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Lessons Learned: EPA's Investigations of Hydraulic Fracturing

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Good morning Chairman Stewart, Ranking Member Bonamici, and members of both subcommittees, and thank you for inviting me to be a part of this discussion.

Today I provide testimony on behalf of the New York State Water Resources Institute (NYSWRI), a federally authorized research entity established by the The Water Resources Research Act of 1984, designated by the New York State legislature to reside at Cornell University. We receive base funding through the United States Geological Survey. We also receive funding from, and collaborate with, the New York State Department of Environmental Conservation and Hudson River Estuary Program. Additional funding for NYSWRI comes from the College of Agriculture and Life Sciences, as well as the David R. Atkinson Center for a Sustainable Future, both at Cornell University. Our federal and state mandates direct us to undertake research and perform outreach with the goal of improving water resources management in the state of NY and across the nation. We seek to identify and explore water resource issues of emerging interest in order to provide and disseminate information to State agencies, water resource managers, the academic community, and citizens and stakeholders in general.

Shale gas development, particularly of the Marcellus Shale, has been a topic of great interest in NY for the past several years. Currently there is a moratorium on high-volume hydraulic fracturing related to shale gas development while NY State agencies complete environmental and public health impact assessments. In the meantime, NYSWRI has taken the opportunity to learn from unconventional resource extraction occurring in other states across the country. We have therefore been following EPA's investigations with interest, seeking to understand how the events investigated may and may not be applicable to NY, what they might reveal about environmental risks, and how policy influences water resource impacts. Our goal is to use that understanding to inform prudent policy-making, and to act as a neutral and informed voice within a polarized and contentious discussion. A sample of our most relevant research and activity, including peer-reviewed publications, can be found at the end of this testimony.

In this testimony, I will:

- Discuss the main water resource-related risks associated with shale gas development
- Discuss what the EPA investigations in question can and cannot do
- Summarize the lessons learned

What are some of the main water resource-related risks associated with shale gas development?

I'd like to describe what I have come to understand about water resources risks associated with shale gas development. This will serve to illustrate the scope of what water resource managers and researchers think and care about with respect to shale gas. Although the title of this hearing specifies hydraulic fracturing, I wish to be clear that I will be discussing shale gas development as a whole, of which hydraulic fracturing is just a part.

Please look at **Figure 1**, which is a simplified cartoon of activities commonly associated with shale gas development. These activities include land clearing for the establishment and construction of well pads; vertical drilling – often through potable groundwater supplies; horizontal drilling through the target formation; water acquisition from surface or ground sources; transportation, storage and mixing of chemicals with water for use in hydraulic fracturing; and storage, transportation, treatment and disposal of waste fluids. These activities necessarily draw the attention of water resource managers and regulators whose job it is to minimize any associated negative environmental impacts. Given all of this, it is fair to ask: what are the main risks to water resources that arise from this development, and are they substantially different from risks we already face from the activities around us?

The answer to this question is complicated, can change from one location to another, and evolves over time. But to illustrate a part of the answer I'd like to share some information NYSWRI has gathered from our neighboring state of Pennsylvania (PA), where Marcellus Shale development has been occurring in earnest for several years.

Figure 2 demonstrates the prevalence of certain violations issued by the PA Department of Environmental Protection to unconventional gas operators over the last few years. While this information is only one way to assess risk, you can get a sense of where problems may lie, at least in the eyes of PA law and the inspectors that enforce it. According to our analysis, the most common types of violations are related to spills of various kinds at the surface (often of waste fluids), erosion control and site restoration issues, and proper cementing and casing practices below the surface. From this data, we observe no violations or impacts related to hydraulic fracturing, per se. That being said, it is clear from this information that things can and do go wrong, often times at the surface, and that the frequency of these events (or the conditions that make events possible) can be high.

