Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

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Comments Received from Chesapeake Physicians for Social Responsibility

On behalf of *Chesapeake Physicians for Social Responsibility*, please accept the attached comments from Dr. David Brown, and from Dr. Anthony Ingraffea and Renee Santoro of Physicians, Scientists and Engineers for Healthy Energy. These expert reviewers are among the most knowledgeable individuals in the country on the topic shale gas development and risks to public health.

Our comments are as follows:

We believe that the deep structural flaws in this risk assessment result in a significant underestimation of the risks to Maryland residents from unconventional gas development and production. The risk assessment contains incorrect assumptions and omissions of pertinent information that lead to falsely low risk levels being reported. For example, air emissions are not fully catalogued or analyzed, yet form one of the primary sources of risk to public health and the environment. The regular purging and venting of wells, pipelines and equipment, a major risk leading the adverse health effects from human exposure, is not discussed in this risk assessment. In addition, assumptions about the likelihood of contamination of water supplies are based on unrealistic assessments of the risk of failure of well-casings and cement, failure rates that have been well-documented in Pennsylvania and remain unacceptably high despite Pennsylvania's recent efforts in 2011 to tighten their regulatory framework. Of critical importance, the assessment does not adequately analyze cumulative risks.

We are also concerned that there was little input into this risk assessment from professionals in the field of public health or from health care providers who are actually dealing directly with the health effects of shale gas development in neighboring states.

We acknowledge that Maryland has led the nation in attempting to study the complexities of unconventional gas development and production, and to develop a regulatory framework before allowing UNGDP to commence in the state. However, the lack of data and scientific support for many of the proposed best management practices means that it is impossible to assess what effect these will truly have on risk reduction, even in the unlikely scenario of perfect implementation. The purpose of this risk assessment as stated on p. 3 is "*to provide a comprehensive risk evaluation for UGWD in the Marcellus Shale in Western Maryland. Specifically, risks are evaluated through a qualitative assessment of probability and consequence to achieve an overall risk ranking. This RA does not seek to determine a single aggregate risk evaluation for UGWD in Maryland. The RA findings are intended for consideration by the State of Maryland and the Marcellus Shale Advisory Commission to determine if UGWD can be conducted safely in Maryland with current proposed BMPs.*"

Given the limitations of data available to determine risk levels or to evaluate impacts of specific best management practices, especially in the realm of public health, we believe that

the current state of science indicates we do not know whether unconventional gas development can be conducted safely in Maryland. We believe it is incumbent upon MDE and DNR to make this clear to the Maryland public in this risk assessment.

Response: Please refer to the Departments' detailed responses to the attached references (Brown and Ingraffea/Santoro) which are inclusive of your comments above.

Respectfully submitted,

Gina Angiola, MD
Board Member, Chesapeake Physicians for Social Responsibility

Tim Whitehouse
Executive Director, Chesapeake Physicians for Social Responsibility

Comments Received from Mr. David Brown, ScD, Prepared for Physicians for Social Responsibility

I. Introduction:

The Maryland Safe Drilling Initiative is attempting to determine whether gas production in Western Maryland can be accomplished without unacceptable risks to public health, safety, the environment and natural resources. The "Assessment of Risks" document was prepared by the Maryland Department of the Environment and the Maryland Department of Natural Resources to inform that determination.

This review, which was requested by Chesapeake Physicians for Social Responsibility, considers the strengths and limitations of the "Assessment of Risks" in informing deliberations on health, safety and the environment. There are three important questions that are addressed in a Risk Assessment of health and environmental concerns.

1) What is known with certainty about the plausible hazards?
2) What are the hazards present and potential for human or environmental exposures that could damage health and the environment?
3) What are the limitations in the information available and the impact on conclusions in the Risk Assessment?

The "Risk Assessment" establishes that human health and environmental risks are present but does not analyze the risks sufficiently to determine the level of hazard to public health or the environment. This failure is due in part to limited data, but also it is the result of an untried novel, and limited approach used in the assessment.

II. Scope of risks

In order to determine the impact unconventional natural gas development on the two counties it is important to understand the scope of the proposed gas extraction project in Western Maryland. The following paragraph taken from the European Parliament analysis June 2011 Report, "Environment, Public Health and Food Safety with Gas Drilling" provides overall perspective on the likely impact of Gas Development. (http://www.europarl.europa.eu/activities/committees/studies.do?language=EN)

> *'One of the unavoidable impacts is huge land consumption and major landscape changes as the well density must be very high in order to fracture the source rocks at large scale for access to the stored gas. The individual well pads – in the USA up to 6 well pads per kin or even more are reported – must be prepared developed and*

connected by roads which are accessible for heavy duty transport. Producing wells must be connected by gathering lines with low throughput, but also with purging units to separate waste water and chemicals, heavy metals or radioactive ingredients from the produced gas before it is pumped into the existing gas grid.'

Although the European Union paragraph does not mention the health and welfare impacts, it is because the health hazards have only recently been documented in the peer reviewed literature. Reports of health effects are found at all shale development sites and the scope of health risks is a cause for public health concern. The Maryland Risk Assessment Report had a formidable task from a public health perspective.

III. Analysis of the Conclusions in the Risk Assessment Report:

The central question addressed in this Risk Assessment is whether the impact of unconventional natural gas development and production (UNGD) on public health, safety and the environment can be managed by the ability of Maryland state agencies to reduce the risk to acceptable levels using three tools; 1) best management practices (BMPs) 2) current state programs in environmental management, 3) legislation.

The overall Conclusions of the report, on Page 2 of the Executive Summary and Page 12 of the Risk Assessment, do not provide guidance to this core question. The Risk Assessment conclusions assert that:

1) "the utilization of proposed practices serve to **reduce many** of the risks to the citizens, economy and quality of water, air and natural resources' and
2) further that if risks are found **unacceptably high** additional mitigation steps could be taken
3) or extraction can be deferred until risks are reduced by new technology or until data is obtained that they are effective to reduce the risk."
(formatting added)

These conclusions are vague and general. The conclusions do not provide the information needed by decision makers. Further, although the conclusions are based on findings from information that is extremely limited both in scope and technical depth, those limitations are not listed anywhere in the Risk Assessment.

Response: You are correct that an important purpose of the risk assessment is to apply the current proposed BMPs and existing regulations to determine where risks still remain. Where they do, the Departments will use this information to identify areas where additional BMPs or regulations will be necessary to mitigate risks. In addition there are other studies under the Executive Order (i.e., the Public Health Study) that looked at risks independent of Maryland proposed BMPs. The Departments are confident this combination of approaches (i.e., with and without BMPs/regulations) provides complete and independent analyses of risk that best protect public health and the environment, as well as provides decision makers with the best available information for decision-making. Having said this, the Departments' also acknowledge that there is uncertainty or limitations in the risk

assessment findings (additional language has been added in throughout the summary document to indicate this) and that best professional judgment is used in risk conclusions. The Executive Summary language in the risk assessment has also been updated to more accurately reflect the conclusion language in the air emissions appendix.

The conclusions in the Executive Summary are not compatible with the findings in the Appendices sections of the risk assessment. There is no discussion or determination of magnitude and scale of the known health risks in the Risk Assessment. There is not available in the reviewed literature any systematic evaluations of the human health impacts that have been conducted by reliable health scientists or any other group. The evaluations of the risks to the environment are also limited. When the extent of the risks is unknown there is no way to determine which risks would deemed to be acceptable or addressed by the BMPs and regulations.

Response: See above response.

Further, the Risk Ranking assessment methodology used to evaluate individual hazards lacks the quantitative information needed to support the risk rankings in terms of either the extent of the hazard or the potential for occurrence of any individual hazard at any gas site. The Summary Risk Chart (Appendix A), which assigns a qualitative rank to each of the multiple risks, is not a valid assessment of the health risks.

> If one takes this Summary Risk Chart presentation at face value and follows the logic of the risk approach to the end, and finally uses it to predict the aggregate hazard, you reach a startling conclusion. Not that there are minor risks but that there will be a substantial number of accidents what would impact human health and the environment each year.
>
> > *Notice that there are 66 entries in the risk ranking summary chart ranked 'low' or higher (only 7 risks are rated high and 33 of the 66 are ranked 'moderate"). If one assumes that the occurrence of "low risks" has a chance of 1 in 1000 per year per well, one could infer a probability of 66 x]/1000 events per year and next assume that there are 100 wells. There would be 6600/1000 or 6.6 events per year, AN EVENT EVERY 7 to 8 WEEKS). But the scenario model predicts up to 450 wells.* ***That would be 29 events per year. That would be an event every 2 to 3 weeks. One out of ten of them would be severe giving high risks to human health and the environment. One half of the events would be moderate (producing short term damage to health and the environment according to the definitions in the risk assessment).***

Response: From the very outset, Maryland's risk assessment was intended to be qualitative in nature and not assign a numeric risk. The reasons for this, which has been discussed above by the commenter, is that for most risks there were not sufficient scientific literature or other information to determine rates of occurrence. Furthermore, it was also part of the risk assessment scope to consider the proposed BMPs effectiveness in mitigating risk. So in performing the risk assessment the Departments were faced with a two-fold difficulty of having to determine a probability where rates often were not available and a consequence in consideration of BMPs that likewise did not often have efficiency rates. This necessarily made the risk assessment subject to limitations as well as introduced best professional judgment into the analysis. Given these limitations, however, the Departments are confident that the risk assessment does provide some meaningful differentiation between levels of risk and indentifies activities where additional BMPs should be considered.

IV. Omission of a major hazard from the Risk Assessment:

Omissions and gaps in a risk assessment are serious. This risk assessment omits analysis of the scheduled and unscheduled venting (purging), which is routinely conducted in well development and gas production. It is the major source of all air emissions in gas development. Referral to the Pennsylvania inventory for 2012 will illustrate the seriousness of the problem.

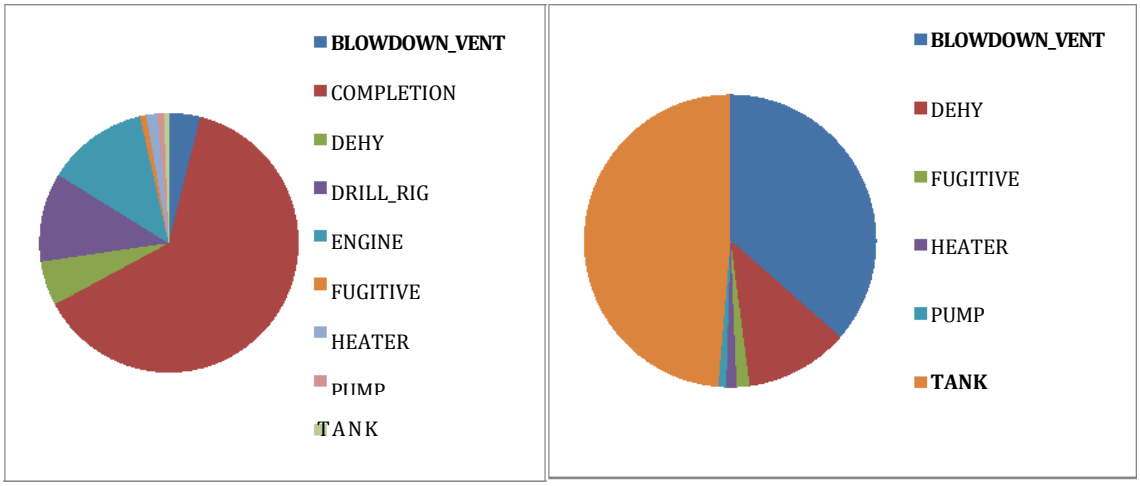
The figures below, prepared from data taken from the Pennsylvania inventory, show the activities that are the source of all emissions (methane, carbon dioxide and nitrogen oxides are removed to highlight the health concerns). Proportions are shown for 1) the overall phases in development of UNGD sources (on the left) and 2) sources of emissions from producing wells on the right. It is obvious that the venting (purging) of equipment and tanks are important major emissions during both overall development of unconventional gas fields and the ongoing producing gas wells, compressors, gathering lines and storage.

The Maryland "Risk Assessment" completely omits evaluation of the majority of emissions from producing wells. Those emissions are an important component of the environmental and health hazards.

Inventory of Reported Emissions

except methane, carbon dioxide and nitrogen cpds.

Overall Phases in Development of UNGD (PA data)	Sources of Emissions from Producing Wells (PA data)



Response: This is incorrect. There is a complete discussion of purging (referred to as well "unloading") in the risk assessment for Phase 5 – the production/processing and ancillary infrastructure phase. Risks resulting from noncombustion emissions associated with well unloadings are presented in one of the risk assessment rows in Table 20. Overall risks are considered moderate.

V. The Risk Assessment does not document the limitations in the available data, the analytical approach or the conclusions of the report.

Clear statements on the "limitations" of a risk analysis are important. Risk Assessment requires that the limitations of both the available information and analysis be clearly documented in each separate section of the report. The absence of a clear statement of the limitations is a major flaw in the overall report. Were such a section provided, it would be clear to the readers that the conclusions are not and cannot be supported by the information available presently on UNGD.

Response: The Departments concur and a discussion of uncertainty is included in the summary of findings document.

Limitations in the assessment

The following illustrates the seriousness of the problem with the overall conclusions:

- Three of the conclusions on Section B cite a serious risk to air for all phases of the UNGD activity and note that because the emissions are from multiple sources, they are difficult to reduce with BMPs.
- Further it is concluded that there is insufficient information to evaluate the differences between the low and high activity scenarios.
- The concerns documented in Appendix B are consistent with current reports that further study is needed and that there are minimal direct emissions measurements. But they are not compatible with the Conclusions in the Executive Summary and the Risk Assessment sections.

    - Moreover assessment of the rates and efficiencies of BMPs are based on voluntary industry reporting and a single narrowly limited 'on site' study. That study report emphasized extreme uncertainty between sites as well as a selection bias for measurement allowed by the industry between sites. Even so overall **high** probability for air emissions was determined.
    - That information is extremely limited and thus insufficient to determine whether BMP combustion efficiencies and set backs will protect health and safety.
    - Had the Risk Assessment considered the available Pennsylvania data on number of reported accidents for different drillers and contactors, the preparers would have seen extreme differences in reported accident rates between companies that ranged from 0 to 5 to rates that exceed 50 for the same time periods. This demonstrates a wide span in industry's attention to safe practices by different drillers and their contractors and an endemic industry failure to report accidents by drillers and sub contractors.

Given the above uncertainty, it is difficult to accept the interpretation of ranking of risks reported in the detailed analysis section of the Risks Assessment section of the report. Further risks are reported as high to moderate (Appendix A) but then characterized as low to moderate for all processes. In fact on closer reading it is clear that there is minimal information available on which to draw any conclusion with respect to public health and safety. Only the Road and Traffic Appendix appear to support assumptions with adequate data.

Response: More specifically the overall conclusion regarding air emissions is that there is a high probability of occurrence but insufficient information at this time to determine consequence. The Departments agree that risks with high probability and insufficient data to determine consequences should have been more clearly highlighted and Appendix A has been revised accordingly. Furthermore, Appendix A has also been revised not just to show the overall risk ranking but the probability and consequence rankings as well to provide additional detail regarding risk analysis.

Sections of the report that draw no conclusions:

Some sections of the report offer no conclusions. Instead of conclusions, Appendix C, D, E, F, G and H give general summaries of the section. In contrast Appendix I, Waste Disposal, gives a brief conclusion in three sentences, stating that: "the **probability of** harm is low, **consequence** of harm is moderate and overall **risk ranking** is low."

> This raises an important question: If the consequence of harm is "Moderate," which is defined on page 7 as " considerable adverse impact on people or the environment: could affect the health of persons in the immediate vicinity: localized or temporary environmental damage". How can the overall risk be rated as "Low" which is defined on page 6 as "Rarely happens under ordinary conditions; not forecast to be encountered under foreseeable future circumstances in view of current knowledge and existing controls on extraction".

The conclusion of Low Risk is not possible from the perspective of public health and human welfare.

> *The implication of this type of thinking is: 'that some health effects are acceptable in certain nearby persons if the effects are moderate and seen only in some people'. But what is considered moderate? Effects on birth rate, fetal viability and development have been reported in the published-peer reviewed literature. Effects on respiratory function and dermatitis have also been reported in the peer-reviewed literature. Further, more serious health conditions are reported from residents near gas drilling and waste sites.* From the perspective of public health, these health hazards are not moderate health effects that can be dismissed merely because they are only induced in a small number of people.

Response: The commenter is confusing the definitions of probability and consequence with the overall risk ranking. As discussed in the "Individual Risk Assessments" section of the summary document, the overall risk ranking of low, moderate or high results from combining the probability and consequence rankings. For example, the following combinations of probability and consequence, respectively, result in an overall low risk rank: low probability and moderate consequence, moderate probability and minor consequence, low probability and minor consequence. See Table 3 in the summary document for additional details. The Departments agree that this overall risk ranking methodology is fairly coarse and have revised Appendix A to show the probability and consequence as well. Furthermore, and as discussed in an above response, the Departments have included a discussion of uncertainty.

VII. Need for Public Health experience and expertise:

The above observation reveals a structural flaw in the overall preparation of the Assessment project: That flaw is the absence of involvement of a health agency or health professionals.

Response: Public health officials were represented on the Advisory Commission, which reviewed and provided input on this risk assessment. Furthermore, Maryland commissioned a public health study conducted by the University of Maryland School of Public Health, Institute for Applied Environmental Health and that considered risks independent of BMPs.

VIII. **Documentation of the limitations of the report is essential. An examination of limitations shows the important weakness of the "Risk Assessment".**

Any decision maker reading a Risk Assessment needs a clear statement of limitations of the risk analysis, especially the impact of limited data on the conclusions about health. That information is critical to any risk assessment. A section that clearly documents the limits of the report is important to understanding and making decisions based on the findings. In this report there is no discussion of limitations in either the body of the report or in any of the appendices. There is a clear lack of information to support the discussions and conclusions in all sections of the report.

A possible exception in terms of detailed references of impact is on roads and traffic. It is noteworthy that Impact on Roads and Traffic is the only section, other than Noise, that rated any of the risks as High. In all other sections, all risks are rated as moderate or lower. The final discussion in this evaluation of the Risk Assessment report will demonstrate the damage incurred with omission of discussions of limitations.

Response: The Departments concur and a discussion of the uncertainty/limitations has been provided in the summary of findings document.

IX General and Specific Comments

The following comments and suggestions address specific parts of the Risk Assessment from the perspective of:

1. What is known with certainty about the plausible hazards?
2. What are the hazards present and potential for human or environmental exposures that could damage health and the environment?
3. What are the limitations in the information available and the impact on conclusions in the Risk Assessment?

<u>A. Strong points in the report:</u>

- Use of public scoping.
- Selection criteria for literature (although key information was excluded)
- Use of agency expert groups (with the exception of public health)
- Analysis of road and traffic hazards
- Discussion of limits to Best Management Practices.

