered and non-peered review data between chapters

This reviewer applauds the report and the approach to be inclusive of data sources. The quote below from the review document is excellent and represents a monumental approach to compiling relevant data from many sources some of which have been extremely difficult to obtain and locate in one place. This is a great success of this document. The EPA has met its intent as stated below:

"EPA authors examined over 3,500 individual sources of information, and cited over 950 of these sources for this assessment. Sources evaluated included articles published in science and engineering journals, federal and state reports, non-governmental organization reports, oil and gas industry publications, other publicly-available data and information, and data, including confidential and non-confidential business information, submitted by industry to EPA. The assessment also included citation of relevant literature developed as part of the Study Plan. "

However given this statement and approach this reviewer feels that the EPA assessment is not a consistent "synthesis of the science." For example in Chapter 5, there is extensive use of all data sources and many non-peer reviewed documents are listed –see page 5-70, lines 4 to 13 and discussion of strategies for reducing toxic chemical use across these documents.
Yet in Chapter 9 a very strict criteria for data use and access in provided (see pages 9-16 through 9-18). In fact for this chapter's assessment, the lack of formal risk evaluation numbers such as oral RfV,or lack of available data on frequency of use negated the review of those chemicals and resulted in a dramatic drop in the number of the chemicals to be assessed from 1,076 and 134 representing chemicals used in hydraulic fracturing fluid and flowback and produced water

respectively to only 37 and 23 respectively for further health impact. This only represented 3 percent of the total chemicals of interest and found present in these fluids under review to be assessed as few chemicals met this criteria not that the other chemicals were without hazard. This reviewer feels strongly that other health impact assessment approaches should have been presented perhaps in parallel.
Figure 9-2 presents the fraction of chemicals that appears in ACTor but what are these numbers if the criteria is shifted and each chemical searched on whether that are any peer-reviewed reports on these chemicals that provides assessment of toxicity. It is difficult to determine from such analyses as presented is it that ACTor did not assess these chemicals or is the data for most of the chemicals missing. Additional assessments such as 9-2 could be available for systematic review of the literature not just info in the ACTor database.
As limited as they are Table 9-6 and Table 9-8 are useful for the chemicals that passed the data hurdle. What is less clear is what I would do with the Hazard potential score for these very few chemicals given the larger proportion of chemical over 97% that are not being included. Can EPA provide some context for what to do or future steps especially for the report users—how to deal with this uncertainty.

This reviewer is very supportive of multi-criteria decision models and there are many options available for these methods that would be more appropriate for these data limited situations. Some of these maybe more qualitative but this reviewer feels that it is essential that the data drives the tools and not the reverse that the tool drives the data as appears in this case.

The EPA clearly states in multiple places that it is not "[ I] t is not a human exposure or risk assessment, and does not attempt to evaluate policies or make policy recommendations. Rather, it focuses on the potential impacts of hydraulic fracturing activities, and factors affecting the frequency or severity of any potential changes. As such, this report can be used by federal, tribal, state, and local officials; industry; and the public to better understand and address vulnerabilities of drinking water resources to hydraulic fracturing activities. ". It is the opinion of this reviewer that the document does not meet this later purpose since so many chemicals were excluded from the evaluations that were conducted.

**Comments from Dr. Joseph N. Ryan**

The assessment used available information and data to identify chemicals used in hydraulic fracturing fluids and/or present in flowback and produced waters. Known physicochemical and toxicological properties of those chemicals were compiled and summarized. This is addressed in Chapter 9.

Does the assessment present a clear and accurate characterization of the available chemical and toxicological information concerning chemicals used in hydraulic fracturing?

*Yes, with significant limitations and uncertainty.*

*FracFocus 1.0 is limited to fracturing fluid data entered from January 2011 to May 2013 – compounds introduced or removed from use after May 2013 are not considered, so any recent changes toward greener ingredients would not be considered. Additionally, the exemption for proprietary compounds means that the list is incomplete.*

*Examining changes in fracturing fluid composition over time should be done to evaluate whether or not any changes toward greener compositions has been achieved.*

*The mobility of the compounds is evaluated by sorption to organic matter. Three parameters are used to assess mobility ($K_{ow}$, $K_{oc}$, and solubility), but these three parameters do not vary independently – they are redundant. Sorption by other mechanisms should be considered, particularly for cationic surfactants, which would require accounting for proton exchange reactions.*

*Data for the chemical composition of flowback and produced water is extremely limited for organic compounds.*

*Ultimately, toxicity, mobility, and persistence data were available for a very small fraction of the total list of compounds – 37 of 1,076 in fracturing fluid (3.4%) and 23 of 134 in flowback and produced water (17%).*

Does the assessment clearly identify and describe the constituents of concern that potentially impact drinking water resources?

