HARVARD LAW SCHOOL
Environmental Law Program
POLICY INITIATIVE

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RE: Risk Assessment

Ms. Kenney:

I submit for your review and consideration my comments on Maryland's Marcellus Shale Risk Assessment (RA). At the outset, I wish to express my deep appreciation to the authors of this report. The document reflects a lot of hard work and improves on other risk assessments, for instance by considering the cumulative effect of actions taken in the Marcellus region of the state (see, e.g., page 41 of Appendix B). I urge Governor O'Malley and Governor-Elect Hogan to rely on this RA for any future decisions regarding shale gas development in Maryland.

In summary, I offer recommendations in the following categories:

- Maryland's Methodology and Structure of the Risk Assessment.
- Maryland's Assumptions and Stated Uncertainties
- Maryland's Conclusions and Inferences
- Additional Data and Evidence to Consider
- Additional BMPs to Consider
- Small Editing Suggestions

Thank you very much for considering these comments. Please do not hesitate to reach out if you have any questions or need further information on any of these points.

Maryland's Methodology and Structure of the Risk Assessment

RECOMMENDATION #1: Consider modest changes to RA methodology and structure.

The RA describes 8 categories of risks, evaluated across five phases of unconventional gas well development. Appendix A lists dozens of risks that do not appear organized by risk category.

a. **Recommendation 1(a):** Arrange the risks in Appendix A to track the 8 categories of risk. Headings of the 8 categories would be helpful.

Page 5 of the core document describes how the report team considered best management practices (BMPs). I strongly support this approach, which places a higher value on prescriptive

and well-established BMPs than qualitative, flexible, or unproven BMPs. However, the five bullets are a bit unclear.

b. **Recommendation 1(b):** Clarify the different uses of "efficiencies" or select different terminology. The first "efficiencies" seems to mean "cost-effective," the second seems to imply "short-cuts," and the third seems to imply effectiveness of performance. Moreover, describe the ideal BMP before jumping into how Maryland proposes to weigh different characteristics; for instance by stating, "it is best when a BMP is prescriptive, uniform across sites, documented as effective, and verified through reporting."

Table 3 on page 7 of the core document describes the risk ranking methodology. Sometimes the relative risk ranking is not clear. For instance, a moderate consequence with high probability is "high risk," as are a serious consequence with medium probability and a serious consequence with high probability. Are they the same level of "high risk?"

c. **Recommendation 1(c):** Describe the risk ranking process a bit more.

Very few risk rankings change between the low scenario and high scenario. Is that because the number of wells projects under the low and high scenarios are not so different? Is it because the RA is not sensitive to different inputs? Or, as noted on page 43 of Appendix B, reviewers did not have enough information to detect a difference?

d. **Recommendation 1(d):** Describe in the core document why risk rankings remain the same for most risks under the high and low scenario, and what is different about the handful of risks where the two scenarios drive different conclusions.

Page 12 of Appendix B explains that the high/low end scenarios would not drive a different outcome for air pollution from seismic activity because "a single survey application from PA General Energy Company covered an approximately 3.9 mile transect."

e. **Recommendation 1(e):** Add another sentence to finish the thought – what is the relevance of the 3.9 mile transect? How large is the potential development area? Or is the high end scenario projected to take place over the same area as the low end scenario? (As a related point, page 14 of Appendix B noted a "common assumption" that there will only be one well pad per square mile but did not explain basis for this.)

For the most part, the report team described the scope of each assessment quite well. However, the scope of the air pollution assessment was a bit unclear. Appendix B discusses a number of different pieces of emitting equipment, but does not specify which are considered in the RA. Page 36 of Appendix B says the RA considers the well pad, one off-site compressor, and on-site gathering lines. Page 37 mentions a line heater and two compressors (one on-site and one off-site). Page 38 reports the results of a New York study regarding glycol dehydrators, and a site visit to West Virginia where authors saw five compressors on a well pad.

f. **Recommendation 1(f):** Clarify the equipment considered in the air emissions risk assessment in Appendix B.

Appendix B broke out "activity duration and scope" from the description. I found this quite useful, since these factors are assumptions relied on for the risk assessment.

g. **Recommendation 1(g):** Break out "activity duration and scope" across all appendices.

Appendix G included a "rationale for findings". I found this to be an incredibly useful format for a reader, to identify quickly the basis for assumptions and conclusions.

h. **Recommendation 1(h):** Include a "rationale for findings" section in the discussions throughout the Appendices.

Maryland's Assumptions and Stated Uncertainties

RECOMMENDATION #2: Reconsider the assumption of a 100% compliance rate.

