

**Comments from Members of the Chartered SAB on the SAB Draft Report  
Draft SAB (4-26-2016) Review of Assessment of the Potential Impacts of  
Hydraulic Fracturing for Oil and Gas on Drinking Water Resources**

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## Comments from Lead Reviewers

### Comments from Dr. Kimberly L. Jones

#### 1) Were the charge questions to the committee adequately addressed?

- The committee did a very nice job of addressing the 8 charge questions. The SAB response is thorough and attempts to address each of the 4 sub-questions linked to the charge questions (organized by chapter).
- The response included specific recommendations, some of which could conceivably be addressed in the short-term (i.e., clarifying conclusion on page ES-6 of Agency report, linking major findings to specific evidence in the body of the report), and others that would require substantial re-analysis or data gathering (i.e., conducting preliminary analyses of trends derived from updated FracFocus data). The response should give more guidance on the prioritization of the recommendations so that the Agency can prepare a response that reflects these prioritizations.
- The dissenting opinions are noted and reflect the complexity of evaluating a report that attempts to assess an important topic that currently has limited and evolving scientific datasets. The Agency will likely understand this issue, however this is a public document, and repeated qualifications such as “4 of the 30 panel members”, may add an air of dissent to the recommendations and weaken the response. Similarly, the repeated mention of “all but two Panel members...” on many recommendations sounds like consensus was not reached. Since this is a consensus document, it should not be necessary to repeatedly note the dissent in the body of the report, but to acknowledge it and include the minority reports (as has been done in Appendix B). *(This seems like a touchy issue and I look forward to further insight at the meeting)*

#### 2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

- I did not find any obvious technical errors or issues in the draft report. The panel did a methodical job of addressing each section of the charge questions.

#### 3) Is the draft report clear and logical?

- The report is generally clear, however there are a couple of instances where the information in the letter, ES and body of the report should be synced better. Understanding the need for a relatively short letter, it would still be helpful to highlight the same information in the letter, ES and body. For example, the 12 main recommendations highlighted in the letter are good, however there are a few that should be mentioned in the letter, such as the concern (related to local impacts) that EPA did not conduct some of the planned field studies and other research, and the text regarding the evolving regulatory framework. In fact, I got a slightly different idea of the “major”

findings when I read the letter vs. the ES vs. the report body. The wording in the ES and body are similar in many cases, but the attempt to synthesize this into a relatively short letter lost some of the emphasis points.

**4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?**

- Yes, the conclusions and recommendations in the report are supported. The issue, evidently, is with interpretation of many qualifiers in the recommendations. The dissenting opinions point to the difficulty in interpreting a large body of research, determining what is “good enough” in regards to securing and interpreting new data, and how specific the wording has to be in the Agency document. Given this challenge, the panel’s draft report should go farther in highlighting the most important recommendations (prioritization) and giving clear, unambiguous language for the recommendations. Some recommendations are clear, but the qualifiers muddy the waters a bit on others.

**Comments from Dr. Robert Mace**

As requested, I’ve organized my comments according to four quality review questions and a request to also assess the alignment and consistency of the message given in the letter to the administrator, the executive summary, and body of the report. I’ve included a few additional editorial comments as well at the end.

On balance, the Advisory Panel provided an impressive and reasonable review of the draft report. My comments address a few potential omissions and identify review comments that could be amplified or clarified. My comments reflect my experience and knowledge of hydraulic fracturing and water resources, particularly in Texas.

**A: Were the charge questions to the [advisory panel] adequately addressed?**

I found the charge questions to be, in general, adequately addressed; however, I offer the following suggestions to improve the review:

A1: Omissions from the hydraulic fracturing water cycle. There are two omissions from the hydraulic fracturing water cycle in EPA’s draft report: (1) potential water quality and quantity impacts from drilling an oil, gas, or rig-supply well and (2) potential water quality impacts from disposing flowback liquids and produced water in injection wells. When drilling an oil, gas, or rig-supply well, drilling-fluids could impact nearby water wells; this is not addressed in EPA’s draft report. Not assessing potential water-quality impacts from disposal wells in EPA’s draft report was surprising during my initial casual read. EPA’s draft report needs to clearly explain why these important parts of the hydraulic fracturing cycle are not included in the assessment. *Please consider commenting on the need to include an assessment of well drilling impacts on water resources and amplifying comments on clearly explaining why water quality issues from injection wells is not included in the draft report.*

A2: Impacts to drinking water sources. EPA's draft report describes impacts to drinking water sources (groundwater and surface water) due to use to support hydraulic fracturing. A casual reader may interpret these impacts as unique to hydraulic fracturing rather than general impacts for any use of water from aquifers and rivers.

*Please consider commenting on the need to note that the impact of water withdrawals from aquifers and surface-water sources are not unique to hydraulic fracturing.*

A3: Wastewater versus wastewater. The term wastewater is sometimes used in the review and EPA's draft report when referring to wastewater from oil and gas operations and wastewater from municipal operations.

*Please (a) consider ensuring that all references to wastewater in the review are clear as to the source of wastewater and (b) consider commenting that EPA's draft report do the same.*

A4: Municipal wastewater as a water resource. More and more, treated municipal wastewater is a direct and indirect source of water supply for agriculture, industry, steam-electric power, drinking water, and other uses, including hydraulic fracturing. This use is not mentioned in the EPA's draft report discussion on water acquisition; the review briefly mentions wastewater (presumably municipal) as a historically underutilized source of water worthy of additional analysis.

Admittedly, this supply of water from treated municipal wastewater is likely dwarfed by the use of conventional groundwater and surface-water sources, but it should be mentioned. Municipal wastewater is a source and is becoming a more important source of drinking water, particularly in the west, and that the use of wastewater often impacts downstream surface-water use (*de facto* reuse) and environmental flows as if the water was sourced directly from the river (in many cases municipal wastewater is returned to surface water bodies). Depending on contract terms, the use of municipal wastewater for hydraulic fracturing could remove this source for future consideration as a permanent or emergency water supply.

*Please consider amplifying the comment that the draft report needs to include a discussion on the use of treated municipal wastewater as a source of water for hydraulic fracturing.*

A5: Underground Source of Drinking Water. EPA's draft report would benefit from a discussion of how underground sources of drinking water are defined (generally less than 10,000 ppm of total dissolved solids) and how EPA and states protect these sources from oil, gas, and, if appropriate, injection wells via well completion standards. A discussion of aquifer exemptions, as applicable, would also be useful.

*Please consider requesting that EPA include a discussion of underground sources of drinking water and aquifer exemptions in its report.*

**B: Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?**

Below are a handful of technical errors and omissions I noted during my review:

B1: Loss of water from the water cycle. In my interactions with the public on water issues, I often hear and read concerns that water injected into the subsurface from hydraulic fracturing represents a permanent loss of water from the water cycle.

*Please consider requesting that EPA include a discussion on how hydraulic fracturing does or*

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*doesn't impact the water cycle.*

B2: Extrapolation of water use data to the nation. While I agree that the local impacts of hydraulic fracturing on water resources can be significant, I believe that comparing hydraulic fracturing water use to national water use numbers is informative as to the overall scale of the usage.

*Please consider ensuring that the comment is not interpreted as a request to remove this comparison.*

B3: Well completion. In the discussion of the length of time for well completion, it would be good to define what well completion includes (namely hydraulic fracturing) and note that existing wells may be hydraulically fractured again in the future.

*Please consider defining well completion and including a discussion on potentially re-fracturing wells in the future.*

B4: 10-ft fractures (p. 78, lines 10–11): A discussion of Myers (2012) notes that "...the model grid limits the smallest width of fractures to be tens of feet and continuous from the target zone to the land surface, which is geologically unrealistic." While I agree that Myers' interpretive model greatly simplifies the geologic setting he investigated, he is not simulating fractures with 10-ft apertures. Instead, he is simulating the hydraulic effect of a fracture through an equivalent porous media approach. This approach allows a fracture of any width to be considered within a model cell.

*Please consider removing reference to 10-ft wide fractures.*

B5: Brackish water. The review uses the term brackish in a general sense; however, this term can apply to both groundwater (generally 1,000 to 10,000 ppm) and surface water (generally 1,000 to 35,000 ppm), usually occurring in bays and estuaries where surface-water inflows transition to seawater. It appears that the reference to brackish in the review is for brackish groundwater, but it's not clear. Furthermore, the use of brackish water and seawater, if considered in the final EPA report, should also include an assessment of impacts.

*Please consider specifying what brackish refers to in the review and asking for an assessment of impacts of the use of brackish and seawater resources.*

### **C: Is the draft report clear and logical?**

I found the draft report to be clear and logical. Perhaps this is more of a larger cultural issue within EPA, but I found that the use of acronyms limits the rate of understanding. Documents such as this, intended for a broad audience, should minimize the use of acronyms to facilitate the ease of understanding the content. EPA should consider greatly limiting acronym usage to only a few (such as SAB and EPA) in these types of reports.

### **D: Are the conclusions drawn or recommendations provided supported by the body of the draft report?**

Outside of the relevant comments previously mentioned, I found the conclusions and recommendations supported by the body of the review.

### **E: Alignment and consistency of the message given in the Letter to the Administrator, the Executive Summary, and body of the report**

I found the letter, executive summary, and body in alignment and consistent with each other. However, I did find two cases of what I would consider value judgments in the body:

**E1: p. 10, line 44.** The review states: "...the regulatory framework in Pennsylvania that is discussed in the draft Assessment Report and its positive effects on managing water withdrawal could be cited among the EPA's major findings." The use of the word "positive" is a value judgment.

