

TOWARD AN EVIDENCE-BASED FRACKING DEBATE

**Science, Democracy, and Community Right to Know
in Unconventional Oil and Gas Development**



The Center for Science and Democracy at the Union of Concerned Scientists

TOWARD AN EVIDENCE-BASED FRACKING DEBATE

**Science, Democracy, and Community Right to Know
in Unconventional Oil and Gas Development**

Gretchen Goldman

Deborah Bailin

Paul Rogerson

Jessie Agatstein

Jennifer Imm

Pallavi Phartiyal

**[Union of
Concerned Scientists**

OCTOBER 2013

© 2013 Union of Concerned Scientists
All rights reserved

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

The UCS Center for Science and Democracy works to strengthen American democracy by advancing the essential role of science, evidence-based decision making, and constructive debate as a means to improve the health, security, and prosperity of all people.

The full text of this report is available on the UCS website at www.ucsusa.org/HFreport or may be obtained from:

UCS Publications
2 Brattle Square
Cambridge, MA 02138-3780

Or, email pubs@ucsusa.org or call (617) 547-5552.

DESIGN: Penny Michalak

COVER PHOTOS: (main) ©2013 Trudy E. Bell; (left to right) © US Geological Survey; © Flickr/chesapeakeclimate; © Shutterstock.com/Glovatskiy; © Brookhaven National Laboratory; © Architect of the Capital

Contents

CONTRIBUTORS	iv	BOXES	
ACKNOWLEDGMENTS	iv	1. Fracking and Climate Change	6
CHAPTER ONE	1	2. Drinking Water Contamination in Dimock, Pennsylvania	9
Introduction		3. Air Pollution Concerns in Dish, Texas	12
CHAPTER TWO	7	4. Hidden Science and Silenced Citizens in Legal Settlements	18
Probing the State of the Science on Unconventional Oil and Gas Development		5. Industry Interference in Community Decision Making	19
2.1. Fracking Impacts: What the Science Tells Us	7	6. Chemical Disclosure and Public Health	22
2.2. Interference in the Science	17	7. Data Disclosure Sources Should Be Approached With Caution	27
2.3. Current Research Needs	22	8. Policy Makers and Corporate Connections	31
CHAPTER THREE	25	9. A Need for Comprehensive Laws	34
Understanding the Regulatory Landscape		10. What Makes a Good Government Information Source	40
3.1. Federal Regulation	25	11. Silencing Community Discussion of Fracking	42
3.2. State Laws	30	12. Academia as an Information Source	49
CHAPTER FOUR	35	13. A Toolkit for Community Decision Making	53
Right to Know in the Public Dialogue: Best Practices for Empowering Citizens			
4.1. Online Sources	37		
4.2. Government Resources	37		
4.3. Mainstream News Sources	43		
4.4. Navigating Information about Risk	46		
CHAPTER FIVE	51		
Toward Improved Dialogue and Decision Making			
REFERENCES	54		

Contributors

Gretchen Goldman is an analyst in the Center for Science and Democracy at the Union of Concerned Scientists (UCS).

Deborah Bailin is a democracy analyst and ACLS Public Fellow in the Center for Science and Democracy at UCS.

Paul Rogerson was a research assistant in the Center for Science and Democracy at UCS.

Jessie Agatstein was a research and outreach associate in the Center for Science and Democracy at UCS.

Jennifer Imm was a research intern in the Center for Science and Democracy at UCS.

Pallavi Phartiyal is the senior analyst and program manager for the Center for Science and Democracy at UCS.

Acknowledgments

This report was made possible by the generous support of the Arkay Foundation and UCS members.

The authors would like to thank the following external reviewers for their time and thoughtful input: Adam Brandt (Stanford University), Susan Christopherson (Cornell University), Jean Goodwin (Iowa State University), Aubrey Miller (National Institute of Environmental Health Sciences), and Hannah Wiseman (Florida State University).

We also would like to thank the many UCS staff members who reviewed, edited, and otherwise helped shape the direction of this report: Adrienne Alford, Don Anair, Christina Carlson, Steve Clemmer, Danielle Fox, Peter Frumhoff, Michael Halpern, Aaron Huertas, Yogin Kothari, Dave Reichmuth, Kathleen Rest, Michelle Robinson, Andrew Rosenberg, Seth Shulman, Bryan Wadsworth, and Celia Wexler.

Finally, we would like to thank Trudy E. Bell for her masterly editing and Penny Michalak for her deft layout and design.

Organizational affiliations are listed for identification purposes only.

The opinions expressed in this report are solely the responsibility of the authors.

CHAPTER ONE

Introduction

Fracking. A few years ago, this was not a familiar term for most Americans, but today it is a household word in many parts of the country. It sparks contentious debates in town halls, in company board rooms, in state houses, in the halls of Congress, in news outlets, and on social media.

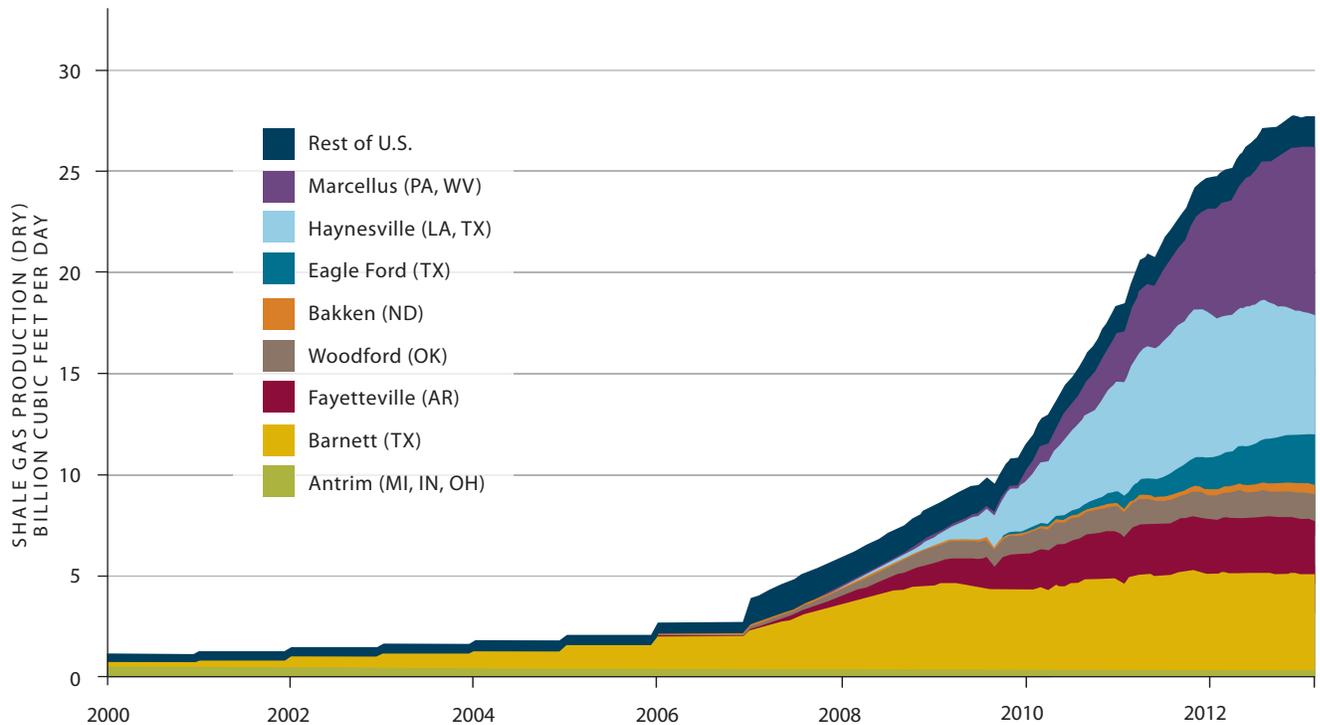
Hydraulic fracturing is one key step in what is considered an “unconventional” method for extracting oil and natural gas from shale or other types of rock formations a mile or more underground. While hydraulic fracturing has been used for several decades to extract oil from shales in Texas and elsewhere, recent advances have adapted the process for the extraction of natural gas and also made the process more economical. Thus, hydraulic fracturing—together with horizontal (directional) drilling and several other key technologies—has spurred the rapid expansion of oil and gas extraction in shale and other tight rock formations that had been previously inaccessible, from Pennsylvania to North Dakota to Alaska.

It is important to note that the oil and gas industry uses the word “fracing” (without a k) or “fracking” (with a k) narrowly to mean the single specific engineering process of hydraulic fracturing (often taking only a few days), whereas the general public and news media have come to use the word fracking (with a k) to mean the entire enterprise of unconventional oil and gas development, from drilling (which can take a month or more) to final extraction (which can take years) (Bell 2013; FracFocus 2013; Mooney 2011). This report looks at unconventional oil and gas development broadly—from the perspective of an affected community—and thus employs the broader term fracking as it is used in general parlance, because community concerns encompass many parts of unconventional oil and gas development, including the well construction, production, wastewater disposal, distribution, and storage.



While hydraulic fracturing has been used by industry for many decades, recent technological advances have enabled a rapid expansion of unconventional oil and gas development in the United States only in the last few years, creating new risks in new places.

The expansion of unconventional oil and gas development has made the United States one of the world’s leading producers of natural gas and has contributed to recent declines in natural gas prices, resulting in significant fuel switching from coal to natural gas in the electricity sector and increased natural gas use in the industrial sector (EIA 2013). And the boom seems unlikely to lose momentum in the near future (Figure 1, p. 2, and Figure 2, p. 3). The Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) projects shale gas will grow from about one-third of total U.S. natural gas production in 2012 to nearly half by 2040 (Sieminski 2013). For oil, the agency expects similar increases, with more than half of oil production in the lower 48 states coming from tight formations (which are likely to necessitate hydraulic fracturing) by 2040, compared with a third today (Sieminski 2013).

Figure 1. PRODUCTION OF SHALE GAS IN THE UNITED STATES

Production of natural gas (methane) from shale in the United States has expanded rapidly in the last 10 years, and is projected to continue increasing through 2040 (EIA 2013; Sieminski 2013). “Dry” means that the natural gas is extracted in gaseous form rather than in liquid form.

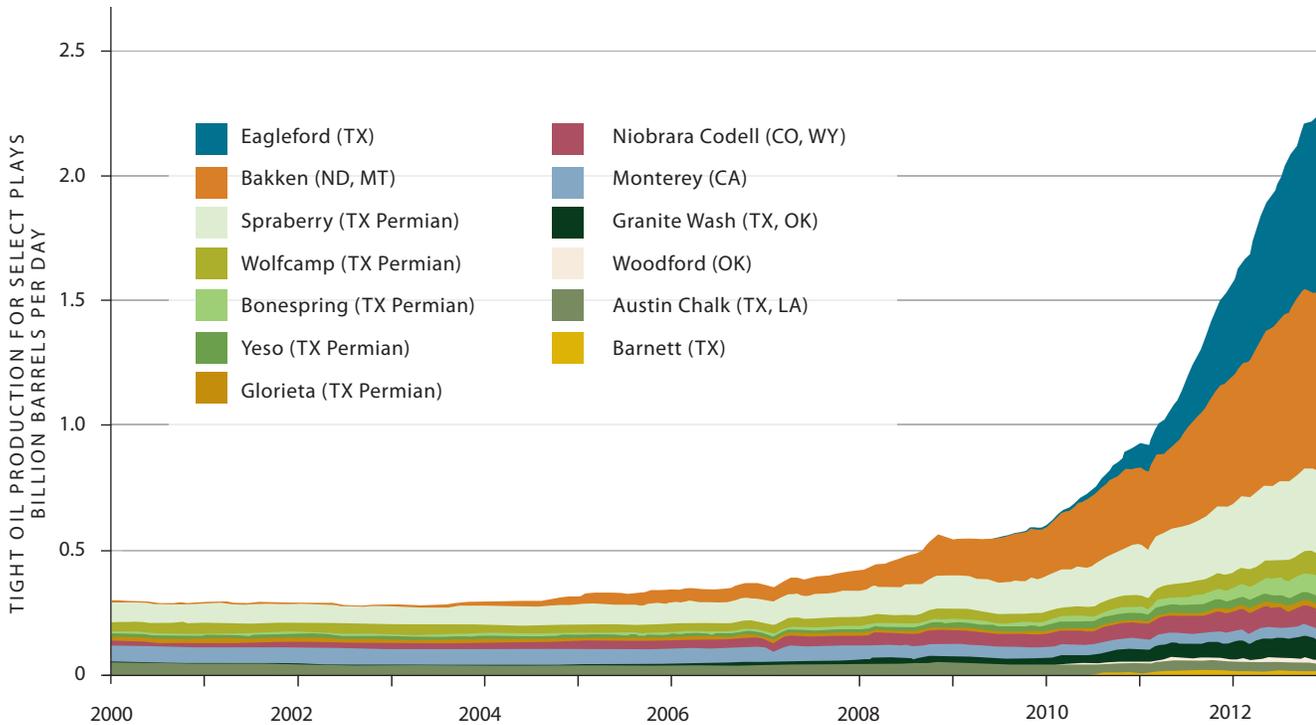
The dizzying speed at which unconventional oil and gas development has expanded across the country has created scientific, legal, and social challenges as our democratic institutions have struggled to keep up. Promises of economic growth and community revitalization have led many states and local communities to embrace development. At the same time, communities are worried about the risks that come along with any benefits, as well as about the unequal distribution and short-lived duration of economic benefits. *Will my drinking water be contaminated? Will I experience related*

The dizzying speed at which unconventional oil and gas development has expanded across the country has created scientific, legal, and social challenges as our democratic institutions have struggled to keep up.

health problems? What will happen to the social fabric of my community? Will I be exposed to the risks without receiving the benefits of such development?