Some of these risks are familiar to us. Construction and agricultural activities in particular share many risks with shale gas development. They involve clearing of land and subsequent risk of erosion via storm water runoff. They involve the use of fuels or chemicals that can be transported to and stored onsite, with a subsequent risk for spills. Cementing and casing activities resemble conventional oil and gas practices, as does the production of waste fluids with complex chemistries that need to be collected, stored, transported, treated, and sometimes discharged.

What is different, however, is the pace, scale, and sometimes location of shale gas development across landscapes. Well pads are larger in order to accommodate bigger rigs. The volumes of water that need to be acquired from surface and ground waters is substantially greater than for conventional drilling and fracturing operations, leading in turn to larger volumes of waste fluids requiring treatment and discharge. Perhaps most importantly, these activities are quickly accelerating in places where historical activity may not have occurred, and where policies and practices have not had the chance to evolve over time. Northeastern PA is an example of this, as are parts of the southern tier of NY State where development is likely to proceed.

Making the distinction between planned and unplanned environmental risks

Looking again at **Figure 1**, one of the important distinctions made in this cartoon is the difference between planned and unplanned events. This distinction is important because these types of events get assessed, studied, and regulated differently. Planned events are certain to occur because they are a necessary part of the shale gas development process. Operators, regulators, and surrounding communities know that well pads need to be constructed, water needs to be obtained, and waste fluid will be produced and processed. The magnitude of these events is also directly related to the pace and scale of development in general: the more wells, the larger the cumulative impact of planned events.

Much of my work at NYSWRI has focused on planned events and how the cumulative impact of a collection of individual activities might have negative consequences for water resources. Water withdrawals for hydraulic fracturing operations provide a case in point. Individual withdrawals, say for a single well, generally do not result in environmental impact when they are taken from medium to large rivers. When multiple withdrawals are made within the same river system, however, the potential for negative impact is greatly increased. Because we know, or can approximate, how much water is required for hydraulic fracturing, as well as the flow of the river or stream, it is possible to plan withdrawal activities in such a way as to minimize negative impacts. This, of course, requires oversight, and an institution or agency capable of understanding and analyzing the system. Other researchers have also estimated and observed negative cumulative impacts associated with planned events during shale gas development[1].

[1] For example:

- R. Vidic *et al.*, Impact of Shale Gas Development on Regional Water Quality, *Science* **340**, 2013. DOI: 10.1126/science.1235009
- S. Olmstead *et al.*, Shale Gas Development Impacts on Surface Water Quality in Pennsylvania, *PNAS* **110**(13), 2013. DOI: 10.1073/pnas.1213871110
- B. Rahm & S. Riha, Toward Strategic Management of Shale Gas Development: Regional, Collective Impacts on Water Resources, *Environmental Science & Policy* 17, 2012. DOI: 10.1016/j.envsci.2011.12.004

Unplanned events are accidents. These can be anticipated only in the sense that they are likely to occur at some rate over time, although their occurrence and consequences at any given location are difficult to predict. The likelihood and potential impact of unplanned events must be inferred or estimated using data from similar activities over time and across space. Risk assessments related to unplanned events inform decision-makers who need to balance the benefits of an activity against the potential negative consequence that might occur if something were to go wrong. There is often room to invest in protective measures against likely or catastrophic risks while still realizing benefits from the activity. That being said, risk cannot be avoided altogether, and some tolerance of unplanned events is necessary.

EPA investigations in Pavillion, WY; Dimock, PA; and Parker County, TX: what they do and don't do

From my perspective, the EPA investigations in Pavillion, Dimock, and Parker County are dealing with unplanned events. That is to say they are responses to complaints regarding alleged impacts that were unintended. Furthermore, the events and impacts in question would have been difficult to predict with spatial and temporal accuracy ahead of time. I bring this up because I think it is critical to understanding what types of questions such investigations can and cannot address.

These investigations of unplanned events can address the question of whether or not contamination of some kind is present, and whether or not this represents an immediate risk to environmental or public health.