*Please consider deleting the word "positive".*

**E2: p. 16, line 22–28.** The review states that "A key aspect of reducing impacts from HFWC operations on drinking water supplies is responsible well construction and operation, location and characterization of abandoned/orphaned oil and gas wells, and isolation of potable water from hydraulic fracturing operations." The use of the word "responsible" is a value judgment.

*Please consider changing "responsible well construction and operation" to "well construction and operations protective of drinking water resources".*

**F: Typos and minor comments:**

**F1: p. 74, line 6.** Please consider deleting "(completion)"; completion involves more than fracking.

**F2: p. 9, lines 14–15.** The phrase "aquifer continuity" is not a typical hydrogeologic term, so I'm not sure what the term means (Is it referring to lateral continuity? Vertical continuity? Hydraulic connection with overlying or underlying confining layers?). Please consider clarifying this phrase.

**F3: p. 9, lines 20–21.** The review includes this sentence: "In addition, in regard to potential impacts on aquifers, the final Assessment Report should present more information regarding situations where the vertical distance between the hydraulically fractured production zone and a current or future drinking water source is relatively small compared to local hydrogeological conditions." It's unclear what's being compared here when referring to "local hydrogeological conditions."

**F4: p. 40, line 41.** "Basic" should be "Basin"

**F5: p. 65, line 24.** Unclear what "shallow groundwater flow systems" refers to since shallow is undefined.

**F8: multiple occurrences.** It wasn't always clear what "the SAB agrees" "the SAB Panel agrees" was referring to.

**F9: multiple occurrences.** Comma and semicolon usage.

**Comments from Dr. Gina Solomon**

**General Comments:**

The draft SAB Review of EPA's draft Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources is in general a well-organized and thorough review document. I like the consistency of the structure throughout the report, and the attention to responding to each sub-part of each charge question. I found the report to be a bit long and repetitive, but otherwise clear and readable. My concerns with the document are not so much with how it addressed the charge questions, or with errors/omissions, lack of clarity, or lack of logic. Instead, my concerns relate largely to three issues:

**(1) The committee should better triage its recommendations.**

The report provides long lists of recommendations, but does not point to a reasonable number of recommendations that should be high priority to address. I appreciate that the committee acknowledges that “there are a large number of recommendations included in the body of the SAB report” (p. 2, lines 34-35) but despite flagging some as longer-term future activities, there are still far too many recommendations, some of which are surely more important than others. There should be more effort to boil this down to the really key issues. I also appreciate that the SAB committee acknowledged the enormity of the effort that went into the EPA report (e.g., Executive Summary lines 26-27, pointing out that EPA examined over 3,500 sources of information and included over 950 citations in the draft). Yet then the committee went on to recommend the addition of 206 additional references in the body of the report, and an additional 19 pages of references at the end. Is the committee really saying that EPA needs to add all of these in order to adequately cover this issue? Or did the committee members just dump lists of references into the report, mingling critical ones with less important ones? Which of these references are really important to include?

Similarly, there are major, highlighted recommendations in the report that seem to this reviewer to be things that would involve a lot of work for very little incremental benefit. One example is the recommendation that EPA list all “best management practices” that the industry is doing voluntarily to attempt to reduce impacts on water (letter p. 5, lines 6-9 and numerous other places) – this seems like a lot of work, and it is not EPA’s job to try to find out and highlight everything that any company is trying out. I would oppose including this recommendation. Other major recommendations also seem overly broad. For example, the recommendation that “EPA should include additional discussion on background and preexisting chemistry of surface and groundwater.” (Letter, p. 5, lines 14-16). This recommendation is also something that could be a huge undertaking for uncertain incremental benefit. It is not clear from the committee’s report why these recommendations are really so critical. The EPA document is not intended to be a textbook on the hydraulic fracturing water cycle (HFWC), and the review sometimes seems to lose track of the purpose of the EPA document. The review needs to be focused much more on assuring that the EPA document presents the key issues clearly and in a balanced fashion, and less on assuring that every possible study is referenced and every peripheral issue explained. It’s not clear to me that this SAB review report does an adequate job providing a focused critique that really gives EPA a roadmap to completion of the report.

Dr. Faustman’s dissent addresses this issue indirectly by saying that the EPA report is lacking in several critical areas, but she does not list which specific areas she sees as critically deficient. This reviewer is still struggling to see the bulleted short list of critical deficiencies.

**(2) The report is repetitious.**

There are entire paragraphs repeated within the report in numerous places. The high degree of repetition makes the SAB draft tiresome to read, and is unnecessary. This is especially a problem in the responses to Questions 2 and 4. I understand that this is partly related to the fact that some of the charge sub-questions overlap, and the committee attempted to provide complete responses to each sub-question. However, repeating entire paragraphs verbatim is not an effective way of doing this. If the committee wishes to incorporate by reference its responses to prior questions, that’s fine, or it could paraphrase. Alternatively, making the point once within the body of the report really is sufficient. I provide some examples in my specific comments below, but a full

review to eliminate redundancies is beyond the scope of my review.

**(3) The major recommendations and conclusions could be stated more clearly.**

It is interesting that the committee was split over the main conclusion of the EPA document (e.g. letter p. 2, lines 12-27 and repeated many times thereafter). Unfortunately, the majority report gives EPA very little guidance in figuring out what the committee actually thought would be a reasonable conclusion to draw from the data. Instead, the majority report states numerous times that “the statement requires clarification and additional explanation”. It also cryptically calls for unspecified “modifying adjectives”, without any suggestion of what types of adjectives the committee was imagining. The statement causes this reviewer to recall the game “Mad Libs” and wonder how the EPA report would read with random “modifying adjectives” inserted into this sentence. To avoid a game of Mad Libs, it would be helpful for the committee to actually drop a hint as to what types of adjectives they are suggesting. More helpful still would be an alternative conclusory formulation to suggest to the Agency. It’s easy to criticize the EPA framing of the conclusions, but coming up with a defensible and clear summary statement is difficult, and I would challenge the majority to offer up something more substantive for EPA to consider, even if the statement does not receive the support of the entire committee. On balance this reviewer agrees with the majority report on the substance of the concern, but the lack of a more specific set of suggestions for an alternative framing detracts greatly from the quality of the majority report.

Many statements on p.4 of the letter are also too vague to be useful recommendations. On lines 1-6 the committee recommends that the agency “should include additional major findings” but it’s not completely clear what the additional findings should be, beyond the general topic area of “well construction, well integrity, and well injection problems” all of which are already discussed in the EPA report. Similar concerns exist with lines 8-9, recommending unspecified “additional major findings” associated with spill events and leaks, both of which are also covered in the EPA report. It would be very helpful for the committee to be more specific about the major findings that they are recommending.

On p. 4 of the letter, line 24 criticizes the “agency’s lack of breadth...” In reading that paragraph, as well as the relevant sections of the ES and the report, it seems that the committee isn’t actually concerned about a lack of breadth, but rather of the failure of EPA to integrate information and focus on the scenarios of greatest potential concern. That’s very different from a lack of breadth. This paragraph and the source paragraphs should be rewritten to more clearly capture the concern here. Otherwise it appears that the committee is saying that EPA didn’t consider enough data and potential scenarios, and I don’t think that’s the intent.

**Responses to the Charges:**

1) Were the charge questions adequately addressed?

Yes, overall the charge questions were adequately addressed. The structure of the report, with a summary statement on the charge questions at the beginning of the response, and then a fairly clear response statement followed by a discussion, is well-constructed. It is quite easy to follow the structure of the report, and the summary statements ensure that the charge questions are identified and responded to.

2) Are there technical errors or omissions or issues that are not adequately dealt with in the draft report?

No, the draft report appears to be extremely thorough and to address issues in great detail.

3) Is the draft report clear and logical?

Yes, the structure of the report is generally clear and logical, although there are sections that are overly repetitive, and some recommendations that are too broad and general to be useful as illustrated in my general comments above. These issues should be addressed prior to finalization of the report.

4) Are the conclusions drawn or recommendations provides supported by the body of the draft report?

Yes generally, although sections of the report do seem to be recommending inclusion of references, analyses, or report sections without clear justification in the discussion. Other recommendations are too broad and it's therefore difficult to understand if they are supported.

### **Specific Comments:**

#### Executive summary

p. 3, lines 34-35, recommends that EPA “should include those hydraulic fracturing practices demonstrated to be effective in safeguarding drinking water resources.” This is not an appropriate major recommendation because it requires EPA to endorse specific practices without full data on their efficacy. It is not EPA’s job to give a “seal of approval” to any specific industry practices, and the SAB should not be asking it to. This recommendation should be deleted.

p. 6, lines 40-45, these recommendations are very important and the discussion in the body of the report is very clear and compelling. Unfortunately this short paragraph in the ES does not fully capture the salient points from the body of the report. In particular, it doesn’t mention the specific concern with the high bromine concentrations in the wastewater, or the concern that NDMA formation is not mentioned in the EPA report, nor does it mention the issues with TENORM (radium, strontium) that are discussed in the body of the report. A sentence should be added highlighting these important issues.

p. 7, lines 15-25, I strongly believe that the issues discussed in this paragraph are outside the scope of the charge to the panel, and are outside the scope of the EPA review. The committee admits as much by saying “The SAB recognizes that the EPA did not intend for the final Assessment Report to serve as a guide to best management practices for hydraulic fracturing operations. Nevertheless...” This recommendation is unnecessary, overbroad, outside the scope, inappropriate, and appears to be forcing EPA to endorse certain industry practices, which is not something the agency can or should do. This paragraph should be deleted. If other entities outside government wish to highlight industry ‘best practices’ they are free to do so in their own reports or on their own websites, but this is not EPA’s job.

p. 13, lines 13-16, this statement is clear and concise, and would be appropriate for inclusion in the highlights of the ES and the letter to the Administrator as a major finding of the SAB.

p. 14, lines 13-16, this statement is clear and should also be reflected in the highlights of the ES and the letter to the Administrator as a major finding.

p. 20, lines 3-5, this statement is clear and should be reflected in the highlights of the ES and the letter to the Administrator as a major finding.

p. 20, bulleted list, should include a bullet on the TENORM issue discussed in the response to Charge question 6, and should more clearly highlight the issue with NDMA that is discussed in that response.