B. Weak Points that need improvement:

- Ranking system rationale
- Lack of available public health information
- Omission of discussion on exposure due to regular purging of equipment
- No discussion of social and societal impacts
- No discussion of uncertainty in specific data and limitations of the conclusions.
- Structure of the report does not provide coherent relationships between sections.
- Depth of analysis of water risks is limited
- Depth of discussion of air health risks is limited
- No discussion of impact on the local public health systems
- No discussion of barriers to quantitative assessment

C. Major limitations in the report:

- Insufficient information about the chemicals and time of exposures
- Determination of the variability in emissions between and with-in sources
- Lack of follow-up by Health Departments of reported health effects
- Time is insufficient to determine the presence of chronic health effects
- No assessment of the risk to susceptible populations and children
- Assessment of capacity of county ecosystems to absorb chemical stresses
- Discussion and identification of toxic materials brought to surface
- Lack of health and safety support for determination of set-back distances

D. Recommendations necessary to strengthen the report:

- The aggregate risks need to be determined and "bounded" for specific activities.
- Pennsylvania inventory reports for 2012 and 2014 should be used to characterize variability; well-to-well, compressor station to compressor station and processing plan to processing plant. PA data shows variability of orders of magnitude.
- Compounds present due to processing and drilling and due to flow back from fracked and producing wells need to be identified, categorized and ranked with respect to health actions and potency in air, water and food.
- All compounds need to be ranked with respect to UNGD sources and potential for human exposures.
- Report needs to be reorganized so that each section has clearly stated conclusions and limitations and objectives.
- Discussion of actual exposures to and long term implications of radioactive materials. Discussions relative to general background are insufficient to determine potential health risks.
- Quantitative analysis of the effect of each BMP rule and proposed statute on the potential for human health outcomes.

- Discussion of other reports in the United States and international literature on the quantitative human health risks from current UNGD practices in the United States.
- A discussion of the quantitative impacts of major accidents and ongoing exposures at other sites and their relevance to the Maryland Counties.
- Identifications of resources available to inform physicians and health providers of health conditions expected to occur in persons residing near UNGD.
- Discussion plausible findings available with respect to human health and exposure that have been presented in publicly available forums but not yet published in the peer reviewed literature.

Response: Noted and many of these items are responded to in the previous or following responses. Revisions, where necessary, have been made in the risk assessment to address these points.

X. Specific Comments on Each Section of the "Risk Assessment"

A. Executive Summary:

The Executive Summary is a brief discussion of process in preparation of the assessment. It is the only mention the Comprehensive Gas Development Plan, which addressed the effect of gas drilling on forested landscapes and terrestrial and aquatic resources and the impacts of water withdrawal. That report asserts that Maryland's drinking water resources are protected by the Water Appropriation Program. Other than the general thoughts that "risks are inherent in any types of mineral extraction" and that "existing and proposed practices serve to reduce many risks Maryland Citizens," public health and safety are not mentioned, nor is impact on communities. However the report is addressing unacceptable risks to public health and the environment.

The absence of concerns for public health continues throughout the report.

Response: The Comprehensive Gas Development Plan is indeed mentioned and considered in the appendices (for example, see Table 3 of Appendix B). Public health, safety, or similar terms are mentioned many times in the Executive Summary. Furthermore, the Executive Summary has been revised to address some of these concerns and includes additional mention of human and ecological consequences/risks.

B. Risk Assessment sections: This is the body of the report.

Although the Advisory Commission and the public participants requested a "formal Risk Assessment", this report does not follow the format or content of a 4 step Risk Assessment which are: 1) Hazard identification 2) Dose response assessment, 3) Exposure assessment and 4) Risk characterization. Moreover, the four principles - Transparency, Clarity, Consistency, and Reasonableness required in risk assessments are not present. There is also no clear discussion of limitations and conclusions.

Instead this risk assessment describes:

- Methodology and identification of risks for evaluation (Literature and information sources)
- Consideration for Best Management Practices
- Development scenarios, individual risk assessments
- Risk Assessment for 5 Phases of UNGD, and
- Conclusions

The list of risks for evaluation is incomplete. A major risk leading to adverse health effects from human exposure, the regular purging and venting of wells, pipelines and equipment, is omitted from the list. *This omission seriously reduces the value of the Risk Assessment for determining potential health risks.*

Response: The Departments disagree. As you mention in the first bullet above, the Departments conducted extensive review of the scientific literature on the human and environmental impacts of UGWD, which is a standard approach to identifying hazards, dose/response relationships, and exposures. This included use of EPA's Integrated risk Information System which evaluates information on health effects that may result from exposure to environmental contaminants. After this scientific literature review regarding human and environmental exposures/impacts during the different UGWD phases, the strength/effectiveness of the BMPs or existing regulatory were evaluated in terms of risk mitigation, and then an overall risk ranking/characterization was performed. Having said this, the Departments do acknowledge that this is a qualitative risk assessment because numerical data regarding risks are not generally available and thus best professional judgment is used to characterize risks. This results in some uncertainty or limitations in the risk findings which has been included in the report. Further, as mentioned in an above response, well purgings or unloadings were indeed considered in the risk assessment.

Background sections of the RA.

- Literature and information sources are limited and do not include the information concerning human health exposures nor mention the extensive citizen reports of effects on children, nearby residents, farm animals and pets or wildlife. *Gas <u>horizontal</u> drilling and hydraulic fracturing began in 2005. There is insufficient time for the observed human health impacts to have reached the peer reviewed literature. The few reports that have been published indicate a major health problem for nearby residents to nearly all UNGD activities. The decision to limit information when selecting information precludes a useful analysis of health hazards.*

  Response: The Departments concur that some studies and reports indicate human health effects associated with UGWD and that future studies will shed additional light on this matter. The Departments' made every attempt to consider the latest science and information in our risk assessment, but to complete the study and come to some conclusion you have to at some point stop reviewing additional literature. Where risk assessors ascertained that there was still insufficient information to assess risks after consideration of proposed BMPs, this has been indicated in the findings.

- Best Management Practices asserts where there is uncertainty about existing laws, regulations, permits, BMPs would be adequate to protect the respective resources. It also states those uncertainties are noted in the document. *Instances citing conditions where the resources would not be protected by existing statutes and BMP are extremely difficult to find. Yet the policy maker is expected to take those into consideration. Such "failure to protect" uncertainties must be listed separately and discussed in detail.*

  Response: As noted in the above responses, discussion of limitations/uncertainty has been included in the summary of findings document.

- Development of scenarios: It is rare to see fewer than 6 wells at a site and there can be as many as 12 or more. The time of impact, disruption due to machinery and trucks could be twice the projected levels. Recycled water is discussed but there are limits to number of recycling times. It seems unlikely that scenario number 1 is economically feasible.

  Response: The Departments are able to limit the number of wells on a pad using our permitting authority and to protect public health and the environment. Furthermore, the Comprehensive Gas Development Plan is another mechanism that can be used to limit the number of wells on a pad as well as the number of pads, roads, etc. in a given UGWD area. The Departments concur these two mechanisms provide adequate controls.

Summary of individual risks (page 6)

Individual Risk Assessments in the Risk Assessment are based on qualitative opinions on the probability and consequences of each risk assigned. A matrix was developed based on low medium and high **risk factors** and minor moderate and serious **risk consequences.** A consequences/risk ranking probability matrix table was developed to obtain overall risks.

- What is obtained from this exercise is not a probability of risk but a relative estimate based on extremely limited quantitative information. *It is difficult to see how this provides meaningful data for assessing risk to public health. A minimal level of certainty is required when advising a person on the safety of themselves and their families. I recommend that the table should not be used to assess the hazard to the public and be carefully reviewed before advising on environmental risk.*

  Response: As noted in the above responses, discussion of limitations/uncertainty has been included in the summary of findings document. Furthermore, Appendix A has been revised to provide additional details regarding risk ranking. The Departments concur that

this information is of value to the decision-makers and compliments many other studies (public health, economic, best practices, etc.) conducted under the Marcellus Shale Safe Drilling Initiative Executive Order. These other studies are available at: http://www.mde.state.md.us/programs/Land/mining/marcellus/Pages/index.aspx

Five Risk Assessment Phases

A brief risk summary paragraph is provided for each of the five phases of unconventional gas development. Each finding is listed in a sentence together with an assessment of the level of risk for the individual risk. Judgmental phases such as, "high standards set for casing etc. are among the many best practices that reduce surface and ground water risks" are inserted from time to time.

It is clear that human exposures are occurring. But this risk assessment approach lacks the power necessary to determine health and safety.

- There is no evidence of quantitative support for the comments. The comment relative to production is especially noted where the assessor concludes "that stringent controls and setbacks from ecological and community feature are among the many best practices that reduce the risk of contamination for human consumption." The author next follows with the observation that insufficient data were available to assess the health consequences from of air emissions because of uncertainties. In spite of this data gap a moderate risk was assigned based on methane.
- *The actual organics in the emissions have not been measured in the hourly time periods needed to evaluate human health effects.*
- *The content of the mixtures in water and air are only partially known.*
- *When human exposures have occurred, non-disclosure agreements put in place by industry and the courts have prevented the obtaining of health information on potential exposures.*
- *Given these limitations to the obtaining of human health information critical to assessment of health it is impossible to determine the safety of any person or facility near the gas drilling.*
- *Schools, hospitals, and daycare centers need to be considered high-risk locations but there is no mention of these populations.*

Phase 1 Site identification summarizes the risks as low for vibration and visual impacts for communities and moderate for air emissions and ecological impact. The paragraph refers to appendix B, C and F, Air emissions, Road and Noise, respectively.

Phase 2 and 3 Drilling and Hydraulic fracturing/completion, summarize the risks as low for noise, impact on ground and surface water, releases from tanks or spills; moderate for accidents and inconvenience, air emissions, aquatic systems: high for road repairs and emissions for 75% scenario. These paragraphs refer to Appendices B through I.

Phase 4 Production summarizes the risks as low for truck traffic, low for compressors, drinking water contamination, except for methane, community features such as schools; moderate for gathering line

and forest ecology, some compressors and human health. This paragraph refers to appendix B, C, F, G and I.

Phase 5 Well Abandonment/Reclamation summarizes risks as low for soil contamination/subsurface leaks and minimal for truck traffic and ecology. This paragraph does not refer to any other section of the report.

Conclusions

The overall Conclusions of the report, on Page 2 of the Executive Summary and Page 12 of the Risk Assessments, assert that:

1) "the utilization of proposed practices serve to **reduce many** of the risks to the citizens, economy and quality of water, air and natural resources' and
2) that if risks are found **unacceptably high** additional mitigation steps could be taken
3) or extraction can be deferred until risks are reduced by new technology or until data is obtained that the best practices are effective to reduce the risk."
(format added)

The Conclusions are vague and general. These are not acceptable conclusions for any Risk Assessment. The conclusions do not provide guidance or direction to decision makers. Further the conclusions are based on findings from information (reports) that are limited both in scope and technical depth. They are also incomplete and do not capture the information found in the analytical sections of the report.

Careful reading of the information and the analysis in the Appendices leads to the opposite conclusion: There are major human health and ecological risks, but insufficient information is known about the mechanisms and sources of the hazards to address the mitigation of the hazard until more careful basic studies are completed at currently active sites.

- Limitation discussions are an integral part of Risk Assessments. The limitations section should identify the gaps in information in report as well as the limitations of any process described. The impact of the data gaps should be included in a discussion of the actual conclusions.

There are three important questions addressed in a Risk Assessment of health and environmental concerns.

1) What is known with certainty about the plausible hazards?

2) What are the hazards present and potential for human or environmental exposures that could damage health and the environment?
3) What are the limitations in the information available and the impact on conclusions in the Risk Assessment?

This risk assessment section, which is the core of the report, fails to meet any of the above criteria. There is no detail or discussion in the risk assessment section. Each paragraph merely mentions the findings from each of the Appendices without critique. Even when the information in the appendices is considered, the analysis and the information is insufficient to assess the risks.

Response: Noted. These comments reiterate those made above where responses have already been provided.

XI. Implications of the failure to address the incomplete data and limitations in the risk assessment:

The following are three case examples of the consequences when limitations in available information are not considered.

- Example 1 is the failure to identify the chemicals in the emissions and the health and environmental damage induced by the chemical mixture (Air Emission Risk Assessment Appendix B)
- Example 2 is the failure to accurately identify probabilities of release of toxic chemicals (Drilling fluids and cuttings, Appendix C)
- Example 3 is failure to recognize the limits of the remedial action available to the state and towns (Road and Traffic appendix C)

Example 1

The health and environmental damage induced by the chemical mixture, Air Emission Risk Assessments Appendix B.

The Air analysis reached the following conclusions:

1. The probability for air emissions is high but consequences cannot be determined due to insufficient information on BMP and set back efficiencies and other factors.
2. There is a 'high' probability of air pollution emissions from all phases even when BMPs are in place.
3. Most of the high probability emissions result from multiple overlapping sources. There is insufficient information to determine the consequences.
4. There is insufficient information to determine the differences between the low and high drilling scenarios.
5. The hydraulic fracturing/completion phase emissions projected for 60 to 80 percent of the year for high scenario and 20 to 27 percent for the low scenario yielding moderate consequences and low consequences respectively.

Thus the risks are determined to be high but the consequences are not determined because of lack of information on the identification and effects of the chemicals.

Some of the Limitations are:

1. No data to determine the consequences of the multiple sources.
2. Only one study has measured on site emissions and it is limited in scope.
3. EPA is unable to quantify the emissions.
4. Hydraulic fracturing phase risk differences are undeterminable.
5. RA is not unable to integrate peer reviewed health findings in the assessment of consequences.
6. RA does not quantitatively determine the benefits of BMPs and cumulative synergistic health risks.

Response: The Departments concur and a discussion of the uncertainty/limitations has been provided in the summary of findings document. Furthermore, the Executive Summary has been revised to better reflect conclusion reached in the individual appendices.

While there is information available to identify the chemical agents released from UNGD and the toxic hazards to human health and the environment, the Risk Assessment did not acquire or use it.

- *The Pennsylvania Inventory Reports documents the release of 14 chemicals released by site and location for 2011 and 2012. Monitoring data has been published in Peer reviewed sources from Colorado, Texas, Pennsylvania, West Virginia and Wyoming. A landmark report was released from Dish, Texas that measures chemical releases from overall sites and as precise as specific valves and tanks.*

  Response: The Departments did indeed review, analyze and discuss the findings of many of these reports. Please refer to the references section of each appendix for additional details..

- *A cursory examination of these data show the presence of diesel particulate, formaldehyde, a spectrum of 1 to 3 carbon compounds containing chlorine, fluorine and bromine, aldehydes, biocides, hydrogen sulfide, toxic silica as well as benzene, toluene, ethyl benzene and xylenes, radium and other radioactive materials. The toxic actions of most of these compounds are well understood. But there are also chemicals produced in the shale itself which have never been studied and the toxic actions are unknown.*

  Response: Again, many of these chemicals are indeed addressed or mentioned in the risk assessment. See the appendices for more details.

- *What is clear from the risk assessment is that these compounds will be released into the air at high amounts during drilling, fracking, purging of equipment, waste disposal and accidents.*

Response: It is more correct to say that the Departments agree that there is a high probability that these chemicals will be released to the air. This does not necessarily mean they will be released in high amounts and more information is needed to make that determination.

The Maryland "Risk Assessment" report acknowledges, on Page 33 paragraph 3 that blow–backs are a hazard to workers but because they are rare (1 in 1000) and the workers are not considered in this report, blow-backs are ranked as a minor hazard. The report further asserts that a 1000 to 2000 foot setback would remove the hazard to the public health.

- *Table 14 page 21 shows blowout rates for offshore gas wells which are not the type of wells proposed for the Maryland counties, even so when all categories of blow outs are counted, occurrences are not 1 in 1000 but 4 in 1000.*

- *Further, when it is considered that in the mountains of Western Maryland about 1/4 of the days experience hours of low wind speeds, 1 to 2 miles per hour, onsite releases will move off site, past the 1000 and 2000 foot setbacks, in minutes.*

- *At 1 mile per hour wind speed air will travel 1000 feet in 6 minutes and 2000 feet in 12 minutes, insufficient time to dilute the chemicals released by blow-backs or silica used in during fracking to safe levels.*

- *Finally on page 43 first paragraph comment # 4 states that, "impacts from leakage is not large enough to outweigh natural gas benefits over coal." While that discussion involved global climate change and energy it reflects the quality of the judgments relative to hazards made throughout the Appendix. A choice is being made between health and the environment and the need for the technology. Thus the consequences of the projected exposures are ruled as minor with respect to human health and the environment in contrast to development rights.*

Response: Regardless of whether blowouts are 1/1,000 or 4/1,000 they are still relatively rare and the greatest risk remains to workers on site. Again and as you mention, worker safety is not the purview of the Departments and is thus considered outside the scope of the risk assessment. It is correct that in the rare event of a blowout emissions would travel off-site. You provide the example of 1 mile/hr. wind speeds (equals 5,280 feet per hour) and 1,000 feet is approximately one/fifth of a mile. One fifth of a mile times 1 hour/mile results in approximately 12 minutes travel time. So, a 1,000-foot setback with 1 mile/hr. winds equates to a 12 minute travel time, while a 2,000-foot setback equates to a 24-minute travel time.

There are many factors that determine rate of dilution such as wind turbulence, land surface impacts on wind speed/direction, the rate of rise of lighter-than-air emissions over a given distance, etc. Moreover, wind changes direction over time/days, the fact that neighboring residents likely work or are otherwise indoors and not receiving constant exposure also come into play in assessing risk. It is the Departments' conclusion that only

under perfect environmental conditions would direct exposure with little dilution be an issue, and even if this occurred it would likely be short-lived as wind speeds/direction change with the weather. Given the rarity of a blow-out to begin, the rarity/short duration of perfect environmental conditions, and the proposed setbacks, the Departments consider blowouts an overall low environmental and public health risk for off-site residents.

This analysis fails to meet any of the following criteria:

1) What is known with certainty about the plausible hazards?
2) What are the hazards present and potential for human or environmental exposures that could damage health and the environment?
3) What are the limitations in the information available and the impact on conclusions in the Risk Assessment?

Example 2

Appendix D - Drilling fluids and Cuttings, ranks all Environmental Impacts as minor based on low Probability. All consequences are rated as moderate. But are the probabilities actually low?

All of the low ranks are based on one of two reports,

- The first report, described on page 5 & 6 under "Transport of Drilling Fluid Additives to the Well Pad," are based on the 2004 to 2013 tabulation of incidents by the Pipeline and Hazardous Materials Safety Administration. On road incidents (14,074 annual average incidents over 10 years PHMSA 10 year incident summary report.) was divided by the total number of shipments of hazardous materials of 800,000 reported in Craft 2004. **The probability of a release is calculated to be less than 0.005% this factor is used to calculate all of the transportation risks!**
    - **Shipment data collected before 2004 is compared to accident data collected after 2004 to 2013.**
    - **Accidents for all hazardous materials is used to evaluate UNGD transport accidents.**
    - **The source of these files need to be validated.**
    - **How representative is all of the hazardous materials accidents vs. all of the transportation all hazardous materials in the United States of the accidents that would occur in two western Maryland counties impacted by gas transportation of hazardous materials on country roads? It is not. But more troubling is that no data was found relevant to the key questions in the Risk Assessment.**

- The second report used to estimate the likelihood of a spill or leak is described on page 10 'Risk Identification'. A study of Wells in Bradford County identified that 8% of the wells had violations handed out to gas operators for spills and leaks on the well pad. (NYSWRI 2010). All subsequent calculations of risk are based on this 8% 'spills and leaks' report in spite of

the fact that in the next three sentences the Risk Assessment says " THE INCIDENCE RATE IS LIKELY TO BE GREATER." Further, the risk assessment states that there is no information of the spill rates at any of the individual stages evaluated but they may be fewer at individual stages.