Given sufficient resources, these investigations might be capable of determining the possible causes of contamination in the past, and what the levels of contamination may look like in the future. What I can tell you from my experience in working with chloroethene-contaminated groundwater sites is that to achieve a high degree of certainty with respect to contamination cause and its evolution in the future can require extensive study and substantial resources.

What these types of investigations cannot do, by virtue of their design, is act as definitive risk assessments of water resource impacts from shale gas development in general. They cannot do this because individual investigations occur within the context of a specific set of conditions - local geology, a specific operator or set of operators, a unique site history, and a local regulatory environment. More general risk assessments – or better yet, risk assessments that are robust enough to account for variability of the characteristics I just mentioned – require a different, broader approach. I will revisit this concept in a moment.

Despite the limitations of these investigations, I believe they can provide valuable information, as well as spark important discussions about risk, best management, and policy. That being said, I'd like to relate some key points I take away from the investigation in Pavillion, Wyoming, which is the most developed of the three in the sense that EPA has drafted a report. A more complete NYSWRI commentary on the Pavillion investigation can be found on our website at http://wri.eas.cornell.edu/Comment_on_EPA_Pavillion_Study.pdf.

- Investigation and research design must be well thought-out and articulated – The stated objective of the investigation was to determine whether ground water contamination had occurred and, if possible, to differentiate between shallow sources of potential contamination – such as surface pits - and deep sources – such as gas production wells. It was not the intent of the study to evaluate the extent of contamination, nor was the objective to evaluate the hydraulic fracturing process itself as a route of potential contamination.

- P. Drohan *et al.*, Early Trends in Landcover Change and Forest Fragmentation Due to Shale-Gas Development in Pennsylvania: A potential outcome for the Northcentral Appalachians, *Environmental Management*, 2012. DOI 10.1007/s00267-012-9841-6

While the investigation's speculative conclusions are open for debate, the data collected was still useful so long as its purpose is kept firmly in mind. This suggests that the design, scope, and outreach related to future EPA investigations and studies should be carefully thought through, adhered to, and communicated.

- Regional differences matter – Each gas play has its own characteristics and challenges, its own regulatory environment, and its own mix of land use, industry, and infrastructure that will influence environmental risk and industry best practice. Regulatory agencies need to be aware of this local character and develop management strategies that are effective and appropriate. In some ways, this illustrates the critical role of state-level regulation. In other ways, the variability in the coverage of regulations from state to state suggests the need for at least some form of oversight at an interstate, regional, or federal level.

- Management of waste fluids is a critical issue – Although this investigation does not definitively link ground water contamination with the use of open, unlined waste pits, it does place the practice into the spotlight for critical evaluation. In New York, regulators have chosen to move toward the requirement of closed-system waste containment as a way to minimize contamination risks associated with wastewaters that have complex and sometimes toxic chemistries. Although wastewaters will vary across the country as a result of differences in fracturing strategies and geology, it is prudent for state and federal agencies to closely assess the risks of waste pits. On-site and centralized wastewater management and treatment technologies have evolved rapidly and provide the industry with alternatives that may not have been available in the past, but which should be encouraged or required in the future. The high prevalence of waste fluid spills (at least in PA, **Figure 2**) indicates that waste fluid storage is a potential area in which general basic standards are worth implementing.

- Cement quality and gas production well integrity are essential – Again, this investigation does not demonstrate a direct link between cementing practices and ground water contamination. However, it does show that cementing in the area of study was often done poorly in terms of quality, and insufficiently in terms of depth and coverage relative to the screened depth of local domestic water wells. Best practice with respect to cementing, bond-logging, and gas well integrity has received significant attention in recent years, particularly in the Marcellus Shale where public scrutiny and criticism has been intense. State agencies should examine their own guidelines, while federal agencies should consider basic standards.