#### Question 1:

p. 30, lines 9-16 about well density and proximity to population should potentially be highlighted in the ES.

Question 2:

p. 35, lines 18-20. Why does the SAB have “concerns with the EPA’s use of the term “cumulative impacts”? What’s wrong with that term? Clarify or delete.

Question 3:

p. 48, lines 9-10, about how many hydraulic fracturing constituents do not have analytical methods are are not undergoing monitoring is a very important point, and should be highlighted in the ES.

Question 4:

p. 56, line 4. Why does the SAB allege that EPA is extrapolating to the “nation or world as a whole” by saying that “the quality of drinking water may have been affected by hydraulic fracturing fluids escaping the wellbore and surrounding formation in certain areas, although conclusive evidence is currently limited.”? I understand the SAB’s concern that the sentence is internally contradictory and should be therefore clarified to reduce the apparent contradiction. I disagree that the sentence is extrapolating to the nation or world as a whole, and I think this phrase should be deleted or else better explained.

p. 58, lines 4-6, I don’t understand the committee’s concern with the word “conduits” to describe cracks/fissures in the rock. The implication of the term is that these cracks could serve as routes whereby material could pass between layers, but the scale of such conduits is not specified. I don’t think this recommendation makes sense and suggest deleting it.

p. 61, lines 44-47, It’s not clear why a lengthy discussion of geology is necessary in the EPA report. Suggest deleting or clarifying that this should be a few sentences, not a long geologic treatise.

p. 62, lines 11-16, again, this seems to be getting into too much detail, and is more like a geology textbook than an EPA report. Suggest deleting this recommendation, or narrowing it.

p. 62, lines 28-39 don’t belong in an SAB report. This paragraph cites to unpublished, unvalidated modeling, and the reference is to a personal communication. This is especially ironic after the discussion above in which the committee expressed great skepticism of models in general. This paragraph should be deleted.

p. 65, lines 10-11, is the committee indirectly suggesting that EPA delete the Bainbridge and Kildeer cases? It appears that way from the phrase “...if references to these cases are to remain included in the final report.” The committee should either delete that phrase, or more directly recommend deletion of these case studies with a full explanation as to why they are not relevant for inclusion. This reviewer finds those two cases to be very relevant, so I would recommend just deleting the phrase above.

p. 65, lines 13-14, is the committee asking EPA to provide data or case studies on this gas migration behind well casing issue? Are such examples publicly available to the Agency? Perhaps the committee could recommend a specific example or two for EPA to add.

Question 5:

p. 73, lines 15-16, the issue of chemical and radioactive tracers seems important, yet it is not mentioned in the Executive Summary. I recommend that this be included in the ES.

p. 75, lines 23-45, this lengthy discussion of the source of the brine in the produced water is perhaps of academic interest, but it isn’t at all clear to this reader why any of this matters in any practical way. This paragraph needs to be rewritten to clarify why the source makes a meaningful difference in the assessment. If it does not, then this paragraph should be deleted.

Question 6:

p. 101, lines 10-23, this discussion of NDMA and its precursors is very important, and a mention

of this issue should be included in the ES.

p. 105, lines 15-21, this discussion is confusing to the reader, in particular because the committee says elsewhere in the report that brominated and iodinated DBPs are more toxic than others. This paragraph therefore appears to contradict the report itself (see p. 108, lines 15-16). In addition, aren't there animal toxicity tests on DBPs that support this statement? The statement here refers only to cells vs human studies but doesn't mention animal studies. In addition, there are biochemical reasons why the brominated and iodinated compounds are more reactive, so this is an additional supporting explanation. I don't think it's so necessary for EPA to get bogged down in explaining all these details, so I question the need for this recommendation.

p. 107, lines 19-32, the recommendation on radionuclides is important and should be included in the ES.

p. 108-109 includes a lot of important material on disinfection byproducts and strontium that could be excerpted for the ES. I would recommend adding an additional major recommendation to the report on this issue.

Question 8:

p. 137, line 1, it's unclear what the phrase "make this major finding" is referring to. I read the preceding paragraph a few times and still don't understand what the committee is trying to say. This should be clarified.

p. 138, lines 18-21, these two sentences are really clear and to the point. These would fit well in the ES, and are clearer than the discussion that is currently in the ES.

Dissent by Dr. Faustman

This dissent focuses on the characterization of the EPA report in the ES and letter. It seems that this could be addressed by characterizing the EPA report as extensive, detailed, and encyclopedic. I think it is important for the committee to be clearer about the specific list of critical areas in which the report is lacking. The ES currently doesn't give a clear view of the really critical and major deficiencies, as opposed to other more general recommendations.

Examples of Repetition within the body of the report:

p. 29, lines 17-21 is repeated on p. 30, lines 29-33.

p. 32, lines 35-36 is repeated on p. 33, lines 26-27.

p. 39, lines 22-25 is repeated on p. 40, lines 18-21.

p. 57, lines 19-30 is repeated on p. 59 line 41 to p. 60, line 8.

p. 58, lines 40 et seq is repeated on p. 60, lines 26-32.

p. 59, lines 27-32 is repeated on p. 64, lines 4-9.

**Comments from Dr. Charles Werth**

**1) Were the charge questions to the committee adequately addressed?**

The SAB's review of EPA's draft Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources is comprehensive, methodical, technically sound, and overall well written. In all instances, the charge questions were thoroughly addressed.

**2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?**

Overall, the SAB review is technically sound and complete. However, there are a few omissions and issues worth noting. These are noted below.

Executive Summary, Page 7, Lines 1-11, Main Report, Page 37, Lines 14-17: There is very little mention of the impacts of more novel fracking fluids on water quality in the SAB review, and I'm not sure if this is because the EPA report covered this topic well, or if it did not come up. I'm specifically thinking of energized fluids, foams, and gases. As an example, foams contain 53% to 95% gas by volume, so they use much less water. When is foam use advantageous for hydrocarbon recovery? What is the impact on water resources compared to conventional fracking fluids? Are similar chemicals used in foams? How much is flow back and produced water reduced, and how is their water quality impacted? The Frac Focus data base has information on chemical masses and types used in various fracking fluids, and it seems important for inclusion if not already done.

Main Report, Page 34, Lines 42-46: The SAB recommends that "the EPA should use case studies to quantify the effects of hydraulic fracturing water withdrawals on short-term water availability, since case studies may provide information on the most relevant and appropriate spatial and temporal scales discussed in the draft Assessment Report for assessing the impacts of water acquisition." I agree that case studies are valuable and will help identify potential water availability issues. However, case studies imply a limited number of locations will be evaluated, and this will not provide a comprehensive picture of "the effects of hydraulic fracturing water withdrawals on short-term water availability." Assuming I'm not taking this recommendation out of context, then a longer-term effort should be to collect a comprehensive data set on water scarcity from many individual sites in water stressed areas.

Main Report, Page 43, Line 42: Perhaps this reference was already cited in the main report. If not, spill volume information is reported by: <Brantley, Water resource impacts during unconventional shale gas development: The Pennsylvania experience, Int J Coal Geol 126, 140–156, 2014>.

Main Report, Page 45, Line 45: The SAB recommends that "the EPA clarify in this section of the final Assessment Report that many issues may play an important role in the hydraulic fracturing industry's substitution of fracturing fluid additives for currently used additives. " As I mentioned above, I would like to see a discussion on the effects of energetic fluids, foams, and/or gases on water quality. A specific example relevant to this section is the use of CO<sub>2</sub>-based foams. CO<sub>2</sub> is at supercritical conditions, and is an excellent solvent. It will impact chemical constituents in flow back and produced water differently than conventional fluids.

Main Report, Page 54: Perhaps this reference is already in the main EPA report. If not, information on percent of NOV's of wells in Marcellus shale, and types of violations can be found in: <Brantley, Water resource impacts during unconventional shale gas development: The Pennsylvania experience, Int J Coal Geol 126, 140–156, 2014>. Also, percent of leakage from tens of thousands of wells in OK and TX were surveyed in: <Bachu et al. Well Integrity: Challenges and Risk Mitigation Measures, The Bridge, NAE, 2014>

Main Report, Page 62, Lines 16-17: See also a very useful paper with fracture propagation distances by: <Davies et al., Marine and Petroleum Geology 37, 1---6, 2012>.

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Main Report, Page 63, Lines 23-29: Here the SAB review provides guidance on information to include regarding seismicity. If not already discussed in the EPA report, information on the source of seismic activity in class II injection wells should be presented. For example, is the source induced fracturing or slippage along natural fractures? If fracturing is induced, what is the vertical extent of fracturing and is it expected to be large relative to hydraulic fracturing. Since seismic activity is larger with class II injection wells than with hydraulic fracturing wells, the potential for larger fracturing events seems possible and is a concern.