The core document and the Appendices assume a 100% compliance rate with state rules and BMPs. This is highly unlikely.

A 2014 paper reviewing compliance data from Pennsylvania reported that of the 8030 wells targeting the Marcellus shale inspected between 2005 and 2013, 6.3% reported violations based on well barrier or integrity failure. In turn, this paper cited a study of 3533 Pennsylvania wells monitored between 2008 and 2011; of these, there were 85 cases of cement or casing failures (2.4%), 4 blowouts, and 2 examples of gas venting. [NOTE: I provide a description and link to this study on page 7 of these comments.]

Compliance rates in other state oil & gas programs, or compliance rates with existing rules in Maryland (such as storm water runoff) could be used to predict levels of compliance.

This may not change the report's risk conclusions, since it may be difficult to quantify the additional risk posed by a predicted rate of non-compliance. At the very least, the RA could observe that risk conclusions appear conservative, given their assumption of a 100% compliance rate which is highly unlikely under the best of circumstances, despite all the best intentions.

RECOMMENDATION #3: Describe Towson's modeling of the "boom and bust" cycle, as basis for intensity assumptions.

Page 5 of the core document provides well and well pad development assumptions for Maryland. These are based on scenarios crafted by Towson University's Regional Economic Studies Institute in consultation with the MDE and DNR. However, there is no explanation of the basis for these assumptions. A brief explanation for the pace of drilling and total wells drilled (what is the basis for thinking 600 wells would be the total number necessary to exploit 100% of the available natural gas resource?) would be helpful.

RECOMMENDATION #4: Consider active states for duration of activity assumptions.

The duration of activities for each phase of unconventional gas well development are based on the New York Supplemental General EIS and draft permit applications submitted to Maryland. Meanwhile, large scale unconventional gas production is occurring in other Marcellus shale states, including West Virginia and Pennsylvania. Where possible, it makes sense to rely on data in active drilling states for these assumptions, rather than data from states with a moratorium on high volume hydraulic fracturing.

For instance, it is very helpful when the RA relies on a Pennsylvania spill study (page 10, Appendix D), or a tour of West Virginia sites to assess traffic volume (page 10, Appendix C), since these neighboring states share characteristics with Western Maryland and its dry gas Marcellus shale play. For this reason, I suggest that the report team consult the Pennsylvania studies I've cited below, in Recommendations #9 and #10.

RECOMMENDATION #5: Explain the assumption about drilling rig size.

On Page 18 of Appendix B, the RA assumes drilling rigs will be 5,400 hp. However, later on page 18 (and on page 20 of Appendix D), the RA assumes that two drilling rigs will be used at a site – one large, and one small. Does the 5,400 hp size represent both rigs, or does it represent one size of rig? Meanwhile, Argonne National Lab has assumed rigs will be 2,000 hp. The report team might consider explaining the basis for this assumption.

RECOMMENDATION #6: Explain the assumptions of "simultaneous emissions."

On Page 14 of Appendix B, the RA assumes site preparation would occur simultaneously at multiple well pads under the low end scenario, which projects an average of 2.5 well pads developed each year, or an annual maximum of 4 well pads over 16 weeks of activity. On page 27 of Appendix B, the RA assumes hydraulic fracturing would occur simultaneously at different pads under the low end scenario, which projects a maximum 75 days of activity each year. The report team may need to explain the basis for assuming that site preparation will occur during the same 16 weeks, and that fracturing will occur over the same 75 days.

<u>Maryland's Conclusions and Inferences</u>

RECOMMENDATION #7: Explain the discrepancy between the conclusions for air pollution from trucks during different phases of development.

Below is an excerpt from Appendix A, making risk conclusions about air pollution from truck traffic during different phases of development:

Aspect	Agent/ chemical	Impact on	Phase				
			Site identification/ preparation	Drilling, casing and cementing	HVHF / Well completion	Production	Well abandonment/ reclamation
Truck trips	Dust/PM	Human	Moderate	Insufficient data	Low for Scenario 1, Insufficient for Scenario 2	Moderate	Low
Truck trips	NOx, benzene, PM	Human	Low for Seismic Assessment, Moderate for Site Preparation	Insufficient data	Insufficient data	Moderate	Low

As an initial matter, the reference to pm in both rows of the table is confusing. The text that accompanies this table distinguishes between Combustion and Non-Combustion emissions; consider including this distinction in the rows to clarify matters.