The limited availability of objective and independent data about the physical impacts of this new widespread industrial activity on public health and the environment plus its social effects on communities has created barriers to scientists trying to improve understanding of its risks and benefits. Indeed, rapid industry growth and future profit potential have left science vulnerable to interference from special interests. Biased science, conflicted politicians, and misinformation in the public dialogue create a noisy landscape for decision making. Government officials and lawmakers are challenged to regulate the activity effectively through a patchwork of local, state, and federal laws. Moreover, many federal laws exempt oil and gas companies from some statutory requirements that apply to virtually all other industries.

Citizens are demanding answers. In the past five years, more than 300 communities in four states—New York,

Figure 2. PRODUCTION OF TIGHT OIL IN THE UNITED STATES

The two key technologies of horizontal drilling and hydraulic fracturing have made oil in tight formations more technically feasible to extract. As a result, unconventional oil production has expanded rapidly in recent years and is projected to continue to expand through 2040 (EIA 2013; Sieminski 2013).

Ohio, Pennsylvania, and West Virginia—have passed resolutions or statutes in response to shale gas development (Christopherson 2013). Many of these communities are outright banning the practice. Some are passing local moratoria on drilling—not necessarily because they want the process banned permanently, but because they feel they do not have enough information and because their concerns currently are not being addressed by state and federal governments or by oil and gas operators.

The public has a right to know about the risks and benefits of unconventional oil and gas development in their communities, including the pollution caused, the chemicals used, the regulatory decisions made, and the implications for public health, the environment, and community well-being. Transparency in company operations and government processes should empower individuals and communities to make evidence-based decisions about unconventional oil and gas development.

In this report, we survey the current state of science and laws in the United States, identify barriers to effective decision making, and offer recommendations for developing a transparent and evidence-based dialogue on unconventional oil and gas development enabled by hydraulic fracturing.

1.1. Technical Background

Hydraulic fracturing is one key process in the extraction of oil and gas from resources previously deemed not economical to develop. In conventional oil and gas extraction, a well is drilled vertically to a reservoir with a high concentration of oil or natural gas that lies perhaps several hundred feet or just a few thousand feet underground; the liquid fossil fuels are then pumped to the surface. In the United States, most such easily tapped oil and natural gas reservoirs have long since been pumped dry. However, certain shales or other rock formations much deeper—a mile or two—underground are

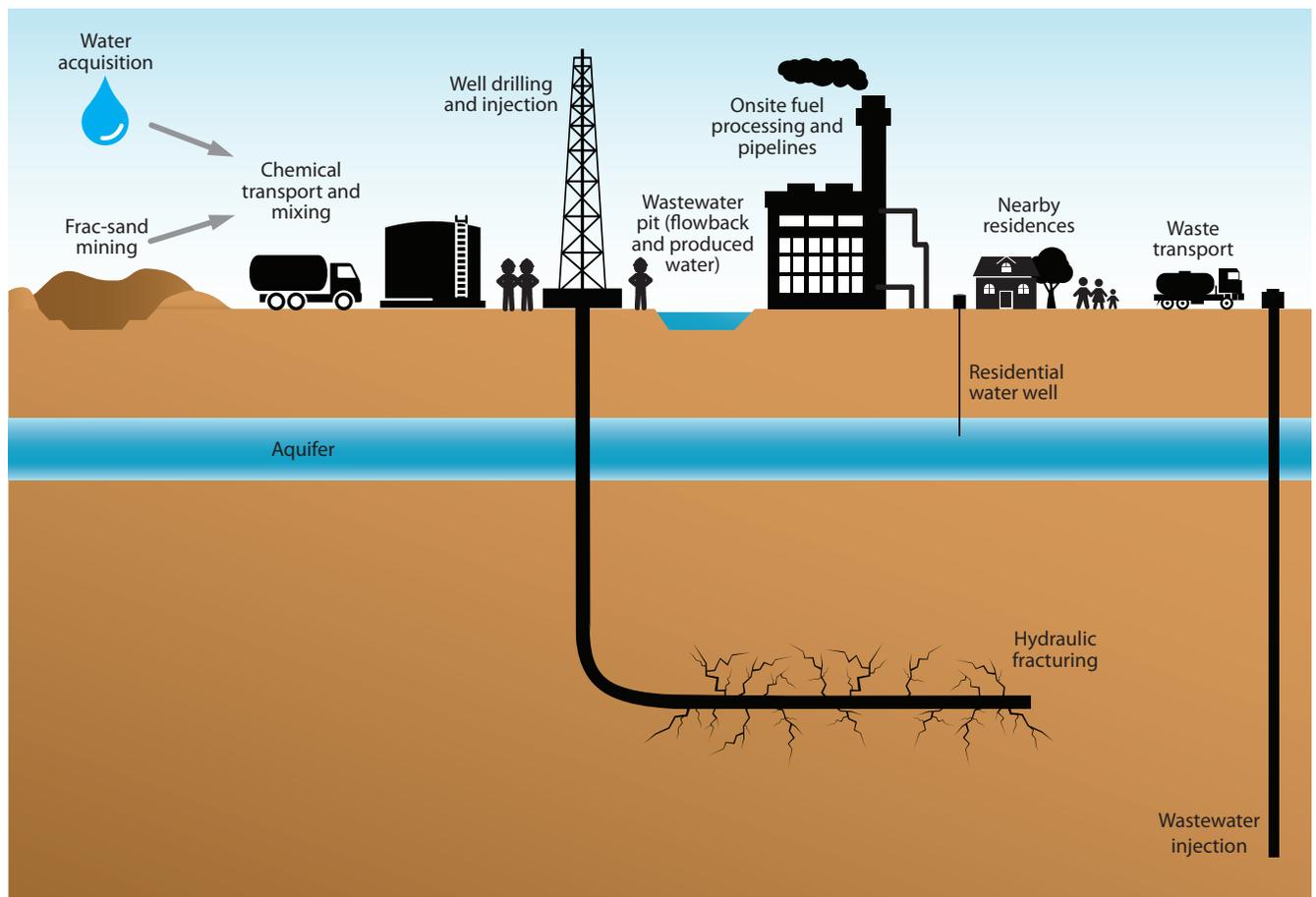
filled with microscopic holes (analogous to the tiny holes seen in bread) holding molecules of oil or natural gas. Fracturing the rock formations under high pressure can release the molecules, which can then be pumped to the surface. Oil and gas trapped within shale or other such “tight” geological formations are considered unconventional resources, for which unconventional extraction techniques have been developed.

Two technologies key to unconventional oil and gas extraction are horizontal (directional) drilling, and hydraulic fracturing. Horizontal drilling is literally drilling sideways, important because most layers of shale or other rock formations are only a few hundred feet thick vertically but may extend for hundreds of miles horizontally. A vertical wellbore (hole) is first drilled to the desired layer of shale, and then the drill bit is turned to continue drilling horizontally through the shale layer for 5,000 to 10,000 feet (Figure 3), steered in

a desired direction by reference to the earth’s magnetic field. The wellbore is then cased with a steel lining; in the vertical section, the steel lining is secured by concrete to prevent leakage from the well into surrounding rock, but in the lateral (the horizontal portion of the wellbore) the lining is perforated with strategically placed holes.

After testing the well to check that construction is satisfactory, a mixture of water, chemicals, and special pure silica sand is injected at high pressure down into the horizontal lateral of the drilled well, where it exits through the holes into the rock itself. The high water pressure creates an extensive network of narrow fractures in the shale, which are propped open by the grains of sand, leaving cracks through which oil or gas molecules flow to the wellbore and are pumped to the surface. The composition of the hydraulic fracturing fluid that is injected into the well varies but typically numerous

FIGURE 3. ILLUSTRATION OF TYPICAL STEPS OF UNCONVENTIONAL OIL AND GAS DEVELOPMENT



Although hydraulic fracturing has been done for several decades in vertical wells as well as in horizontal wells for oil, the scale, number of wells drilled, and technology involved have advanced rapidly in the last few years and also allow extraction of natural gas. This expansion has opened up development of many oil and gas resources previously thought inaccessible (EPA 2013c).

chemicals—for dissolving chemical scale, killing bacteria, reducing friction, and other purposes—comprise about 1 percent of the fluid volume (EPA 2012f). Often the composition, volume, and concentration of the chemical additives are not fully disclosed to the public, as industry has asserted such detailed information constitutes trade secrets.

During and shortly after hydraulic fracturing, some of the hydraulic fracturing fluid flows back up the well to the surface, carrying with it some of the injected chemical additives plus dissolved clays, other solids, salts, naturally occurring radioactivity, and other substances naturally occurring in the shale or rock formation. This is referred to as “flowback.” In addition, the shale or rock formation itself is naturally permeated with water; this water is released not only during the processes of drilling and hydraulic fracturing, but also continues being pumped to the surface as long as the completed well is producing oil and gas—a lifetime of years or even decades. This is called “produced water.” Like the short-lived flowback, the long-lived produced water commonly includes dissolved solids, salts, metal ions, radioactive compounds, and other substances naturally occurring deep underground (Schramm 2011). Thus, drilling wastewater, a combination of both flowback and produced water, can be highly saline and often toxic or radioactive (Haluszczak et al. 2012; Rowan et al. 2011). As a result, the drilling wastewater needs to be disposed of properly. Commonly, the wastewater is discarded by being injected at high pressure into what are called Class II injection wells for permanent storage in rock formations deep underground (often deeper than horizontal oil and gas wells themselves). Alternatively, it may be processed in specialized treatment plants for reuse in fracturing future wells; sometimes this involves temporarily storing untreated wastewater in lined holding ponds or storage tanks on the surface.



Hydraulic fracturing wastewater, including flowback and produced water, is often stored at well sites in lined pits, such as this one in the Fayetteville Shale gas play of Arkansas.

Once a well has been fractured, it can produce oil and gas for years. The productivity of some wells, however, can decline very fast, by as much as two-thirds to three-quarters over their first three years after completion (Kelly 2013; *New York Times* 2011). Thus, while many wells are fractured only once, others may be fractured more than once over their lifetime to increase productivity. When a well is no longer producing economic levels of oil and gas, the operator will abandon the well and plug it to prevent oil and gas from leaking out over time, although in the past some abandoned wells have not been plugged (PADEP 2000).

Often the composition, volume, and concentration of the chemical additives are not fully disclosed to the public, as industry has asserted such detailed information constitutes trade secrets.

The footprint of unconventional horizontal wells tends to be larger than that of conventional wells. Because of the technology and the volumes of water and sand needed for hydraulic fracturing, well pads need room not only for the well itself but also space for aboveground drilling machinery, storage of chemicals, support, and possibly facilities for wastewater storage or processing. While each well pad is bigger, there are fewer well pads overall because horizontal drilling allows laterals to radiate out horizontally for a mile or two and several wells can be drilled from each pad (USGS 2013). The necessity for using millions of gallons of water and thousands of tons of sand per well as well as possible removal of wastewater to Class II injection sites for disposal also requires high truck traffic to transport materials to and from the site—averaging up to 1,500 truckloads per well (King 2012).