Main Report, Page 65, Lines 36-38: Here the SAB recommends that the EPA characterize the toxicity and mobility of the most important hydraulic fracturing constituents of concern that are injected into hydraulically fractured wells. Perhaps this reference is noted in the main EPA report. If not, then an overview of HF fluid constituents with toxicity risks is presented by: <WTSStringfellow et al., J. Hazardous Materials, 275, 37-54, 2014.>

Main Report, Page 65, Lines 42-43: The SAB recommends that the EPA “discuss in Chapter 6 what is known or inferred about the fate of un-recovered fracture fluids that are injected.” In case these articles are not yet covered in the main EPA report, two papers with information on constituents in flow back fluid are: <Abualfaraj, Gurian, Olson, Environmental Engineering Science, 2014> and <Acharya, Henderson, Matis, Komepalli, Moore, Wang, Cost effective recovery of low-TDS frac flowback water for re-use, USDOE DE-FE0000784, 2011>.

Main Report, Page 66, Lines 9-10: In case it has not already been used in the EPA report, the following papers/reports include information on fracking regulations: <Robert Horner, Argonne National Laboratory, ASME Open Forum, Washington DC, June 19, 2014> and <Freyman, Hydraul Fract Water Stress, Ceres Report, February 2014>.

Main Report, Page 83, Lines 22-24: Here, the SAB review recommends increasing the emphasis on and better explain the use of impoundments for hydraulic fracturing flowback and production waters. Perhaps it’s already covered in the EPA report, but it is important to include discussion on pit liner requirements, and associated impacts on fluid loss and/or groundwater contamination. Some states, e.g., OH, do not require pit liners (Robert Horner, Argonne National Laboratory, ASME Open Forum, Washington DC, June 19, 2014). Is product lost from these pits, have groundwater impacts evaluated, etc.

Main Report, Page 135, Lines 12-18: The SAB review recommends that the Synthesis in Chapter 10 should integrate information and findings from the various chapters, and “prioritize such findings according to expectations regarding the magnitude of the potential impacts of hydraulic fracturing-related activities on drinking water resources.” I think the recommendation to “prioritize such findings according to expectations regarding the magnitude of the potential impacts of hydraulic fracturing-related activities on drinking water resources” is very important, and should be a key output of the EPA report. I think this should be in the SAB Executive Summary and the Letter to the Administrator.

### **3) Is the draft report clear and logical?**

Overall the draft report is clear and logical, but there are several places where improvements are possible. These are noted below.

Letter to Administrator, Page 2: The SAB review notes “These local-level impacts, when they occur, can be severe....” My impression from reading the SAB review is that severe impacts have not been clearly documented. Therefore, consider changing the text to read “These local-level impacts, when they occur, have the potential to be severe.....”

Executive Summary, Page 2, Lines 22-32: This comment on EPA's plans to conduct various assessments, field studies, and other research does not appear to belong here. It is repeated under section heading More Attention to Local Impacts on page 4, and seems to fit well on that page.

Executive Summary, Page 2: The section “Thematic Areas for Improving the Draft Assessment Report” starts on this page. The section “Highlights of Responses to Specific Charge Questions” starts on page 8. There are some paragraphs that are repeated in both sections. While this may be by design, I think it makes reading long. Below are examples:

Executive Summary, Page 9, Lines 35-41: This text on including regulations in Chapter 1 is redundant with text on page 7 under section Evolving Regulatory Framework. Is there a way to format so information is presented once in Executive Summary?

Executive Summary, Page 11, Lines 3-14: This text on case studies is redundant with text on page 5 under section heading More Attention to Local Impacts. Also, quite a bit of information is repeated in the next three paragraphs. It seems some condensing is possible here.

Executive Summary, Page 25, Lines 1-14: This text on overall impacts of HF on drinking water resources is redundant with text on page 2.

Executive Summary, Page 14, Lines 18-38: These bullet points are repeating at least some of the information in the previous two paragraphs. On later pages when bullet points are used in the executive summary, it is not so much to summarize key points of previous paragraphs but to make recommendations for the first time. Also, bullet points are used in some sections, but not others. Some more uniformity with respect to location and content of bullet points would improve Executive Summary.

Main Report: Page 26-156: There are a number of recommendations that appear multiple times in the main report. Examples are the user of tracers in fracturing fluid, better coverage of regulations, case studies argument, formation of disinfection byproducts, etc. Perhaps this is by design, but it does feel like some information is repeated too often.

Letter to Administrator, Page 2: The EPA report notes “We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States.” Most members of the SAB Panel conclude that the statement requires clarification and additional explanation (e.g., discuss what is meant by “any observed change” in the definition of “impact” in Appendix J, and consider including modifying adjectives before the words “widespread, systemic impact” in the statement. I agree that qualifications on this statement are critical. I would further add that key statistical results for spills, well variances, reported groundwater incidents, etc., should accompany this statement so that the perceived risks (albeit low) are clearly articulated, along with an explanation of how the data analyzed represents only a small fraction of total hydraulic fracturing sites.

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Main Report, Page 38, Line 42: The SAB recommends that the “EPA should compile the various regulatory approaches in local areas as a shorter-term activity...” This is the only location in the report that identifies a “shorter-term” activity. While a number of longer-term activities are noted, all other activities have no time prioritization. Hence, remove the “shorter-term” activity phrase at this location.

Main Report, Page 49, Line 22: The sentence here reads: “The SAB recommends that it is sufficient for the EPA to note that these hydraulic fracturing constituents “fully occupy” the chemical property space.” The meaning of this sentence is not clear to me.

Main Report, Page 66, Section on “Systems View”: This paragraph seems more like a recap of prior recommendations, and not a systems perspective as the section heading suggests. I wonder if more guidance on a systems approach should be given so that the EPA knows what is being recommended.

Main Report, Page 76, Lines 24-27: This is a little confusing. For CBM, is the SAB saying that when pores degas, they collapse? If not, then like shale, they are always filled with gas or liquid and the distinction being made here is not clear.

Main Report, Page 76, Lines 39-42: Here the EPA report is first cited: “*spills of wastewaters from oil and gas development have happened and have affected drinking water resources.*” The SAB review then states that “while the SAB concurs with this statement, the EPA should place this statement in context by also describing whether such spills result in a temporary or permanent impact.” I don’t think temporary or permanent is a very clear way to think about such impacts, as the impacts span a continuum of timescales.

Main Report, Page 87, Line 1: BTEX represents six distinct chemicals. The meaning of this sentence is not clear.

Main Report, Page 87, Lines 8-15: The SAB review is recommending that the EPA further describe microbial reactions, especially for organic constituents. This recommendation is a bit vague, and more direction is needed. For example, microbial processes that affect the transformation of chemicals recovered in flow back and produced water, and the transformation of chemicals that may impact ground and surface waters, are perhaps the most relevant to EPA report. Less relevant might be microbial reactions that affect shale permeability, oil and gas quality, etc.

Main Report, Page 97, Line 41: Should this be “in addition to bromide” rather than “other than bromide”.

Main Report, Page 122, Lines 30-32: Here, the text quotes the EPA report: “*Potential hazards associated with these chemicals 27 include carcinogenesis, immune system effects, changes in body weight, changes in blood 28 chemistry, cardiotoxicity, neurotoxicity, liver and kidney toxicity, and reproductive and 29 developmental toxicity.*”

It then concludes that:

“In its present form, this statement does not take into account factors that affect the frequency,

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duration, or severity of exposure. This major finding should be qualified with “depending on the level and duration of exposure”.

It’s not clear why this phrase is needed if phrase starts with "Potential hazardous". Perhaps the context of the EPA report makes this more clear. However, there would be other factors such as body weight, metabolism, etc. that would also be important, and I don’t think “level and duration of exposure” need to be singled out.

Main Report, Page 124, line 40: The text implies that “magnitude of exposure” information is within the FracFocus database for 89% of HF constituents. I’m pretty sure this is not the case.

Main Report, Page 136, Line 21: Change “there insufficient” to “there is insufficient”.

#### **4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?**

In general, conclusions and recommendations are supported by the body of the draft review. I have only one comment.

Main Report, Page 31, Lines 3-5: The SAB “does not recommend that the EPA make generalizations regarding how constituents will behave.” While I think the EPA has to be careful with such generalizations, and provide appropriate qualifiers, I think it’s appropriate and useful (when it is technically feasible) for the EPA to identify chemicals that are likely to be more persistent, more strongly sorbing from water, more reactive under certain conditions, etc., based on relevant physical, chemical, and biological properties. I agree with the SAB review text that a more thorough discussion of the relevant chemical properties is important.

### **Comments from other SAB Members**

#### **Comments from Dr. Kiros Berhane**

- 1) Were the charge questions to the committee adequately addressed?

*Yes, the charge questions were adequately addressed in a detailed and exhaustive manner. The large number of the charge questions and the many subparts within each charge question were multifaceted and challenging. The committee has done an excellent job in addressing the many issues raised and has adequately documented the rich discussion that led to the draft report – including providing adequate space and considerations to dissenting voices.*

- 2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

*As far as I can tell, there are no technical errors or issues that are not adequately addressed in the draft report.*

- 3) Is the draft report clear and logical?