- **This risk number has not been validated in any way that justified the assumed risk assessment application.**
- **Pennsylvania does not regularly inspect any well pad but reacts to industry reported incidences. Thus the management at the drill sites decides what will be reported and the inspector has the option of issuing a citation.**
- **The number used is meaningless with respect to the assessment of Drilling and Fluid Cutting Risks. Moreover, it cannot be used as a basis for determination of effectiveness of the Current regulations and Proposed BMPs. IT IS VERY LIKELY TO UNDER ESTIMATE THE HAZARD.**
- The Data in the Risk Assessment table showing low probability of risks is not supported by the cited references and is probably incorrect. But the calculations are used to support the risks listed in Table A and subsequently used to support the conclusion in the Risk Assessment and Executive Summary that **"the utilization of proposed practices serve to reduce many of the risks to the citizens, economy and quality of water, air and natural resources".**

Response: As mentioned in responses above, the risk assessment is qualitative in nature and thus subject to limitations and uncertainty. Revisions have been made, as described in the above responses, to address these concerns.

Example 3

Appendix C, Road and Traffic, ranks the probabilities of four of the seven Risk Categories as moderate or high. Only site identification, site preparation and production and site reclamation are rated low. Five of the seven consequences are rated as moderate to serious. This is based on a detailed and strongly supported analysis of the information with abundant pertinent references.

The assessment of the current regulations and the BMPs indicate steps that could be employed to reduce but not eliminate the risks.

- In the conclusion the report notes that driver fatigue and agreements with the industry to ensure the performance of their agreed obligations is essential.
- Fatal accidents involving residents of these counties are likely to occur. There is no acceptable risk number for fatalities and disabilities.
- Driver fatigue is central to the safety question but is not under the statutory control of the State of Maryland or the local officials. Most of the activities that support the site are conducted by subcontractors that are not under the control of the well owners, leaving no oversight or control.
- There is no mechanism to reverse the habitat loss, fragmentation, increased sedimentation, storm water runoff and recreation impacts.
- Page 26 is an example of the effect of oil field exemptions that applies to the oil and gas industry. These cannot be changed by local governments or the State of Maryland.
- Thus even when the hazards are well documented and assessed there is no assurance that current regulations and Best Management Practices can reduce them to levels that protect health and the environment.

Response: The commenter correctly notes some of the limitations and uncertainties described in the risk assessment.

XII. Summary:

1. The "Risk Assessment" establishes that human health and environmental risks are present but does not analyze the risks sufficiently to determine the level of hazard to Public Health or the Environment. This failure is due in part to limited data, but also it is the result of the untried novel, and limited approach used in the assessment.

2. The Conclusions are vague and general. They do not provide the information needed by decision makers. Further, although the Conclusions are based on findings from information that is extremely limited both in scope and technical depth, those limitations are not listed anywhere in the Risk Assessment.

3. The Conclusions in the executive summary are not compatible with the findings in the Appendices sections of the risk assessment. The Risk Ranking is not valid.

4. The Maryland "Risk Assessment" completely omits evaluation of the majority of emissions from producing wells. Those emissions are important components of the environmental and health hazards

5. The absence of involvement of a health agency or health professionals is a serious error in the organization of the risk assessment project.

6. There are major human health and ecological risks, but insufficient information is known about the mechanisms and sources of the hazards to address the mitigation of the hazard until more careful basic studies are completed at currently active sites.

7. The Risk Assessment's most serious flaws are the failure to identify the limitations of the available health and environmental data, the failure to clearly state the conclusions and failure to discuss the limits of the BMP and regulatory options to protect Public Health and the Environment.

Response: These bullet points summarize the comments made above which have already been responded to. No further responses are needed here.

Comments Received from Dr. Anthony Ingraffea and Renee Santoro, on Behalf of Physicians, Scientists and Engineers for Healthy Energy

Thank you for inviting us to review the draft *Assessment of Risks from Unconventional Gas Well Development in the Marcellus Shale of Western Maryland* (MDRA). As a national organization comprised of physicians, scientists, and engineers, we appreciate the opportunity to share with you our views regarding the MDRA. PSE Healthy Energy is an independent non-profit that provides evidence-based information on various forms of novel energy development. We maintain formal affiliations and relationships with faculty members across a range of disciplines at a number of national institutions, including Pennsylvania State University, Cornell University, Duke University, and Stanford University.

We applaud the relative strength of the proposed best management practices (BMP) and revised regulations for unconventional wells in Maryland; however, we feel the current MDRA is incomplete, the effect of BMPs in some instances over-estimated, and overall, MDE's ability to enforce compliance of the BMPs questionable. In particular, the absence of any assessment of regional air impacts and climate impacts concerns us. We also question the conclusion of "low" risk to groundwater due to well-bore failure and/or impairment. Our detailed comments and concerns are provided below.

Air pollutants

The MDRA assesses ambient air quality impacts from Marcellus shale development in western Maryland based on the NYDEC (2011) ambient air quality analysis and concludes that emissions, though high, will have only low to moderate impacts on local human populations due to emission controls and the proposed setbacks. We agree that the proposed BMPs *if* effectively and consistently enforced will likely reduce the ambient concentrations of criteria pollutants resulting from individual stages of Marcellus shale development and the risks posed by these to discrete, local populations to the extent possible given the intensity of industrialization required in shale exploitation. However, the MDRA fails to assess environmental impacts of new emission sources locally and at a distance, specifically if and how development emissions might affect on-going efforts to restore the Chesapeake Bay.

Much of the Chesapeake Bay is impaired due to excessive anthropogenic nitrogen (N) loads, resulting in algal blooms and seasonal dead zones, loss of sea grasses, fishery declines, and overall poor water quality. Atmospheric deposition of N emissions sourced within the Bay's airshed makes up roughly a third of the total N load to the Bay.

Despite great efforts over the past 25 years, little progress was made in improving the health of the Bay. In 2010, the U.S.EPA (2010) established total maximum daily loads (TMDL) to reduce N loading from the watershed states (MD, DC DE, PA, NY, VA, and WV) to the Chesapeake Bay by 25% by 2025. Maryland has already made great strides in reaching its TMDL goals with a total reduction of 4.4 million lbs N from 2009 levels as of 2013. The state has committed to a target load of 45.5 million lbs

N by 2017 with an additional reduction of 4.5 million lbs N by 2025, or annual reductions of roughly 0.5 million lbs N between 2017 and 2025.

Assuming annual well and one-way truck trip counts from the RESI development scenario 2 (RESI 2014, Figure 21), peak annual NO_x emissions associated with Marcellus development in western MD are estimated at 0.44 million lbs N yr^{-1} (Table 1). Emissions from light-duty and heavy-duty short haul trucks assume the median emission factor for all model years from the year of drilling activity to ten years prior (Cai et al. 2013), federal pollution controls, and a 50 mile round-trip distance. Well emissions assume ALL (2010) upstream emission factors adjusted for 30hr flaring and a 10-stage completion on all wells. As per the RESI (2014) analysis, all wells are assumed to be horizontal. Mass of NO_x is converted to mass of N assuming 100% NO2 (N:NO2 = 14:46.01). Assuming that 25% of N inputs are loaded to the Bay (Howarth et al. 2011), these emissions equate to a peak annual load of 0.11 million lbs N yr^{-1} in 2018, or more than 20% of the expected annual load reductions for that year. Percent of MD anticipated annual load reductions over the full time period range from 11% to 22%.

The estimates of additional N loading presented here are only preliminary estimates of atmospheric N loads to Chesapeake Bay based on reasonable, though greatly simplified, assumptions. Yet these calculations do indicate a potential for substantial environmental risks which are not assessed in the MDRA. Drilling and mobile source emissions associated with Marcellus development in Garrett and Allegheny Counties may substantially undercut statewide efforts to reduce nitrogen pollution to the Chesapeake Bay. A more complete analysis of new emissions and assessment of the environmental risks related to these new inputs (including emission impacts of population/vehicle count growth in the airshed over the same time period) at the regional scale is needed. Without this the MDRA is incomplete.

The MDRA also fails to assess other non-local environmental and community impacts (e.g. acidification, photochemical smog) from air emissions, and cumulative impacts of all stages. While the review team does discuss the difficulty of assessing the cumulative air quality risks of development in the concluding paragraphs of Appendix B, the Executive Summary does a very poor job of highlighting this important caveat (see section below on *Transparency*).

Response: The Executive Summary document has been revised to better reflect the air emissions risk conclusions presented in Appendix B and should help address your comments in the last paragraph. As to UGWD impacts on nitrogen (N) loading in Chesapeake Bay, the analysis you present is oversimplified in that to truly assess impacts you would need to also look at the N emissions from other current energy sources (such as coal), calculate a mass balance for each, and then compare to see which results in greater N loading. This is no trivial undertaking and due to the level of analysis entailed coupled with the fact that it needs to be assessed from a larger airshed sources perspective, it is considered outside the scope of the risk assessment.

Climate

The MDRA omits a full assessment of climate impacts stating that, "the scientific community is still divided on whether GHGs emitted during the production and transmission of natural gas outweigh the lower GHG emissions of natural gas when it is burned and over what timeframe" and that the level of analysis necessary to accurately assess whether development would create an unacceptable risk to global warming is outside the scope of the MDRA. We strongly disagree.

While there was considerable debate regarding the life-cycle climate impacts of natural gas as recently as early 2012, a growing number of studies have since clarified the climate impacts of unconventional oil and gas development and natural gas substitution in electric power generation. The majority of these studies conclude that: 1) emissions from unconventional natural gas are higher than previously thought; 2) emissions are substantially higher than estimates reported in bottom-up inventories; and 3) that coal-togas-substitution will *not* bring the previously assumed climate benefits. We've attached a climate brief which highlights the most recent peer-review literature on climate impacts of unconventional oil and gas, including a diverse spatial range of atmospheric measurements and full emissions modeling studies for coal-to-gas substitution.

Several recent studies provide adequate data to qualitatively assess the climate risks of unconventional gas development in Maryland. Taken in combination with Maryland's vulnerability to climate impacts and legal commitment to reducing greenhouse gases and renewable energy portfolio standard, the climate aspects of unconventional gas are absolutely within the purview of a state risk assessment for Marcellus shale development. We urge the State to reconsider the omission of climate impacts in the MDRA.

Response: The Departments do not necessarily dispute your comments above, but there is one important caveat to them: the above studies were not done in areas with BMPs comparable to what Maryland is proposing. As you indicate in your comments on air pollution above, Maryland's "proposed BMPs *if* effectively and consistently enforced will likely reduce the ambient concentrations of criteria pollutants resulting from individual stages of Marcellus shale development and the risks posed by these to discrete, local populations to the extent possible given the intensity of industrialization required in shale exploitation."

To reiterate what is stated in Appendix B's section on climate change "Maryland's proposal to require rigorous leak detection systems and methane offset BMPs will help reduce overall emissions. However, to accurately assess whether UGWD creates an overall unacceptable risk to global warming, it will be necessary to empirically measure the life-cycle greenhouse gas emissions from other fuel sources, such as coal and petroleum, for relative comparison. This type of analysis would include analyzing different energy sectors across the country and recalculating life-cycle energy emissions inventories. Since this level of effort is outside the scope of this risk assessment, increased risks to global warming from shale gas extraction in Maryland has not been considered in this analysis."

Chemical and waste transport spills

The MDRA analysis for surface spills resulting from transportation of frac additives, and drilling and completion wastes relies on poorly chosen assumptions regarding the likelihood of incidences. Shale gas development is associated with a greater truck density over small clustered spatial areas and higher incidence of traffic accidents. This is correctly recognized in the MDRA's assessment of traffic risks, yet ignored in the assessment of surface spills resulting from traffic accidents, which uses 10 year

summary data averaged over the entire U.S. The problem with using this level of PHSMA data is that it does not take higher incident rates locally and over a time frame relevant to modern (i.e. unconventional) well development. A better estimate of incident rate specific to Marcellus development is estimated from state statistics averaged over the 'boom' time of development.

The Marcellus boom in Pennsylvania started in 2008 with 332 wells drilled statewide. Assuming 365 trips per well for chemical and waste hauling (MDRA, Appendix C), these wells are associated with a little over 12,000 trips. The PHMSA records 869 highway incidents (PHMSA, 2014), or an incident rate of 0.72%, which is *two orders of magnitude higher* than the 0.005% incident rate reported in the MDRA, Appendix E and I. Incident rates in Pennsylvania drop in years after 2008 to an average of 0.16%, but this is orders of magnitude higher than the incident rate estimated at the national scale over the last 10 years.

Revised annual incident rates based on Pennsylvania data (Table 2) and applied to the proposed development scenarios for Maryland increases the total number of surface spill incidents from truck hauling of frac chemicals and off-site hauling of wastes to 92 and 277 under Scenario 1 and Scenario 2, respectively.

Response: This is decimal point misplaced in the above comments (869/12,000= 7.2 % not 0.72 %). The Departments reviewed the information cited and available at

(https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/search.aspx**). When a search was performed from 01/01/2008 to 12/31/2008 for highway incidences in transit, only 151 incidences resulted. When the search is narrowed for only "Consequence = Material Entered Waterway/Storm Sewer", two incidences resulted - 2/12,000=0.016% which is still an extremely low percentage consistent with the risk assessment findings.**

Wellbore integrity and groundwater risks

The MDRA asserts that "The high standards set for casing and cementing practices, management of materials and wastes on and off the site and careful siting resulting from location restrictions, setbacks and geologic studies, yield a low risk that ground and surface water supplies will be impacted either through surface spills or subsurface releases during the drilling and waste transport process." This over-confidence in the BMPs to mitigate risks to water supplies ignores the complexities inherent in deep-well planning, construction, and successful casing/cementing for the life of a well. Integrity hazards for unconventional wells, which are often deeper, rely on horizontal well configurations, and frequently penetrate high temperature and pressure formations, are particularly problematic (Ingraffea et al. 2014 and references cited therein).

As an example of the limits of regulating subsurface physics, Pennsylvania (PA) greatly strengthened well construction regulations in February of 2011 after several widely publicized gas migration events and surface blowouts. The revised regulatory text provides detailed requirements for cement and casing characteristics and construction best practices, as well as mandates quarterly reporting of well

integrity measurements carried out by the operator. Analysis of inspections on 6,000+ wells spudded prior to and since the strengthening of state regulations (Table 3) reveal a substantial decrease in well integrity problems. However, the rate of impairment in wells spudded since the regulatory revisions is still alarmingly high (7.7%).

It should be noted, however, that inspection records provide a *lower bound* of actual impairment rates. Not all wells are regularly inspected and not all inspections provide sufficient information to determine impairment status, thus actual impairment rates may be substantially higher. Data collected from regularly scheduled and reported well integrity monitoring will greatly improve rate estimates and understanding of spatial heterogeneity in well integrity risk factors.

While not every well impairment will contaminate a private water supply, a single leaking well can and has been known to contaminate more than one drinking supply. The Pennsylvania DEP recently released a listing of 243 water supplies impacted by oil and gas development between 2008 and August 2014. Determinations are often made when a complaint coincides with drilling or stimulation activity of a nearby well, so many of the determinations should relate temporally with spuds. However, of the 200+ impacted water supplies reported by PADEP, 35% were determined more than a year after the revised well construction regulations took effect. This implies only a minor change in the rate of positive determinations for water supply contamination since enacting stronger well construction and monitoring regulations.

It must be recognized that even with pre-drill assessments, strong well construction guidelines, and ongoing monitoring – such as enacted in Pennsylvania – wellbore integrity problems and water well contamination events persist. The full wellbore integrity hazards posed by high temperature and pressure downhole environments, horizontal drilling, and spatial intensity of development (multi-well pads and clustered drilling) are still poorly understood. Based on the Pennsylvania experience, we see no evidence to support the MDRA assessment of low risk to ground waters from loss of wellbore integrity.

Response: Although as you mention not every well impairment contaminates ground water, the Departments nevertheless share your concerns regarding well integrity and have adopted the best practices currently available to address these concerns. Any specific input regarding additional well construction techniques that can be incorporated to further reduce risks will be seriously considered. The Departments also acknowledge that a robust inspection, compliance and enforcement program is an essential component to ensuring well integrity and plan to adopt appropriate fees to implement.

Additional Concerns

Enforcement of new regulations and BMPs. The assessment places a high-level of confidence in the updated regulations and proposed BMPs to effectively mitigate several potential risks, yet neither the MDRA nor economic impact report (RESI, 2014) discuss in any depth the staffing and training required to effectively enforce such measures. MDE responses to public comments in the appendix of the MSSDI Study II mention the availability of permitting fees to help with the cost of hiring

additional regulatory staff, but, as far as we can tell, no analysis of the expected staffing levels and training requirements has yet been completed. This is worrisome.

Numerous states in active unconventional gas development show inadequate regulatory staff to handle the influx of permits and ongoing regulatory responsibilities associated with unconventional oil and gas development (Lustgarten, 2013). Pennsylvania increased staffing levels in 2011 – more than three years after the start of development and only after highly publicized clusters of serious drilling impacts in densely drilled counties. Strong regulatory codes and BMPs are useless without state capacity to enforce them. That capacity needs to be assessed prior to development, not after the fact, so that inadequacies can be identified and properly planned for.

Even well-staffed regulatory agencies often still lack the resources to oversee all oil and gas activity, thus the efficacy of the proposed regulatory changes relies heavily on the State's capacity to assess penalties for infractions in an amount that provides sufficient incentive for compliance. MDE Subtitle 19.01 provides a penalty limit of $50,000. With the value of the gas produced from a single Marcellus well estimated at $2.9 million (Earthworks, 2012), the potential loss of $50,000 if an inspector happens upon an infraction is hardly incentive to comply with the BMPs. The relative risk is further reduced when compliance costs (e.g. the costs associated with waste disposal, long-term monitoring, wellbore remediation, etc.) are factored in. Thus, the financial incentive to *avoid* penalties must be substantially greater than the compliance costs borne by operators.

Given these limitations, the ability for the BMPs to effectively mitigate the risks assessed in the MDRA is questionable within the current regulatory and enforcement framework. The individual risk assessments need to account for this in order to provide an accurate picture of risk to policy-makers and citizens. Moreover, the proposed BMPs must be supported by higher penalties and the penalty cap removed.

Response: The Departments share your concerns regarding the critical importance of compliance and enforcement, as well as the inadequacy of Maryland's current regulatory framework. Maryland is developing new regulations that incorporate best practices and well as appropriate fees to administer a compliance/enforcement program.

Transparency. Several of the MDRA teams made important qualifications in the concluding remarks of their reports regarding their ability to assess phase-specific consequences and cumulative risks with the data available. Unfortunately, the Executive Summary of the MDRA makes no mention of the concluding remarks and critical caveats discussed by any of the assessment teams. It is critical that policy-makers and citizens understand the limits of the individual risk assessments, as well as the potentially larger, but not yet assessed, cumulative impacts to specific human and the environment receptors.