- Chemical additives need to be on record – Situations in which contamination is thought to occur, but for which the exact nature of the contamination source is unknown, highlight the need for better documentation of chemical additives used during the drilling and hydraulic fracturing processes. At the very least, there is a need to make information regarding chemical additives and their volumes available to state or federal regulatory personnel and emergency responders, regardless of location or purpose. Replacing the most toxic additives is, and should continue to be, a priority. **Figure 3**, taken from a study by Resources For the Future, a nonprofit, nonpartisan research organization, illustrates the variability in fracturing fluid disclosure requirements from state to state. Again, this suggests a role for basic federal standards on this important issue.

- Targeting of formations containing an underground source of drinking water (USDW) should elicit strict regulation – Whether by mistake, or through the fault of one or more involved parties, gas production wells in Pavillion were allowed to contain surface casing that did not extend below nearby domestic water wells. I know it is common in some cases, such as coal bed methane, to target gas-bearing formations that also act as an USDW. However, to do so without strict oversight of both gas and water well construction seems irresponsible. In cases where such development occurs on federal land, this is an opportunity for the Federal government to lead the way in ensuring that development occurs safely or not at all.

The investigation in Pavillion demonstrates both the importance of state regulation in dealing with local conditions, as well as the need to constructively discuss the role of federal agencies in regulating activity on federal lands, and setting basic standards for activities that are cause for concern across states and gas plays. It is fair to mention that many states, particularly those with a long history of regulating oil and gas extraction, would meet or exceed any basic standards likely to be set. Still, there is significant variability in state approaches on at least some issues of broad concern. And, as development spreads into new plays, some of which lie outside historic regions of development, a basic threshold for safety becomes more important. Using PA as an example, states that face rapid unconventional development should be able to respond with appropriate regulations within a few years. It is during this initial period, however, when activity is occurring even as new policies are being worked out, that communities may benefit from basic regional or federal protections.

What kind of approach would address stakeholder concerns regarding water resources – a role for the EPA study on drinking water resources?

The investigations in Pavillion, Dimock, and Parker County have value insofar as they are able to respond to complaints and identify contamination if it exists. With additional resources, they might provide insight regarding the origin and evolution of contamination. But I think that what we are all after are risk assessments robust enough to be used in general, not just in one location at a time. So, the question becomes: if single investigations are not sufficient, what more is needed to assess risk in a comprehensive way?

It is difficult to answer this question, but I can offer my opinion on what would be needed. First, more data, research, and analysis is needed on the events that we know occur and which transcend local conditions, such as spills and erosion at the surface, and poorly designed casing and cementing below the surface. Such data should come from academic research, industry, state and federal agencies, and should encompass a representative sampling of development sites, not just places where complaints have been lodged, or where known contamination events have occurred. It is just as important to know how often things go right, as it is to know when things go wrong, so that we can determine the proper balance between precaution and mitigation.

Of course data alone is not sufficient for developing a risk assessment. Analysis must be conducted on a large enough scale to address the general concerns raised by our communities. Industry has a wealth of data and expertise, but is not structured so as to collect data from competing operators, and is not incentivized to provide results in a transparent fashion. This is understandable. State agencies are often intimately familiar with local conditions, but do not have staff, time, or mandate to engage in analyses which stretch beyond their jurisdictions. Institutions or agencies with broad interstate, regional, or federal missions are needed so that a transparent analysis can be conducted with the input of all involved stakeholders.

Another important reason to involve entities with broad mandates is the potential for cumulative impacts to dominate risk once a certain pace and scale of development is achieved. As I discussed previously, cumulative impacts may arise even when each individual activity is conducted safely and in accordance with rules and regulations. Water resource impacts from the combustion of coal provide a case in point. The cumulative impact of coal-fired power plants throughout the Midwest, initially unforeseen, is exacerbation of acidification and nutrient contamination of water resources in the Northeast.