*While the draft report is clear and logical for the most part, I found several sections to be repetitive. I think the report could be streamlined by eliminating redundancy and consolidating similar points that seem to appear several times. I believe this would make the report more effective and useful.*

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

*The conclusions and recommendations in the draft report appear to have been supported by the body of the draft report. However, there were several instances where the rationale behind the conclusions and recommendations were not clear. Below, a few typical examples are outlined.*

*On the issue of giving more attention to local impacts:* *The draft report states that despite the “EPA’s initial goal of assessing the HFWC using national-level analyses and perspective was appropriate”, the final assessment report should acknowledge that “local-level potential impacts can be severe”. However, the argument on this issue was not clear to me and probably not clearly articulated. Why is this issue important? Isn't the national level assessment derived from compilations of local assessments?*

*On planned (but not carried out) activities:* *The draft report’s request for the EPA to explain why “the SAB is concerned that the EPA had planned to but did not conduct various assessments, field studies, and other research, were not carried out” is an important one. It is indeed incumbent upon the EPA to provide satisfactory reasons for why these planned activities (especially the prospective case studies) were not carried out.*

*On clarity of report:* *I agree with the draft report that the material in many cases is “very densely written and may not be accessible to the nontechnical reader” (e.g., Chapter 6). This overly technical writing style and the fact that there are repetitive pieces of text make the report cumbersome and not user friendly. The SAB report rightfully requests “that the EPA include additional, clearer diagrams and illustrations” whenever appropriate to facilitate readability.*

### **Comments from Dr. Sylvie M. Brouder**

Q1) Charge questions adequately addressed?

As a non-expert in this field, my perception is that the charge questions are, for the most part, adequately addressed. The eight charge questions were not necessarily distinct questions but many were similar questions applied to specific phases of the HFWC. In the main text of the report, the responses to the multi-part questions were carefully aligned with each phase of HFWC, which is appropriate, and the responses were thorough if not overly dense. Stylistically, the text in response to a charge question is formulaic with an initial, overview statement on the general findings followed by a strong series of “should” statements. While this approach can be sufficient to address the charge questions, it lacks some clarity and forgoes some conciseness by omitting a clear statement(s) of findings of critical deficits. The laundry lists of “should” statements does eventually characterize the deficit(s) but stronger statements regarding gaps, omissions, critical weaknesses can provide a summative overview and may be more effective in conveying the general nature of the gap that needs to be addressed; this could be otherwise be lost in a series of highly granular, prescriptive statements about recommended actions. It is clear

that the SAB Panel has given substantive effort to each part of each charge question so this comment is specific to presentation for maximum accessibility of findings.

Q2) Technical errors or omissions / issues not adequately addressed?

The draft of the letter to Administrator McCarthy contains no direct description of the charge questions, simply referring the Administrator to Appendix A. This seems an important contextual oversight. Yes, the charge questions themselves are long but elsewhere in the text the SAB Panel has provided shortened restatements and the overall nature, scope of the charge questions could be summarized in a couple of sentences. This seems a necessary preface to the statement of summary findings. Likewise, in the Executive Summary the eight charge questions are acknowledged as existing (Pg 1 L43) but are otherwise uncharacterized. A summary statement regarding the charge questions on page 2, L3 would improve clarity of purpose. As the Executive Summary is currently formulated, the reader does not see any specifics regarding the motivation for the findings until page 8 where the charge questions are finally enumerated with “Highlights of Responses.”

Q3) Draft report clear and logical?

The way the report is currently structured requires a lot of repetition of findings and the repetition may detract from the impact of the document. Even within the Executive Summary there is a remarkable amount of repetition of findings. Presumably for clarity given the large number of recommendations that are presented in main body of the text, the SAB panel has chosen to construct the first part of the Executive Summary as a series of statements of “Thematic Areas for Improving the Draft” followed by a series of “Highlights” of responses by charge questions. Theoretically this is a fine approach if the information presented in the two sections is not overly repetitive, which is currently not the case. I strongly recommended that most if not all repetition of detail removed from the Executive Summary and question whether the “Highlights” are actually needed given their summation as “Thematic Areas.” Again, this may seem a picky, stylistic concern but the overall main document is long and dense and an Executive Summary risks defeating its own purpose if it becomes overly detailed and long. Overall, the document could benefit from rigorous editing perhaps by someone not tasked with drafting the initial text. Fresh eyes could strip repetition and improve clarity and impact. There are occasional nuggets that are buried mid-paragraph that seem to be major findings and rigorous editing can ferret these out and position statements for higher impact. For example, it appears that the Panel is suggesting that the absence of evidence is being construed by EPA as absence of impact (see Pg 13, L 20 – 22); if this is the case, I recommend a stronger statement regarding the occurrence of this in the EPA report and absolute necessity of removing text that suggests this. Likewise, there are places where the text is overly convoluted and I do not feel the intent of the statements are easily accessible. For example, what are the two sentences on Pg 11 L5-7 intended to convey? Are there important data gaps (gaps that matter) or not? Such language seems unnecessarily confusing and detracts from the message.

Q4) Conclusions drawn / recommendations provided supported by body of draft report?

Some recommendations for additional information extend beyond what appears to be the intent of the Assessment Report and, perhaps, are better couched as suggestions for future research and analysis. (Perhaps what is really needed in the Assessment Report is a much stronger statement of scope and purpose?) In particular, the recommendation that the agency describe “Best

Management Practices” used by industry at each stage of the HFWC seems premature. Given the dynamic nature of the technologies and on-going emergence of new technologies, as described in the Assessment Report, it seems that EPA may be able to provide some anecdotal observations on “better” practices that reduce risks with respect to water quality/quantity. However, this is not the same as an evidence-based recommendation for a “best” management practice, complete with appropriate description of recommendation inference space.

Likewise, there are some recommendations that are not fully explained given the framing context provided by the charge questions. The recommendation for including a summary of policies/regulations at the Federal, State and Tribal levels seems like it could be an unnecessary rabbit hole for the EPA to descend into (e.g. reviewing the HF related standards and regulations in a few key states is certainly interesting but does not seem a trivial task especially if they are to be linked directly or indirectly to observed HF impacts on drinking water) and I am unclear how it would improve the characterization of the state-of-the-science *per se* regarding potential impacts of HF on drinking water resources.

Finally, some of the recommendations seem to be for activities that the SAB thinks are a good idea but seems not to actually know whether these activities will be useful. For example, contacting state agencies to fish for additional data to “update the final Assessment Report to reflect a broader analysis” sounds generally worthy but, unless we are recommending inclusion of specific data that the SAB knows is there, accessible, and relevant to the Assessment Report, could turn into a large task with limited eventual return beyond delaying release of the report (e.g. Pg 39, L39-41: “ The EPA **could potentially** reduce gaps in understanding... by using available information from the Well File Study...” – this definitely suggests we are proposing the EPA go on a fishing mission that is of uncertain outcome to the SAB). I suggest we keep recommendations for inclusion of data to that that is specifically identifiable now.

For clarity, it may be best to segregate recommendations for “longer-term future research activity” in a discrete section of the report.

Given the vast number of recommendations, I suspect it would be helpful to prioritize some over others (“musts” vs “should”).

### **Comments from Dr. Ingrid Burke**

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

This is probably the most robust report from a review panel that I have seen on the SAB. It is long and detailed and it addresses the original charge questions adequately.

Beyond that, the report provides overarching review comments, mostly related to gaps in a program that I think are very important. Each of the overall recommendations seems to be focused on the report, but might be interpreted as recommendations for a larger program. It was not possible to tell all the time. This is set up in the text on page 2, Lines 35-40, “  
“The SAB has identified recommendations that the agency may consider longer-term future activities that the agency can conduct after finalization of the Assessment Report. If there are recommendations that the EPA is unable to fully address before finalizing the Assessment Report, the SAB recommends that the agency describe the additional research needed to adequately assess the topic and include this in Chapter 10 or in a chapter that the EPA would add to the final Assessment Report on ongoing research, and data and research needs.”

This section makes it very difficult to tell which of the following overarching recommendations

the panel thinks should be included in the report, and which should not. Certainly, the first, about major findings, is one that the panel thinks should be in the report (well, most of the panel, and more on that in a minute). I think each of these needs more specificity about where and how we expect the recommendation to be met.

Related to that, the recommendation on more attention to local impacts implies that all local scale impacts must be short-term. I think that is a faulty assumption. There are certainly some spills that can be long-term or even irreversible in impact.

The recommendations in response to the Charge Questions are very long and detailed. I look forward to hearing discussions about the second dissenting opinion, on whether the agency had conducted a generally comprehensive overview. Nearly all of recommendations related to the Charge Questions ask for more data, more analysis, more current review, etc. I find the dissenting opinion to be rather well-supported.

2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

Not that I know of.

3. Is the Committee's report clear and logical?

There are a few typographical errors in the report; it needs to be gone over rather carefully (particularly Appendix B. There are typos that a spellchecker won't find).

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

The dissenting opinions are quite interesting. As I stated earlier, the second dissenting opinion seems to have a lot of support; the committee recommendations are many and they are long, so the conclusion that EPA had prepared a generally comprehensive review might be a stretch. I imagine that the offending statement, that the "agency provided a generally comprehensive review", exists because we all try to say something nice at the beginning of a review, particularly a critical one. Could not we rectify this apparent dissent with a little word-smithing? The issue does not seem to be worthy of a dissention and its presence resonates with "this panel didn't work well together".

The larger dissenting opinion (the first one) also seems partly semantic. These panel members object to the other panel members stating that the report should clarify and expand upon the meaning of the conclusion that "we did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources". I do not think that there is harm in asking the panel to better clarify and expand their statement, nor why it is worthy of dissention. The public debate over hydraulic fracturing is a contentious one; I think it is incumbent upon the EPA Science Advisory Board and its panels to be clear about what is known and what the uncertainties are, and to have consensus about that. If not, we will further the public chasm that is based on values about the issue, rather than bring scientific clarity, and we will be subject to criticisms that we are led by our biases rather than our science. That is the elephant in the room with this report, and we risk the appearance that one or both sides of the committee were reflecting biased values, not differences in scientific interpretation. Surely, we need not present a divided front over what seems to be mostly semantic issues raised and reinforced to uphold positions. *The panel should work together to find language we can all agree on, related to this review.* Given all the 184 pages of agreed-upon recommendations, and the two phrases causing dissent, I believe that consensus is possible.