*See above.*

Are the major findings fully supported by the information and data presented in the assessment? Are there other major findings that have not been brought forward? Are the factors affecting the frequency or severity of any impacts described to the extent possible and fully supported?

*With limited number of compounds that can be taken through this approach, the findings are not really "major".*

Are the uncertainties, assumptions, and limitations concerning chemical and toxicological properties fully and clearly described?

*Yes, but these limitations (data available for this characterization) should be further emphasized when evaluating the usefulness of this approach. The small fraction of compounds that can be evaluated using this MCDA approach should translate in strong warnings about EPA's ability to fully assess the risks associated with fracturing fluid and wastewater.*

What additional information, background, or context should be added, or research gaps should be assessed, to better characterize chemical and toxicological information in this assessment? Are there relevant literature or data sources that should be added in this section of the report?

*More toxicity data!*
*Up-to-date FracFocus data.*
*All compounds (no CBI).*
*Further consideration of mobility of compounds (sorption of cations).*
*Consideration in context of release scenarios.*

Rogers, J. D.; Burke, T. L.; Osborn, S. G.; Ryan, J. N., A framework for identifying organic compounds of concern in hydraulic fracturing fluids based on their mobility and persistence in groundwater. *Environmental Science and Technology Letters* **2015,** *2*, (6), 158-164.

## Charge Question 8: Synthesis of Science on Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, and Executive Summary

The Executive Summary and Chapter 10 provide a synthesis of the information in this assessment. In particular, the Executive Summary was written for a broad audience.

a. Are the Executive Summary and Chapter 10 clearly written and logically organized?
b. Does the Executive Summary clearly, concisely, and accurately describe the major findings of the assessment for a broad audience, consistent with the body of the report?
c. In Chapter 10, have interrelationships and major findings for the major sections of the water cycle been adequately explored and identified? Are there other major findings that have not been brought forward?
d. Are there sections in Chapter 10 that should be expanded? Or additional information added?

### Comments from Dr. Elizabeth W. Boyer

The EPA's conclusion that the EPA did not find evidence of widespread, systemic impacts on drinking water resources has been widely quoted and interpreted in many different ways. The executive summary and press materials should be carefully reworded, to be clearer on their meaning and interpretation.

### Comments from Dr. Elaine M. Faustman

The Executive Summary and Chapter 10 provide a synthesis of the information in this assessment. In particular, the Executive Summary was written for a broad audience.

Are the Executive Summary and Chapter 10 clearly written and logically organized?

> Yes, this reviewer thought the Executive summary was especially well done and did not suffer as did some of the chapters in "glossing over the significance of the findings". Please note the request for additional analysis to be a part of Chapter 9 as this will affect these document.

Does the Executive Summary clearly, concisely, and accurately describe the major findings of the assessment for a broad audience, consistent with the body of the report?

> This reviewer felt that in many places the impacts that were found in the chapters were "downplayed" or covered in a context of uncertainty. For example, Industry's own database FracFocus (non-peer reviewed) found "annual hydraulic fracturing water use

was 10% or more compared to 2010 total annual water use in 6.5% of counties with FracFocus disclosures analyzed by the EPA, 30% or more in 2.2% of counties, and 50% or more in 1.0% of counties." Yet the document does not acknowledge these impacts and continues to discuss this as potential impacts.

Example wording of sections such as page ES-23 lines 16 to 17 in the Conclusions needs to be rewritten: "Through this national-level assessment we have identified potential mechanisms by which hydraulic fracturing could affect drinking water resources." The word "could" needs to be replaced with the word "has" and the summary needs to provide a clear path to address both the data inadequacies as well as better address what is already known. Lack of information in many cases in this report is not treated as what it is "lack of study" and replacement of statements in the body of the report that says no impacts have been seen under these conditions be replaced.