The EPA study on the potential impacts of hydraulic fracturing on drinking water resources is an example of a broader risk assessment. In theory it is designed to identify a set of shared and/or

cumulative risks that transcend local conditions, and that are beyond the purview of any single operator or state agency to manage. I am keen, as I'm sure the Committee is, to see that the drinking water study is designed and performed effectively, and I am curious to know what will be found.

What are the lessons learned?

- There are a variety of risks and impacts to water resources as a result of activities and events associated with shale gas development. Many have little to do with hydraulic fracturing itself but are nevertheless important to water resource managers. Some of these risks are similar to those we face from conventional oil and gas development, and construction and agricultural activity in general. Still, the pace and scale of development, particularly in areas unaccustomed to shale gas development, necessitates a fresh look at how we undertake, manage, and regulate this activity.

- Local differences in geology, hydrology, policy, infrastructure, and industrial capability mean that states are still the appropriate level at which much of the regulation of shale gas development should occur.

- Best practices exist (and are promulgated by industry) that help to provide environmental protection as development continues; some operators observe them and others do not.

- Planned events, such as the withdrawal of water and the treatment and discharge of waste fluids, are certain to occur and have the potential to impact water resources, especially if cumulative impacts over time and space are not properly understood. Therefore, planned events and their cumulative impacts must be studied, planned for, and considered within regulatory frameworks.

- Unplanned events, or accidents, are also certain to occur, but in locations and with impacts that are difficult to predict. Analysis of a wide range of data, conducted on an interstate, regional, or federal scale, should help in development of assessments of risks that are shared across states and shale plays.

- The EPA, and/or other relevant agencies, can and should play a role in regulating and investigating complaints on federal lands. More broadly, federal agencies should continue developing approaches that identify shared risks across states and plays, regardless of local differences, so that basic standards may be justified, agreed upon, and established. Issues regarding chemical disclosure, proof and maintenance of well integrity through cementing and casing, and the storage, treatment and discharge of waste fluids, are candidates for shared risks. States with a history of oil and gas development are likely to meet or exceed these basic standards, while a regulatory floor is critical in states experiencing new development.

Lastly, I'd like to acknowledge that the presence of risk does not necessarily mean that an activity should not proceed. Like other activities that pose risks to our water resources in one way or another (the treatment and discharge of sewage, for example), shale gas development requires oversight, some aspects of which are most appropriately local, while other aspects of which require broader perspectives, abilities, and mandates. It is critical that we – scientists, industry, policymakers, and communities - acknowledge and continue to discuss risks from unconventional oil and gas development, even as development continues on a large scale. The nature of scientific research is to build understanding over time through repetition and consensus. This requires patience, the ability to articulate and discuss alternatives, and most importantly, a willingness to accept new information over time, sometimes at the expense of old paradigms. Polarized discussions on hydraulic fracturing are rarely constructive. We should be working more thoughtfully toward understanding the benefits and

risks of our energy choices and how they interact with our valuable water resources. To not know the benefits and risks of shale gas development while the activity is new is fair enough – we have not had enough time to fully understand. But to not know them a decade from now because we either ignored the issues or refused to address them, would be irresponsible.

Thank you again for this opportunity. I'd be happy to take any questions.

Figure 1. A simplified cartoon of shale gas development events associated with potential water resource risks and impacts