Maryland has proposed strong BMPs for shale gas development, which may reduce the risk of the local-scale impacts to the extent possible given the large-scale industrialization associated with shale-gas development. However, there are important caveats:

1. The efficacy of the BMPs rely heavily on the state's enforcement capacity;

2. Unconventional gas and oil well construction is a complex task and each well will have somewhat unique challenges. Despite best intentions, accidents and downhole surprises occur

often. Though strong regulations can aim to minimize the impacts of such occurrences, it is difficult to estimate the mitigating effect of such regulations; and,

3. Cumulative impacts are not assessed, and may be more significant than the sum of the parts.

Some of these caveats are discussed in concluding remarks of the individual reports, but are ignored in the Executive Summary. This should be corrected with the team conclusions & recommendations compiled in the conclusion of the Executive Summary. Moreover, while the draft MDRA is a good start at a difficult task, in its current version, it is incomplete and in some aspects relies on inappropriate assumptions. Further analysis of off-site air quality impacts (N pollution to the Bay, photochemical smog, etc.) and climate impacts are needed. Additionally, transport of hazardous chemicals and waste needs to be re-assessed with data specific to active development areas.

Response: The Executive Summary has been revised to address these concerns and a discussion of uncertainty/limitations has also been provided in the summary report. Again, as stated above the Departments concur that a robust compliance and enforcement program will be necessary and are pursuing an appropriate fee structure, as well as new regulations, to address this concern. In addition the Departments are proposing rigorous monitoring programs be put in place to determine if/when practices fail or are not properly implemented, as well as development of Comprehensive Gas Development Plans and robust setbacks to minimize impacts on the landscape. These and the other best management practices proposed will help address both site-specific and cumulative impacts.

Comments Received from Mr. Erik Milito, American Petroleum Institute

The American Petroleum Institute (API) is a national trade association representing over 600 member companies involved in all aspects of the oil and natural gas industry. API's members include producers, refiners, suppliers, pipeline operators, and marine transporters, as well as service and supply companies and contractors that support all segments of the industry. API and its members are dedicated to protecting the environment while economically developing and supplying energy resources for consumers. API members carry out operations for safe and environmentally responsible exploration and production of natural gas, crude oil, and associated liquids on lands administered by state and federal authorities, including production via the use of hydraulic fracturing AND HORIZONAL DRILLING in unconventional plays. The U.S. oil and natural gas industry supports 9.8 million domestic jobs and comprises more than 8% of the U.S. economy.

API is also the worldwide leading standards-making body for the oil and natural gas industry. Accredited by the American National Standards Institute (ANSI), API has issued over 600 consensus standards governing all segments of the oil and gas industry. These include standards, guidelines, and recommended practices regarding effective water management, spill prevention and protection. Many API standards and practices are incorporated into state oil and natural gas regulations, including Maryland's, as well as into numerous other federal agency regulations. In our ongoing effort toward continued improvement of oil and natural gas operations, in May of 2011, API completed a series of industry guidance documents specific to hydraulic fracturing:

- HF1, Hydraulic Fracturing Operations—Well Construction and Integrity;
- HF2, Water Management Associated with Hydraulic Fracturing Guidance;
- HF3, Practices for Mitigating Surface Impacts Associated With Hydraulic Fracturing;
- Standard 65-Part 2, Isolating Potential Flow Zones During Well Construction; and
- RP 51R, Environmental Protection for Onshore Oil and Gas production Operations and Leases.[1]

This set of API standards was shared with participating staff from the Maryland School of Public Health (U MD SPH) in response to its report titled "Potential Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland" as well as the staff for Governor O'Malley's Marcellus Shale Safe Drilling Initiative Advisory Commission. We believe this series provides the blueprint for the environmentally sound development of oil and natural gas.

In 2013, HF1, HF2, and HF3 underwent a required review process. All three documents are expected to be released as revised recommended practices by the first quart of 2015. Finally, during this review, a new document, focusing on community engagement, was developed. ANSI/API Bulletin 100 Part 3 – *Community Engagement Guidelines* will serve as a gold standard for good neighbor policies that address community concerns, enhance the long-term benefits of local development, and ensure a two-way conversation regarding mutual goals for community growth. Released on July 9, 2014, 100 Part 3

provides a detailed list of steps that oil and natural gas companies can take to help local leaders and residents prepare for energy exploration, minimize interruption to the community, and manage resources.[2]

With this as background, it should be of no surprise that API has a strong interest in the Advisory Commission's final recommendations to the Governor on unconventional development in Western Maryland. With regard to the draft "Assessment of Risks from Unconventional Gas Well Development in the Marcellus Shale of Western Maryland" (hereafter referred to as the draft Assessment of Risks Report), API was particularly pleased to see the MDE's recognition that risks are inherent in any industrial or construction activity, including oil and natural gas development and that these risks are manageable. Similar to MDE, API recognizes that strong state regulatory programs, coupled with industry's best management practices are an effective combination for managing the risks. API was founded as a standard setting organization with that very goal in mind – by establishing industry standards focused on operations safety, reliability, and interchangeability, operational risks could be minimized.[3]

[1] The "HF Series" (HF1, HF2, HF3) provides an important complement to two other recommended practices – Standard 65 Part 2, which ensure multiple levels of protection between sources of drinking water and the production zone of an oil and gas well and RP 51R, which provides recommendations to reduce the environmental footprint at E&P sites as much as possible.

[2] The document is available on API's website via this link: http://www.api.org/news-and-media/news/newsitems/2014/july-2014/api-issues-good-neighbor-standards-for-oil-and-natural-gas-developers

[3] API's standard setting mission began as a result of the drilling delays noted during World War I – caused by a lack of uniformity of pipe sizes, threads, and couplings. API tackled the challenge of developing industry-wide standards and published its first in 1924. Today, API maintains more than 600 standards and recommended practices covering all segments of the oil and gas industry to promote the use of safe, interchangeable equipment and proven and sound engineering practices.

The draft Assessment of Risks Report states (page 12)

> "if risks are found to be unacceptably high, additional mitigation steps could be taken, or gas extraction in the Marcellus shale in Maryland could be deferred until risks can be reduced by new technology or practices, or until additional data demonstrates that the proposed practices are effective to reduce risks."

Appendix A indicates that the highest risk rankings are predominantly associated with vehicle traffic in the well completion phase of operations and include: noise and vibration; traffic accidents resulting in injury and death; cost and repair from road damage; delay of emergency vehicles; and increased risk of roll over from road damage. It is important to note that while the risk of traffic-related incidents may be high due to the number of vehicles introduced during the well construction and completion phase of operations, this phase lasts a relatively short period of time – typically 2-4 months – compared to a 2030 year life of a well. In addition, in the near future, due to the geologic formation and current market demand for natural gas, Western Maryland would only be producing the less lucrative dry gas and would not face a rapid development scenario with the risks as high as noted in Appendix A and Appendix C. Further, recognizing that vehicle traffic is a concern, API offers additional information to MDE on steps taken by the industry to address many of these vehicle-induced risks.

The Houston-based Consumer Energy Alliance (CEA) – a broad-based association comprised of transportation, agriculture, businesses, consumers and energy organizations – launched an initiative in 2012 to seek improved communications about road safety among its membership and the broader public. The recommendations were formally adopted by oil and gas companies and the trucking industry in April 2013 and promote improved road safety and traffic management in heavily travelled producing areas like the Eagle Ford in south central Texas, the Marcellus region in the Northeast and the Bakken in the upper Midwest.

API, the American Trucking Associations, and the National Tank Truck Carriers have collected nearly two dozen recommendations for roadway safety and more considerate driving practices. The recommendations are important reminders for member companies and to help develop informational materials on the need to provide safe and responsible trucking operations for the mutual benefit of producers, transporters and the communities in which they operate.[4] For motor carriers, examples of recommendations include holding frequent meetings to evaluate safety issues, methods for encouraging a culture of safety, techniques to promote access to safety education resources, and practices to properly inform all drivers on the delivery and removal of equipment and materials used during oil and natural gas production. For their part, producers are encouraged to monitor and enforce requirements for proof of regulatory compliance by motor carriers. It is also recommended for both transporters and producers to be sensitive to local impacts and, to the extent possible, "schedule deliveries and movements to minimize the traffic impact on local communities."

4 The Consumer Energy Alliance Trucking Safety Task Force recommendations are available via this link: http://consumerenergyalliance.org/trucking-safety-taskforce/

Additionally, in API's Bulletin 100 Part 3, under the discussion for "Development Phase" (which includes activities such as the Drilling Casing and Cementing Phase and the High Volume Hydraulic Fracturing/Well Completion Phase in the draft Assessment of Risks Report) there is clear recognition that this phase brings the highest level of activity to a community and will include an increase in road traffic.

> "Industry activities move into the development phase once it has been determined that an area has proven beneficial resources. In the development phase, oil and gas operators determine what additional capital investment is required to develop the full resource potential of the area. Several aspects of the exploration and development phases are similar (e.g., well pad construction/drilling/completions). A key difference is the significant increase of those activities during the development phase.
>
> Furthermore, preparation for the production phase includes the construction of new facilities, pipelines, and compressor stations that will contribute to distribution of the resources. In areas where multiple wells are drilled on a single pad location, the development and production phases can overlap. Communities can expect to see the highest level of industry activities during this phase, particularly an increase in road traffic."

Key Considerations for operators during the Development Phase which specifically addressing vehicle traffic include:

a) Provide updates by engaging emergency services and first responders keeping them aware of activities, drilling dates, construction and infrastructure development, and for planning personnel movements at peak times or in high volume traffic areas.

b) Maintain collaborative relations with local authorities and regulatory agencies having direct oversight to traffic management and road safety, and include maintenance and seasonal challenges. Build awareness campaigns on safe driving; collaborate with other operators and contractors in the area for multi-use campaigns.

c) Assess, plan, and implement strategies for additional potential operational impacts specific to development and soon-to-be production as it relates to engagement with stakeholders on various issues.

d) Maintain relationships with surface and mineral owners; include specific information addressing their reasonable needs and issues.

e) Manage and promote best practices and industry standards in safety, environment and health, implement 'good neighbor policies,' and stress ethical business practices and behaviors.

Continuous improvement and maintenance of high standards and behaviors for road and traffic safety are critical components of this industry's license to operate. If you would like to discuss any of the initiatives or documents mentioned in this letter in greater details, please let me know. API is eager to assist MDE in reaching a positive conclusion on unconventional development in western Maryland.

Response: The Departments have received and read your comments and are happy to see these continuous efforts towards process improvements. Maryland is proposing to require adherence to API standards as a best management practice. If gas development occurs in Maryland, we look forward to working with you to address any ongoing public health and environmental impacts identified through regulatory monitoring and oversight efforts.

Comments Received from Mr. Gregory Slater, Maryland State highway Administration

The State Highway Administration (SHA) submits the following comments for consideration in the Maryland Department of Transportation's (MDOT) response to the draft *Assessment of Risks from Unconventional Gas Well Development in the Marcellus Shale of Western Maryland* coauthored by the Maryland Department of the Environment (MDE) and the Department of Natural Resources (DNR).

Background

On June 6, 2011, Governor Martin O'Malley signed an Executive Order establishing the Marcellus Shale Safe Drilling Initiative to assist State policymakers and regulators in determining whether and how gas production from the Marcellus Shale in Maryland can be accomplished without unacceptable risks to public health, safety, the environment and natural resources. The Order requires MDE and DNR, in consultation with an Advisory Commission made up of a broad array of stakeholders, to undertake studies of natural gas drilling in the Marcellus Shale of Western Maryland.

SHA General Comments

Upon review, SHA found this report to be a comprehensive evaluation of the impacts from Unconventional Gas Well Development (UGWD) on the state roadway system. For SHA, the two significant issues in this document are: 1) the safety concerns related to increased truck volumes on smaller rural state roads with constraining geometry; and, 2) the significant increase in funding requirements related to the impact of heavy truck traffic on roads and bridges. SHA's Motor Carrier Division in the Office of Traffic and Safety (GOTS) provided MDE with the Detail Listing Commercial Vehicle Code materials and an executive summary of the Virtual Weigh Stations (VWS) program in advance of these comments.

SHA Specific Comments

- SHA is responsible to the Federal Highway Administration (FHWA) for the state's Size & Weight Plan and Federal Motor Carrier Safety Administration (FMCSA) for the Commercial Vehicle Safety Plan and should Maryland allow the extraction of natural gas from the Marcellus Shale Formation significant impacts to state roadways are anticipated by SHA.

  Of particular relevance is Page 23 of Appendix C where the report notes that enforcement efforts in Pennsylvania have found as many as 56 percent surveyed trucks exceeded the legal weight limit and 50 percent were cited for safety concerns. To address this issue, SHA would need to expand the existing VWS program in western Maryland and increase overall enforcement to limit damage to state roadways and bridges by overweight trucks.

Additionally, MDOT currently funds the Maryland State Police (MSP) Commercial Vehicle Enforcement Division (CVED) which is the only agency in the western region that has commercial vehicle weight enforcement capabilities. These resources are quite limited with a single roving crew in Garrett County which received no local law enforcement agency support due to lack of certification to perform commercial vehicle inspections. Therefore, it is strongly recommended that additional funding be provided for CVED in support of adequate personnel and equipment in that region.

As of April 2014, there were no structurally deficient bridges in Garrett or Allegany County that are not funded for design or construction. SHA notes that state-maintained bridges will be damaged from the projected increased heavy truck traffic related to UGWD, and this may accelerate the timetable for rehabilitation or replacement for rural bridges and other structures.

- Page 22 of Appendix C discusses existing fees and taxes that could be utilized to *partially* off-set the costs of road maintenance and repair. As mentioned above, the presence of significant numbers of heavy or overweight vehicles increases costs for a variety of SHA and MDOT programs beyond road maintenance and repair, and it is recommended additional fees, taxes, or legislative action be discussed in advance of any final approval of UGWD in Maryland to address the anticipated shortfall in funding.

  It is also recommended that the final report support State assistance to local governments so that they may develop strong, consistent, and legally binding Road Use and Maintenance Agreements (RUMA). This would help to insure all impacts to local roads are mitigated.

- Page 28 of Appendix C paragraph states in part that *"The projected increase in trucking accidents could result in injuries or fatalities. This outcome is a social cost of economic growth that occurs with other industries."* SHA is not comfortable with this language and suggests it be revised.

- Addressing issues with roadway geometry, climbing lanes, signals, increased emergency response efforts, and other safety related mitigation projects will need to be considered as MDOT/SHA programs funding for future projects.

Response: We appreciate SHA's insight and excellent comments. The Departments have considered SHA's concerns in the drafting of the proposed regulations, the Marcellus Shale Safe Drilling Initiative Study Part III Final Report: Findings and Recommendations, and the final report to the Advisory Commission. If unconventional gas well development does occur and permits are received, the Departments recognize the importance of ongoing coordination with SHA to effectively manage truck traffic and roadway issues. Also, the suggested wording revision has been made.

Comments Received from The Nature Conservancy

The Nature Conservancy appreciates the opportunity to provide comments on the *Draft Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland*. This report is a very important addition to the work of the Marcellus Advisory Commission and provides valuable insights to help evaluate risk from potential shale gas development. Overall, the Conservancy believes that the report and analysis is well done and accurate in regard to risk analysis. However, we offer some general and specific comments to address perceived gaps and recommended changes to the report.

General Comments

1. The report should probably make it more explicit that the risk analysis was prepared assuming that the BMPs recommended by the Marcellus Advisory Commission were in place. This topic is touched on in the discussion at the top of page 5 under Consideration of Best Management Practices. However, it is not made clear enough to the reader that the risk analysis is based on the full application of BMPs.

   Response: The Executive Summary has been updated to make this clearer.

2. The Risk Table (Appendix A) in the column for Agent/Chemical uses the term *Brine*, *Flowback*, *Fracturing Fluid* and *Produced Water*. The definition of these four terms needs clarification, since they seem somewhat duplicative, particularly as it regards *Brine* and *Produced Water*. It would be helpful to better define these terms in the report.

   Response: Appendix A has been modified to provide cross-references to appropriate sections of the appendices. Hopefully this clarifies where risk rankings came from and also clarifies distinctions between terms. The commenter is correct that a glossary would have been helpful; time limitations have prevented the Departments from including this in the final risk assessment.

3. The Risk Table (Appendix A) does not evaluate the risk to drinking water from vibration and disturbance from drilling operations and truck traffic. It appears that many private drinking wells and springs near UGWD well sites experience temporary water quality problems from the suspension of particulate matter and heavy metals

within groundwater in the hard rock aquifers due to vibration and shaking during well pad/road preparation and drilling operations. This is evident from the number of temporary drinking water reservoirs that pop up in house yards near drilling sites. This risk should be acknowledged and evaluated.

Response: It is correct that the Departments did not evaluate this in the risk assessment, mainly because the scientific literature on unconventional gas well development (UGWD) did not suggest pollution from this process. If literature sources can be provided, this risk will be considered.

4. The Risk Table (Appendix A) has no evaluation for sediment pollution from well, road, and gathering line construction. Although Maryland does have very good regulations for sediment and erosion control, the typography and extent of possible land disturbance would warrant some consideration of risk to streams and aquatic species from sediment runoff from this source. The potential risk was acknowledged at the bottom of page 13 of Appendix C under Ecological Impacts, where it states "Creation and maintenance of roads sufficient to accommodate truck traffic can generate sediment pollution and increase forest loss. The potential changes to water quality from construction activities could impact aquatic species via sediment impacts to steam from road construction". However this risk did not make it into the Risk Table.

5. The Risk Table (Appendix A) also has no evaluation for stormwater problems caused by road construction. Stormwater for well pads is accounted for through BMPs, but stormwater from hard packed dirt roads could pose risk for stream health. This was also acknowledged on page 13 of Appendix C under Ecological Impacts, but didn't make it into the Risk Table.

Responses to comments 4 and 5: This risk has been added to Appendix A for clarification. Furthermore, Appendix A has been modified to more completely show all of the risks evaluated as well as the combination of risk probability and consequence that lead to the overall risk ranking.

6. Under the Aspect of Construction and Gathering Lines, there was no mention in the Agent/Chemical column for invasive species that would be a threat due to disturbance from well pads, roads and gathering lines. It may be lumped in with "harm to wildlife" or "harm to aquatic or terrestrial species", but it's not clear that it was evaluated.

Response: It is correct that it has been lumped in with harm to wildlife, both for the construction of gathering lines and site preparation (i.e., roads, wells pads). This is discussed specifically in the "Ecological Impacts" section of Appendix C.

Specific Comments on Risk Table

1. **Proppant Use**

The ranking in the Risk Table (Appendix A) for Proppant Use is in conflict with the text. On page 28 of Appendix B, the text states that worker exposure to silica proppants exceeds occupational health criteria at all sites monitored, but that worker exposure is outside the scope of the risk assessment. This section goes on to state that silica emissions are occurring and could be transported off-site. However, on Page 31 of Appendix B, the report states that the consequences are considered minor as the proposed BMPs and setbacks will significantly reduce exposures to human receptors off-site. Given that there is no data provided for off-site transport and the report minimizes the consequences for off-site exposure, why is the risk rated Moderate for HVHF/well completion in Appendix A?