## Comments from Dr. Michael Dourson

1. Were the charge questions adequately addressed?

This is not my area of expertise but the committee appears to have been very well appointed and appears to have addressed the given charge questions very well.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

Please see response to question 4.

3. Is the draft report clear and logical?

Yes, the report was very easy to read and it generally made sense.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

I am not adept in this area, but was nevertheless struck by the number of public comments on 6-8-16 that focused on individual or localized community issues associated with hydraulic fracturing (HF) operations. Some of these comments are likely to be based on issues associated with, but not caused by, HF. For example, the description of Beth Voyle's experiences found in the comments of Dr. Richard Guildi appear superficially to be due to hydrogen sulfide exposure. (If true, this situation needs to be resolved immediately.) A common source of hydrogen sulfide is an improperly functioning sewage system, and so this situation might not have anything to do with nearby HF operations. However, some of these public comments are likely based on HF operations and are either well stated, or perhaps over stated. In either case, the HF operation appears to be in part responsible.

One of the dissents from the SAB report state that:

“Only a very small percentage of those wells have had an operational issue that may have impacted drinking water resources. Even among this small percentage, the identified impacts to drinking water resources have primarily been associated with surface spills, well construction, and well cementing – not hydraulic fracturing.” (SAB Report, page B-3)

If I assume that the small percent referred to by the SAB dissenters is 1, and if I use the statement that 30,000 HF wells are drilled each year in the US (page B-3), then this results in 300 such incidents per year. HF has been going on for a number of years, and we heard from ~20 folks about such incidents on 6-8-16. Should any of us be surprised?

I beg your indulgence with this next example. Several years ago I had the opportunity to be on a scientific panel on dental amalgams for the US Food and Drug administration. Our panel listened to over a day of public comments on whether or not metallic mercury in this amalgam was useful or harmful. One thing that I did not know at the time, is that dentists often mix metallic mercury in with other constituents in their office to develop a paste which is inserted into the drilled tooth, shaped to the appropriate form and which sets quickly. What struck me then, was that exposure to metallic mercury depends in part on how the dentists does the mixing. A poorly done mixing job can yield more mercury in some patients over others, as do more mercury amalgams in any one patient. That is to say, the difference that our panel was hearing in

the public comments on dental amalgams, in my opinion, had much to do with the fact that the dose makes the poison. Fewer fillings done properly were not associated with any ill effects; more fillings done poorly were.

Well, how does this relate to HF? It may be true that if HF is done properly, then one would “not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States.” (EPA Report, page ES-6). In such cases, few contaminants, if any, are released and the community benefits in jobs and wealth. However, if HF is done poorly, or if multiple HF activity occurs in any one area, then we may risk poisoning wells, landscapes, our ecosystem and our neighbors, similar, perhaps, to what several public commenters have stated. Remarks by one public commenter that industry was improving its operational processes were encouraging.

It seems reasonable to me that “Most members of the SAB Panel find that this statement [EPA’s statement above found on its page ES-6] does not clearly describe the system(s) of interest (e.g., groundwater, surface water), the scale of impacts (i.e., local or regional), nor the definitions of “systemic” and “widespread”. (SAB Letter to McCarthy, page 2) I would encourage the SAB panel to enhance this conclusion by referencing a balance of public comments. For example, if we are having local problems and potential solutions, then they both need to be documented.

### **Comments from Dr. Kristina D. Mena**

- 1) Were the charge questions to the committee adequately addressed?

Yes – The report thoroughly addresses each of the charge questions.

- 2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

The report is well written, and gives lots of detailed recommendations. A few issues may warrant clarification:

- 1) Regarding lines 48-49 in the Cover Letter, what *specific* “follow-on activities” can be linked to filling *specific* gaps?
- 2) One recommendation in the SAB report is for the Assessment document to discuss Best Management Practices (BMPs); however, the tone of most of the SAB report is that there is not enough available data to identify current or inform future BMPs. Would this be possible to achieve at this point?
- 3) The SAB report mentions identifying “several cross-cutting thematic areas” (bottom of page 2, Cover Letter). What are these themes? Are they the sub-section headings that follow?
- 4) The opinions discussed regarding the appropriateness and usefulness of the MCDA on page 4 of the Cover Letter seem contradictory.
- 5) Since there are dissenting views among the SAB Panel and this fact is included in the SAB report, it would be helpful to have more details explaining the rationale driving these differing opinions.

3) Is the draft report clear and logical?

It isn't clear what the SAB Panel is recommending regarding the purpose of the Assessment report. Although there are several important recommendations provided to the EPA to improve the Assessment document, some appear to indicate or direct a particular purpose. Some recommendations seem to imply different purposes. For example, is the Assessment document supposed to simply compile and synthesize the information found in the literature, and identify data gaps? Is it supposed to serve as a source of information using available data at this point in time, or anticipate future industry changes and provide a forward-thinking practice tool? Were prospective case studies supposed to be conducted that generated data that fill those data gaps? Is the document supposed to provide a user-friendly, site-specific Guidance Document for a lay audience, or as a technical read? Is the Assessment supposed to provide a springboard for future risk assessments since the SAB report recommends exposure scenario building and hazard identification (although the Assessment document's purpose is not to present a risk assessment)? Or, is the EPA supposed to create the Assessment document by proactively contacting States where data are lacking (such as regarding spills), and therefore create and include some new databases? Is the document supposed to inform Best Management Practices for the hydraulic fracturing industry (see comment in previous question)? Or, is the overall purpose to characterize current databases, identify data gaps, and then provide recommendations for future work that address those data gaps? Or, is it some or all of the above?

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

It would be beneficial to have a discussion explaining why most of the SAB Panel is "concerned" that the field studies and assessments were not conducted. Also, a discussion of other views would help clarify the different perspectives on the implications of this key issue.

The importance of addressing data limitations and associated implications is already emphasized in the SAB recommendations. Perhaps this recommendation warrants a distinct section on (overall) data gaps with various sub-sections on how each could be addressed.

I appreciate the differing opinions regarding the controversial statement mentioned on page 2 of the Cover Letter reading, "We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water . . ." The key word in that statement is the word "find." I do, however, agree that the addition of modifying adjectives would add clarity. Also, are there differing opinions regarding the adequacy of what the EPA conducted (or did not conduct) that warranted this statement?

### **Comments from Dr. James R. Mihelcic**

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

The SAB Hydraulic Fracturing Research Advisory Panel has done a very good job of addressing the many original charge questions provided by EPA. My major comment (that is addressed below) is that several of the major findings that come out of the Panel's report could be addressed or highlighted better not conveyed in the letter to the Administrator.

2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

I did not identify any major technical errors or omissions in the report. The Panel and SAB should consider making it clear in the Section on Treatment of Hydraulic Fracturing Wastewater that EPA should consider the potential impact treatment of any resulting fluids would have on a local POTW's ability to recover resources (energy, water, nutrients) from wastewater. This is important because EPA, DOE, other federal agencies, and some professional organizations have been organizing high profile meetings the past two years on accelerating this aspect of the wastewater sector. In addition, it was not clear to me if EPA considered the impact of resulting fluids on local POTWs in terms of their staffing levels and operator training. This is because some plants are operated 24 hours per day while others are staffed only during day time operating hours.

3. Is the Committee's report clear and logical?

Yes, overall the report is clear and logical. I have one minor comment. Page 103, lines 36-38. Because this section is on wastewater treatment, should this bullet on aeration be clearer that in wastewater treatment, aeration refers to the transfer of oxygen, through mechanical processes to wastewater.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Overall I would agree the conclusions drawn and recommendations provided are supported by the report. However, after I read the letter to the Administrator, the report, and then the letter to the Administrator a second time, I thought the letter could be better organized and some items better emphasized in the letter that are clearly take-home messages from the report.

First, the first sentence of the third paragraph on page one of the letter of the Administrator reads that "In general, the SAB finds the EPA's overall approach..... to be appropriate and comprehensive." Yet, reading the overall report, there are several concerns that are listed and then repeated in several occasions, most of these are covered then on the second and third pages of the letter to the Administrator. However, these seem quite important and significant findings, especially the "high level conclusions statement" and section on "clarity and support for major findings". These items appear on the second page of the letter, I would move them to the first page. So on the second page of the letter to the Administrator it is written "The SAB has concerns regarding the clarity and adequacy of support for several major findings presented within the draft Assessment Report that seek to draw national-level conclusions regarding the impacts of hydraulic fracturing on drinking water resources" should be moved to the first page."

This sentence should be on page one of the letter to the Administrator, along with the very important statement “Of particular concern in this regard is the high-level conclusion statement on page ES-6 that “We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States” which is buried in the middle of a paragraph on page 2 of the letter. In my professional opinion, it should be highlighted as the first sentence of the third paragraph on the first page of the letter along with the bulleted list of items referred to in the “clarity and support for major findings” section as well. Again, this is because as you read the report, these appear as important take home messages. I agree with the Panel’s comment on Prospective Case Studies that the SAB should strongly recommend that EPA clearly explain why they did not perform planned assessments, field studies, and other research.