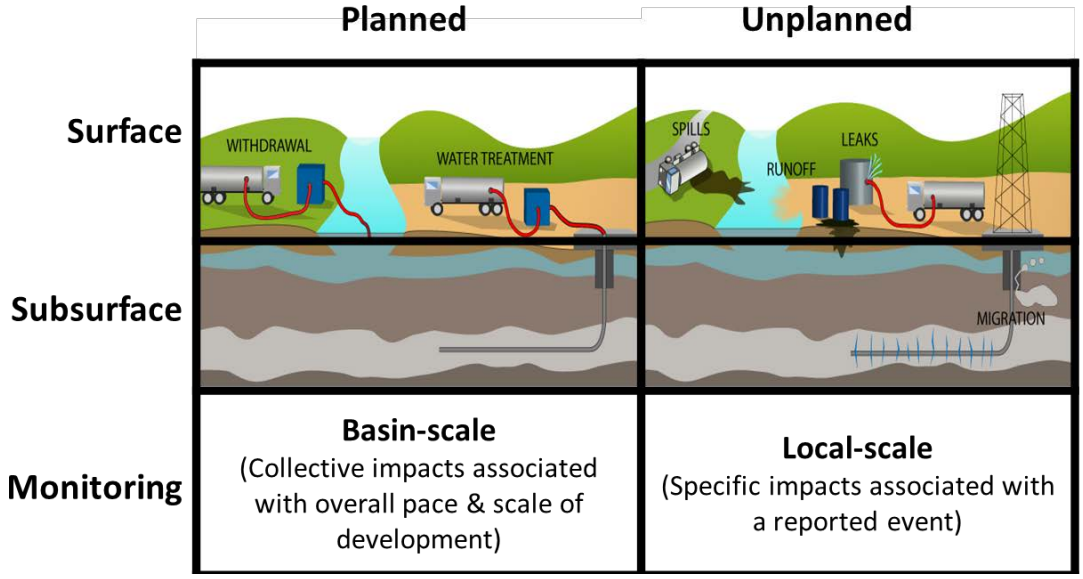


Figure 2. Prevalence of environmentally-relevant violations issued to operators in Pennsylvania since 2007 - data for analysis taken from PaDEP online database found at: http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_compliance_report/20299