Response: The moderate rating is correct. Silica proppant is rated as overall moderate risk because e there is a high probability of emissions, albeit with minor overall consequence.

2. **Releases from pipes, valves, fittings – Methane**

This risk is rated Moderate for "Community" In Appendix A. If this risk is for explosion or fire, than "Community" would be appropriate, but I would question the Moderate ranking and probably change it to a Low ranking. If the risk of methane releases is related to climate change, than I would change the impact to "Ecological and Human" and raise it to High given the current uncertainty about actual methane releases from gas development and the fact that methane is such a potent greenhouse gas.

Response: The risks evaluated at this stage in terms of human/community health were the risks of explosion and inhalation due to methane leakage. Since there is a high probability of leakage, but the consequences are likely minor given the relatively small amounts anticipated at any given time, risks were ranked as overall moderate.

3. **Storage of flowback, venting and separation events – Methane, H2S, VOCs, NGLs, BTEX**

This risk is given a Moderate ranking for Scenario 1 and High for Scenario 2. The recommended BMPs call for the use of Green Completion during the flowback stages of well

completion and faring of any gases that can't be contained. Are these rankings based on the assumption that even with Green Completion there will be significant releases of methane and other gases after drill out of the plugs following HVHF, even with the use of flaring of gases that can't be captured by Green Completion?

Response: A primary reason risks were ranked this way is because efficiencies for green completions could not be verified, even after multiple data requests to EPA. Furthermore, it is the Departments' understanding that flaring cannot commence until after the initial flowback period and when the well is steadily producing gas. As a result there are emissions and associated health risks during these periods.

4. **Truck Trips – Dust/PM and NOx, benzene, PM**
On the face of it, it would seem that there would be many more truck trips during the HVHF/Well completion phase (unless you assume that water and chemicals are already on site) than the production phase. Given that, in Appendix A, why does Dust/PM have a Moderate ranking for the production phase, but a Low ranking for HVHF/well completion. The same would apply for NOx, benzene and PM. Shouldn't these be reversed so that the higher ranking is given for the HVHF/Well completion phase?

Response: The Departments agree that this was an inconsistency and changed the HVHF/well completion phase to insufficient data due to the larger number of truck trips and absence of mobile sources modeling.

5. **Construction – Forest fragmentation, sediment, harm to wildlife**
The ranking for Construction should be changed so that it is Moderate for Scenario 1 (25 well pads) and High for Scenario 2 (75 well pads). It should be noted that the ranking for Gathering Lines differentiates between the two scenarios. Although I agree that gathering lines represent a more fragmenting feature than well pads because they are a linear feature, 75 well pads up to four acres apiece (including ponds and roads) could represent a high degree of fragmentation on the landscape.

Response: The reason for the difference between fragmentation risk level impact for gathering lines and well pads is that the well pads will be a significant consideration of the Comprehensive Gas Development Plan. For well pads the consideration is the location of the pad within the land holdings of the applicant while gathering lines, as a linear feature that must by nature cross a range of "willing seller" land holdings to connect to existing gas transmission and related infrastructure. This represents a

difference in the flexibility of location decisions and thus regulatory requirements. That said, the Departments could reconsider the risk level for well pads at some point in time, particularly after the ability of the CGDP to minimize impacts is evaluated in actual situations.

6. **Contamination of soil, ground water or surface water by surface spill or release**
   It is not clear in this section on risk whether the potential for spill from the transport of Flowback or Produced Water was considered in the analysis. There is a recommended BMP that calls for reuse of frack fluid on site, but eventually there will be transport of Flowback/Produced Water off site, which would probably represent the highest probability for spill or accident.

   Response: Two appendices address these risks independently. Appendix D covers spills on the well pad from chemical handling/mixing as well as during flowback. Appendix E covers chemicals spills during chemical transport to and from the site and includes hydraulic fracturing chemicals as well as flowback and produced water.

7. **Subsurface releases or migration – Flowback (Ecological), Fracturing Fluid (Ecological), Produced Water (Ecological)**
   These were all given a Moderate rank either during the HVHF/Well completion or Production phases. First off, there is little or no evidence that fluid from UGWD has contaminated groundwater from subsurface releases, so I question the Moderate rank. Secondly, if we assume that the risk is Moderate, why would it be higher for Ecological and Low for Human. On page 11 of the Executive Summary, it states "Moderate risks associated with subsurface releases of fracturing fluid, flowback, and produced water were noted for aquatic communities because these contaminants would be expected to remain in the groundwater and because of the sensitivity of pollution-intolerant aquatic life to low concentration of salt and other chemicals". Freshwater aquatic species would be more sensitive to salt than human populations, but that does not hold for other chemical compounds, especially since we don't have a clear understanding of what compounds will be used in the fracking process.

   Response: The reason ecological risks ranked an overall moderate risk is because, although the probability of contamination is low, the consequences if this were to occur could have serious ecosystem affects. Specifically, this could entail permanent environmental damage and, unlike drinking water sources, there are no setbacks to protect ecosystems from subsurface releases.

8. **Disposal of wastewater in UIC wells – Flowback and Produced Water**
   The risk ranking under this aspect was NA in Maryland and Moderate in states with UIC wells for Production. I would agree with the rankings, but would place this under HVHF/Well completion rather than Production, as was done in the next row for Earthquakes.

   Response: Noted.

Comments Received from the Chesapeake Climate Action Network

Thank you for offering us this opportunity to provide public comment on the October 2014 report titled *Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland*. Please find below some general comments on the report and our assessment of what protections need to be in place before deciding whether or not to allow fracking in Maryland. We have also included a more detailed review of the risk assessment at the end of this document.

Our main comment: Under Maryland's existing regulatory scheme, the current risks of fracking are unacceptably high. MDE and DNR need more time to develop additional BMPs to reduce remaining moderate and high risk areas. **Maryland should not make a decision on whether to allow fracking until there is an enforceable regulatory framework in place that can credibly be shown to reduce the wide array of risks to acceptably low levels.**

Response: It is Maryland's intention to update the State's current regulatory framework to address environmental and public health concerns associated with unconventional gas well development, as well as to adopt an appropriate fee structure to fund compliance/enforcement efforts.

Current risks of fracking are unacceptably high

It is very important to point out that MDE and DNR performed a risk assessment of the state's proposed Best Management Practices (BMPs) from the July 2014 Interim Final Best Practices Report. The risk assessment did not evaluate the risks of fracking in Maryland today, and in fact, we already know that the current risks of fracking are very high. The July 2014 BMP report stated that "our current regulations for oil and gas wells are not appropriate for high volume hydraulic fracturing."

Many of the more than 70 BMPs would require new regulations and in some cases new legislation. While the state's BMP report offers one roadmap for future oil and gas regulations, the fact remains that the future regulatory landscape for fracking in Maryland is unknown. Most of the regulatory decisions will be made under the next Administration, and even if efforts to promulgate those regulations began today, full implementation could take several years and could end up being very different from the recommendations in the July 2014 BMP report.

Any discussion about moving forward with fracking in Maryland needs to be rooted in the fact that the current risks are unacceptably high, and that future risks can only be reduced through full regulatory implementation of all the BMPs and through the development of new BMPs to address the outstanding risks uncovered in this report.

Response: The Departments concur that Maryland's current regulations are not sufficient to regulate unconventional gas well development (UGWD). New regulations,

incorporating the findings of Maryland's Marcellus Shale Safe Drilling Initiative, will be proposed to conduct UQWD safely.

Additional BMPs are necessary to mitigate outstanding moderate and high risks

MDE and DNR worked hard to compile a comprehensive set of BMPs that could potentially reduce risks to low levels across many of the studied areas. However, their risk assessment also shows that even with full implementation of the BMPs, there is still a range of outstanding moderate and high risks that would continue to pose unacceptable risks to Western Maryland—and potentially to other parts of the state that overlie the various shale basins in Maryland.

The overall Conclusion on page 12 of the risk assessment is fair, and highlights that no mineral extraction activity is free of risks. This is true, but it seems inappropriate to press ahead with fracking when the risk assessment highlights risks which are of moderate or high concern. The study goes on to state that it may be appropriate to design additional measures to deal with these risks; and/or that the decision of whether to pursue shale gas extraction in Maryland could be deferred until new technologies or additional information is available.

Next steps

We believe that MDE and DNR need more time to develop additional BMPs to reduce the remaining risks that are of moderate and high concern to low levels. If those risks cannot be reduced, the state should wait until new technologies or additional information become available before deciding how to proceed with fracking.

If all of the risks can be reduced to low levels, the state should promulgate regulations and seek any additional legislation necessary to formalize the BMPs. Once the regulatory framework is in place, a new risk assessment should be carried out that reflects the new regulations as they will have actually been written, as well as the latest available data.

Maryland should not make the final decision on whether to allow fracking until there is an enforceable regulatory framework in place that can be credibly shown to reduce the wide array of risks to acceptably low levels. Starting now, the Departments should begin developing additional BMPs and set a timetable to promulgate new regulations. They should also clearly identify areas in which new legislation would be needed to mitigate other risk areas where new regulations would be insufficient.

Response: One of the key purposes of the risk assessment (RA) is to identify areas where high risks still remain so that additional BMPs to mitigate those risks can be considered. Accordingly, the RA, in combination with other studies conducted under the Executive Order, will be used to draft a final report and

recommendations as well as proposed regulations to conduct UGWD activities safely in Maryland.

Please see below for more detailed review of the risk assessment.

Page 4 Identification of risks for evaluation

One of the key impacts is land take and habitat fragmentation. Fragmentation is referenced in the risk assessment – it would be useful to confirm/explain here how these impacts on biodiversity were taken into account.

Response: In short, one of the key considerations that was projected to result in forest fragmentation is the gathering lines used to direct gas from the well pads to the main lines. It was the judgment of the Departments that, even with Comprehensive Gas Development Plans and other proposed BMPs, this aspect of UGWD would be difficult to manage without impacts to natural resources.

Pages 5-6 Development activity

A total of 450 wells for Scenario 2 seems relatively low as a high-end estimate of likely drilling activity. E.g. Sage Policy Group suggested up to 670 wells. It would be important to know how the number of wells affected the results of the risk assessment.

Response: Two development scenarios were considered in assessing overall risks, a 25% extraction scenario (150 wells) and a 75% extraction scenario (450 wells). These extraction level assumptions were developed by Towson University's Regional Economic Studies Institute to assess the economic impacts of UGWD and were also used in the RA for consistency. Overall risk assessment findings generally did not differ between these two development scenarios for several reasons. First, for many risks (e.g., spills, well failures, noise, water withdrawals, etc.), increases in the number of wells drilled either did not change risk the probability or consequence enough to change the overall risk ranking. For example, a low probability and a minor consequence has the same overall risk ranking (i.e., low) as a medium probability and a minor consequence or a low probability and moderate consequence. This results from a relatively coarse methodology for assigning overall risk due to the qualitative nature of the assessment. Second, there was not enough information to numerically quantify risks. Where there was sufficient information to provide numerical estimates of risk (e.g., the rate of

accidents associated with increases in well drilling) it was a flat rate and independent of the number of wells drilled. This and the lack of location-specific information on the actual distribution of wells and well pads created difficulty in differentiating risk between the two development scenarios. To better characterize these and other study limitations, the RA has been revised to include language regarding overall uncertainty in the study findings.

Page 6 Assessment of BMPs

The risk assessment only considers the situation with BMPs in place. Not all the BMPs are guaranteed to be in place, or are within the remit of MDE officers to put in place, if shale gas extraction goes ahead. Therefore, it would be helpful for the risk assessment to assess risks without BMPs in place, then assessing risks with BMPs in place. This enables all stakeholders to understand the value of the BMPs, and would ultimately be valuable to MDE in justifying why BMPs are being made a requirement on operators, in the event that shale gas extraction is permitted in Maryland.

Response: A public health study was also commissioned by the State under the Marcellus Shale Safe Drilling Initiative Executive Order that considers risks without the proposed BMPs. This study can be found at: http://www.mde.state.md.us/programs/Land/mining/marcellus/Pages/Health_Study.aspx

P6 Definition of risk factors

The "Probability" definitions should be specific as to whether they apply to individual well pads, or to the overall development of Marcellus Shale in MD. E.g. "High: Occurs frequently under ordinary conditions" – does that mean that a high frequency event would occur frequently at an individual site (and hence, very frequently across Garrett and Allegany Counties), or that such an event would be expected to occur frequently in MD as a whole?

An example is the assessment of blowout probability in Appendix B. The probability is assessed as approximately 1.2 per 1,000 wells. The text states: "probability of well blow-outs is considered low" (p23). However, if 450 (or more) wells would be required for Scenario 2, this would correspond to an estimated incidence of 0.54 blowouts during the development of the whole gas field – broadly speaking, an incident is more likely to happen than not. This should not be described as a "Low" probability (*Rarely happens under ordinary conditions; not forecast to be encountered under foreseeable future circumstances in view of current knowledge and existing controls on gas extraction*). It should better be described as a "Moderate" probability (*Occurs occasionally...*)

Response: The Departments do not agree that .54 blowouts over the whole UGWD area is a moderate probability. Furthermore, the greatest risk from well blowouts is to workers on the well pad. Since worker safety is not within the purview of the Departments, worker risks are considered outside the scope of the risk assessment. Generally speaking, the probability definition was applied to individual well pads and the two scenario extraction levels were used to characterize broader risk levels across the landscape. See above response in terms of the limitations in differentiating risks between the two scenarios.

P6 Insufficient data

What steps will be taken to address risks for which there is insufficient data to determine significance?

Response: Several steps could be taken from enhanced monitoring or modeling efforts to additional BMPs as an extra layer of protection against uncertainty. A final report under the Safe Drilling Initiative as well as proposed regulations will be developed to conduct UGWD activities safely in Maryland.

P8-12: Conclusions

The study finds that a range of impacts have moderate or high risks, with BMPs in place. Although BMPs are effective at reducing risks, some high significance impacts remain – e.g.:

- Site preparation phase impacts on biodiversity and farmland forecast to occur
- Drilling phase – high risk of road damage and air pollution impacts
- Fracking/completion phase – high risks due to road traffic, water extraction and emissions to air
- Production phase – high risks for ecology and visual impacts; also groundwater contamination risks and air emissions.

The overall Conclusion on p12 is fair, and highlights that no mineral extraction activity is free of risks. This is true, but it seems inappropriate to press ahead with shale gas extraction when the risk assessment highlights risks which are of moderate or high concern. It goes on to state that it may be appropriate to design additional measures to deal with these risks; and/or that shale gas extraction in Maryland could be deferred until new technologies or additional information is available.

Response: As mentioned above, a final report under the Safe Drilling Initiative as well as proposed regulations will be developed to conduct UGWD activities safely in Maryland.

P8: Description of Drilling

The activity description is useful. However, are prescriptive standards in place to ensure that triple casing is used for well bores? This doesn't seem likely, as the text says that this technique is "typically" used. If standards are not in place, it's hard to see how the risk assessors can rely on the protection to groundwater given by this design approach.

Response: Prior to drilling a well, companies are required to provide plans that describe how geologic zone isolation will be achieved for each well and how the cementing and casing system will be designed to achieve that. In addition to plans, well logs, pressure tests and other appropriate information must be submitted to ensure wells are constructed properly. Adherence to this drilling, casing, cementing plan, and pressure testing will be required as a condition of the drilling permit and set appropriate standards.

P9: Hydraulic fracturing

No mention here of Reduced Emissions Completion, which is critical for control of air pollution impacts, and will be a requirement for all gas wells. This is identified in Appendix B Table 2 – would warrant mentioning in this summary.

Response: Noted and this section has been revised to include this language.

P10 – Production

The study notes that downstream infrastructure is out of the scope of this assessment, but this remains a potential source of impacts for local residents and the environment.

Response: The commenter expresses concern that downstream infrastructure is not addressed in the Risk Assessment. That understanding is not entirely correct. The risk for gathering lines, a major component of downstream transmission, is included.

Appendix A

It would be useful for "High for Scenario 2" risks to be highlighted in some way – e.g. using red coloring, to distinguish from low or NA. E.g. Aspect: Combustion from pumps, drill rigs, and compressors; Phase: HVHF/Completion

Response: Appendix A has been revised to better display risks.

Appendix C: Traffic

"UGWD will mean markedly increased traffic in communities near well pads. Increased gas development traffic leads to congestion, a higher likelihood of vehicle collisions, and would impact the character of rural communities."

The risk assessment highlights that road trips could be reduced (eg via the specified BMPs, or more speculative measures such as use of CO2 rather than water-based fracking fluids), but cannot be eliminated. Hence traffic is rightly rated as a "high" risk.

Response: Noted.

Appendix D: Drilling

The assessment indicates that 12 – 36 spillage incidents may be expected to occur during drilling fluid preparation, and the same during drilling – however, this risk is given a Probability ranking of "Low" in each case. 12 – 36 incidents seems to warrant a higher ranking than "Low" – could this be reviewed and revised/explained? Presumably, the assessment of probability is linked to the controls in place following a spillage, but this needs to be discussed in more detail in order to reach a conclusion of "low" impact.

Response: The "Low" ranking refers to the probability of groundwater or surface water contamination from spills/releases on the well pad. While 12-36 spills/releases may occur on the well pad based on an incident rate of 8% for scenario 1 and 2, it is highly unlikely that the contamination will transport off the well-pad due to the implementation of the proposed BMPs. Therefore there is a "low" probability of groundwater or surface water contamination.

Appendix E: Fracking fluids

"For purposes of this risk assessment, we have assumed that best practices are followed; for example, that spills are always promptly and completely cleaned up and that accumulated stormwater is removed from the pad and placed in storage tanks before the pad overflows. If this does not occur, however, intense and/or sequential storm events

could overwhelm stormwater capacity at the well pad resulting in stormwater runoff and chemicals from prior spills being discharged into streams and thereby impacting aquatic species and recreational activities." Would this plausibly occur at every one of 450 pads, throughout the 10 year use of fracking fluids?

Response: The Department believes that would be unlikely. However, it is reasonable to state that an accidental spill or release on a drill pad may occur concurrently with a large storm event. The Departments are proposing to further increase berm heights to capture a 25-year storm which will further decrease the probability of this causing an environmental impact.

Appendix F: Visual impacts

The assessment of visual impacts does not appear to take account of the high value landscape of Garrett and Allegany Counties. This may increase the significance of the lighting and visual intrusion impacts referred to.

Response: This has been considered in the risk assessment.

Appendix G: Water resources

This chapter describes competing water requirements, and the methods used for managing water resources. The 2008 Garrett County Comprehensive Plan forecasts that there will be a water resource deficit for the Mountain Lake Park/Loch Lynn Heights and Grantsville areas by 2030. This could potentially pose a constraint to the development of shale gas resources in these areas. This should be considered in the MDE-DNR Risk Assessment.

Response: Water appropriation decisions are made on a case-by-case basis. As expressed in Appendix G, the Departments are confident the current regulatory program is adequately rigorous to protect local water supplies.

Appendix H: Wells and Formations

There are concerns about long-term well integrity post-abandonment. This section does discuss well plugging and abandonment briefly, but it should also consider long-term well monitoring and management arrangements post-abandonment.

Overall comments

The study does not address re-fracking/re-stimulation which may be needed during the production phase. This could result in impacts during the Production phase, similar to

those associated with the fracking and completion phases. Re-fracturing is mentioned on p26, but does not appear to be assessed.