This report employs the term fracking to be inclusive of the specific process of hydraulic fracturing itself as well as all the associated engineering activities of construction, drilling, wastewater handling, etc. In addition, many aspects of the drilling and hydraulic fracturing processes will vary from place to place depending on geological conditions, and some differences exist between fracturing for oil and fracturing for natural gas. Unless otherwise specified, discussion in this report is inclusive of both oil and gas extraction. While the expansion of unconventional oil and gas development has global effects, including implications for global warming and energy prices (see Box 1, p. 10), this report focuses on local and regional effects of unconventional oil and gas development within the United States.

BOX 1

Fracking and Climate Change

Although this report focuses on local societal impacts, unconventional oil and gas development also plays a role in global warming emissions.

Studies have shown that hydraulic-fracturing-enabled oil and gas extraction has contributed to a switch away from coal to natural gas in the U.S. power sector (EIA 2013). Although that switch has been an important driver for reducing U.S. carbon emissions during combustion for end-use energy consumption, carbon emissions from natural gas do contribute substantially to global warming. Thus, from a climate standpoint, natural gas is less attractive than lower- and zero-carbon alternatives such as energy efficiency and renewable energy. In addition, the drilling, extraction, and transportation through pipelines of oil and natural gas result in leakage of methane, a potent heat-trapping gas that is 25 times stronger than carbon dioxide over a 100-year time period (Forster et al. 2007).

A large number of studies are under way to better understand the climate impacts of unconventional oil and gas development. For natural gas, preliminary studies and field measurements show that such “fugitive” methane emissions range from 1 to 9 percent of total natural gas production (Tollefson 2013; Cathles et al. 2012; Howarth et al. 2012; Petron et al. 2012; Skone 2012; Weber and Clavin 2012). The studies suggest that fugitive methane emissions from natural gas may be a significant source of U.S. global warming pollution. Whether natural gas has lower life-cycle heat-trapping emissions than coal and oil depends on the assumed leakage rate, the global warming potential of methane over different time frames, the energy conversion efficiency, and other factors (Bradbury et al. 2013).

Methane leakage during production and transport of oil is also a significant concern, especially if it is released into the air (venting) rather than burned off (flaring) or captured (green completion). In North Dakota, for example, the extraction of oil can yield significant quantities of natural gas; however, there it is often deemed not economical to transport the gas to markets. Instead, some 30 percent of the gas produced in the state is flared on-site, contributing to global warming emissions and other air quality concerns (Helms 2012; Krauss 2011).

Importantly, several studies have shown that cost-effective technologies are available both to improve monitoring and to reduce methane leakage, but deploying such technologies would require new policies and investments (Bradbury et al. 2013; Harvey, Gowrishankar, and Singer 2012; IEA 2012). The impact that unconventional oil and gas development will have on climate change will largely depend on the technology employed and regulations enacted and enforced in the coming years.



© 2013 Trudy E. Bell

The Union of Concerned Scientists currently is studying the impact of fracking on climate change and has a natural gas position statement available online at www.ucsusa.org/naturalgasposition. For more information on the climate risks of an increased reliance on natural gas for electricity, see www.ucsusa.org/gasceiling.

In places like North Dakota, where it often is not economical to harness and transport the natural gas produced during oil extraction operations, the gas instead is flared, contributing to global warming emissions and other air quality concerns.

CHAPTER TWO

Probing the State of the Science on Unconventional Oil and Gas Development



The rapid expansion of unconventional oil and gas development has limited the time researchers have had to study it. Nevertheless, scientists from diverse fields have come together to assess the activities' impacts on public health, community welfare, and the environment.

The rapid expansion of unconventional oil and gas development in the last few years has limited the time researchers have had to study its environmental, health, and societal impacts and risks; as a result, gaps remain in our understanding (Schrope 2012). Moreover, the potential profitability and economic returns have left the science vulnerable to political and corporate interference. Below we outline current scientific understanding of the potential impacts of unconventional oil and gas development, cases of interference in the science, and current research needs.

2.1. Fracking Impacts: What the Science Tells Us

The science behind unconventional oil and gas development is complex and interdisciplinary. Although all impacts of development have not been uniformly experienced in

all locations, evidence suggests that unconventional oil and gas development may pose significant risks in a considerable number of locations or types of wells. Research to characterize risks to human health and the environment are discussed below along with associated areas of uncertainty.

2.1.1. Water Quality and Use

Unconventional oil and gas development may pose health risks to nearby communities through contamination of drinking water sources with hazardous chemicals used in drilling the wellbore, hydraulically fracturing the well, processing and refining the oil or gas, or disposing of wastewater (Colborn et al. 2011). Naturally occurring radioactive materials, methane, and other underground gases have sometimes leaked into drinking water supplies from improperly cased wells; methane is not associated with acute health effects but in sufficient volumes may pose

flammability concerns (Airgas 2013). The large volumes of water used in unconventional oil and gas development also raise water-availability concerns in some communities.

Groundwater Quality. There have been documented cases of groundwater near oil and gas wells being contaminated with fracking fluids as well as with gases, including methane and volatile organic compounds. One major cause of gas contamination is improperly constructed or failing wells that allow gas to leak from the well into groundwater. Cases of contamination have been documented in Ohio and Pennsylvania (PADEP 2009; Ohio DRM 2008). Some research suggests that, at least in Pennsylvania, approximately 3 percent of wells are inadequately constructed and thus could run risks of groundwater methane contamination (Vidic et al. 2013; Boyer et al. 2012). In some studies, however, it is difficult to attribute contamination specifically to faulty wells because no predrilling baseline data were available (see Box 2).

There have been documented cases of groundwater near oil and gas wells being contaminated with fracking fluids as well as with gases, including methane and volatile organic compounds.

Another potential avenue for groundwater contamination is natural or man-made fractures in the subsurface, which could allow stray gas to move directly between an oil and gas formation and groundwater supplies. There is ongoing scientific debate about whether this process occurs naturally, because of drilling, or both. Such contamination may be more of a risk in some regions than others because of differences in local geology or drilling practices. For example, some studies found evidence for stray gas migration pathways in northeastern Pennsylvania near drilling sites (Jackson et al. 2013; Osborne et al. 2011). But other studies suggest that shallow groundwater in Arkansas near the Fayetteville formation has shown no signs of methane contamination from such pathways (Warner et al. 2013; Kresse et al. 2011), and another study in Pennsylvania found no systematic differences in methane concentrations in about 50 drinking water wells before or after drilling, no matter how close the wells were to a drilling site (Boyer et al. 2012).

In addition to gases, groundwater can become contaminated with hydraulic fracturing fluid (NMOCD 2008). In several cases, groundwater was contaminated from surface

leaks and spills of fracturing fluid. Fracturing fluid also may migrate along abandoned wells, around improperly sealed and constructed wells, through induced fractures, or through failed wastewater pit liners (Vidic et al. 2013; Harrison 1983). At least two instances document apparent groundwater contamination from fracturing fluids through underground migration (NMOCD 2008). A 1987 report by the U.S. Environmental Protection Agency (EPA) found drinking water wells in Jackson County, West Virginia, contaminated by fracturing fluid that appeared to have migrated from a shallow vertical well located near several abandoned wells (EPA 1987). More recently, the EPA and the U.S. Geological Survey (USGS) have investigated groundwater contamination from fracturing fluids in shallow, faulty wells in Pavillion, Wyoming—research that is still ongoing by the state of Wyoming (WOGCC 2013; Wright et al. 2012; DiGiulio et al. 2011) (see Section 2.2.1.). In addition, it may be possible for hydraulic fracturing fluids to migrate from an oil and gas formation into groundwater through naturally occurring pathways (Myers 2012; Warner 2012). Between half and 95 percent of the injected hydraulic fracturing fluid does not return to the surface as flowback but is absorbed by rock formations deep underground (King 2012); it is unknown if this fluid could eventually contaminate drinking water. In short, there is still a great deal of scientific uncertainty and ongoing research on possible contamination pathways.

It should be noted that many sites of unconventional oil and gas development have not seen any evidence of groundwater contamination from stray gas or hydraulic fracturing fluids. But before drilling, it may be difficult to know how big a risk contamination could be, as the extent of the risk appears to depend on the depth of a formation in relation to the depth of drinking water supplies (something that varies dramatically by region and even within a given region). Risk also appears to vary with a host of other factors, including the number and location of abandoned wells nearby and the construction techniques used to drill, cement, and case a well (Molofsky et al. 2013; Warner et al. 2013; Boyer et al. 2012). In most places, it is likely that the risks of groundwater contamination largely can be minimized by best engineering management practices such as stronger and deeper steel casing, thorough cementing, adequate drilling mud removal, and appropriate geological and well integrity monitoring (Vidic et al. 2013; Harrison 1985).

Surface Water Quality. Unconventional oil and gas development also poses contamination risks to surface waters through spills and leaks of chemical additives, spills and leaks of diesel or other fluids from equipment on-site, and

BOX 2

Drinking Water Contamination in Dimock, Pennsylvania

Concerns about drinking water contamination have been raised in a number of locales with unconventional oil and gas development. The experiences of Dimock, Pennsylvania, demonstrate the scientific and legal challenges that communities may face when presented with potential water contamination.

In 2008, Cabot Oil and Gas Corp. began drilling horizontal shale gas wells in Dimock, Pennsylvania. Just months after the completion of the first horizontal wells, local residents began to report problems with their drinking water (Statelmpact 2013). Concern about public safety rose when Dimock resident Norma Fiorentino's backyard water well exploded. Following the explosion, state officials discovered large amounts of methane in her drinking water, leading them to believe that the flammable gas was the cause of the explosion (Lustgarten 2009). More than a dozen families joined together to file a federal lawsuit against Cabot, claiming the company had contaminated their drinking water. The Pennsylvania Department of Environmental Protection (DEP) fined Cabot, told them to cease drilling in the county, and ordered them to provide safe water supplies to the affected residents (Statelmpact 2013).



Dimock, Pennsylvania, drilling site of Cabot Oil and Gas.

© Stieracubillinois.com

Although Cabot maintained that the methane had migrated into the water wells through natural processes, the company reached a final Consent Order and Agreement with the DEP in late 2010. The agreement required Cabot to pay more than \$4 million in settlements and provide in-home water filtration systems to the residents with contaminated wells. Cabot also monitored the water for a year, noting several instances in which the concentrations of methane reached levels considered hazardous, despite the fact that no drilling was taking place (Legere 2011). Cabot used this information to justify their belief that they were not responsible for the methane migration, and at the end of 2011, requested and received permission to stop providing water to Dimock residents (Statelmpact 2013).

After Cabot stopped delivering water, the company handed its water monitoring data over to the U.S. EPA, which began its own review of the data. At first, the EPA concluded that the water was safe, but after further review, noted hazardous levels of barium, arsenic, and manganese. Both the DEP and Cabot were highly critical of the EPA's involvement, accusing the EPA of lacking appropriate knowledge and misrepresenting data, respectively. In the summer of 2012, however, the EPA concluded that the dangerous levels of the three chemicals could be reduced to safe levels with water treatment systems already installed in the homes, and that there was no need for any further study of the case (Statelmpact 2013).

But in July 2013, an internal PowerPoint presentation by the EPA office working on the Dimock case was obtained by the media. The presentation reported results from more than four years of water quality testing in 11 wells and concluded that "methane and other gases released during drilling ... apparently cause significant damage to the water quality" (Banerjee 2013). The presentation further indicated that other contaminants including manganese and arsenic were found in some wells. Despite this new development, the EPA has yet to re-open the case and Dimock residents continue to struggle with receiving compensation for their damages and potential exposure to hazardous chemicals.



© Bill Cunningham, USGS

The process of hydraulic fracturing uses large quantities of silica sand, or “frac-sand,” along with water and chemicals, to extract oil or natural gas from rock formations. The sand serves to hold open the newly created fractures in the rock so that the oil or gas can be released.

leaks of wastewater from facilities for storage, treatment, and disposal. Unlike groundwater contamination risks, surface water contamination risks are mostly related to land management and to on- and off-site chemical and wastewater management.

The EPA has identified more than 1,000 chemical additives that are used for hydraulic fracturing, including acids (notably hydrochloric acid), bactericides, scale removers, and friction-reducing agents. Only maybe a dozen chemicals are used for any given well, but the choice of which chemicals is well-specific, depending on the geochemistry and needs of that well (EPA 2012f; NETL 2009). Large quantities—tens of thousands of gallons for each well—of the chemical additives are trucked to and stored on a well pad. If not managed properly, the chemicals could leak or spill out of faulty storage containers or during transport. While some of the chemicals commonly used in hydraulic fracturing are known to be toxic and thus require careful management, there is limited information available on the toxicity of many additives (EPA 2012f).