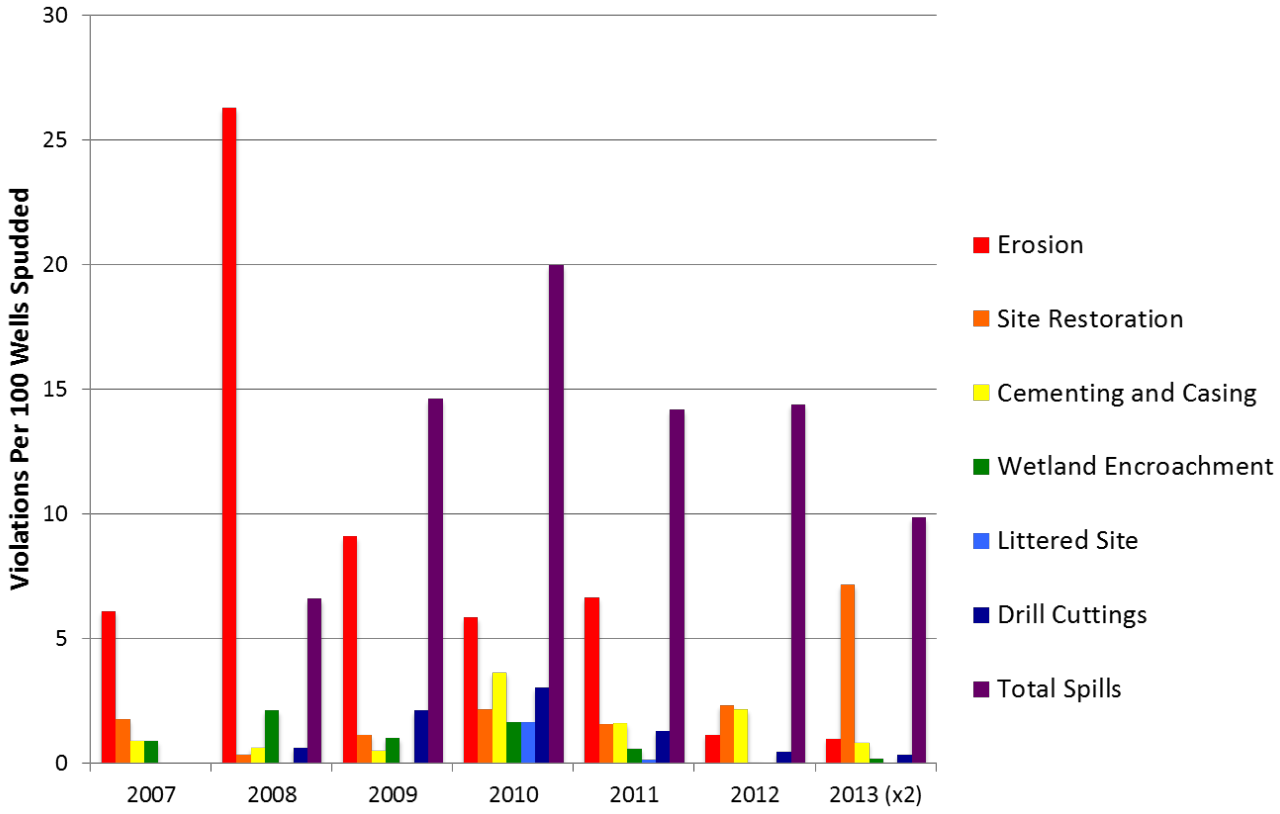
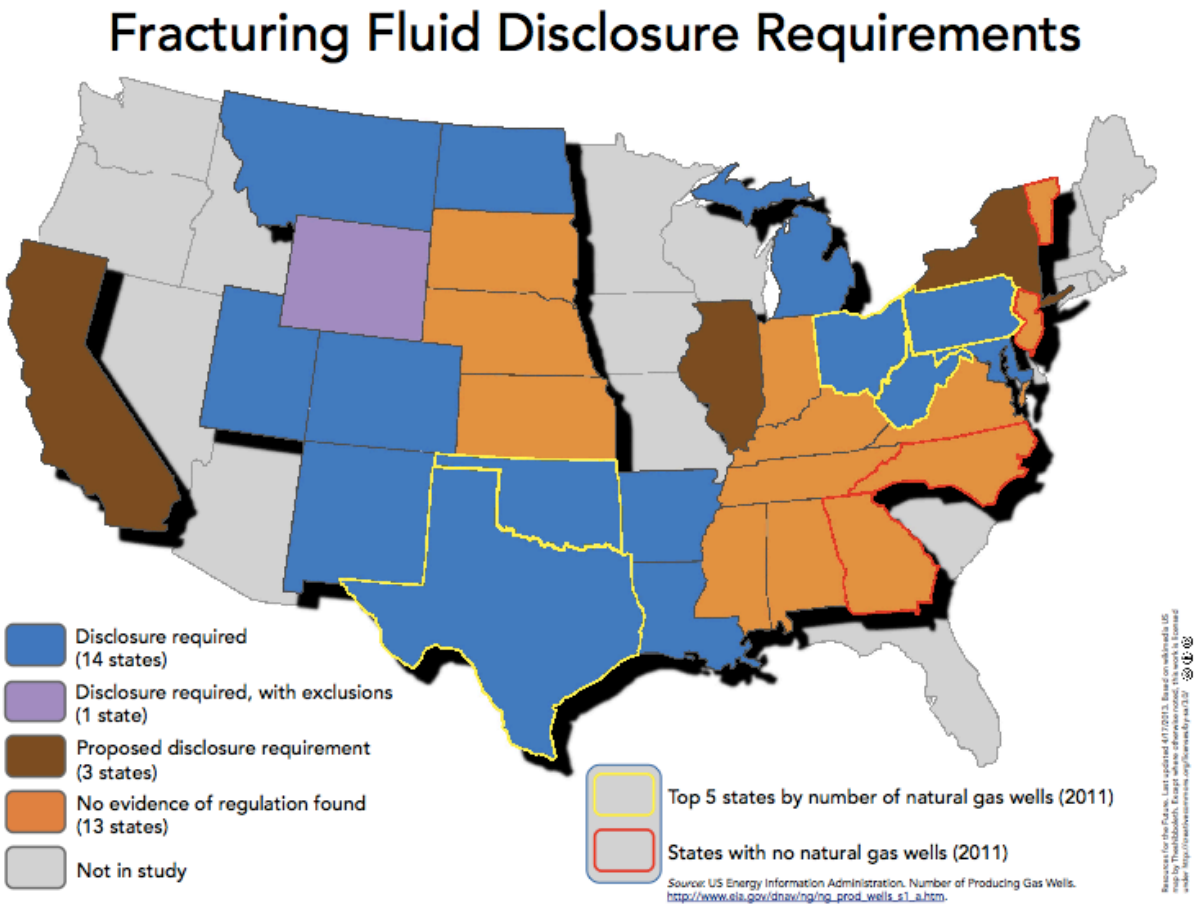