Response: This is correct that the Departments did not assess risks with refracturing as they are considered to be relatively low compared to risks associated with the original wells.

Minor/editorial comments

P5 – reference error

Response: Corrected.

P10 – reference to Pennsylvania, is this correct?

Response: Yes, Pennsylvania is correct.

Comments Received from Miss Brenda Smith, The Greater Cumberland Committee

Dear Chairman Vanko and Commission Members:

As you know, The Greater Cumberland Committee (TGCC) is a regional, business based organization serving three states (MD, PA and WV) and five counties, specific to this case and point, Allegany and Garrett in Western Maryland. We would like to take this opportunity to congratulate you and the other members of the Marcellus Shale Safe Drilling Initiative Advisory Commission for your commitment and work to date, as well as allowing each respective side to articulate their positions.

In addition, as you are also aware, TGCC favors the responsible drilling of Marcellus Shale and views it as a means to restore prosperity to the poorest part of the state through job growth and a stronger economy. We strongly believe that energy, regardless of its form, is a vital natural resource that connects us to our past and we need to insure our heritage and history is also preserved and honored. Thank you for allowing us an opportunity to comment on the Risk Assessment draft document.

Upon its review, we recognize there are strong arguments on both sides of the issue. For every opposing debate, there is an equally supportive counter-argument to be considered and the cycle continues. It is imperative at this juncture that we find strategies and solutions in order to work together, while allowing professionals within MDE and DNR the ability to effectively do their jobs. We recognize that harvesting natural gas in Western Maryland is a very complex matter and while it is impossible to project the exact impact that shale gas development would have on our region, any economic activity that is well-managed will strongly benefit both Western Maryland and the surrounding counties.

Similarly, risks are inherent in any type of mineral extraction, industrial and construction activity. Across the lifecycle of the well, from initial site identification to well abandonment and reclamation, unconventional gas well development (UGWD) encompasses a broad range of these activities. Maryland draws from its robust storm water management, soil erosion and control, and water appropriations programs and examines the effectiveness of proposed best management practices for revising its existing gas and oil development regulations. Together, these existing and proposed practices serve to reduce many risks to Western Maryland's citizens, economy and its high quality water, air and natural resources.

Now, more than ever, the State of Maryland is at a unique crossroads with a transition of power set to take place in the Governor's mansion in early January. Once again, it is our belief that there is ample opportunity for both sides of the issue to come together in a respectful way that will serve to fully support the Commission's efforts. In keeping with our regional mission, TGCC would be honored to help identify opportunities for collaboration to enhance the quality of life in the region; to identify broad and sound solutions to community issues; and to serve as a convener, facilitator and catalyst for regional responsiveness and community improvement.

Thank you again for allowing us this opportunity to comment, as well as your time and consideration. TGCC welcomes the occasion to work with you for the greater good of our region.

Response: On behalf of both the Departments and the Advisory Commission, we appreciate your constructive approach to responsibly addressing this complex issue. There will be much work to do ahead in the event that UGWD moves forward and local organizations such as TGCC will be instrumental to ensuring a balanced approach.

Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

Comments Received from Mr. Thomas Jackson, Halliburton Energy Services, Inc.

Halliburton Energy Services, Inc. ("HESI") appreciates the opportunity to submit these comments on the draft "Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland" ("Draft Risk Assessment") prepared by the Maryland Department of the Environment ("MDE") and the Maryland Department of Natural Resources ("DNR"). HESI agrees with the Draft Risk Assessment's conclusion that the risk of impact to groundwater from hydraulic fracturing ("HF") fluids via migration through old faults and wells is low.[1] HESI also agrees that the risks to human health associated with potential surface spills of fracturing fluids or flowback is likewise low. HESI would like to offer additional information to support these conclusions and proposes that MDE and DNR consider including these resources in the final report. While HESI supports public disclosure of HF fluid information to FracFocus and availability of all HF fluid information to regulators and first responders, in light of this low risk there is no need for full public disclosure of all constituents used in HF fluids.

I. HESI agrees with the Draft Risk Assessment's conclusion that the risk to human health from subsurface releases or migration or surface spills of fracturing fluids or flowback is low.

HESI would like to make MDE and DNR aware of the following additional research that supports the conclusion of a low risk to groundwater from subsurface migration of fracturing fluids:

HESI's consultant Gradient undertook a detailed analysis of the potential risks to drinking water associated with the use of HF fluids in 2013 in which Gradient evaluated whether it is possible for fluids pumped into a tight formation during the HF process to migrate upward to reach drinking water aquifers.[2] Gradient determined that once the fracturing fluids are pumped into a tight formation, it is simply not plausible that the fluids would migrate upwards from the target formation through several thousand feet of rock to contaminate drinking water aquifers.[3] Gradient found that even if the fracturing fluids could migrate upward through hundreds or thousands of feet of bedrock, the fluids would be so highly diluted that the concentrations of the chemical constituents would be well below levels that would begin to give rise to any human health concerns.[4] Accordingly, the report concludes that the fluids pumped

[1] Maryland Department of the Environment and Maryland Department of Natural Resources, Draft *Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland*, Appx. H, 13 (Oct. 2014) ("Draft Risk Assessment").
[2] Gradient, *National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives* (May 1, 2013) ("Gradient 2013 Study"), available at http://www.energy.senate.gov/mwg-internal/de5fs23hu73ds/ progress?id=Ud/dG+zh3g.
[3] *Id*. at ES-4.
[4] *Id*. at 42.

into a target formation as part of the HF process do not present a risk to human health.[5]

- A peer-reviewed 2013 paper also by Gradient discusses the physical constraints on upward fluid migration from black shales such as the Marcellus and Bakken shales to shallow aquifers and concludes that upward migration of HF fluid and brine as a result of HF activity does not appear to be physically possible.[6] The authors found that the conditions for upward migration of fluids (*i.e.*, upward hydraulic gradients) are found only in the presence of low permeability layers such as shales and that the rock layers between shales being hydraulically fractured and shallow aquifers are generally dominated by multiple low-permeability layers, effectively ensuring that any upward migration will be very slow, resulting in migration timescales of hundreds of thousands or millions of years.

- Another peer-reviewed 2013 paper by Gradient and a HESI expert examines the potential for fluid migration via induced fractures and considers the potential for interactions with natural faults to provide migration pathways.[7] The paper finds that given the constraints on upward flow of fluids from tight oil and gas formations, the upward migration of fracturing fluids will be governed by the extent of upward fracture growth and any related movement of natural faults. Based on principles of geophysics as confirmed by extensive microseismic data, the authors further concluded that fracture heights are limited by HF fluid volume and natural mechanisms such as in situ stress and the tendency of fractures at shallower depths to grow horizontally rather than vertically, and that additional fluid migration as a result of interactions with naturally occurring faults is minimal. As a result, it is not physically plausible for induced fractures to create a hydraulic connection between tight formations at depth and overlying drinking water aquifers.[8]

- A recent peer-reviewed paper by researchers at Lawrence Berkeley National Laboratory reports on some of the results of modeling being conducted by the researchers for EPA's HF Study, focusing on the potential for injection-induced fault reactivation and notable seismic events associated with HF operations.[9] The paper concluded that the possibility of hydraulically-induced fractures at great depths causing activation of faults and the creation of a new flow path that can reach shallow groundwater resources is remote.[10]

[5] *Id*. at ES-5.
[6] Flewelling & Sharma, "Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine," *Groundwater* (Jul. 29, 2013), available at http://onlinelibrary.wiley.com/doi/10.1111/gwat.12095/abstract.
[7] Flewelling et al., "Hydraulic fracturing height limits and fault interactions in tight oil and gas formations," *Geophysical Research Letters* (Jul. 26, 2013), available at http://onlinelibrary.wiley.com/doi/10.1002/ grl.50707/abstract.
[8] *Id.*
[9] Rutqvist et al., "Modelling of fault reactivation and induced seismicity during hydraulic fracturing of shale-gas reservoirs," *Journal of Petroleum Science and Engineering* (2013), available at http://dx.doi.org/10.1016/j.petrol.2013.04.023.
[10] *Id.*

- Another recent peer-reviewed paper found that there are no forces propelling fracturing fluid upward from gas shale along natural pathways because the physics dominating these processes ensures that the fluid is propelled into the shale, permanently sequestering it.[11] Moreover, hydraulic fracturing actually reduces the risk that brine could escape from the target formation and migrate upward towards near surface aquifers.

  These findings from the peer-reviewed literature have been confirmed by field data on multiple occasions.

- For example, the microseismic data used in Gradient's 2013 analysis described above comes from over 12,000 HF stages in shale plays and other tight formations across the country, showing that the fractures created during HF are of limited height and that the presence of natural faults in the bedrock does not significantly contribute to the upward movement of fluids.[12]

- Similarly, an October 2012 report regarding HF operations in the Inglewood Oil Field in the Baldwin Hills area of Los Angeles County showed that, based on actual groundwater monitoring results, the groundwater quality in the area was not affected by HF activities.[13] Moreover, microseismic monitoring showed that most of the induced fractures were contained within the target formation, and that the few fractures that were outside the target formation did not contain any proppant and therefore would have closed back up once the HF operation was completed.[14]

[11] Engelder et al., "The fate of residual treatment water in gas shale," *Journal of Unconventional Oil and Gas Resources* 7 (2014) 33-48. Another recently published paper concerning modeling of the potential impacts of hydraulic fracturing of the Bowland Shale in the UK on overlying aquifers concludes that fracturing of the Bowland Shale is unlikely to pose risks to water quality in overlying aquifers. The paper finds that high-permeability layers can also act as barriers to upward migration because the flow in such layers is predominantly horizontal rather than vertical and any upwardly-migrating fluids tend to be captured in the horizontal flow. Cai and Ofterdinger, "Numerical assessment of potential impacts of hydraulically fractured Bowland Shale on overlying aquifers," *Water Resour. Res* (2014)., 50, 6236-6259, doi:10.1002/2013WR014943.

[12] Gradient 2013 Study at 38.

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

[14] *Id.*

- In addition, the U.S. Geological Survey published a report in January 2013 regarding the results of an analysis of water samples from 127 drinking water wells representing the western third of the Fayetteville shale.[15] The study used two comparative analysis methods to identify potential impacts to water quality from gas production activities in the area and found no evidence of migration of gas production fluids into the shallow groundwater.[16]
- Most recently, researchers from the National Energy Technology Laboratory published a paper and report regarding a study of HF operations at a Marcellus Shale well site in Greene County, Pennsylvania.[17] The researchers took samples from Upper Devonian/Lower Mississippian wells at depths of up to about 4,400 feet below ground surface both before and up to 14 months after fracturing of the deeper Marcellus (at depths of about 8,000 feet). The study found no compelling evidence that the shallower wells – which were still about 4,000 feet below drinking water aquifers – were affected by any upward migrating fluids from the Marcellus over the study period.[18] Indeed, the researchers found that there was no evidence of migration of gas from the Marcellus to the shallower wells over the 14 months.[19]

  In light of the above, there is an emerging consensus that the risk of contamination of drinking water by HF chemicals through subsurface migration of fluids from the target formation is not, in fact, significant.

[15] Kresse, et al., *Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-Production Area, North-Central Arkansas*, U.S. Geological Survey Scientific Investigations Report 2012-5273 (Jan. 2013), available at http://pubs.usgs.gov/sir/2012/5273/sir2012-5273.pdf.
[16] *Id*. at 28.
[17] U.S. Department of Energy, National Energy Technology Laboratory, An Evaluation of Fracture Growth and Gas/Fluid Migration as Horizontal Marcellus Shale Gas Wells are Hydraulically Fractured in Greene County, Pennsylvania, NETL-TRS-3-2014 (Sept. 15, 2014), available at http://www.netl.doe.gov/research/on-site-research/publications/featured-technicalreports.
[18] Kohl, et al., "Strontium Isotopes Test Long-Term Zonal Isolation of Injected and Marcellus Formation Water after Hydraulic Fracturing," Environ. Sci. Technol. 48, 9867-9873 (July 2014).
[19] Sharma et al., "Assessing changes in gas migration pathways at a hydraulic fracturing site: Example from Greene County, Pennsylvania, USA," Appl. Geochem (2014), available at http://dx.doi.org/10.1016/j.apgeochem.2014.07.018. Another recently released study of the presence of methane in 113 drinking water wells in Pennsylvania and Texas reached essentially the same conclusion, with the authors finding that "our data do not suggest that horizontal drilling or hydraulic fracturing has provided a conduit to connect deep Marcellus or Barnett Formations directly to surface aquifers." "Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales." Proceedings of the National Academy of Sciences, available at 222.pnas.org/cgi/doi/10.1073/pnas.1322107111.

- This emerging consensus is reflected in a report issued by Resources for the Future setting forth the results of a survey of 215 experts from state and federal regulatory agencies, academia, non-governmental organizations and industry regarding the "priority environmental risks related to shale gas development."[20] The experts were asked to identify priorities from among 264 potential "risk pathways" for both routine operations and accidents. The report states that "almost every priority routine pathway that garnered broad attention from experts has to do with risks present in most drilling operations or with the disposal of waste produced by fracturing, not with the actual hydraulic fracturing process itself."[21] The report further states that with respect to "pathways involved with the fracturing process and its effect on groundwater, only the flowback of reservoir fluids breaks any groups' top 20 most selected pathways."[22] As for accidents, the report indicates that all groups (regulators, academia, NGOs and industry) shared the same top two priorities, *i.e.*, casing failure and cementing failure.[23] In short, those most knowledgeable about the actual risks posed by shale development – including those affiliated with NGOs – do not view the HF process as a primary concern.

- Just last month, the California Council on Science and Technology, Lawrence Berkeley National Laboratory and the Pacific Institute issued a study conducted for BLM regarding the use of HF and other well stimulation technologies in California.[24] The study found that where the target formation is more than 2,000 feet below the overlying aquifers, the creation of migration pathways as a result of HF operations seems unlikely.[25] The report noted that most studies comparing baseline trends to post-stimulation measurements have not found any statistically significant changes in water quality in nearby drinking water wells.[26] The study concludes that the primary impacts to California's environment from well stimulation activities will be indirect impacts due to increases in oil and gas production, not impacts due to well stimulation itself.[27]

[20] Resources for the Future, Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development (Feb. 2013), at 1, available at http://www.rff.org/centers/energy_economics_ and_policy/Pages/Shale-Gas-Expert-Survey.aspx.
[21] Id. at 26.
[22] Id.
[23] Id. at 36.
[24] California Council of Science and Technology et al., *Advanced Well Stimulation Technologies in California: An Independent Review of Scientific and Technical Information*, 234-37 (Aug. 28, 2014), available at http://ccst.us/projects/fracking_public/BLM.php/.
[25] *Id*. at 36.
[26] *Id*. at 233.
[27] *Id*. at 42.

- Other governmental studies across the world have likewise concluded and continue to conclude that the HF process poses little risk to human health or the environment. For example, the Energy and Climate Change Committee appointed by the British House of Commons concluded in May 2011 that hydraulic fracturing itself does not pose a direct risk to water aquifers, provided that the well casing is intact before this commences.[28] In addition, the UK Royal Society, the Council for the Taranaki Region in New Zealand, the New Zealand Parliamentary Commissioner for the Environment, and the UK Department of Energy and Climate Change all completed comprehensive studies on HF in 2012-2013, finding a lack of risk to freshwater aquifers from properly conducted HF operations.[29] Most recently, Cape Breton University −□which undertook an assessment of the potential impacts of shale development for the government of Nova Scotia −□issued its report, which states that "it is recognized that the risk to water quality from shale gas operations is more related to operational practices (*e.g.*, chemical handling, waste management) rather than the fracturing and extraction process."[30]

HESI also agrees with the conclusion that the risk to human health from surface spills of fracturing fluids and flowback is low. HESI has evaluated the risks to drinking water quality from chemical handling at the surface as it relates to HF chemicals and fluids and has concluded that these risks are limited. In accordance with regulatory requirements and industry best practices, programs are in place to manage any spills at the surface. For example, well pads typically include secondary containment that succeeds in preventing many spills from being released into the environment.

[28] United Kingdom Parliament, House of Commons, Energy and Climate Change Committee, *Fifth Report: Shale Gas* (May 10, 2011), available at http://www.publications.parliament.uk/pa/cm201012/cmselect/ cmenergy/795/79502.htm.
[29] The Royal Society, Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, 33 (June 2012), available at http://royalsociety.org/policy/projects/shale-gas-extraction/report/; Government of New Zealand Taranaki Regional Council, *Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region* (May 2012), available at http://www.trc.govt.nz/hydraulic-fracturing/; Government of New Zealand, Parliamentary Commissioner for the Environment, *Evaluating the environmental impacts of fracking in New Zealand: An interim report* (Nov. 2012), available at http://www.pce.parliament.nz/publications/all-publications/evaluating-the-environmental-impacts-of-fracking-in-new-zealand-an-interim-report/; AMEC Environment & Infrastructure UK Limited, Department of Energy and Climate Change, *Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing*, 96 (Dec. 2013), available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/273997/DECC_SEA_ Environmental_Report.pdf.
[30] Cape Breton University, *Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing*, 178 (Aug. 28, 2014), available at http://energy.novascotia.ca/oil-and-gas/onshore/hydraulic-fracturing-review.

This conclusion has been confirmed by research. Gradient analyzed the potential for any spills of HF fluids (or flowback fluid) that might reach drinking water wells or surface waters to pose human health concerns.[31] Using a "probabilistic" approach to address a wide range of spill scenarios and very conservative assumptions (*e.g.*, no spill mitigation measures in place and no adsorption of chemical constituents to the soil or degradation in the environment), Gradient determined the concentrations at which HF constituents might be found in surface water or a drinking water well as a result of a spill and compared them to levels at which health effects might become a concern.[32] Gradient found that any human health risks would be insignificant because various dilution mechanisms would further reduce the already low concentration levels of HF constituents before they ever reached drinking water sources.[33]

Response: The Departments appreciate these additional sources of information which support the risk assessment findings. These sources will be attached to the final risk assessment as a comment response appendix.

II. Due to the low risk of impacts to groundwater from migration of fracturing fluids,

HESI believes that full <u>public</u> disclosure of all fracturing fluid ingredients is not necessary.

Although HESI supports making HF fluid chemical ingredient information available to regulators and first responders, the company does not support full <u>public</u> disclosure of all HF fluid ingredient information. Given the low risk of impact to groundwater from these materials, the harm to HESI's valuable trade secret information that would be caused by public disclosure of the information does not outweigh any environmental or health benefits that would be gained.

Trade secret protection is a concept that dates back at least two centuries. The purpose of protecting trade secrets is to foster innovation, and countries in all corners of the globe today recognize the critical role that trade secrets play in creating incentives for innovative efforts in a variety of fields that over the years have resulted in a wide range of benefits. The history of the oil and gas industry amply demonstrates the benefits of innovation. The shale boom itself is the product of innovation with respect to horizontal drilling and hydraulic fracturing. HESI and other service companies continue to develop new and innovative products used in drilling, casing, cementing and stimulating shale gas wells and other types of wells which provide significant environmental and economic benefits. HESI itself invests hundreds of millions of dollars every year to develop new and innovative products that enhance the ability of operators to optimize production from wells to meet the nation's energy needs. Because of HESI's major investments and leading innovations, HESI seeks protection for all trade secret and proprietary information regarding its HF formulations and related technologies.