It appears the letter to the administrator did not address the issue of the Panel’s concern of EPA’s reliance on the February 2013 FracFocus version 1.0 (which was acknowledged in the Panel’s report to perhaps not be complete or sufficient) for its findings in the final Assessment Report. The Panel’s report also mentions there is uncertainty regarding which hydraulic fracturing constituents have been used globally and at any specific site. Later in report it is also written that “SAB identifies issues with the EPA’s reliance on the FracFocus version 1.0 database” Then it was written that “The SAB finds that a central problem regarding use of the FracFocus 1.0 dataset is that it does not represent the full suite of hydraulic fracturing operations taking place within the United States during the study period.” I think with all of these mentions in the report this should be conveyed in the letter, not just the Executive Summary and report.

### **Minor Editorial Comments**

On the Acronyms and Abbreviations page and later in the report (page 106 line 34), BOD is BIOCHEMICAL oxygen demand (not biological). EPA Standard Method 5210 B  
Page 40, line 42. Add space after “Commission( SRBC)”  
Page 42, line 12-13, formatting of bulleting is incorrect  
Page 54, line 9. I think “improvements have occurred” should be written as improvements THAT have occurred  
Page 65, line 28. I don’t believe there is a comma after first author for “(Bosquez, et al.,”  
Page 75, line 24. mg/L is incorrectly spelled as m/L  
Page B-3, line 3 there is a spelling error (Unites States)

### **Comments from Dr. H. Keith Moo-Young**

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed? Yes, the charge questions were adequately addressed.
2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee’s report?  
No.

The report is well written and provides adequate detail on the issues.

One point of concern is the EPA report's assertion that hydraulic fracking may not cause widespread systematic water quality impact. Long term monitoring is a future research area that will help to answer these questions. In addition, I strongly support the committees

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recommendations on the complexity of the fate and transport related to fracking fluids in the subsurface.

There is little emphasis in the report on the seismic activities caused by hydraulic fracking. This may require a joint study by EPA and the USGS to gain a greater understanding of the impact of fracking on the subsurface with especial attention being paid to the potential for preferential pathways that could be created through the subsurface as a result of the seismic activity. The committee provide some excellent reference for the agency, but future research is needed in this area.

3. Is the Committee's report clear and logical?

Yes. There are two dissenting comments which provide the committee's scientific opinions. I am particularly supportive of the committee's recommendation on localized impacts and the need to study cases where hydraulic fracking is perceived to cause drinking water impact.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes.

### **Comments from Dr. James Opaluch**

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes

2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

None other than the items indicated below

3. Is the Committee's report clear and logical?

Yes

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Letter to the Administrator, Page 2, lines 43-44; Executive Summary Page 3-4 and Report Page 139 lines 4-15. I'm confused about the panel's conclusion that "...EPA's initial goal of assessing the HFWC using national-level analyses and perspective was appropriate." which is then followed by a statement that impacts "...are often localized in space and temporary in time" and that "local-level impacts can potentially be severe." I agree with the subsequent text on pages 2-3 in the Letter; on pages 3-4 in the Executive Summary and on page 139 in the Report. But absent other discussion, this material appears to contradict the statement that the EPA

“national-level analyses and perspective was appropriate”. Aren’t virtually all fracking-related drinking water impacts localized?

One might take a national perspective by focusing on local impacts of fracking operations at sites across the nation, but otherwise taking a national view seems inappropriate to what is primarily a potentially severe, but localized problem. For example, as noted in the SAB report, it is not especially helpful for EPA to note that hydraulic fracturing represents a minor use of water on a national scale (e.g., SAB Executive Summary page 10 line 32), given that there could be important impacts on stream flows and groundwater levels in the vicinity of fracking operations.

Page 4, line 38-39. Does the panel think this statement should be stronger? Should we “recommend” rather than “suggest”? This is consistent with the wording on page 39 line 20.

Also, rather than simply recommending that EPA consider carrying out case studies, the report might better link together the sentences in the Executive Summary page 4 lines 31 through 32 and lines 35-38 to make a stronger appeal for a strategy for selecting case study sites that address important information gaps to augment the existing body of evidence available from investigations conducted by other organizations. Note that this approach of addressing important gaps in the existing literature is in contrast to the approach on page 26, line 41 which recommends “... five to ten in-depth studies be conducted at locations selected to represent the full range of regional variability of fracturing across the nation.” Some locations (or geophysical conditions) may be better studied than others in the existing literature. Given that a small number of case studies is the best that can be hoped for, EPA should target information gaps with the goal of building the most robust body of knowledge, taken as a whole, rather than viewing its own case studies in isolation as suggested on page 26, line 41.

The focus on filling the important information gaps in the existing literature could also be helpful in resolving the different of opinion between the majority of the committee and the two committee members who did not see the lack of case studies as a major concern. What are the most critical information gaps in the existing case studies that are essential to fill?

Page 16, lines 31-32, and Page 59 line 36 through Page 60 line 8. Regarding the assessment of adequacy of cement and well casing. It is important that EPA select sites with appropriate statistical design criteria, given that the resulting data are intended to support a subsequent statistical analysis. Absent an appropriate statistical design, any statistical inferences from the data would be invalid. The relatively small number of sites (327 out of 24,000 wells) is not necessarily a problem in itself, if a carefully designed (possibly stratified) random sample were used. Conversely, having a larger sample of wells in itself will not help in developing valid statistical inferences, in the absence of a considered statistical design. At the same time, a larger number of observations could be needed to identify relatively rare, but potentially very serious cases.

### **Comments from Dr. Tara Sabo-Atwood**

1. Were the charge questions to the committee adequately addressed?

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Yes, the SAB report highlights strengths and addresses several gaps and limitations of the hydraulic fracturing assessment document (2015) and makes several recommendations. The executive summary is clear in outlining these recommendations.

2. Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No, I did not identify and technical errors or omissions/issues in the report based on my area of expertise.

3. Is the draft report clear and logical?

Yes, for the most part, the report is clear and logical. A few areas could use further clarification:

The report describes the need to determine/quantify ‘baseline’ water quality prior to HF (See page 65). It is not clear what defines ‘baseline’ water quality measurements. It is likely that such assessment would vary based on region/locale. Clearly this is complex as we still do not have a clear identity of all the associated chemicals of concern (or not). While this point was alluded to in the report, future research directions/suggestions should consider *emerging non-targeted chemical analysis* – to aid in identifying both known, suspected and unknown chemicals. These approaches would also capture analysis of transformation/degradation products.

On page 79 the report refers to ‘level of impacts’ but it is not clear what ‘level’ refers to.

Minor edits:

Page 27, line 33: March 10, 2016

Page 40, line 42: Commission (SRBC)

Page 45, line 19: remove ‘notes that’

Page 46, line 17: reliance on

Page 49, line 42: not (?)

Page 85, line 28: remove ‘of’

Page 101, line 47: iodate are

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes. In general the conclusions and recommendations are supported by the report.

### **Comments from Dr. Jeanne VanBriesen**

#### **1. Were the original charge question to the SAB Committee adequately addressed?**

Yes. The charge questions were addressed. The SAB committee does an excellent job addressing each component of each charge question and provides clear responses on whether a particular aspect of the report meets the stated goals. The detail and clarity provides excellent guidance to EPA on necessary analysis and revisions to the report.

**2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?**

A few minor points would benefit from additional articulation or the inclusion of additional data.

The letter, executive summary and body of the report provide a consistent and clearly articulated message. In one case, I am concerned that the conclusion but not its justification made it into the letter. In the executive summary (p. 10, lines 31-32) the SAB finds that the extrapolation is unwarranted and masks local issues. In the letter, the conclusion that EPA should consider local issues is included, but the reference to the unwarranted extrapolation did not. I think it is important that the SAB is not saying the EPA did not consider local issues. Rather, SAB is saying EPA incorreced extrapolated from national numbers to lead to a conclusion that masks important information at the local level. Missing local issues might be an oversight, while extrapolating without adequate justification is an error.

Executive Summary (p. 3 line 7) "The SAB is concerned" seems a weak word choice. I'd suggest turning this into a recommendation or leaving the 'concern' out.

Executive Summary (p. 13, lines 19-21). The issue of an absence of evidence rather than evidence of an absence of impact is a critical one. I would suggest that the SAB recommend that EPA comment on the likelihood of detecting an impact given the current state of groundwater and surface water monitoring in the US. If routine monitoring systems are adequate to capture this impact if it occurred, then a lack of evidence of impact *does* support a conclusion that there was no impact. If the routine monitoring systems would not be expected to capture an impact that occurred, then a lack of evidence of impact does NOT support a conclusion of no impact. So, the relevant question for EPA is: are they justified in assuming that if impacts were occurring they would be detected? EPA should provide justification of this assumption through reference to the state of monitoring of groundwater and surface water in the US.

Executive summary (p. 16, line 31-32). The SAB notes that EPA should look at more data for well files. Did EPA provide any details of how the 327/24,000 were selected? Statistical sampling can be representative if done correctly. EPA should provide details of how the data reviewed were selected, and in following the SAB recommendation to look at additional data, they should again provide details of how the selections were made. The issue of the low percentage of horizontal completions in the reviewed data should be covered in this summary of data selection as well (p. 16, line 41).

Executive Summary (p. 20, lines 4-5) It is not clear if this was a conclusion in the chapter summary by EPA or if SAB is making this conclusion.

Executive Summary (p. 20, lines 14-16) SAB should be more clear here that the conclusion is not only not supported by the data in Chapter 8, but is not supported by peer review literature that has demonstrated contaminants from oil and gas wastewater disposal facilities have reached drinking water facilities and have had effects. E.g., States et al (2013) and Landis et al (2016).