Page 12 of Appendix B says air pollution risk from combustion sources is low during seismic activity, and makes no mention of the risk from non-combustion sources. The table scores air pollution risk from non-combustion sources as moderate during seismic activity and site preparation. Should risk conclusions distinguish between seismic and site preparation, as they were in the second row? Otherwise, the narrative should support the finding of a moderate risk of air pollution from non-combustion sources in both phases, which would appear to be inconsistent from the text accompanying this table.

Finally, the paper notes there is insufficient information in the literature about air pollution from trucks. Below in my comments, I provide citations and hyperlinks to papers that should provide helpful additional information. However, if the data is truly insufficient, it is unclear why Maryland is nonetheless able to reach a risk conclusion in some cases and not in others. An explanation would be useful to justify the different outcomes. (The same holds for the conclusions in Table 20, page 40 of Appendix B.)

RECOMMENDATION # 8: Clarify the Probability of Risk of Drilling Fluid Spills, and Explain Conclusion that this Probability is Low.

Appendix D assesses an 8% probability factor that spills will occur at multiple steps in the drilling process (drilling fluid preparation; drilling operations; drilling cuttings separation/ storage/transfer). Each drilling step is described in a separate row in the risk conclusion table (Table 1, pages 31-32). Does this mean that the probability of spill in each step is summed to determine the risk of spills for the drilling phase? The report team should clarify this.

In addition, the RA assigns a low probability to the risk of spill from transport of drilling fluid additives to the well pad, because the incident probability for highway transportation of hazardous materials is 0.005% (page 6 of Appendix D). The RA also assigns a low probability to the risk of spill from drilling fluid preparation, drilling operations, and drilling cuttings separation, storage, and transfer, based on a Pennsylvania study indicating spills occurred 8% of the time (pages 10, 14, and 20 of Appendix D). Finally, the RA assigns a low probability to the risk of spill from a blowout, assuming a blowout rate of 1 per 1,000 wells (page 17 of Appendix D). A brief explanation for concluding that all of these rates drive low risk would be useful (particularly if the 8% spill rate is additive, as discussed in the previous paragraph).

Additional Data and Evidence to Consider

RECOMMENDATION #9: Consider Additional Data/Evidence Available to Assess Air Pollution Risk from Heavy Truck Traffic.

Page 9 of the Risk Assessment notes that during the drilling phase, "insufficient consequence data were available to assign a risk ranking to air emissions associated with truck traffic." Page 22 and Table 15 of Appendix B (page 24) reflect this lack of data. Page 9 notes that "[t]ruck traffic is most intense" during the hydraulic fracturing/ completion stage, yet the summary fails to mention air pollution consequences. Page 30 and Table 18 of Appendix B (page 32) reports "insufficient data" exists to determine consequence or risk from truck traffic during the completion stage. Page 12 of Appendix B similarly remarks that Maryland did not locate literature sources quantifying air emissions from seismic survey assessments.

However, a number of studies are available that estimate air emissions from truck traffic associated with shale gas development. For instance:

- An *Environmental Research Letters* article published in 2011 entitled, Life Cycle Greenhouse Gas Emissions of Marcellus Shale Gas, assessed the carbon dioxide, methane and nitrous oxide emissions associated with shale gas preproduction and production processes. Table I on page 4 of the article lists and provides hyperlinks to the underlying sources of data that the authors relied on for their assessment. As noted in this table and the article itself, several papers were consulted to estimate emissions from truck traffic during the drilling and fracturing/completion stages. Page six of the paper provides an explanation of the author's selection of an energy intensity value for truck transportation of liquids and a diesel fuel emission factor.

- An *Environmental Research Letters* article published in 2013 entitled, Estimation of Regional Air-Quality Damages from Marcellus Shale natural gas extraction in Pennsylvania, estimated emissions of volatile organic compounds, nitrous oxides, and fine and coarse particulate matter from Marcellus shale production. Pages 3-4 and Table 2 summarize the approach taken with truck traffic.

- An *American Society of Civil Engineers* article published in 2013 entitled, Transport of Hydraulic Fracturing Water and Wastes in the Susquehanna River Basin, Pennsylvania, used GIS to estimate actual travel distances of trucks (finding that actual miles traveled

are greater than those used in prior life-cycle analyses) and then estimated carbon dioxide, methane, and nitrous oxide emissions associated with that travel.

- The Alamo Area Council of Governments prepared an "Oil and Gas Emission Inventory Improvement Plan" for the Eagle Ford play in 2012. This inventory includes truck emissions during the seismic, drilling, fracturing, and production phases.

These studies also provide useful information about air pollution from drilling and from compressors, other areas where the RA noted there was a lack of evidence to support a robust conclusion (for instance, page 20 of Appendix B).