[31] Gradient 2013 Study, *supra* note 2.
[32] *Id.* at ES-14.
[33] *Id.*

The economic benefits resulting from the use of HESI's own innovative products have been repeatedly demonstrated. HESI's analysis of various case studies shows an average loss in production of 25% when non-proprietary stimulation fluids are used instead of proprietary fluids.[34] The production increases from advanced technology result in substantial economic benefits, including: (1) increased lease bonuses and royalties for landowners and tax revenue for government at all levels; (2) reinvestment for further development; and (3) the creation of sustainable economic stimulus and thousands of jobs. Overall, the customized fluid systems created by HESI and others using proprietary technologies have been shown to result in increased production levels as compared to the use of commodity products, creating millions of dollars of additional value for operators with corresponding benefits for governments and local communities. For example, HESI has estimated that the use of advanced technologies in the Marcellus Shale will result in an increase in natural gas production of as much as $41 billion dollars through the year 2030.[35]

HESI's innovative technologies also provide significant environmental benefits, which include but are not limited to: (1) a reduction in overall chemical use; (2) the use of chemicals that provide an extra margin of environmental safety; (3) recycling of wastewater to reduce the use of fresh water and to reduce the amount of wastewater that must be disposed of; (4) reduced truck traffic; (5) less packaging and storage of materials; (6) less reworking of fluids at the well site; (7) a smaller well pad footprint; and (8) reduced air emissions.

In short, the benefits of innovation in the oil and gas industry are very significant. Not only have these innovations helped fuel job growth and contributed to the nation's energy security, but they have done so while achieving continual environmental improvements.

This level of innovation simply would not occur without trade secret protection. The innovative technologies described above have taken years and millions of dollars to develop. For example, HESI spent $588 million on research and development in 2013 alone, including significant investments in the development of fluid additives to enhance the production of new and existing wells. In the absence of trade secret protection, competitors could simply copy HESI's new ideas without having to spend the time and resources to invent or develop the technology. The dollars, time, and human resources invested by HESI would essentially be lost. As a result, HESI would have to replace its most innovative products (which include its most effective and environmentally beneficial products) with non-proprietary products the makeup of which could be fully disclosed to the public, with the resulting loss of the environmental and economic benefits described above.

In seeking trade secret protection, service companies such as HESI are not requesting unique treatment from regulators. Trade secret protection is common and has been historically provided for a variety of products and technologies; indeed, the trade secret protections of TSCA

[34] Analysis of Economic Impacts Resulting From Fracturing Stimulation 'Advanced Technology' Within the Marcellus Basin.

[35] *Id.* at 1, 6.

apply to all chemical substances. For example, the formulas of many products that people routinely eat, drink, and use in their homes −□including the identities of key ingredients −□are protected as trade secrets. This includes products such as Coca-Cola[36] and Dr. Pepper, KFC's fried chicken, Bush's baked beans, McDonald's special sauce, designer perfume fragrances, mosquito repellents, and household products such as WD-40. The makers of these products are afforded trade secret protection so that their valuable recipes and formulas are not disclosed to the public and their competitors, while at the same time the public knows enough details about the make-up of the product to assess its function, characteristics and health effects as necessary. Given the lack of any significant risk associated with the use of HF chemicals and the benefits they provide, there is no basis for granting trade secrets for HF chemicals any less protection than the trade secret protection enjoyed by a wide range of other industries.

For these reasons, HESI supports disclosure of HF chemical information through the FracFocus registry.[37] The FracFocus registry is incorporated into the HF chemical disclosure programs in 18 states and has been proposed for use in six other states;[38] these states accounted for over 90% of U.S. onshore oil production in 2013 and over 80% of onshore gas production in 2012. FracFocus currently has disclosures regarding the chemical make-up of HF fluids used on over 80,000 individual well sites in 28 states, including hundreds of reports on HF operations in the three principal oil and gas states that do not currently use FracFocus as part of their chemical disclosure programs (Arkansas, New Mexico and Wyoming). In short, FracFocus reflects the vast majority of HF operations in the U.S. today. Indeed, the very purpose of creating the FracFocus registry was to make information about the chemicals used in HF operations available to the public, and the FracFocus website has already been accessed more than 750,000 times. HESI believes FracFocus best balances the need for an effective way to provide detailed HF chemical information to the public with protection of trade secret information, and would support Maryland's efforts to use FracFocus as the vehicle for disclosure of HF fluid ingredient information.

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

[37] http://www.fracfocus.org. FracFocus is supported by the Department of Energy. It has recently been updated ("FracFocus 2.0") to improve its usability.

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

HESI understands that MDE and DNR are proposing to use a form of disclosure known as the "systems approach," *i.e.*, an approach to reporting whereby the ingredients in a fluid system are not tied to the additives in which they are found. HESI believes that a systems approach is a good way to provide HF ingredient information to the public. However, the systems approach to disclosure does *not* obviate the need for the ability to withhold the identities of certain proprietary chemicals from public disclosure in order to protect trade secrets. In fact, those states that use some form of "systems" reporting also allow operators, service companies and vendors to withhold the specific identities of particular chemicals where those identities qualify as trade secrets.[39] This is because even if chemical ingredients are not listed with the additives in which they are found, an experienced chemist for a sophisticated competitor – knowing the types of chemicals used in different types of additives – would be able to discern which chemicals are found in which additives.

For example, a chemist who has experience in the industry will be familiar with the types of chemicals typically used in different types of additives. Given a list of HESI products used in hydraulically fracturing a well and a separate aggregate list of the ingredients in those products, a knowledgeable individual from one of HESI's competitors who is involved in developing new products would be able to determine with a reasonable degree of certainty which products most if not all of the ingredients were associated with based on the functions of the various products and the functions that could be served by a chemical given its molecular structure. For example, based on over 30 years of experience in the industry (including experience in the development of new fracturing fluid additives), HESI's former Technology Director for Production Enhancement provided sworn testimony that he has been able to review an aggregate list of ingredients in the fluids proposed to be used by another company to hydraulically fracture a well and could identify the ingredients in – and therefore the nature of – the crosslinker the company proposed to use. For these reasons, states that use the systems approach (or some variation thereof) still allow trade secret claims for individual chemical identities.

HESI therefore strongly cautions MDE and DNR against deciding that a "systems approach" to reporting would obviate or reduce the need to make trade secret claims unless and until it further investigates the matter, including discussions with experts within the industry who have experience with these issues.

[39] *See, e.g.*, 2 Colo. Code Regs. 404-1 § 205A; 16 Tex. Admin. Code § 3.29; WOGCC Rules Ch. 3 § 45(f).

Response: The Departments believe that the systems approach proposed as the best practice strikes the right balance between disclosure and trade secret protection to safeguard public health and proprietary industry information, respectively.

III. Conclusion

HESI appreciates the opportunity to submit these comments and would welcome the opportunity to discuss its comments with the MDE and DNR.

Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

Comments Received from Wenonah Hauter, Food & Water Watch, and Robin Broder, Chesapeake Waterkeepers

We appreciate your consideration of these comments on the Marcellus Shale Safe Drilling Initiative (MSSDI) assessment of risks regarding potentially opening up the state of Maryland to drilling and fracking.

In September 2013, we submitted comments identifying ways in which a prior study, the Best Management Practices (BMPs) study, could be improved, but we also emphasized that the proposed BMPs, even if perfectly enacted and enforced, would still lead to unacceptable negative impacts on communities in Maryland.

Now, in these comments on the draft risk assessment, our two groups continue to maintain that "unconventional gas well development" presents unacceptable risks to the state of Maryland, and should be prohibited. As we argue again below, these unacceptable risks are inherent to the practice.

Generally, the state's "Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland" supports our convictions. In key dimensions of the potential collective impact on the state, however, the risk assessment does fall short in its appreciation of the risks and harms.

This is in part because the risk assessment methodology – the process of ranking risks – is necessarily over-simplistic. But the shortcomings of the draft risk assessment, and of the other MSSDI studies, also stem in part from the fact that opening up the state of Maryland to fracking is an inherently political decision.

We believe the public's interest is best served if the content of the risk assessment is framed as such.

Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

The draft risk assessment suffers from simplistic logic

The draft risk assessment looks at each of 41 distinct impacts to come up with a qualitative risk ranking: either "low," "moderate" or "high." Each risk ranking is qualitative, based on the draft authors' evaluations of: i) the relative likelihood of an event ("low", "medium", "high"); and ii) the potential significance of the event should it happen ("minor", "moderate", or "serious"). Some of these separate evaluations are problematic, but even before taking those problems into account, the risk "matrix" used to combine these two evaluations, and to arrive at a ranking, is dangerously simplistic.

For example, the method presumes that highly likely pollution events and other impacts with relatively minor consequences make for "moderate" risk, just the same as incidents that may be less likely but that may have very serious consequences. In other words, the cells in the "risk matrix" derive from simple averaging of "probabilities" and "consequences."

We question the wisdom of this approach, in no small part because we believe the prospect, discussed below, of communities suffering serious long-term contamination to their drinking water resources defies such simplistic logic.

Response: From the very outset, Maryland's risk assessment was intended to be qualitative in nature and not assign a numeric risk. The reasons for this is that for most risks there were not sufficient scientific literature or other information to determine rates of occurrence or otherwise provide a finer level of resolution than a low, medium or high ranking. Furthermore, it was also part of the risk assessment scope to consider the proposed BMPs effectiveness in mitigating risk. So in performing the risk assessment the Departments were faced with a two-fold difficulty of having to determine a probability where rates often were not available and a consequence in consideration of BMPs that likewise did not often have efficiency rates. This necessarily made the risk assessment subject to limitations as well as introduced best professional judgment into the analysis. A section regarding limitations/uncertainty has been incorporated into the final risk assessment to address these concerns. Furthermore, Appendix A has been revised to show both the probability and consequence rather than just a simple averaging. Even with these limitations, however, the Departments are confident that the risk assessment does provide some meaningful differentiation between levels of risk and indentifies activities where additional BMPs should be considered.

Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

The draft risk assessment suffers from a narrow geographic scope, and short time horizon

While the risk assessment is mostly qualitative, it is premised on two scenarios of future development: A "25%" scenario of 15 new wells per year, and a "75%" scenario of 45 new wells per year, both over 10 years. These are low estimates, and they account for a very limited time frame, two factors that affect what a risk ranking means. For example, if there are just 45 new wells per year, is a probability of 1 in 45 wells having some problem a "low" probability, or a "high" probability? How would the risk ranks change for the 100% scenario of 600 new wells per year for 20 years? Such a scenario is not inconceivable if drilling and fracking were to spread from the Marcellus shale, but also the Gettysburg, Culpeper, Taylorsville and Delmarva Basins.

That is, drilling and fracking would not just target the Marcellus shale, beneath western Maryland. Instead, we can expect companies to also target the Gettysburg, Culpeper, Taylorsville and Delmarva Basins, which stretch from central Maryland to the Eastern Shore.[1] The oil and gas industry's plans to export large amounts of natural gas overseas, including from a terminal proposed for Cove Point on the Chesapeake Bay, would only increase the pressure to drill and frack throughout the state.

Response: The scenarios chosen were developed by Towson's University's Regional Economic Studies Institute and used for the economic study conducted under the Executive Order (see http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/RESI_Marcellus_Shale_Report_Revised_FINAL.pdf). Accordingly, it made sense to the Departments to maintain consistency with the assumptions used in related studies. If UGWD development activities are proposed in other areas of the Maryland, the Departments will work with those local communities to address their concerns before any permits are issued. The Governor's Office also has the authority to issue another Executive Order to study those areas, similar to the efforts conducted by the Marcellus Shale Advisory Commission, before UGWD is permitted.

Dubious ranking of the risk of long-term threats to drinking water resources

In some cases, individual impacts are not ranked, because of insufficient information, but in other cases, impacts are ranked presuming that there will be sufficient information in

[1] U.S. Geological Survey. "Assessment of undiscovered oil and gas resources of the East Coast Mesozoic basins of the Piedmont, Blue Ridge Thrust Belt, Atlantic Coastal Plain, and New England Provinces, 2011." June 2012 at 1 and 2.

the future. It is not clear why, or how, the authors arrived at this distinction; and the public deserves to know.

For example, the authors repeat a general statement with respect the long terms risks to drinking water resources; e.g., the draft risk assessment states:

> "The high standards set for casing and cementing practices, management of materials and wastes on and off the site and careful siting resulting from location restrictions, setbacks and geologic studies, yield a low risk that ground and surface water supplies will be impacted either through surface spills or subsurface releases during the drilling and waste transport process."
>
> "The stringent controls on well casing and cementing, stormwater and spill management on the pad, proper siting using geologic studies and setbacks from sensitive ecological and community features are among the many best practices that reduce surface and ground water risks for people and the environment to low."
>
> "The stringent controls on well casing and cementing, stormwater and spill management on the pad, proper siting using geologic studies and setbacks from sensitive ecological and community features are among the many best practices that serve to reduce the risk of water contamination for human consumption to low except for the specific case of methane."

Clearly, each of these three statements presumes that "high standards" or "stringent controls" put into place and enforced will make the probability of events low.

Each one of these three statements also derives from presuming that the potential

consequences are not high – since it is otherwise not possible to have a "low" overall risk ranking.

There are three major problems with these "low" ranks of risk.

First, the consequences of aquifer contamination can persist over a generation, and come at enormous costs for a community. This, for over a generation or more.

Second, the assessment generally assigns a "low" probability when an impact "rarely happens under ordinary conditions; [or is] not forecast to be encountered under foreseeable future circumstances in view of current knowledge and existing controls on gas extraction." Now, with the potential for many hundreds of new wells drilled and fracked in Maryland for decades, there would be leaky wells. Because scientists do not know how these leaky wells might interconnect with contamination pathways, it is true that they cannot "forecast" specific contamination events given "current knowledge," but that does not make such events unforeseeable. Indeed, such events or most likely

inevitable with thousands of abandoned, aging and degrading wells. These events are inevitable regardless of industry's best management practices.

Third, of course it is unlikely that that the BMPs would become strongly enacted and enforced by a new, high-budget bureaucracy in the state that is reliant on the oil and gas industry for both technical and financial support. Maryland can expect that the oil and gas industry will contaminate the regulatory and enforcement process, leading to lax rules and implementation.

Response: As stated in an above response, the risk assessment is qualitative, contains uncertainty and limitations, and also incorporated some best professional judgment. This uncertainty also translates into the Departments' evaluation of BMP effectiveness and these limitations have been further described in the report. However, some of the rationale used to rank risks to drinking water sources as overall low include:

1. **The Departments propose to prohibit use of pits for storing fracking chemicals which will eliminate those sources from contaminating groundwater:**
2. **The well pads are proposed to be lined and contain up to a 25-year storm so that any chemical spills or leaks from tanks on the well pad are expected to be contained;**
3. **The Department is proposing setbacks from public water supplies, private wells, existing gas wells, and depths to the target formation;**
4. **Stringent casing and cementing standards are being proposed; and,**
5. **Pilot holes and wells logs are proposed to be required.**

Additional open questions regarding risks to underground sources of drinking water

The amount of natural gas that can be produced from a single fracked well varies significantly within a shale gas play, and the rate of production declines rapidly soon after a well is fracked.[2] Operators drill and frack the sweet spots of the play first, leaving the less productive and thus less profitable portions of the play for later. This means that the industry has to increase the rate of drilling and fracking just to sustain a constant level of shale gas production.

A decades-long span of drilling and fracking for natural gas would play out as waves of drilling from one community to the next, with selection of well sites to place them in such a way to maximize the amount of surface area exposed by fracturing the underlying hydrocarbon source rocks.

Allowing the oil and gas industry to ride out this fracking treadmill in Maryland – targeting not just the Marcellus – would turn the state into a pincushion of fracked gas wells. According to the Maryland Department of the Environment, one "industry representative" has suggested that over 2,200 new shale gas wells could be drilled in Garrett and Allegany Counties alone.[3]

Over years and decades, these wells would age, degrade and be abandoned, creating pathways through which injected chemicals and natural contaminants can seep into underground sources of drinking water.[4] The result would be a legacy of risk shouldered by generations of Marylanders.

Put simply, scientists do not yet know how drilling and fracking thousands of new wells in a region will ultimately change the way contaminants — not just the cancer-causing fracking chemicals but also hydrocarbon gases and even radioactive brines — mix and move deep underground, over long periods of time.[5]

Therefore, in essence, those living in regions with widespread shale gas development — and more broadly in regions with widespread disposal of toxic wastes via deep well injections — are the subjects of a large, uncontrolled scientific experiment on the fate and transport of the chemicals injected.

Residents and businesses of the Eastern Shore and southern Maryland rely heavily on freshwater from underground aquifers, and in fact even without oil and gas development, these aquifers are in decline – water is being pumped out of them at a rate faster than rains are recharging them.[6] Allowing drilling and fracking in this part of our state would only increase demand on these aquifers, not to mention put them at risk of contamination.

As for central and western Maryland, the U.S. Geological Survey, in partnership with the state of Maryland, is engaged in a study of how groundwater resources in that region change with drought or with periods of heavy rains, and in turn how local changes in groundwater levels impact stream flows there.[7] The aim of the study is build a better understanding of the local balances of supply and future demand for water resources.[8] This understanding is complicated by the many natural fractures in the bedrock where groundwater resides and by how these fractures connect to rivers and streams.[9]

If the oil and gas industry gets its way, shale gas wells may soon intersect many of these fractures before adequate understanding of how groundwater flows beneath the region.[10] By creating new pathways through which contaminants can flow, these new wells would put at risk both the pockets of shallow groundwater and the streams to which this groundwater flows. Again, these wells would age, degrade and potentially leak, as concrete is prone to do. These leaks may lead to "serious" consequences that, again, defy the simplistic matrix of the draft risk assessment.

[2] EIA. "Annual energy outlook 2012 with projections to 2035." (DOE/EIA-0383(2012)). June 2012 at 57.

[3] Maryland Department of the Environment. "Facts about...the Marcellus Shale Safe Drilling Initiative." [Fact sheet]. April 2012.

[4] Myers, Tom. "Potential contaminant pathways from hydraulically fractured shale to aquifers." *Ground Water*. April 17, 2012 at 3 to 4; Brufatto, Claudio et al. "From mud to cement – Building gas wells." *Oilfield Review*. Autumn 2003 at 63; Dusseault, Maurice B. et al. "Why oilwells leak: Cement behavior and long-term consequences." Paper presented at the Society of Petroleum Engineers International Oil and Gas Conference and Exhibition, Beijing, China. November 7-10 2000 at 1; Kusnetz, Nicholas. "Deteriorating oil and gas wells threaten drinking water, homes across the country." *ProPublica*. April 3, 2011.

[5] Myers, Tom. "Potential contaminant pathways from hydraulically fractured shale to aquifers." *Ground Water*. April 17, 2012 at 3 to 4; Dusseault, Maurice B. et al. "Why oilwells leak: Cement behavior and long-term consequences." Paper presented at the Society of Petroleum Engineers International Oil and Gas Conference and Exhibition, Beijing, China. November 7-10 2000 at 1; Personal communication with attendees of U.S. EPA Hydraulic Fracturing Study stakeholder outreach workshop, Research Triangle Park, NC. May 2013.