Drilling muds, diesel, and other fluids can also spill at the surface (Wiseman 2013c). Hundreds of small leaks and spills on well pads have been documented in many states with oil and gas development, including Arkansas, Louisiana, Ohio, Pennsylvania, Texas, and West Virginia (Michaels et al. 2010), although there is no comprehensive study of how frequently chemical spills occur on well pads. Most communities are not prepared to handle such spills adequately (EPA 2012f; TCCOG 2011).

Improper management of flowback or produced wastewater can cause leaks and spills (Haluszczak et al. 2012; Rowan et al. 2011). Before disposal, wastewater is usually transferred from the wellhead to temporary storage in tanks or lined retention ponds near the well pad; in the event of improper management practices, there is risk of leakage into the ground at the wellhead and from storage tanks or pits (Kargbo et al. 2010). A number of spills of flowback and produced water from pits and tanks have been documented (Wiseman 2013c).

Most wastewater in the United States that is not reused is disposed of by deep-well injection into Class II disposal wells, which have limited surface water impacts (Clark and Veil 2009). But some parts of the country instead rely heavily on public or private treatment facilities to process wastewater before it is released to surface water. Special facilities are needed because ordinary municipal and industrial treatment plants are not equipped to remove high salinity, radioactivity, or other components of flowback or produced wastewater (Lutz et al. 2013; Olmsted et al. 2013; Gregory et al. 2011; Rahm and Riha 2011). That fact suggests that surface water downstream of ordinary treatment plants accepting fracking wastewater may be at risk, though further research needs to be done to better understand the actual risk (Garvin 2011).

There is also risk to surface water from deliberate improper disposal of wastewater by bad actors. In 2013 alone, federal prosecutors and state inspectors charged two different hydraulic fracturing wastewater haulers in Ohio with illegal dumping of untreated drilling muds and saline wastewater into surface waters (EcoWatch 2013; Hunt 2013), and similar charges were brought against a Pennsylvania wastewater treatment facility (Kelly 2013b). Previously, more than 1,000 incidents of illegal dumping of fracturing wastewater in farmland and waterways were reported in North Dakota (Kusnetz 2012). Illegal dumping is of particular concern because cows and other grazing farm animals are continually exposed to soil and water; a 2012 study found a link between illegal dumping of fracturing wastewater and farm animal deaths and birth defects (Bamberger and Oswald 2012). Another fear is that contamination could migrate into the human food chain through meat and dairy products.

Water Use. The growth of hydraulic fracturing and its use of huge volumes of water per well may strain local ground and surface water supplies, particularly in water-scarce areas. The amount of water used for hydraulically fracturing a well can vary because of differences in formation geology, well construction, and the type of hydraulic fracturing

process used (EPA 2012f). The EPA estimates that 70 billion to 140 billion gallons of water were used nationwide in 2011 for fracturing an estimated 35,000 wells (EPA 2011a). Unlike other energy-related water withdrawals, which are commonly returned to rivers and lakes, most of the water used for unconventional oil and gas development is not recoverable. Depending on the type of well along with its depth and location, a single well with horizontal drilling can require 3 million to 12 million gallons of water when it is first fractured—dozens of times more than what is used in conventional vertical wells (Breitling Oil and Gas 2012; NETL 2009). Similar vast volumes of water are needed each time a well undergoes a “work over,” or additional fracturing later in its life to maintain well pressure and gas production. A typical shale gas well will have about two work overs during its productive life span (NETL 2010).

Research on air pollution from unconventional oil and gas development has been limited by a lack of information on and access to well sites and other facilities.

Withdrawing such a huge quantity of water over a short period of time can strain local water sources, especially in arid and drought-prone regions such as Texas and other areas in the West. It has been estimated that hydraulic fracturing for natural gas in Texas alone could use 50 billion gallons of water by 2020 (Nicot and Scanlon 2012). A recent study by Ceres analyzed water use nationwide and found that nearly half of more than 25,000 hydraulically fractured wells across the United States were in regions of high or extremely high water stress (Freyman and Salmon 2013). Such large withdrawals in such stressed regions can threaten drinking water supplies as well as affect the environment. For example, numerous operators withdrawing from one stream in a short time period have caused stream levels to drop to levels that could harm aquatic life (Wiseman 2013c; SRBC 2012; NYSDEC 2011).

Although estimates suggest that oil and gas development comprises a much smaller fraction of total annual water use in most states than residential or other industrial uses (Nicot et al. 2012), the activity’s use of water is an increasingly important issue particularly when viewed in terms of daily, simultaneous withdrawals and their impact on surface water levels. At the local level, this can be significant. For example, when water use for oil development was combined with drought conditions in an arid climate, the water supply in Barnhart, Texas, ran dry in summer 2013 (Gold-



Water quality may get more attention, but air quality is also a concern in many communities. Pollutants emitted from well sites, compressor stations, and truck traffic can contribute to air pollution in communities with oil and gas development operations.

enberg 2013). The frequency and severity of limitations on water supplies, such as the situation in Barnhart, is an issue that requires further monitoring.

2.1.2. Air Quality

Water quality issues may receive more attention, but unconventional oil and gas development can also affect local and regional air quality. Some areas where drilling occurs have experienced increases in concentrations of hazardous air pollutants and two of the six “criteria pollutants”—particulate matter and ozone plus its precursors—regulated by the EPA because of their harmful effects on health and the environment (Lyman and Shorthill 2013; EPA 2012i; McKenzie et al. 2012; Petron et al. 2012). Exposure to elevated levels of these air pollutants can lead to adverse health outcomes, including respiratory symptoms, cardiovascular disease, and cancer (EPA 2013f; EPA 2013b; ATSDR 2004). One recent study found that residents living less than half a mile from unconventional gas well sites were at greater risk of health effects from air pollution from natural gas development than those living farther from the well sites (McKenzie et al. 2012).

Air pollutants may be of greatest concern during the well completion phase, when most of the water and chemicals flow back from a well to the surface, and there is significant venting and flaring of gases (McKenzie et al. 2012). Because the venting and flaring may occur at specific stages of the

process and may not be continuously emitting, their impact will vary depending on such factors as the number of oil and gas operations concentrated in a particular area and the existing air quality in a region. Any on-site processing to separate gases from oil or other substances may also contribute air pollutants, especially ozone precursors (Kemball-Cook et al. 2010) (see Box 3). Diesel emissions from truck traffic for transporting water and materials to and from the well pad

may increase air pollution levels near drilling sites (Rodriguez and Ouyang 2013). Diesel vehicles emit particulate matter, which has been linked to decreased lung function, asthma, and respiratory symptoms such as coughing and difficulty breathing (EPA 2013b). While no severe health effects have been associated with fugitive methane being released into the atmosphere, methane is explosive and at high concentrations can be an asphyxiant (Airgas 2013).

BOX 3

Air Pollution Concerns in Dish, Texas

Some communities have been affected by degradation in air quality resulting from nearby unconventional oil and gas development. Residents of Dish, Texas, believe they have experienced such issues, yet they have faced significant barriers—both scientifically and legally—in proving their case. Ultimately, residents needed to make decisions based on inconclusive evidence.



Hog Branch compressor station, Dish, Texas

In 2005, the first of many natural gas compressor stations was built in Dish. Such compressor stations are placed near unconventional gas drilling sites to pressurize the extracted natural gas for transport through pipelines. Ever since the compressor stations were installed in Dish, many residents have complained of health problems including nosebleeds, pain, poor circulation, and cancer, all of which they are convinced are connected to local natural gas operations (Hamilton 2012; Zelman 2011). In 2009, the town hired consulting firm Wolf Eagle Environmental to monitor ambient air in the town. In a final report, Wolf Eagle stated that it found high concentrations of a number of carcinogenic and otherwise hazardous compounds in and around residential areas. Given the nature of the chemicals, and the lack of other heavy industry in the town, the report concluded that the chemicals could be attributed to the natural gas compressors, and a subsequent study from the Texas Commission on Environmental Quality confirmed this conclusion (TCEQ 2009; Wolf Eagle Environmental 2009). However, scientists analyzing available data about Dish have been unable to find a connection between the residents' health

effects and emissions from the local gas facilities. According to epidemiologist Brian Schwartz, who has studied health effects of gas development activities in Dish, the lack of a definitive answer about whether industry is causing health problems in Dish does not mean that the gas operations pose no risk for residents but rather that "there is a pressing need for more scientific research" (Hamilton 2012).

Following the 2009 study, the companies owning the compressors made changes to their production processes, and pollution levels were reduced to safe levels according to an air monitoring system installed by the state. Residents of Dish, however, continue to experience health problems and insist that the air in their town is still not safe. In 2011, the town's own mayor moved away after his two sons began experiencing severe nosebleeds that, he claims, coincided with especially strong odors and higher levels of chemicals, according to air quality monitoring data. To date, residents have been unsuccessful in proving that their health problems are the result of local natural gas operations (Hamilton 2012). As a result, residents must make major life decisions, including whether to uproot their lives and move their families out of Dish, based on incomplete scientific information.

Air quality in North Dakota may be further compromised by the fact that oil development is occurring in areas where unpaved roads incorporate gravel containing a fibrous mineral called erionite, which has properties similar to asbestos. Trucks driving over such gravel roads can release harmful dust plumes of erionite mineral fibers into the air, thereby increasing hazardous airborne exposures and associated health risks for workers and area residents (Royte 2013; Carbone et al. 2011; Ryan et al. 2011).

Research on air pollution from unconventional oil and gas development has been limited by a lack of information on and access to well sites and other facilities (McKenzie et al. 2012; Zielinska, Fujita, and Campbell 2011). Without access to such locations to carry out measurements and obtain information on the timing of different stages of extraction, it can be difficult to determine the source and extent of emissions (Moore, Zielinska, and Jackson 2013) (see Section 2.2.3.). Some work has suggested that utilization of available technologies and management practices can minimize air emissions from drilling sites (Bredfeldt 2013). Indeed, “green completion” technologies, which capture air emissions from flowback water and fractured wells, capture a large percentage of volatile organic compounds (VOCs) and methane. Under federal regulations, green completion technologies will have to be installed on most new gas wells by January 2015. Additional air emission restrictions will apply to certain wellhead compressors, storage vessels, pneumatic controllers, and other equipment (EPA 2012i). More research is needed to assess the full impacts on air quality and public health of all activities involved in unconventional oil and gas development.

2.1.3. Seismic Activity

Hydraulic fracturing itself has been linked to low-magnitude seismic activity—less than 2 moment magnitude (M) [the

moment magnitude scale now replaces the Richter scale]—but such mild events are usually undetectable at the surface (NRC 2013; The Royal Society 2012). The disposal of fracking wastewater by injecting it at high pressure into deep Class II injection wells, however, has been linked to larger earthquakes in the United States (NRC 2013). At least half of the 4.5 M or larger earthquakes to strike the interior of the United States in the past decade have occurred in regions of potential injection-induced seismicity (van der Elst et al. 2013). Although it can be challenging to attribute individual earthquakes to injection, in many cases the association is supported by timing and location of the events (van der Elst et al. 2013). The largest earthquake likely associated with deep-well injection occurred in November 2011 in Oklahoma. The earthquake was rated at 5.7 M and was felt in at least 17 states (Keranen et al. 2013). Researchers have found that the overall recent dramatic increase in seismicity in the midwestern United States may be related to increases in deep injection of fracking wastewater (van der Elst et al. 2013).

The overall recent dramatic increase in seismicity in the midwestern United States may be related to increases in deep injection of fracking wastewater.

The cause of earthquakes due to deep wastewater injection is reasonably well understood, and risks may be minimized if injections are managed by effective site characterization, monitoring, and proactive planning. In addition, such seismic activity could be minimized by processing and reusing wastewater instead of discarding it through deep-well injection (NRC 2013; Zoback 2012). The established link between deep-well injection and increased seismicity, however, suggests that unconventional oil and gas development in



Some researchers studying the impacts of unconventional oil and gas development have only been able to conduct “fence studies” because oil and gas operators have restricted scientists’ access to monitor air, water, and soil near facilities.



© Flickr/mwahisten

Rapid population growth in communities that have never before seen oil and gas operations can strain community resources and public services.

regions known to be prone to seismicity, such as the Monterey Shale in California, should be approached with caution.