Executive Summary (p. 20, lines 32-33) SAB should more clearly articulate what is insufficient in the current analysis and what 'further' is needed.

Executive summary (p. 20, lines 35-36) It is not clear if SAB is noting that there is none of this information and it should be added or if there is some information but it is inadequate.

Report (p.101, lines 26-29) The SAB correctly notes that the quotation from the Assessment

report is misleading. However, the SAB's discussion is also confusing. It is unclear what the SAB means by the chloride being consumed during DBP formation. Bromide is converted to bromine by the applied disinfectant (e.g., chlorine). The bromine and the chlorine are incorporated into DBPs. The ionic chloride present in the source water does not take part in this reaction. It is the ratio of bromide to applied chlorine and bromide to organic matter that affects the bromination fraction in the DBPs. The applied chlorine level is determined by the chlorine demand, water temperature and the required CT for the plant. The dissolved bromide to chloride ratio in the raw water does not play a significant role in DBP bromination. Literature reports have considered bromide incorporation percentages (Luong et al, 1982; Amy et al, 1991) within THM, while incorporation into unregulated DBPs is less well studied.

Report (p. 105, lines 23-24) The SAB notes that EPA should cite appropriate references related to the relative toxicity of brominated and chlorinated DBPs. It might be worth noting that there is extensive information about the human health impacts of DBPs in the Stage I and Stage 2 D/DBP rules as well as numerous EPA documents (e.g., USEPA, *Drinking Water Criteria Document for Brominated Trihalomethanes*, 2005, United States Environmental Protection Agency: Washington DC.)

Report (p. 108 lines 35-40). Pennsylvania drinking water plants have been reporting full speciation data on THM and HAA in compliance data for several years. Further EPA Region 3 has an ongoing study of bromide and DBPs (in the Ohio River). Thus, data exist to assess the DBP formation in drinking water treatment plants downstream from CWTs.

Report (p. 111, lines 17-19) It may be worth noting that EPA used a 5 mile radius for potential effects of coal fired power plant bromide discharges on downstream drinking water plants (in the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, 2015). It is not clear that the five mile radius is sufficient as the discharged bromide is conservative in surface waters; however, some consistency in the proximity analysis for different sources of the same contaminant (bromide) should be expected.

### **3. Is the Committee's report clear and logical?**

This is an extremely well written and clear report. The committee is to be commended.

Minor editorial comments where clarity could be improved:

- a) In the letter (p. 1, line 24), "potentially could" is redundant.
- b) In the letter (p. 2, line 30), what does 'more precise' mean in this context. Can the SAB provide clear guidance on how the EPA is to revise the statements to be more precise? [Same point for Main report on page 135 line28]
- c) In the letter (p.3, line 35), "if any" should be set off by commas to improve readability.
- d) In the letter (P. 3, line 42), This sentence is unclear. Probability of what?
- e) In the executive summary (p. 3, line 15) "The SAB agrees" It is not clear if the SAB is agreeing with EPA or with someone else or if this line is meant to indicate internal agreement/consensus. Same comment for Executive summary (p. 25, lines 5-6)
- f) In the executive summary (p., 3line 19) "EPA should carefully consider whether to revise" This is ambiguous. Is the SAB recommending a revision or not?
- g) In the executive summary (p. 4, line 38) It is not clear here or in the appendix why the dissenters did not think EPA should conduct prospective studies. Insight into the reasoning here would be helpful to the reader. I see this is more clear in the main document; perhaps some of that language could be brought forward.

- h) In the executive summary (p.5, line 12) It is not clear what the meaning of the word “confidently” is in this sentence? Why not just say “The data cannot be extrapolated.” That is not ambiguous. Same comment in executive summary (p. 13, line 41). Same comment in the report (p. 45 line 18).
- i) In the executive summary (p. 6 line 13) “characterize in some fashion” is not clear. What is it the SAB is recommending? What is the meaning of ‘in some fashion’?
- j) In the executive summary (p. 8, lines 10-14) I do not understand what is being suggested here. I do not understand how this would improve the clarity of the document because I’m not sure what the recommendation is here.
- k) In the executive summary (p. 16, lines 22-28), this paragraph seems out of place. Is this within scope of the EPA report or the SAB review? This paragraph starts with “a key aspect of reducing impacts from HFWC operations on drinking water supplies,” but the EPA was not asked to assess how to reduce impacts. They were charged with assessing whether there were impacts, not advising on how to reduce those impacts. A number of organizations produce best management practices and standards. If this topic is within scope, EPA should refer to those organizations and their documents. There is no need for extensive re-articulation of this material. This is also unclear on page 53, lines 36-37 in the report, beginning “To accomplish this . . .” It is not clear what is to be accomplished and who is to accomplish it. It is not clear that it is within the scope of the EPA report to detail how HFWC activities are to be conducted in a responsible manner, but if it is, more than this paragraph is needed. Perhaps this material could be in a textbox as suggested in the following paragraph on pages 53-54.
- l) Similarly, page 54, lines 6-9, it is not clear that the requested summary is within scope for EPA’s charge to assess whether hydraulic fracturing affects drinking water. If it is within scope, then EPA should conduct a quantitative analysis of whether the changes that have occurred since 2012 have resulted in more or less probability of affecting drinking water. This is well described on page 55 in the 2<sup>nd</sup> bullet. The objective is to assess whether new technologies have change the probability of risk of water quality impacts.
- m) Page 55, lines 10-11 “almost every conceivable potential impact” It is not clear what this word choice is designed to convey. The charge to EPA was to identify all potential impacts. Is the SAB saying EPA missed some (“almost every”) or is SAB saying EPA was unusually thorough in this chapter?
- n) Main report (p. 44, line 41) typo “pilled” should be “spilled”
- o) Main report (p., 111, line 3) “The” should not be capitalized near the end of this line.
- p) Main report (p. 113, line 17) This heading should not be bulleted.

**4. Are the conclusions drawn or recommendations provided supported by the body of the Committee’s report?**

Yes, the conclusions and recommendations are supported by the report.

Amy, G., L. Tan, and M. Davis, *The effects of ozonation and activated carbon adsorption on trihalomethane speciation*. Water Research, 1991. **25**(2): p. 191-202.

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Landis, M., A. Kamal, K. Kovalcik, D. Croghan, G. Norris, and A. Bergdale, *The impact of commercially treated oil and gas produced water discharges on bromide concentrations and modeled brominated trihalomethane disinfection byproducts at two downstream municipal*

*drinking water plants in the upper Allegheny River, Pennsylvania, USA*. Science of the Total Environment, 2016. **542**: p. 505-520.

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Luong, T., C. Peters, and R. Perry, *Influence of bromide and ammonia upon the formation of trihalomethanes under water-treatment conditions*. Environmental Science and Technology, 1982. **16**(8): p. 473-479. <http://pubs.acs.org/doi/abs/10.1021/es00102a009?journalCode=esthag>

States, S., G. Cyprych, M. Stoner, F. Wydra, J. Kuchta, J. Monnell, and L. Casson, *Marcellus shale drilling and brominated THMs in Pittsburgh, PA, drinking water*. Journal of the American Water Works Association, 2013. **105**(8): p. E432-E448. DOI:

<http://dx.doi.org/10.5942/jawwa.2013.105.0093>

Weaver, J., J. Xu, and S. Mravik, *Scenario Analysis of the Impact on Drinking Water Intakes from Bromide in the Discharge of Treated Oil and Gas Wastewater*. ASCE Journal of Environmental Engineering, 2016. **142**(1). DOI:

<http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29EE.1943-7870.0000968>

USEPA, *Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category (final)*, in EPA-HQ-OW-2009-08192015, United States Environmental Protection Agency: Washington DC. p. 67837-67903.

USEPA, *Environmental Assessment for the Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category*, 2013, United States Environmental Protection Agency Office of Water: Washington DC.

### **Comments from Dr. Robyn Wilson**

1) Were the charge questions to the committee adequately addressed?

Yes, I thought the charge questions were very carefully and thoroughly addressed.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No.

3) Is the draft report clear and logical?

Yes, the report is very well written and very clear. It was well organized with a good summary of the main findings and recommendations, as well as a thorough overview of the evidence and reasons for the panel's recommendations in the report. The authors provided good summaries and frequently highlighted the key findings in bulleted lists that made the recommendations clear.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes, I thought the conclusions drawn were well documented and justified based on the body of the report. In particular, I thought the draft report did an excellent job pointing out failures of risk communication in the assessment. For example, the authors recommended that terms be better defined (e.g., appears to be low, # of cases was small). EPA assessments should be clear and unambiguous so as not to create further confusion among stakeholders and interested members of the public. Ambiguous language needs to be avoided as terms like "low" and "small" carry

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different meanings to different people. I also thought that the recommendation for the inclusion of case studies focused on current investigations was a great suggestion to offset the lack of data and/or evidence in some cases. Such case studies can also provide the context and concrete examples that individuals need to understand the current state of the science. From a decision making standpoint, I also thought it was helpful to suggest that the assessment include a summary of best practices available to minimize risk, as well as changes in these practices since 2012, given the controversial nature of the topic it is very helpful to emphasize what is currently in place and how recent changes may impact future outcomes. Along the lines of the earlier comment about risk communication and ensuring that the assessment is meaningful to a broad audience, I thought the recommendations to reduce jargon and add visuals/diagrams/etc. to communicate complex concepts was very useful and again, necessary in such a document meant for wide consumption.