RECOMMENDATION #10: Consider Additional Data/Evidence Available to Assess Water Contamination Risk from Spills.

On pages 10 and 13-14 of Appendix E, the RA presents scant literature on the probability and consequence of fracturing fluid spills. While more research needs to be done in this area, a few existing studies could provide Maryland with more information on this point:

- A 2013 *Environmental Science & Technology* article entitled, A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States, maps (Figure 5) and describes Pennsylvania violations resulting in a spill or leak of fracturing fluids, drilling cuttings, or other materials. The data was found at http://www.fractracker.org/downloads/. (NOTE: This paper is in the bibliography for Appendix E but is not discussed in the prevalence portion of the Appendix.)

- As noted under Recommendation #2, this 2014 paper reviewed compliance data from Pennsylvania and includes incident data that could be useful here.

- Another 2013 *Environmental Science & Technology* article on Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania measures and describes potential impacts to surface water quality.

- A 2012 MIT study on the potential impacts on groundwater quality from surface spills of hydraulic fracturing describes the frequency of spills and designs a model to determine probability of harm to groundwater resources.

- A reporter for EnergyWire compiled 2013 spill incident data from 15 states. His database of spills is available online, through this article.

RECOMMENDATION #11: Consider Additional Data/Evidence Available to Assess Contaminant Migration through Faults and Old Wells.

According to page 9 of Appendix H, "[m]ost literature sources indicate that groundwater contamination via migration through faults or old wells would be a rare and site specific occurrence." Maryland's landscape may not have these features and/or the Comprehensive Gas

Development Plan may avoid spatial overlap of new development with these features, in which case this pathway might indeed be rare. However, if there is any risk of this pathway, the report team may want to consult data that has been analyzed and reported on in EnergyWire, including:

- A story reporting 103 downhole communications in New Mexico between 2007 and 2014, with at least one resulting in surface contamination;

- A story indicating a 5,000 gallon spill in Colorado may have been due to a "frack hit" into another well; and

- A story cataloguing ten downhole communication incidents that resulted in spills or blowouts between 2010 and 2013.

RECOMMENDATION #12: Share Data across RA Teams about Blowout Incidents.

Sometimes data used to assess risk in one step or phase in the RA was notably absent from other assessments. For instance, page 20 of Appendix B and Table 14 (page 21) derives blowout probability from offshore wells – the average of the data presented is 1.2 blowouts per 1,000 wells (0.12%). Page 31 of Appendix B and Tables 18 and 19 (page 32-33) rely on data from the Association of Oil and Gas Producers, suggesting an average of 4.5 blowouts per 10,000 wells drilled (0.045%). Page 17 of Appendix D cites an OGP study of a blowout incidence rate of 1 blowout per 1,000 wells (0.1%). (Meanwhile, in a 2013 paper published in Environmental Geosciences noted above (as a study cited in a 2014 paper), a study of 3,533 wells in Pennsylvania revealed a 0.17% rate of blowouts.) The report team may want to review these sources and select the same evidence across all phases assessed in the RA.

In some cases, such data-sharing did take place in the RA. For instance, page 3 of Appendix E referenced truck incident rates from Appendix B. However there, it was not clear whether distance traveled with the chemicals was factored into the 0.005% rate.

Additional BMPs to Consider

Before recommending additional BMPs, I wanted to note how impressed I am with many of the practices Maryland has in place or proposes to adopt before allowing unconventional oil and gas activity to proceed. For instance, while a number of state laws require oil and gas well operators to share data about the chemicals present on site in the event of an emergency, the requirements place the burden on the first responders to track down this information after an emergency has begun. Maryland's proposal to require permittees to prepare a list of chemicals and provided them to first responders before beginning operations would ensure that first responders are ready to respond the moment an emergency occurs.

I'd also suggest that Maryland consider using the term "Leading Practices" rather than "Best Management Practices" which implies that all current practices are optimal.

RECOMMENDATION #13: BMPS

The BMPs listed in each Appendix do not clearly delineate between what is already required by Maryland and what is being proposed.

a. **Recommendation 13(a):** Color-coding of BMPs would make it clearer which are in place and which are proposed. For instance, the industry has begun to move from diesel- to natural gas-powered engines and compressors on site, and Maryland could consider requiring this to reduce air emissions associated with production. However, I could not tell from the BMP description in Appendix A whether the Power Plan could achieve this, or whether the Power Plan is currently required.