2.1.4. Socioeconomic Effects

Unconventional oil and gas development can have direct short-term socioeconomic impacts on communities and regions, including some far from well sites. The availability of jobs in the industry often creates a local population boom in cities and towns near the well sites. Money flows from them into the local economy, increasing business at local stores and restaurants (Costanzo and Kelsey 2012; Kelsey et al. 2012; Christopherson and Rightor 2011). In 2011, for example, Williston, North Dakota, a town that has seen significant increases in local oil production due in

Truck traffic associated with unconventional natural gas development was considered by residents of Bradford County to be “the most constant source of aggravation, stress, and fear.”

part to hydraulic fracturing, saw “a 76.2 percent jump in the city[s] sales tax revenue,” surpassing every other city and county in the state (Ebersole 2012; Williston 2012). In 2010, while much of the country struggled with high unemployment after the widespread 2008 financial crisis, Williston reported an unemployment rate of 0 percent, a number unheard of elsewhere across the nation (Williston Community Profile 2013). Meanwhile, the state of North Dakota has also benefitted from the fracking boom with a 3 percent unemployment rate and \$1.6 billion budget surplus in 2012 (Manning 2013).

These positive economic impacts may be short-lived or even illusory, however, as communities that depend on natural resource extraction frequently have poor long-term

economic development outcomes. In addition, nearby communities with no tax revenues from development may bear costs from air and noise pollution and traffic. Both the costs and economic benefits of unconventional oil and gas development are not confined to the places where drilling occurs (Christopherson and Rightor 2013). Moreover, evidence suggests that economic benefits may not be distributed proportionately to the affected communities. One study of Bradford County, Pennsylvania, found that “the job creation in the county . . . appears small compared to the spending that the natural gas companies report and to estimates of the statewide economic impacts. This would suggest that a large proportion of the economic benefit resulting from Marcellus Shale development in Bradford County is occurring outside the county” (Kelsey et al. 2012). Indeed, ample evidence reveals that many of the highest-paying skilled jobs promised to communities in Ohio, Pennsylvania, and elsewhere are actually being filled by itinerant out-of-state oil and gas professionals from Oklahoma and Texas (WKYC 2013; Food & Water Watch 2011). Such findings suggest careful consideration of whether the economic benefits outweigh the costs and inconveniences associated with oil and gas development at the local level.

Rapid population increases associated with oil and gas development in the short term may strain community resources and public services. Studies suggest that such development leads to increased demand for police, emergency services, building permit applications, and other social services (Christopherson and Rightor 2011; TCCOG 2011). Increased need for emergency services stems from the population influx, traffic and drilling accidents, as well as response to environmental spills and other hazards (TCCOG 2011).

Because of the increase in housing demand, many new residents are forced to live in their cars or in cramped, makeshift villages known as “man camps,” which spring up around energy boom towns (Dobb 2013). The increased demand for housing also causes prices to increase, and forces some existing residents out of apartments and rental homes they can no longer afford (Dobb 2013). Many of the incoming residents are men, and this higher ratio of men to women has been associated with increased rates of crimes against women and prostitution (Eligon 2013). Increases in overall crime rates and rates of alcohol and drug abuse have also been documented in energy boom towns (Ellis 2011; Levy 2011).

Increased truck traffic is another impact of concern. The abundance of trucks for carrying equipment, water, sand, chemicals, pipes, wastewater, and other materials to

and from drilling sites, as well as to disposal wells, adds to congestion, traffic accidents, and road degradation (Perry 2012a). Depending on the depth of a well, up to 1,500 truckloads may be necessary per well (King 2012; TruckGauge 2011; NPS 2008). The infrastructure costs to communities may be substantial to maintain roads not built for industrial use. Many of the trucks carry chemicals and other hazardous materials, creating additional risks associated with traffic accidents (Mauter 2013; King 2012). In Bradford County, Pennsylvania, for example, where by 2009 more than half the residents had leased their land to oil and gas companies, traffic fatalities increased 25 percent between 2008 and 2009 (Perry 2012b). Truck traffic also contributes to noise pollution as well as air pollution. Overall, truck traffic associated with unconventional natural gas development was considered by residents of Bradford County to be “the most constant source of aggravation, stress, and fear.”

Since the drilling process takes four to five weeks of non-stop work per well, increased noise from drilling equipment also can become an issue (Perry 2012b). Furthermore, sta-

dium lighting from around-the-clock drilling rigs contributes to significant light pollution (NYSDEC 2011).

Altogether, such socioeconomic stresses can take a toll on the mental health and well-being of people and communities. Residents of one town unanimously agreed that the arrival of the shale gas industry had permanently changed their relationships with their neighbors, their family, and the land, regardless of their opinions about whether the shale gas developments were having an overall positive or negative impact in the county (Perry 2012b). The study also examined the patterns of social and psychological changes seen amongst the people of towns with unconventional oil and gas development, and found that they were “similar to patterns documented in survivors of bullying and other abusive types of relationships” (Perry 2012b).

2.1.5. Land Use and Ecological Impacts

The construction and land disturbance required for oil and gas drilling can alter land use and harm local ecosystems by causing erosion and fragmenting wildlife habitats and migration patterns. When oil and gas operators clear a site to build a well pad, pipelines, and access roads, the construction process can cause erosion of dirt, minerals, and other harmful pollutants into nearby streams (Williams et al. 2008). A study of hydraulic fracturing impacts in Michigan found potential environmental impacts to be “significant” and include increased erosion and sedimentation, increased risk of aquatic contamination from chemical spills or equipment runoff, habitat fragmentation, and reduction of surface waters as a result of the lowering of groundwater levels (Burton, Nadelhoffer, and Preston 2013).

With respect to sedimentation, another recent study found that sediment levels systematically increased in surface waters near unconventional oil and gas wells across Pennsylvania (Olmstead et al. 2013). This increase in sediment levels stresses fish and other wildlife by clouding water, damaging habitats, and reducing photosynthesis (Entrekin et al. 2011; GAO 2005). These impacts, in addition to water withdrawals, have led the U.S. Fish and Wildlife Service to list as endangered the diamond darter, a small freshwater fish that now is only known to inhabit the Elk River in West Virginia (FWS 2013). The construction process also fragments habitats for terrestrial animals, which can create new pathways for predators, help spread invasive species, and increase noise and other disturbances from humans (GAO 2012). Wastewater spills and leaks from oil and gas operations also impact wildlife. A 2007 spill of hydraulic fracturing wastewater from four well sites caused a massive fish kill in Kentucky’s Acorn Creek, affecting two endangered fish species (Papoulias and Velasco 2013). Unconventional oil



© Flickr/lockthegate

High densities of well sites in an area can transform a landscape, harming local ecosystems through erosion and fragmentation of habitats.



© 2013 Trudy E. Bell

The high economic potential of oil and gas development, coupled with the limited amount of preexisting research on its impacts, has left the science vulnerable to undue influence from corporate and political forces.

and gas development can also harm wildlife regions nationally known for bird watching, sportfishing, and trophy hunting, adversely impacting states' tourism economies from both domestic and international visitors (Macmillan 2013; Western Reserve Land Conservancy 2013; Licata 2009).

2.1.6. Sand Mining

The specific engineering process of hydraulic fracturing also affects local communities—even in places where oil and gas development isn't occurring—through its extensive use of a special silica sand with uniformly sized rounded grains as a “proppant”: an agent for propping open the fractures created in shale or other rock formations deep underground (WDNR 2012). A single well can use thousands of tons of this special “frac-sand.” Indeed, hydraulic fracturing now accounts for 41 percent of all silica sand used in the United States. Total frac-sand production in the nation nearly doubled to 12.1 million tons between 2009 and 2010 (Minnesota Environmental Quality Board 2013). The state of Wisconsin alone has gone from less than 10 mining sites five years ago to more than 100 today (Redden 2013). The majority of U.S. frac-sand mining occurs in the upper Midwest—notably Iowa, Minnesota, and Wisconsin—through surface strip mining (McLeod 2011).

Concerns about exposure to harmful silica dust have arisen for workers mining the sand, for oil and gas workers at the well sites, and for residents living near both mining and drilling operations (Davies 2012; OSHA 2012; Bridge 2009). The National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) recently issued a Hazard Alert for workers exposed to silica proppant used for hydraulic fracturing after finding hazardous airborne silica concentrations at several sites in five different states (OSHA 2012). And in August 2013, the White House Office of Management and Budget finally allowed OSHA to issue its proposed rule to enhance protection of workers exposed to crystalline silica dust (OSHA 2013). The rule may play a role in protecting workers who deal with frac-sand. In addition, there are issues of surface water and groundwater pollution from the use of chemicals in the process of strip-mining the silica sand (Davies 2012; McCurdy 2012; MDH 2009). Increased truck traffic from hauling silica sand as well as overall degradation to the land also are major concerns among those living near sand mining operations.

2.2. Interference in the Science

The high profit potential of oil and gas development, combined with a lack of preexisting comprehensive scientific knowledge, has left research on the health, environmental, and socioeconomic effects vulnerable to undue influence and interference from political and corporate forces. Those challenges have created barriers for citizens, researchers, media members, and decision makers seeking reliable scientific information on the risks associated with the industry. Several instances of inappropriate influence over the science have occurred in recent years.

2.2.1. Interference in Government Science

Corporate actors have influenced the science produced by federal and state agencies. One major target has been the EPA, which has been studying unconventional oil and gas development for many years. EPA studies inform federal policy makers on environmental pollution and thus play a large role in how industry is regulated.

- A 1987 EPA study was unduly influenced by industry, one study author alleges. The study documented a case of water contamination from a nearby well in Jackson County, West Virginia (EPA 1987). According to the study's lead author, Carla Greathouse, the EPA found dozens of cases of drinking water contamination related to hydraulic fracturing; however, all except one case were dropped from the study because of pressure from the industry representatives who were members of an agency working group overseeing the research (Urbina 2011). Unfortunately, researchers have been unable to follow up on the other potential contamination cases because lawsuits settled between landowners and the companies allegedly at fault have sealed off the relevant documents from public view (Urbina 2011) (see Box 4, p. 18).
- An investigation revealed that in 2002, EPA officials approached Congress with concerns that hydraulic fracturing could lead to levels of benzene in underground drinking water sources that exceed federal standards for drinking water (CAP 2004; USHR 2002). When the official EPA report was released, however, the EPA had changed its position to state that the activity would not result in levels of benzene above federal standards. The EPA gave no scientific explanation for its change in position, stating only that it made the change after receiving feedback from an industry source (CAP 2004; USHR 2002).
- In a 2004 study, the EPA concluded that “the injection of hydraulic fracturing fluids into coal-bed methane wells poses little or no threat to USDWs [underground sources of drinking water]” (USEPA 2004). Shortly after the report was released, however, an EPA scientist and whistle-blower, Weston Wilson, called the study “scientifically unsound,” noting that “five of the seven members of the [peer-review] panel appear to have conflicts of interest and may benefit from the EPA’s decision” (Browning and Kaplan 2011). At the urging of lawmakers, the office of the EPA Inspector General promised to conduct a review of the scientist’s claims; however, it appears no investigation was done (Hamburger and Miller 2004a). In addition, the Oil and Gas Accountability Project uncovered earlier drafts of the EPA study, which suggested “unregulated fracturing poses a threat to human health” and “fracturing fluids may pose a threat to drinking water”—information that was omitted in the final report (Wiseman 2009; OGAP 2005).
- In December 2011, the EPA released a study on possible drinking water contamination in Pavillion, Wyoming, and concluded that the data indicated “likely impact to groundwater that can be explained by hydraulic fracturing” (DiGiulio et al. 2011). The study was met with strong industry criticism, and the EPA said that it would carry out further testing (Lustgarten 2013). In June 2013, however, the EPA decided to leave the case to the state of Wyoming, which will use funding from EnCana Corp.—the drilling company that may be responsible for the contamination—to conduct further investigation (EPA 2013e).
- In several recent instances when potential water contamination warranted an EPA investigation, industry actors pressured the agency and the EPA subsequently backed down. For example, in 2010, the EPA was investigating a water contamination case in Parker County, Texas. After home owners reported methane gas in their well water, the EPA issued an emergency order saying that the home owners were in immediate danger (Plushnick-Masti 2013). On December 7, 2010, the EPA announced that the chemical makeup of the gas in the water wells matched gas in the production wells of a company called Range Resources (Gilbert and Gold 2012). The EPA ordered the company to provide affected residents with safe drinking water, and to clean up the water wells. When Range Resources refused, the EPA sued them for non-cooperation. On March 30, 2012, however, the EPA dropped the lawsuit against Range Resources.

BOX 4

Hidden Science and Silenced Citizens in Legal Settlements

There are still many unknowns related to water contamination from oil and gas operations, perhaps partly due to the silencing of those who have experienced such contamination of their drinking water. While more scientific research is needed, some information about potential water contamination cases is known but concealed from public view by industry actors looking to keep the details hidden.