In other section of the report reports on number of counties requiring desalination operations to meet water needs stand in strong contrast to these assessments. Nowhere did I see a statement that says "EPA is concerned about this level of water use"! We have to be honest about the significant levels of potential impact and not hide this behind a veil of unknown or potential concern. Such numbers are of concern, what we do about it and how we handle these challenges is another question.

The Executive Summary did not suffer from such "soft-peddling" however thus was inconsistent with some of the specific chapters. This reviewer would suggest an additional read through of the document to ensure that the "bottom-line" statements with the chapters is reflective of what has been determined in the analysis.

a. ~~Overall in the assessment, and especially~~ In Chapter 10, ~~are the~~ have interrelationships and major findings ~~integrated between~~for the major stages of the hydraulic fracturing water cycle ~~to the extent allowed by available data~~been adequately explored and ~~literature?~~ identified? Are there other major findings that have not been brought forward?

See this reviewer's comments above regarding the assessment in Chapter 9 of chemicals across the water cycle which this reviewer thought was inadequate as written and analyzed.

b. Are there sections in Chapter 10 that should be expanded? Or additional information added?

The last section of the ES page ES-4 starting line 6 to 16 is very open. As a reviewer I am not certain that .."the findings in this assessment can be used by federal, state, tribal and local officials; industry; and the public to better understand and address any vulnerabilities of drinking water resources to hydraulic fracturing activities". Shouldn't this report more clearly help to identify critical missing information versus "interesting to know" information? Each chapter should stop with not only conclusions but some idea of potential level of impact of missing versus known information. That missing part would indeed allow the assessment to be used by the stakeholders. It is very evident

from the stakeholder comments we have received, compiled in the Appendix. Our board members have prepared a very detailed and useful assessment of these comments. Shouldn't this feed into our comments on this last concluding paragraph?

General comments:

Please note that there is inconsistency within the chapters on how they are formatted. Some of the chapters end with a set of "boxed" conclusions ( see Text Box 3-1 in Chapter 3 page 3-12) and some end with a series of Questions and Answers (see Text Box 9-1 in Chapter 9, page 9-40). This reviewer would suggest that there is a need for consistency and that actually both types of information is needed. The conclusions are needed to help the stakeholder audience anticipated for these reports and in this reviewer's opinion would have a conclusion and then key action points that would provide reader with what might be "next steps" in the EPA's assessment. In addition, the questions and answers seemed to be useful and directed to perhaps a more communication purpose.

A large component of impacts could be in ecological impacts and this reviewer felt it was important to state this lack of information and discussion and to ensure that our comments are so noted.

Inconsistent application of peered and non-peered review data between chapters

This reviewer applauds the report and the approach to be inclusive of data sources. The quote below from the review document is excellent and represents a monumental approach to compiling relevant data from many sources some of which have been extremely difficult to obtain and locate in one place. This is a great success of this document. The EPA has met its intent as stated below:

"EPA authors examined over 3,500 individual sources of information, and cited over 950 of these sources for this assessment. Sources evaluated included articles published in science and engineering journals, federal and state reports, non-governmental organization reports, oil and gas industry publications, other publicly-available data and information, and data, including confidential and non-confidential business information, submitted by industry to EPA. The assessment also included citation of relevant literature developed as part of the Study Plan. "

However given this statement and approach this reviewer feels that the EPA assessment is not a consistent "synthesis of the science." For example in Chapter 5, there is extensive use of all data sources and many non-peer reviewed documents are listed –see page 5-70, lines 4 to 13 and discussion of strategies for reducing toxic chemical use across these documents.
Yet in Chapter 9 a very strict criteria for data use and access in provided (see pages 9-16 through 9-18). In fact for this chapter's assessment, the lack of formal risk evaluation numbers such as oral RfV,or lack of available data on frequency of use negated the review of those chemicals and

resulted in a dramatic drop in the number of the chemicals to be assessed from 1,076 and 134 representing chemicals used in hydraulic fracturing fluid and flowback and produced water respectively to only 37 and 23 respectively for further health impact. This only represented 3 percent of the total chemicals of interest and found present in these fluids under review to be assessed as few chemicals met this criteria not that the other chemicals were without hazard. This reviewer feels strongly that other health impact assessment approaches should have been presented perhaps in parallel. (some of these comments are also included in the discussion of Chapter 9).