According to page 10 of the core document, "gathering lines are long term features on the landscape (spanning the production life of the well) and the likelihood of stream crossings is high." Yet operators do not need permission to lay gathering lines (page 2 of the core document).

b. **Recommendation 13(b):** Consider whether Maryland has authority to regulate gathering line siting in sensitive ecosystems or through streams. Meanwhile, page 10 of the core document implies that Maryland's landscape-based planning technique, the Comprehensive Gas Development Plan, could direct or encourage responsible siting. Discuss how the Plan could mitigate impact.

c. **Recommendation 13(c):** Reconsider Maryland's preemption analysis for purposes of setting air pollution standards on compressors (page 38 of Appendix B). I have not conducted a full-blown preemption analysis here, but would be happy to think this through for Maryland on a longer time line than is allowed by this comment period. The Clean Air Act explicitly authorizes states to set stricter standards for stationary sources. It is possible that a compressor that remains in place for at least twelve months could be considered a stationary source under the Clean Air Act.

   Maryland may be preempted from setting air pollution standards on diesel engines in drilling equipment (page 22 of Appendix B), because these sources are more likely to be considered mobile sources. However, Maryland should consider non-regulatory approaches for achieving the same controls; for instance, by directing DERA funds to equipment used for unconventional oil and gas development.

On page 5 of Appendix E, the RA notes that "MDE must approve the use of any [fracturing] chemical, and will encourage the use of less dangerous chemicals."

d. **Recommendation #13(d):** Describe further up (in the "Scope" section of Appendix E) the particular chemicals of concern – for instance, the BTEX compounds (benzene, toluene, ethylene, and xylene). [NOTE: Page 3 of Appendix H lists "chemicals that are human health hazards" – the list could be used for this purpose as well.] The report team should explain that by reducing use of these chemicals, the consequences and therefore the overall risk posed by fracturing fluid spills can be reduced across the board. This BMP should be noted in each BMP section of Appendix E.

Finally, the RA could describe how Maryland plans to encourage the use of less dangerous chemicals. Several states require notice and approval of certain chemicals (Wyoming, potentially Nevada) or outright ban the use of certain chemicals (Alabama and Idaho, Wyoming if fracturing will occur into drinking water). [NOTE: Page 4 of Appendix H notes that Maryland may ban diesel fuel from hydraulic fracturing fluids – this should be noted in Appendix E as well.] Expedited permitting or lower bonding requirements could be used to encourage greener formulations, although to my knowledge states have not adopted these types of mechanisms.

Appendix I, relating to waste disposal practices, briefly mentions but does not describe the recycling of waste water for future fracturing jobs. Although this may not technically be a disposal practice, it would reduce the volume of waste needing to be disposed.

e. **Recommendation # 13(e):** Describe and conduct a risk assessment of recycling waste water for future fracturing events.

Small Editing Suggestions

RECOMMENDATION #14: Consider small edits

Page 42 of Appendix B lists the four "most important" GHGs.

a. **Recommendation 14(a):** Consider describing more precisely what these four GHGs are – the biggest drivers of climate change? The most prevalent GHGs?

Page 43 of Appendix B concludes by stating, "Looking across the risk assessments for each phase . . . ."

b. **Recommendation 14(b):** Since this is just about air pollution, consider including "of air pollution for" to the sentence, so it reads, "Looking across the risk assessments of air pollution for each phase . . . ."

Page 13 of Appendix B, the second paragraph reads oddly as if it were lifted from an instruction manual.

c. **Recommendation 14(c):** Consider changes to this paragraph so it tracks the format and style of the RA.

Page 4 of Appendix D, the last sentence concludes that waste drilling fluids "will be transported and disposed of properly." While we hope that is what happens, we do not know this.

d. **Recommendation 14(d):** Consider ending this sentence, "will be transported for disposal."

On page 10 of Appendix D, under "Risk Mitigation," all lines are bulleted.

e. **Recommendation 14(e):** The first two lines should not be bulleted.

Page 11 of Appendix D refers to "a previous section (Drilling Fluid Preparation)," but the cited text is in the same section.

f. **Recommendation 14(f):** Consider striking the start of this sentence and replacing it with, "As noted above, it will be assumed . . . ."

Page 10 of Appendix G describes the risk tables, which is unnecessary given the discussion in the body of the RA and the use of these tables throughout the material.

g. **Recommendation 14(g):** Consider striking the following sentence: "The rightmost column includes the Risk Ranking, which combines the probability and consequence findings into a single finding according to the matrix in Section III of the core document."

Thank you again for considering my comments.

Sincerely,

/s/ Kate Konschnik

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