Residents who suspect contamination of their water due to oil and gas activities may sue the company they believe is responsible. The majority of these lawsuits end with a settlement or property buyout, in which citizens are compensated for any damages found to result from industry activity in return for their silence on the incident. Such non-disclosure agreements legally bind citizens from speaking about the case and the events surrounding it. As a result, many of the scientific investigations of water contamination that have been performed are hidden from public scrutiny.

This means that even if testing of water and other scientific analyses performed for the court case indicated contamination caused by oil and gas activities, the information is not shared with researchers and regulators. As Aaron Bernstein, associate director of the Center for Health and the Global Environment at the Harvard School of Public Health, was quoted in an interview, non-disclosure agreements “have interfered with the ability of scientists and public health experts to understand what is at stake here” (Efsthathiou and Drajem 2013).

The secrecy (in addition to exploitation of discrepancies in definitions of fracking) has also made it easier for industry actors to claim there has not been a single case of groundwater contamination from unconventional oil and gas development, since much of the data on which this statement should be based are not publicly known. “There has never been a case of groundwater contamination as a result of hydraulic fracturing,” Jack Gerard, president of the American Petroleum Institute, stated in an interview with Bloomberg Radio in April 2013 (Efsthathiou and Drajem 2013). He is not alone—many industry representatives have made similar claims in public interviews, in town hall meetings, and in congressional hearings (USHR 2013; USS 2013; Urbina 2011).

Another concerning element of such settlements is that—in at least one case—the non-disclosure agreement may apply to the children in a family involved in the lawsuit. Chris and Stephanie Hallowich, who experienced health impacts potentially caused by gas drilling near their Washington County, Pennsylvania, home, settled the dispute with Range Resources, the company allegedly responsible for the damages. The settlement included a non-disclosure agreement that seems to bar the couple’s seven- and 10-year-old children from speaking about the experience for the rest of their lives (Breiner 2013). Though Range Resources has since disputed that the disclosure applies to the two children, the settlement transcript itself indicates that the company’s lawyers intended the agreement to “apply to the whole family” (Breiner 2013; Stephanie Hallowich and Chris Hallowich v. Range Resources et al. 2011).



In several recent instances when potential water contamination warranted an EPA investigation, industry actors pressured the agency and the EPA subsequently backed down.

According to a report obtained by the Associated Press, the EPA had scientific evidence against Range Resources, but dropped the case because the company threatened not to cooperate with another EPA study of hydraulic fracturing (Plushnick-Masti 2013). E-mail messages obtained by EnergyWire show that Pennsylvania Governor Edward G. Rendell met with EPA Administrator Lisa P. Jackson about a year before the case was dropped, and argued on behalf of Range Resources that the case be settled. The EPA stated only that it wanted to pursue the issue through collaborative water testing with Range Resources, as opposed to litigation (Soraghan 2013). On July 17, 2012, the EPA Office of the Inspector General issued a memorandum announcing an investigation into whether the EPA's actions in the case complied with agency guidelines; to date, no investigation has been released (EPA 2012h). Others, including the Railroad Commission of Texas, have asserted that there was no contamination by Range Resources and that EPA claims to the contrary were unfounded (RCT 2012).

- Currently, the EPA is working on a comprehensive study of impacts of unconventional oil and gas development on drinking water resources. Industry has already gone on the offensive (DiCosmo 2013). In 2011, before the study had even begun, the American Petroleum Institute (API) and the America's Natural Gas Alliance (ANGA) submitted a 166-page critique of the EPA's study plan (Battelle 2011). Ahead of a peer-review panel meeting for the study in 2013, the American Exploration & Production Council (AXPC), the ANGA, the API, and the Independent Petroleum Association of America (IPAA) sent a letter to Congress claiming the study has flawed methods and an overreaching scope. The letter said that these industry representatives commissioned "a critical review of EPA's study plan." According to the review, the EPA's ability to establish a clear connection between hydraulic fracturing and water contamination would be "challenging given the lack of adequate data" and "would require rigorous scientific analysis to differentiate impacts from all potential sources of contamination" (API 2013).

- Industry influence on government science also has occurred at the state level. The New York State Department of Environmental Conservation (NYSDEC) conducted a review of hydraulic fracturing in order to determine whether the process should be allowed in the state. Some of the firms contracted to help with the review are allegedly members of the pro-fracking industry trade group, Independent Oil and Gas Association of New York (IOGANY). The association recently sent a letter to New York Governor Andrew M. Cuomo, asking him to lift the state's moratorium on hydraulic fracturing and the letter was signed with the names of the group's more than 200 member companies (IOGANY 2013). Though the firms in question have asserted that they previously cut ties with IOGANY and did not authorize their names on the letter, their involvement with IOGANY raises questions about their ability to do an independent review on whether the state of New York should allow hydraulic fracturing (Esch 2013a).

BOX 5

Industry Interference in Community Decision Making



© Wikicommons

In Mount Pleasant Township, Pennsylvania, local residents received letters from Range Resources, an oil and gas exploration and production company interested in drilling in the area. The letters were seen by township officials as "an attempt to intimidate township leaders" shortly before

they were set to vote on an ordinance that would determine where and how drilling could take place. In the letters, Range threatened to abandon drilling operations in the township (emphasizing the cost to local business owners and leaseholders) and possibly even sue the township if officials did not remove certain regulations from the ordinance. "We are outraged," said one resident in response to the letters. "This is an effort by Range Resources to divide a community . . . It's an attempt by the company to get what they want rather than operate within the [township government] process" (Hopey 2011). Range Resources' attempt to interfere with local policy making was ultimately unsuccessful, and the township ordinance was passed with the contested regulations still intact. Later, however, Range Resources filed papers with the state Public Utility Commission, asking it to override the ordinance (Rosenfeld 2012).

2.2.2. Corporate Influence on Academic Studies

Industry interests have influenced the outcome of academic studies of unconventional oil and gas development. Such efforts have produced industry-friendly research results and reports coming from several universities, a circumstance that has been dubbed “frackademia” (Schiffman 2013; Horn 2012). Industry funding of academic research does not inherently mean the science is biased. Private sources often fund research at academic institutions. However, it is essential that such funding sources be listed in reported studies, any conflicts of interest held by study authors be disclosed, and that the study examine all evidence objectively. In the words of Thomas O. McGarity, a law professor at the University of Texas at Austin and a scholar on issues of corporate interference in science, “companies attempt to borrow the prestige of the university. . . . Universities have to be absolutely transparent” (Navarro 2012). For several fracking studies released with university affiliations, ties to industry were not disclosed.

- A 2013 study published by the University of Southern California discussed the economic benefits that fracking would bring to California (Powering California 2013). One of the study’s co-authors failed to disclose that he is the founder and president of an oil and gas industry consulting firm called FACT Inc. (FACT 2013; Horn 2013).
- At the University of Texas at Austin, a 2012 study titled “Fact-Based Regulation for Environmental Protection in Shale Gas Development” (Groat and Grimshaw 2012) met with strong criticism after it was revealed that the lead author of the study failed to disclose that he received material compensation through his affiliation with Plans Exploration and Production, an energy industry firm with an interest in fracking. In response to the controversy, the university requested an external review of the study. The review concluded that the study “fell short of contemporary standards for scientific work.” Besides the lead author’s failure to disclose his industry ties, the review concluded that “the term ‘fact-based’ would not apply to such an analysis” because “much of the report was based on literature surveys, incident reports and conjecture.” Furthermore, the report was a compilation of three white papers that were “not subjected to serious peer review” and that the authors “did not read”—the end result being the “apparent distortion of the substance of the white papers” (Augustine et al. 2012).
- In 2012, the State University of New York at Buffalo closed the school’s Shale Resources and Society Insti-

tute in response to internal and external criticism about an improper relationship between some of the institute’s professors and the natural gas industry (Navarro 2012b; Tripathi 2012). One study by the institute stated that regulations had made unconventional oil and gas development safer in Pennsylvania, and concluded that fracking could therefore be done safely in New York. The report falsely claimed that fracking-related pollution events in Pennsylvania had declined in recent years, and borrowed entire passages from a different report without proper citation. The report also failed to reveal that the authors had strong ties to the oil and gas industry, and regularly received funding for their studies from the Marcellus Shale Coalition, an industry trade association. One of the lead authors of this study was also lead author of a controversial 2009 Pennsylvania State University study described below (Navarro 2012a).

It is essential that funding sources be listed in reported studies, any conflicts of interest held by study authors be disclosed, and that the study examine all evidence objectively.

- A 2012 study by professors at Cleveland State University, Marietta College, and The Ohio State University concluded that fracking would have a positive effect on Ohio’s economy and employment rate. The study states that it was sponsored by the Ohio Shale Coalition and acknowledges that it received insights from “professionals involved in all aspects of the oil and gas industry,” but does not identify any of these companies or individuals because the discussions with them were considered “confidential” (Ohio Shale Coalition 2012). The study also does not disclose the connections of some of the authors to the oil and gas industry. One author was investigated by the state ethics board because a consulting firm he founded was considered a conflict of interest with his appointed position as a member of the Ohio Oil and Gas Commission (McDonnell 2012; Ohio Shale Coalition 2012).
- A 2011 Massachusetts Institute of Technology study titled “The Future of Natural Gas: An Interdisciplinary MIT Study” argued for the increased development of natural gas as a low-carbon transition fuel (MIT n.d.). While the study acknowledged that its funding came from a number of industry groups, it failed to disclose the fact that several of the study’s authors held positions on the boards of firms involved in the oil and gas industry,

for which they received financial compensation (Connor and Galbraith 2013).

- A 2009 study done by Pennsylvania State University stated that implementing a tax on natural gas production in Pennsylvania would harm the state's economy (Considine et al. 2009). The study received funding from an industry trade group, the Marcellus Shale Committee (now the Marcellus Shale Coalition), and the final report failed to disclose that the study's lead author, who is known for his pro-industry publications, has ties to the oil and gas industry (Efstathiou 2012; Magyar 2010).

2.2.3. Restrictions on Access to Data

Scientists researching the effects of unconventional oil and gas development have met challenges in obtaining objective measurements and other necessary data because of restricted access to well sites, limited sharing of data by industry and government officials, data concealed by legal settlements, and trade secret exemptions in chemical disclosure laws (Colborn et al. 2011; Zielinska, Fujita, and Campbell 2011).

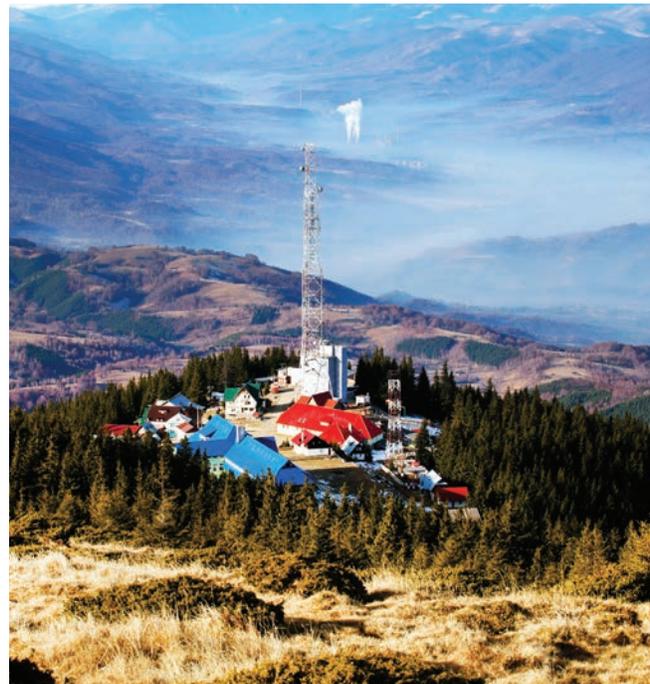
Disclosure of the chemicals used in the hydraulic fracturing fluid, as well as in other stages of oil and gas development, would help scientists detect pollution when it occurs and study its potential impacts on the environment and human health. Many jurisdictions have no requirement that companies publicly disclose this information, leaving researchers to negotiate with companies themselves to obtain what data they can (see Section 3.2.1.). Even where some chemical disclosure is legally required, companies often are allowed to withhold the information if they consider it to be an industry trade secret (Richardson et al. 2013).