[6] U.S. Geological Survey, Water Science Center for Maryland, Delaware and the District of Columbia. "Freshwater use and withdrawals." Webpage, available at http://md.water.usgs.gov/freshwater/withdrawals/ , accessed January 28, 2013; U.S. Geological Survey. [Fact sheet with Maryland Departments of Natural Resources and the Environment]. "Sustainability of the ground-water resources in the Atlantic Coastal Plain of Maryland." [FS 2006-3009] 2006 at 1.

[7] U.S. Geological Survey. [Prepared in cooperation with Maryland Departments of Natural Resources and the Environment]. "A science plan for a comprehensive assessment of water supply in the region underlain by fractured rock in Maryland." [Scientific investigations report 2012-5106]. 2012.

[8] U.S. Geological Survey. [Prepared in cooperation with Maryland Departments of Natural Resources and the Environment]. "A science plan for a comprehensive assessment of water supply in the region underlain by fractured rock in Maryland." [Scientific investigations report 2012-5106]. 2012 at 16.

[9] U.S. Geological Survey. [Prepared in cooperation with Maryland Departments of Natural Resources and the Environment]. "A science plan for a comprehensive assessment of water supply in the region underlain by fractured rock in Maryland." [Scientific investigations report 2012-5106]. 2012 at 16.

[10] U.S. Geological Survey. [Prepared in cooperation with Maryland Departments of Natural Resources and the Environment]. "A science plan for a comprehensive assessment of water supply in the region underlain by fractured rock in Maryland." [Scientific investigations report 2012-5106]. 2012 at 5, 17 and 21.

The heavily fractured bedrock beneath central and western Maryland would only complicate the cementing process, and only increase the likelihood that wells will develop leaks of hydrocarbons and other contaminants.

The draft risk assessment fails to address these issues, and the only explanation lies in how the draft risk assessment assigns a low probability of outcome. The probability of an outcome is deemed low when it is "not forecast to be encountered under foreseeable future circumstances in view of current knowledge and existing controls on gas extraction." However, we plainly foresee the potential for serious consequences to drinking water resources from allowing hundreds if not thousands of oil and gas wells to penetrate the heavily fractured bedrock that holds these water resources in central and western Maryland.

Response: The Departments concur that through the Comprehensive Gas Development Plan requirements and the authority to deny permits that the pace, density, and number of overall wells can be limited as appropriate to protect public health and the environment. As for the likelihood that injected fracking chemicals will contaminate surface aquifers or that induced fractures will communicate with aquifers, experts from both the Maryland Geological Survey and the U.S. Geological Survey provided consultation on this issue. These experts concurred that the likelihood of this occurring is remote. As to the fate of fracking chemicals, these flow back up to the surface immediately after fracking when the well integrity is at its greatest and has not suffered from integrity issues due to aging. After that, any chemicals or formation brines remain trapped at depth in the target formation.

Several authors report that they found no evidence of contamination of drinking water with brine (Osborn et al., 2011; Jackson et al., 2013). In a recent report investigating the mechanisms by which human activity could cause methane gas contamination to occur in drinking water wells, the authors noted that samples with higher levels of thermogenic gas did not also exhibit higher chloride levels, suggesting that the thermogenic hydrocarbon gas had separated from the brine and migrated in the gas phase. For other samples where gas and brine levels did correlate, they concluded that the presence of gas and chloride was natural and possibly a result of tectonically-driven migration over geological time of gas-rich brine from an underlying source formation or gas-bearing formation of intermediate depth (Darrah et al., 2014). Because brine is so dense, it is not likely to migrate upward through casing/cementing failures without significant induced pressure. Many gas shales, including most of the Marcellus, are slightly to moderately over-pressured, but once gas is produced, the formation pressure drops rapidly to hydrostatic and below, and the preferred flow direction of gas and formation brines is along the pressure gradient toward the well bore (personal communication, Daniel Soeder, U.S., Department of Energy, National Energy Technology Laboratory, November 5, 2014). Once gas is being produced, there are no ongoing pressures to drive fluids to the surface.

Will the provision of wearable air quality monitoring gear be a Best Management Practice ?

The draft Scoping Report on public health impacts raised the specter of Maryland residents wearing personal monitoring devices to avoid the sporadic plumes of oil and gas industry emissions. We are heartened, and a bit curious, that the draft risk assessment makes no mention of such devices, which would collect real-time data on individuals' exposure to air pollutants.

The MSSDI was tasked with describing the potential extent of the negative impacts, as well as the extent to which these negative impacts might be minimized. The MSSDI's draft Scoping Report also signals that its recommendations will include actions to "maximize health benefits of natural gas extraction using high-volume hydraulic fracturing."

This appears to be a reference to the fact that natural gas burns more cleanly than coal and heating oil, in terms of the emissions of criteria pollutants. However, this statement sets up a false choice. First, wind energy, solar energy and energy efficiency trump this perceived benefit of natural gas. Moreover, this statement wrongly presumes that natural gas will actually displace, and not just supplement, coal or heating oil use, and that natural gas will not displace other cleaner alternatives.

This false choice aside, the draft risk assessment acknowledges that "air emissions from [unconventional gas well development] require future study and that site specific assessments will be necessary to determine risk." The draft risk assessment concludes that "the overall probability for air emissions is high while the consequences cannot be determined at this time due to the insufficient information on proposed BMP and setback efficiencies, combustion emissions impacts and photochemical transformation [i.e., ozone formation], specific location/density of wells/well pads, and potential for cumulative/synergistic effects."

An important 2014 study, not cited in the draft risk assessment, addresses the specific public health impacts from air pollution, and explains that the "episodic and fluctuating" nature of the toxic plumes of pollutants from industry sites might be why standard air quality measures — which average over a region, and average over stretches of time — appear to miss the "intensity, frequency or durations of the actual human exposures to the mixtures of toxic materials released regularly at [unconventional natural gas development] sites."[11] Wearable air quality monitoring devices would close the data gap, but this would only come in the form of a largely uncontrolled and unethical experiment on human health.

The draft Scoping Report of the public health study acknowledges the limits of the assessment with respect to chronic health impacts. On page 21 of that study, the authors state "The [final health impacts assessment] report will be limited in terms of addressing chronic health outcomes owing to the long latency period between exposures and chronic

health outcomes." An important contributor to the limits of the proposed health impacts assessment is the lack of toxicity data on the many hundreds of chemicals that have been used in fracking fluids, much less the toxicity of combinations of these chemicals at once.

With a ban on fracking, there would be no need to ask Maryland residents living alongside new wells and compressor stations, as there would be new threat to assess.

Response: As indicated in the risk assessment, worker safety is not within the purview of the Departments and was considered outside of the scope of the risk assessment (RA). However, in several places of the RA it is indicated that some of the greatest risks are likely to workers on site. The Maryland Occupational Safety and Health Administration should be taken this into consideration and whether new regulations are necessary to address.

The question of direction, and leadership, in the face of climate change

The draft risk assessment does not weigh in on the open question of whether burning natural gas instead of other fossil fuels is leading to more or less climate damage. But this question is beside the point because regardless of coal, maintaining our economy's dependence on oil and natural gas gives rise to more climate pollution than we can afford. This oil and natural gas dependence is what drives widespread and intensive fracking nationally, and it is what would bring costly global warming impacts to Maryland.

Several recent studies now show that relying on natural gas as a bridge will not avoid potentially dire increases in global mean temperature, even assuming relatively low estimates for the fraction of produced natural gas that leaks into the atmosphere.[12]

Notably, for its "Golden Age of Gas" scenario of increased global dependence on natural gas, the International Energy Agency estimated that the global average temperature would increase by 3.5° Celsius, or by about 6.3° Fahrenheit, by 2035.[13] Maryland's entire economy would be crippled by such extreme climate change.

[11] Brown, David et al. "Understanding exposure from natural gas drilling puts current air standards to the test." Reviews on Environmental Health. Preprint, published online March 2014 at 1.
[12] Myhrvold, Nathan and Ken Caldeira. "Greenhouse gases, climate change and the transition from coal to low-carbon electricity." *Environmental Research Letters*, vol. 7, iss. 1. February 2012 at 4 to 5; Levi, Michael. "Climate implications of natural gas as a bridge." *Climatic Change.* January 2013.
[13] International Energy Agency. "Golden rules for a golden age of gas." 2012 at 91.

According to the Maryland Commission on Climate Change, this large of an increase in global average temperature would mean our state would suffer:

- "the loss of virtually all coastal wetlands";
- the "inundation of more than 100 square miles of presently dry land and loss of the homes of thousands of Marylanders";
- summer-long heat waves "creating life-threatening conditions in Maryland's urban environments";
- "more extreme rainfall events, but also longer lasting summer droughts";
- "declines in agricultural productivity" due to "severe heat stress and the summer droughts"; and
- "the loss of maple-beech-birch forests of Western Maryland" and "the withdrawal of northern bird species such as the Baltimore oriole from Maryland."[14]

Yet the IEA's projection of the climate impact from the "Golden Age of Gas" scenario also presumes that much less methane is leaking into the atmosphere than may actually be the case. Methane, the primary component of natural gas, is a far more potent greenhouse gas than carbon dioxide at trapping heat.[15] Data on just how much methane is leaking from the oil and gas industry varies widely, but methane emissions are clearly significant enough to cancel much if not entirely negate the benefit of lower carbon dioxide emissions that come from burning natural gas instead of coal or oil.[16]

Given the vulnerability of Maryland to global warming and sea level rise, the state should acknowledge the need to accept the science and face the future.

Response: The Departments' proposed best practices to require methane offsets and rigorous leak detection and repair programs are robust measures to address climate change impacts. Moreover and at the State level, Maryland's has an aggressive Climate Change plan in place to reduce greenhouse gases 25 percent by 2020.

An underlying open question of direction, and leadership, for Maryland

The BMPs study stated explicitly that the O'Malley Administration had yet to determine whether or not drilling and fracking for shale gas poses "unacceptable" risks.

[14] Boesch, Donald F. (ed). "Comprehensive assessment of climate change impacts in Maryland." Chapter 2 in Maryland Commission on Climate Change. "Climate action plan." August 2008 at 78.
[15] Matthews, Kevin. "Why claims about reductions of U.S. carbon dioxide emissions are misleading." *Climate Progress*. December 5, 2012.
[16] *See* Food & Water Watch. "The urgent case for a ban on fracking." September 2014.

The stated aims of the risk assessment are that it "assist policymakers and regulators in determining whether and how gas production from the Marcellus shale in Maryland can be accomplished without unacceptable risks of adverse impacts to public health, safety, the environment and natural resources" and that it help authorities "to determine if [Unconventional Gas Well Development] can be conducted safely in Maryland with current proposed [Best Management Practices]."

National – indeed presidential – politics is important context for the O'Malley administration's political decision on this issue, should he choose to take one before he leaves office and after the MSSDI finalizes its prescribed contributions.

The "All-of-the-above" and the "Drill, baby! Drill" approaches that dominate federal energy policy both promise far more climate pollution than we can afford, and both leave a legacy of risk to vital sources of drinking water.[17] The shared bipartisan aim is to maximize the amount of oil and gas that can be brought to the surface, when building local and sustainable energy systems and systemically addressing climate change mean the opposite. Doing that – doing right by future generations – means maximizing the volume of oil and gas left underground. The reality of that fact will only intensify.

States can be leaders in setting the conditions for their cities to build the necessary remaking of the U.S. energy system. Maryland has an opportunity to take this responsible direction, and provide this leadership. We believe an accurate portrayal of this context is essential to the content of MSSDI recommendations, and to the content of any full assessment of the risks.

The alternative future – the future of the status quo – would have Maryland's economy, and the environmental and public health of the state, become increasingly vulnerable to and stressed by the air, water, land, and global warming pollution from the current U.S. energy system, and from mimicry of this system worldwide.

We ask that this underlying question of direction, and leadership, be brought to the fore in MSSDI recommendations.

To date, the reports finalized by the O'Malley administration and Marcellus Shale Advisory Commission show that there are serious public health and environmental concerns associated with fracking. Questionable industry practices highlighted in the BMPs do not give us any reassurance that Maryland can even come close to protecting Marylanders from the dangers associated with fracking.

On climate, and on the issue of long-term risks to underground sources of drinking water, the MSSDI fails to make a convincing case that widespread and intensive drilling and fracking can be "accomplished without unacceptable risks of adverse impacts to public health, safety, the environment and natural resources."

Response: Through use of Executive Privilege, developing and signing the Executive Order that established the Marcellus Shale Advisory Commission, providing State funding

for critical scientific, economic and public health studies, and proposing arguably the most stringent UGWD best practices in the world, Maryland is leading the way in how to responsibly develop this resource to protect public health and the environment.

Departmental Responses to Comments Received from Agencies and Organizations on Maryland's Marcellus Shale Risk Assessment

Comments Received from the Maryland Environmental Health Network

These comments are submitted by the Maryland Environmental Health Network (MdEHN) in reference to the report "Assessment of risks from unconventional gas well development in the Marcellus Shale of Western Maryland" prepared by the Maryland Department of the Environment (MDE) and the Maryland Department of Natural Resources.

This report needs to be considered in context, as one of a number of investments Maryland has made to understand the full suite of risks associated with potential Unconventional Natural Gas Development and Production (UNGDP). MdEHN appreciates the substantial effort that went into preparing this report, but has concerns about aspects of the report.

Our comments are divided into two categories: 1. Clarity and Readability, and 2. Methodology. They are informed by having attended meetings of the Maryland Marcellus Shale Advisory Commission (MSAC) for the past two years and awareness of critical steps and decisions that lie ahead.

The Risk Assessment report can be made more valuable to the new Governor's administration and to elected officials and other policy-makers by including the following:

I. Clarity and Readability

1. Include cross references throughout Appendix A to the subsequent appendices where information is addressed in more detail.

Response: Cross references have been added to Appendix A.

2. Add a bulleted and clearly titled section at the start of the Executive Summary about the Scope Limitations. A list was provided by Matt Rowe during the presentation on November 5 to MSAC. Including study limitations is standard across fields; this Risk Assessment (RA) should not be exempted from this practice.

Response: A limitations/uncertainty section has been added to the Executive Summary document.

3. Revise to maximize readability and usability:

   a. The Executive Summary is printed in very small font and the Table of Contents is redundant with an unnecessary number of lines.
   b. There should be a more concise table that includes the level of risk associated with each of the eight areas first identified in the Executive Summary.

Response: Revisions have been made in the Executive Summary to provide readability and usability.

4. Include the context. The RA is only one of many efforts addressing various aspects of potential UNGDP in Western Maryland. The RA should highlight the already published health study from the Maryland Institute for Applied Environmental Health team at the University of Maryland School of Public Health and the economic study from Towson University. The RA does reference the draft Best Management Practices from MDE.

The RA should make clear that it should not be considered in isolation, but can only inform any recommendations about potential UNGDP in Western Maryland alongside these other documents.

Response: This context has been provided in the Executive Summary.

5. Strengthen the conclusion:

a. "If risks are found to be unacceptably high, additional mitigation steps could be taken, or gas extraction in the Marcellus shale in Maryland could be deferred until risks can be reduced by new technology or practices, or until additional data demonstrate that the proposed practices are effective to reduce risk." (p. 12) If the purpose of the RA is to provide information for "consideration by the State of Maryland and the Marcellus Shale Advisory Commission to determine if UGWD can be conducted safely in Maryland with current proposed BMPs" (p. 3), what then informs their decisions about whether the risks classified in the RA with the very specific ranking system laid out in its methodology are "unacceptably high"? The usefulness of the ranking system laid out in the RA is called into question by its own conclusion.

II. Methodology

1. Change the two types of "Low Risk" to differentiate between those that are Low Probability & Moderate Consequence versus those that are Medium Probability & Minor Consequence. It should be made clear that the first is actually of greater concern than the second. In the first case, harm may be "considerable" though infrequent. The need for protections in such cases is not diminished by the numbers of people or amount of land at risk being smaller. If small numbers were a rationale for low risk, we would not enforce speed limits and seat belts on low traffic roads, or be screening every person who comes into a health facility for recent travel to Africa due to Ebola concerns.

Response: Appendix A has been revised to show both the probability and consequence as well as the overall risk ranking.

2. Streamline the language used in the RA to be consistent with other documents. The language of "Moderate Consequence" is of concern as the detail behind it includes "considerable adverse impact on people." The language of the Health Study was critiqued for not having nuances between Medium High and Medium Low concern, and only including High, Medium High, and Low. The Risk Assessment makes this same miscommunication in the opposite direction, giving the appearance of trying to minimize concerns.

Response: Per above, these concerns are addressed by including both a discussion of uncertainty/limitations, as well as revisions to Appendix A showing both probability and consequence.

3. Consider the study ethics. A study of this type attempting to categorize risks should include some acknowledgement of the ethical dilemmas associated with identifying possible harms to people and property and should clearly state that the economic status and physical vulnerability of those that may be harmed was not assessed. Addressing risks of harming those who are less able to protect themselves is a greater societal responsibility than addressing the risk of harming those with resources or choices, including access to healthcare. Cumulative risks could also be considered in this discussion.

Response: With any kind of industrial/economic activity, there are costs in addition to benefits. Whether the benefits outweigh the costs is a judgment call of our elected officials in consideration of public sentiment. As a result, the risk assessment avoids this kind of ethical discussion and relies on an analysis of the scientific literature and effectiveness of proposed best practices. The cumulative risks are addressed through the analysis of the two development scenarios of 150 and 450 wells. However, and is indicated in the revised Executive Summary, there were limitations tot his analysis.

4. Acknowledge the need to address risks associated with UNGDP in the smaller pockets of shale throughout the state. This is work yet to be done, and the present study should not give the impression that risks will be identical no matter where drilling is conducted in the future.

Response: This is correct but the current risk assessment as well as the Advisory Commission's activities were limited to the Marcellus Shale.

5. Include more information about water contamination. If the RA works under the assumption that 30% of the water used to hydraulically fracture each well flows back to the surface, it also needs to include a comprehensive assessment of the 70% of water assumed not to come back.

Response: The remaining 70% is expected to remain in the target formation and pose no risk to public health or drinking water. Because brine is so dense, it is not likely to migrate upward through casing/cementing failures without significant induced pressure. Many gas shales, including most of the Marcellus, are slightly to moderately over-pressured, but once gas is produced, the formation pressure drops rapidly to hydrostatic and below, and the preferred flow direction of gas and formation brines is along the pressure gradient toward the well bore (personal communication, Daniel Soeder, U.S., Department of Energy, National Energy Technology Laboratory, November 5, 2014). Once gas is being produced, there are no ongoing pressures to drive fluids to the surface.

6. Enhance the discussion around the proposed BMPs. Ranking which BMPs would be most effective in protecting Marylanders from the risks presented in the RA. For

example, setback recommendations should be highlighted, as they are (a) enforceable, (b) practicable, and (c) tentatively supported by science as having real protective value.

Response: The Departments concur that the current evaluations of BMPs are adequate and considerable details are provided in each appendix. As mentioned above, the Departments acknowledge limitations and uncertainty with those evaluations.