Figure 3. Source of graphic – Richardson et al., The State of State Shale Gas Regulation. Resources for the Future. June, 2013. Accessed at: http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale_Maps.aspx



Relevant NYSWRI research and activities:

Peer-Reviewed Publications

- **Rahm, B.G.**, Vedachalam, S., Shen, J., Woodbury, P.B., Riha, S.J. "A watershed-scale goals approach to assessing and funding wastewater infrastructure" *J. Environ. Manage.* In press
- McPhillips, L.; Creamer, A.E.; **Rahm, B.G.**; Walter, M.T. "Spatial analysis of dissolved methane in central New York groundwater" submitted to *Water Resources Research*. In review
- **Rahm, B.G.**, Bates, J.T., Bertoia, L.R., Galford, A.E., Yoxtheimer, D.A., Riha, S.J. "Wastewater Management and Marcellus Shale Gas Development: Trends, Drivers, and Planning Implications" *J. Environ. Manage.* (120) 2013. 105-113
- **Rahm, B.G.**; Riha, S.J. "Toward strategic management of shale gas development: Regional, collective impacts on water resources" *Environ. Sci. Policy*. 2012. 17. 12-23

Other Publications

- Abdalla, C.; Drohan, J.; **Rahm, B.G.**; Jacquet, J.; Becker, J.; Collins, A.; Klaiber, A.; Poe, G.; Grantham, D. "Water's journey through the shale gas drilling and production processes in the Mid-Atlantic region" Penn state Cooperative Extension. 2012
- **Rahm, B.G.**; Ford, L.; Rukovets, B.; Meriwether, M.B.; Riha, S.J. "Protection of Surface Waters Associated with Shale Gas Drilling and Related Support Sites" NYWEA white paper. May 16, 2011
- Riha, S.J.; **Rahm, B.G.** "Framework for assessing water resource impacts from shale gas drilling" NYWEA *Clear Waters*. 2010, 40 (Winter), 16-19
- **Rahm, B.G.**; Riha, S. "Framework for Assessing Water Resource Impacts from Shale Gas Drilling" *Green Choices*, website of Cornell University's Department of City and Regional Planning, December, 2010

Invited Panel & Testimony

- "Farm Foundation Forum: Natural Gas Extraction – Impacts on rural America," Farm Foundation panel held at the National Press Club, Washington, DC, April 3, 2013. http://www.farmfoundation.org/forums.aspx?year=2013
- "Shale Gas Development & Water Resources Planning & Management" Municipal Law and Planning: A Local Perspective on Hydrofracking. Albany Law School. Albany, NY, September 28, 2012
- "Waste Water and Cuttings as they Pertain to Hydraulic Fracturing" New York State Senate Standing Committee on Environmental Conservation, Canandaigua, NY, December 12, 2011
- "USDA Agricultural Landscapes Forum" Northeast Regional Meeting, Panel on water security. Cobleskil, NY, March 10, 2011
- "Hearing on the Continued Examination of Hydraulic Fracturing Including the NYSDEC and DRBC Processes" New York City Council Committee on Environmental Protection, New York, NY, March 1, 2011