Researchers also have faced barriers when they seek to take measurements themselves. Environmental monitoring data provide scientists with important information in assessing environmental and public health impacts of an industrial activity. In the case of unconventional oil and gas development, researchers can better understand impacts if they are able to monitor close to wells. Most well sites, however, are on private land, much of which is owned by the industry itself (Christopherson 2013). In Pennsylvania, for example, 93 percent of wells are on private land (Brittingham 2013). Thus, companies can restrict researchers from collecting data and obtaining other information vital for scientific study (Colborn et al. 2011; Zielinska, Fujita, and Campbell 2011). For example, one research professor studying air quality around well sites noted that her research team was able to do only “fence studies”—that is, take measurements outside fenced perimeters of well sites—

because companies would not allow her team to test the air within the site (Zielinska, Fujita, and Campbell 2011). This situation significantly hampers the level and quality of monitoring that scientists can conduct at well sites (see Section 2.3.3.).

Scientists researching the impacts of fracking have met challenges because of restricted access to well sites, data concealed by legal settlements, and trade secret exemptions in chemical disclosure laws.

Moreover, many of the scientific analyses performed on private lands are not available to researchers. Lawsuits surrounding potential pollution of residences by oil and gas activities almost always end in non-disclosure agreements (Efstathiou and Drajem 2013). The agreements conceal any data or analysis that was done to determine if the pollution was caused by the industrial activity. These agreements not only prevent the affected citizens from speaking about the incident but also suppress the valuable science that could bring better understanding of the risks associated with oil and gas development (see Box 4, p. 18).



Many scientific studies of potential water pollution from oil and gas operations are concealed. Investigations of contamination occur as part of lawsuits between residents and companies alleged to be responsible, but the cases nearly always end with non-disclosure agreements that hide the scientific analysis from public view.

BOX 6

Chemical Disclosure and Public Health



© iStockphoto.com/Vetta Stock Photo

Strong chemical disclosure laws can help scientists better understand the risks to communities and workers from chemicals used in unconventional oil and gas development. Disclosure laws also can have direct benefits to public health officials; conversely, the absence of such laws can lead to serious health consequences.

In 2008, Cathy Behr was working as an emergency room nurse in Durango, Colorado, when Clinton Marshall, a gas drilling worker, arrived complaining of a headache and nausea (Tsou 2012). Marshall had spilled hydraulic fracturing fluid on himself, so Behr helped him remove his contaminated clothes and rinse off the chemicals in a shower. A few days later, Behr appeared jaundiced, was vomiting fluid, and had difficulty breathing. She was admitted to the hospital and diagnosed with liver, respiratory, and heart failure. Her doctors suspected that her illness was caused by her exposure to the hydraulic fracturing fluid, and contacted the company that employed Marshall. The company, however, refused to reveal the chemicals used in its fluid because they were considered trade secrets. Behr came close to death. Eventually, her doctors were able to save her but without knowledge of the chemicals with which she had come into contact (Greene 2008).

Similar incidents prompted the Commonwealth of Pennsylvania to pass a law that gives doctors access to information about trade-secret chemicals if they suspect that their patient may have been exposed. However, the law has been limited in its effectiveness in addressing public health needs. Doctors are not allowed to share the information with anyone else, including other doctors and the patients themselves (Phillips 2012). Doctors also worry that the complicated legal procedure they must follow to obtain this information will cost them critical time and put their patients' health at risk (Tsou 2012).

2.3. Current Research Needs

Despite the ongoing work by many researchers, gaps remain in our understanding of many environmental and health impacts of unconventional oil and gas development. Additional research is necessary to quantify these risks and determine whether, and how, they can be mitigated. Researchers could better study the impacts of fracking if the following key information needs were addressed.

2.3.1. Baseline Studies

To better assess the impacts of unconventional oil and gas development on public health and the environment, scientists should know baseline conditions in communities before the start of drilling. In some cases, scientists are able to attribute changes in air and water quality without baseline studies through the use of chemical fingerprints and other technologies. If scientists had data on the quality of a community's surface water and groundwater, soil, and air before drilling and hydraulic fracturing, however, they could better determine whether fracking had an adverse effect on a community's environment. If so, this could help communities hold those responsible for the damages accountable. Currently, only a few baseline studies have been done in communities (Wiseman 2013a; Schrope 2012).

Additionally, there is need for toxicological studies of individual chemicals and mixtures used for hydraulic fracturing to provide needed risk information to the public, health officials, and industry, and to support shifts to chemicals that are safer for oil and gas workers, the environment, and public health.

2.3.2. Ongoing and Long-term Environmental and Health Monitoring

Ongoing long-term monitoring of environmental conditions is needed to detect any adverse effects after drilling and hydraulic fracturing. Some studies have suggested that groundwater can be contaminated years after hydraulic fracturing operations occurred in an area (Vidic et al. 2013; Myers 2012). In 2013, the EPA Office of the Inspector General released a study on the EPA's capacity to assess air quality impacts of oil and gas development and found it to be insufficient. The report concluded that the "EPA has limited directly-measured air emissions data . . . for several important oil and gas production processes and sources" and recommended that the agency develop a comprehensive data collection strategy to address this gap (EPA 2013d). Such air pollution measurements would aid the agency in determining short- and long-term air quality impacts from unconventional oil and gas development.

Moreover, relatively little research has been done to assess the long-term health effects associated with unconventional oil and gas development. Preliminary studies and anecdotal accounts of residents living near wells suggest that such activities may present risks to human health, but more work is needed (McKenzie et al. 2012). For example, while there is evidence of water contamination in some places, there has been little study of the long-term health impacts such water contamination may have (Rozell and Reaven 2012).

Additional work is also needed to understand short-term and long-term socio-psychological and economic effects on communities that may result from stress, noise pollution, loss of social cohesion, and boom and bust cycles associated with unconventional oil and gas development (Jacquet 2013; Martin 2012). Continuous and long-term monitoring of communities would help identify health and environmental effects long after hydraulic fracturing has come and gone.

2.3.3. Access to Industry and Government Data

Fracking operators routinely collect data on the well sites, chemicals used, wastewater contents, and other information about their activities. If these data were shared in an open, timely, and accessible way, researchers could better understand health and environmental impacts of unconventional oil and gas development as well as the specific processes that increase or mitigate risks. Other industries are subject to regular reporting requirements of similar information for public knowledge. For example, the locations of hazardous waste sites, the smokestack emissions of

power plants, and the components of wastewater released from industrial activities all have public disclosure requirements. Though there are limitations on the details disclosed in these cases, much of the information is readily available on the EPA's website so the public can learn about environmental impacts and potential public health risks. Yet, there is often no mention of hydraulic fracturing in industrial spill reports to state governments, for example. As a result of such restrictions, it is more challenging for researchers to determine how frequently spills, leaks, and other environmental impacts occur (EPA 2012f).

“EPA has limited directly-measured air emissions data . . . for several important oil and gas production processes and sources.”

Public data sharing about unconventional oil and gas development may well benefit the industry as well as independent researchers; information could help identify risk mitigation strategies that would save companies money. For example, the Texas Commission on Environmental Quality uses infrared camera technology to identify high-emitting industrial plants that process extracted oil and gas (Bredfeldt 2013). By working with industry directly, not only can the commission understand sources of risk to nearby communities, but companies are also able to find and correct leaks in their plants.



Pipelines are built to carry natural gas from well sites to markets. Better access to information and data on all steps in the production and transport process would help researchers better understand the public health and environmental impacts of unconventional oil and gas development.



© 2013 Trudy E. Bell

Scientists have been studying hydraulic fracturing for many years. Better coordination of research methods between states to create comparable data would allow researchers to better understand how hydraulic fracturing impacts vary with different geologies and drilling practices.

2.3.4. Research and Coordination across Localities

The impacts of hydraulic fracturing can vary across the country, depending on local geology, drilling practices, and a host of other factors. Even so, most research to date has focused on only a few regions. Almost all water quality and quantity research has been done in Pennsylvania and Texas, respectively. Very little research has been done about unconventional oil and gas development in western states such as North Dakota or Wyoming. Thus, there is a need for more location-specific data.

There is also a need for coordination on data collection elements, methods, and analyses across studies and regions. Currently, different states monitor different environmental

metrics at different times (pre- versus post-drilling, for example), making comparison across regions more challenging.

Research into oil and gas drilling effects in different regions would help scientists understand what factors influence the risks of hydraulic fracturing, by allowing them to compare impacts in different geologies and with different drilling and fracturing methods. Comprehensive regional comparisons would also help decision makers in various states make more informed decisions about risks and benefits of unconventional oil and gas development, tailoring their decisions to the risks present in their own regions.

CHAPTER THREE

Understanding the Regulatory Landscape

As hydraulic fracturing has expanded rapidly, state and federal regulations have struggled to keep up. Outdated laws create regulatory gaps in covering hydraulic fracturing operations. Where new laws have been passed, they are frequently limited in scope or contain loopholes for the oil and gas industries that diminish their effectiveness, sometimes as a result of industry influence. Moreover, this lack of laws has been coupled with the weak role that federal agencies have taken more generally with regard to science, management, monitoring, and enforcement of the laws that do exist.

Where new laws have been passed, they are frequently limited in scope or contain loopholes for the oil and gas industries, sometimes as a result of industry influence.

Strong, well-crafted laws and regulations can play an important role in filling information gaps, advancing scientific knowledge, and protecting the public. Laws requiring companies to disclose—in a full, timely, and publicly accessible fashion—the chemicals used in hydraulic fracturing and the composition of wastewater can overcome incomplete voluntary disclosures. Laws requiring the monitoring of water and air quality near drilling sites—before and after drilling begins—can ensure that a capable party is collecting the necessary data and has access to the places needed to collect data. In its final report, the Secretary of Energy Advisory Board’s Shale Gas Production Subcommittee recommended such laws, which it believed “would assure that the nation’s considerable shale gas resources are being developed responsibly, in a way that protects human health and the environment, and is most beneficial to the nation” (SEAB 2011).



Photo courtesy of Jones Township, Pennsylvania

Without strong federal laws in place, regulation of hydraulic fracturing happens largely at the state level. State laws governing the practice vary widely in how much the industry is regulated.

In this section, we discuss the current status of federal and state regulations governing unconventional oil and gas development, focusing on disclosure of chemicals and air and water quality monitoring. Federal regulation is absent in many cases due to exemptions in federal laws. Many states have laws on the books, but they are frequently weak and fail to generate the information needed for robust public debate. The failings of federal and state laws point the way toward effective regulations that hold operators accountable and protect public health and the environment.

3.1. Federal Regulation

Many federal laws that would govern activities around hydraulic fracturing have loopholes that exempt the oil and gas industry from regulation (Table 1, p. 26). Sometimes these exemptions have been the direct result of the industry’s influence on lawmaking.

Table 1. EXAMPLES OF FEDERAL LAWS WITH EXEMPTIONS FOR HYDRAULIC FRACTURING OPERATIONS

FEDERAL LAW	BASIC PURPOSE	EXEMPTION	APPLICATION
National Environmental Policy Act (NEPA)	Requires consideration of environmental impacts for major federal actions through an assessment process	The Energy Policy Act of 2005 created an exemption for oil and gas extraction	
Clean Air Act (1970)	Regulates the release of pollutants into the air from stationary and mobile sources and authorizes the EPA to set national air quality standards	Pollution from certain groups of oil and gas wells cannot be aggregated for the purpose of determining regulatory standards	In 2012, the EPA released new regulations for air pollution from hydraulic fracturing wells requiring “green completions” that capture volatile organic compounds
Clean Water Act (1972)	Regulates discharges of pollutants into waters and authorizes the EPA to establish quality standards for surface waters	Hydraulic fracturing wastewater is not considered to be a pollutant if the waste is managed by the state and therefore a federal permit is not needed for disposal	Prohibits discharges of produced water into surface waters east of the 98th meridian (and treatment for grease prior to discharge for certain wells west of the 98th meridian); the EPA will begin a rule-making process for hydraulic fracturing wastewater in 2014
Safe Drinking Water Act (1974)	Protects the quality of drinking water and regulates the injection of waste into drinking water, both above and below ground	The Energy Policy Act of 2005 exempted hydraulic fracturing from the definition of “underground injection” under the Act, unless the fracking fluid contains diesel fuel	In 2012, the EPA released new draft guidelines for hydraulic fracturing wells that use diesel fuel in the fracking fluid
Resource Conservation and Recovery Act (1976)	Gives the EPA authority to regulate hazardous waste and non-hazardous solid waste	In 1988, the EPA decided exploration and production wastes from oil and gas fields do not qualify for regulation under this act, due to generally adequate state regulation and costs of compliance	Unused fracturing fluids do qualify
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) (1980)	Establishes a federal fund to clean up abandoned hazardous waste sites and emergency spills, plus mechanisms to locate those responsible and require their cooperation	Natural gas and petroleum are not considered hazardous under the law	Other substances used in hydraulic fracturing, including certain chemicals, are covered by the law, and the EPA is using CERCLA authority to conduct studies of groundwater contamination
Emergency Planning and Community Right-To-Know Act (1986)	Increased community planning for emergency releases of toxic chemicals, including establishment of the Toxics Release Inventory (TRI), which requires companies in certain industrial sectors to report to the EPA the amount of toxic chemicals released, recycled, treated, or disposed	In 1997 the EPA decided that oil and gas production is not one of the sectors included in the TRI	Operators must maintain Material Data Safety Sheets for certain hazardous chemicals stored on-site in sufficient quantities
Federal Motor Carrier Safety Administration Rules and Regulations	Govern the hours that drivers of property-carrying commercial motor vehicles can work	Drivers working in the oil and gas industry are exempt from some of these rules, allowing companies to require drivers to work and drive for longer periods of time	

3.1.1. Federal Chemical Disclosure Law

Significant exemptions in current federal laws mean that there is no strong, national system of chemical disclosure for hydraulic fracturing. As a result, chemical disclosure for most oil and gas wells is governed by laws of the state where the drilling takes place.

Bureau of Land Management. In May 2013, the Bureau of Land Management (BLM) released a revised version of new regulations for hydraulic fracturing on public and tribal lands that includes some provisions for chemical disclosure (BLM 2013). However, a close look at the BLM rules reveals that they fall significantly short of full, public disclosure in a timely and accessible manner.

First, they cover fewer than half of all oil and gas wells, since the BLM only has jurisdiction over drilling that takes place on federal and Indian lands (Tracy 2012). Even for the wells the BLM rules do cover, the chemical disclosure is inadequate. The rules do not make full disclosures available to the public because a provision allows companies to refrain from disclosing the identities of chemicals that are “trade secrets” (i.e., information that the company believes would damage its business interests if disclosed). Additionally, the rules do not mandate timely disclosure because companies do not have to disclose the chemicals used until after drilling is complete. Furthermore, the disclosed chemicals are posted on the website FracFocus, an online database that has been criticized for storing data in an inaccessible manner (see Box 7) (Konschnik et al. 2013). Finally, the rules have no requirement to disclose the chemical contents of the wastewater—both flowback and produced water—that comes back out of wells, leaving the public to guess its composition based on the company’s incomplete disclosures of the chemicals that were originally put into the well—information that will only be available once drilling is already complete. Thus, the public would have no information about the salinity, radioactivity, or concentration of other hazardous substances present in the wastewater.

Toxics Release Inventory. The principal federal program for disclosure of toxic chemicals used by companies is the Toxics Release Inventory (TRI) program (EPA 2012a). It is part of the 1986 Emergency Planning and Community Right-To-Know Act (EPCRA), which was passed in response to several accidental releases of toxic chemicals from industrial facilities located near communities (Schierow 2012). Companies in industrial sectors covered by the program must file an annual report with the EPA disclosing information about the identity and quantity of toxic chemicals they treat, recycle, dispose, or release into the

BOX 7

Data Disclosure Sources Should Be Approached with Caution

Companies and governments disclose data and information through programs such as FracTracker (nonprofit) and FracFocus (public/nonprofit partnership). FracTracker is foundation-funded and provides maps of unconventional oil and gas wells, downloadable data of well locations, permits, and violations, and basic information about hydraulic fracturing (FracTracker 2013). FracFocus was created in 2011 by the Groundwater Protection Council (an association of state water regulators) and the Interstate Oil and Gas Compact Commission (an association of state oil and gas regula-



tors) to serve as a forum for voluntary disclosure by companies of information about chemicals used in hydraulic fracturing (FracFocus 2013). The site provides information about specific well sites, including the chemicals used, as well as information about the various state regulations related to hydraulic fracturing.

When, what kind, and how much information is disclosed are important factors to consider when seeking information from these sources. Although there is general consensus that these resources provide objective scientific information, questions about industry influence and reliability have been raised about FracFocus. A 2013 Harvard University study identified a number of shortcomings. First, FracFocus does not report to states when companies submit disclosure forms, making it impossible for states to enforce disclosure deadlines. FracFocus also does not provide state-specific disclosure forms, making it difficult for companies to reconcile differences between reporting requirements for states and reporting requirements for FracFocus. There is no oversight of trade secret claims, meaning almost anything can be claimed as a trade secret. Furthermore, information about a given product may vary across different forms, and only one form may be viewed at a time (Konschnik et al. 2013). The Natural Resources Defense Council has argued that FracFocus “hinders public access to information” and “does not meet minimum standards for managing government records” because information may be altered or deleted at any time (McFeeley 2013).

environment. The EPA makes this information available to the general public on the agency's website.

The program does not apply to hydraulic fracturing because oil and gas exploration is not one of the industrial sectors covered by it (Schaeffer and Kron 2012). For industrial sectors that are covered, the TRI program is far from perfect. The program has high thresholds for the quantity of chemicals that a company must release before being required to disclose those releases; it also allows companies to claim certain disclosure exemptions (Vladeck 2009). The program does ensure, however, that some basic information about the identity and quantity of toxic chemicals that companies are handling and releasing in large quantities makes its way into the public domain on a regular basis.

3.1.2. Federal Environmental Laws

Due to exemptions and limitations in scope and resources, federal laws do not create an adequate system of water and air quality monitoring near unconventional oil and gas development operations.

Most hydraulic fracturing operations are exempt from regulation under the SDWA because of a provision inserted in the Energy Policy Act of 2005 commonly known as the "Halliburton loophole."

Federal Water Quality Laws. The major federal law protecting sources of drinking water in the United States is the 1974 Safe Drinking Water Act (SDWA) (EPA 2012b). The law sets standards for the public water systems that supply most people with their drinking water. But the SDWA also has a section that regulates the injection of fluids into the ground that pose a risk of contaminating sources of drinking water (EPA 2012c). Under the Underground Injection Control Program (UICP), a company that wants to drill a well and inject fluids into it must get a permit from the EPA (or a state agency authorized by the EPA) and follow standards for the testing, construction, operation, and closure of such a well.

A central component of hydraulic fracturing is the injection of millions of gallons of water, sand, and chemicals deep underground; however, most hydraulic fracturing operations are exempt from regulation under the SDWA (EPA 2012d) because of a provision inserted in the Energy Policy Act of 2005 commonly known as the "Halliburton loophole." Although the EPA had not historically treated

hydraulic fracturing as underground injection, a federal case in Alabama in 2009 held that hydraulic fracturing indeed counted as underground injection (Legal Environmental Assistance Foundation v. EPA, 11th Cir. 1997). That legal case, in part, led Congress to consider and ultimately implement the exemption at the urging of the Ground Water Protection Council, an organization comprised of state groundwater regulatory agencies and others (Tiemann and Vann 2013).

Evidence suggests that the Halliburton loophole was put into the law by oil and gas interests. This exemption was recommended by the Energy Policy Task Force, a team of experts convened during the George W. Bush administration to advise on energy policy issues (Phillips 2011). The task force was chaired by Vice President Richard "Dick" Cheney, who served from 1995 to 2000 as chairman and CEO of Halliburton Co., one of the largest companies engaged in unconventional oil and gas development. An initial draft of the task force's report expressed concerns about possible water contamination from the hydraulic fracturing, but such concerns were absent in the final report (Hamburger and Miller 2004b).

As a consequence of the Halliburton loophole, the EPA cannot regulate the majority of hydraulic fracturing operations. In 2012 the EPA released new guidelines on the regulation of hydraulic fracturing operations that use diesel fuel in fracturing fluid (EPA 2012e). The guidelines contain updated monitoring requirements, including some baseline testing of nearby underground sources of drinking water. Diesel fuel is used in a relatively small fraction of all wells, however, and is likely to be used even less over time. As a result, the 2012 rules will not cover most wells that are drilled (Soraghan 2012b).

The BLM's revised rules for unconventional oil and gas development on public and Indian lands, mentioned above, do not mandate baseline testing of water bodies located near wells before drilling occurs nor any continuous monitoring of water quality during and after hydraulic fracturing. The BLM rules do leave open the possibility that federal authorities will conduct baseline testing if circumstances require it; however, for most operations in the United States, baseline testing and continued monitoring are performed only if required by state laws. As we will see in the next section, such laws do not exist in all states and are not always stringent enough when they do.

To some extent, the federal government has investigated groundwater quality near drilling sites (USGS 2012). At the request of Congress, the EPA is conducting a study on potential impacts of hydraulic fracturing on drinking water resources. The EPA also used its authority under the



Photo courtesy of US Geological Survey

More comprehensive laws governing hydraulic fracturing are needed to ensure that public health and the environment are protected in all states. Mandatory baseline monitoring of air and water quality, for example, would allow for better detection and attribution of any pollution resulting from oil and gas activities.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to begin studying cases of potential groundwater contamination in Dimock, Pennsylvania, and Pavillion, Wyoming. Moreover, the EPA additionally used its authority under Section 1431 of the SDWA to issue an emergency investigation into a case of possible drinking water contamination in Parker County, Texas (EPA 2013c; EPA 2012h; Waeckerlin 2012). Had these studies been completed, they could have produced valuable information not only about those three cases in particular, but also about the mechanisms by which unconventional oil and gas development can contaminate groundwater in general. However, the EPA recently abandoned its study of water contamination in all three locations—causing concern among some who fear that it signals unwillingness by the EPA to pursue investigations of the possible impacts of hydraulic fracturing activities (Lustgarten 2013; Upton 2013). The final draft of the EPA's larger study on the impacts of hydraulic fracturing on water resources will not be released until late 2014 (EPA 2013c). In any event, individual studies are no substitute for a comprehensive program of water quality monitoring.

Federal Air Quality Laws. Laws governing federal monitoring of air quality near hydraulic fracturing sites are significantly limited as well. The EPA is the federal agency with

the authority to monitor and regulate emissions of pollutants into the air, and in 2012 the EPA released new regulations that cover oil and gas wells using hydraulic fracturing (EPA 2012i). These regulations will require companies to use green completion technology that captures some of the pollutants emitted into the air during a well's lifetime and are expected to decrease the quantities of heat-trapping gases such as methane as well as other pollutants entering the atmosphere from the well sites (Obeiter 2012).

The new 2012 regulations, however, do not address the gaps and limitations in the EPA's ability to monitor and measure air quality. In 2013, the EPA commissioned a report from the Office of the Inspector General to "determine whether the U.S. Environmental Protection Agency (EPA) has the data needed to make key decisions regarding air emissions from oil and natural gas production activities" (EPA 2013d). The report concluded:

Limited data from direct measurements, poor quality emission factors, and incomplete NEI [National Emissions Inventory] data hamper EPA's ability to assess air quality impacts from oil and gas production activities. With limited data, human health risks are uncertain, states may design incorrect or ineffective emission control strategies, and EPA's decisions about regulating industry may be misinformed. (EPA 2013d)

Without good data on water quality and air emissions, it will be nearly impossible to tell whether regulations are achieving their intended goals, or to assess the risks that expanded hydraulic fracturing operations may pose to human health.

National Environmental Policy Act. In the majority of cases, other than drilling on federal lands, it appears that the requirements of the National Environmental Policy Act (NEPA) are not being applied to new drilling activities in large part due to broader exemptions for the oil and gas industry related to the Clean Air Act and the Clean Water Act. Those exemptions, described above, mean that the federal role and the need for federal action have been effectively removed and, as a result, an environmental impact statement is not required unless a given state requires such an analysis.

NEPA requires federal agencies to consider environmental impacts for major federal actions and to consider alternatives to those actions. A detailed assessment known as an Environmental Impact Statement (EIS) must be developed and reviewed by the EPA before actions can be taken. Thus, the law requires federal agencies to integrate environmental values into their decision-making processes.

Without the need to comply with NEPA, and therefore develop any environmental assessment, there is no clear requirement for the oil and gas industry proposing to drill a well or a field of wells in a given location to consider alternatives to its plan. Nor is the public afforded an opportunity to consider alternatives and to comment on the proposed drilling plan in light of the broader environmental impacts. Although a notice and comment process accompanies permitting, this process does not fully substitute for the NEPA process (or equivalent state processes). Permitting affords the public a limited opportunity to comment on a proposal for a well, but without the full information of an environmental impact statement or analysis of alternatives in front of them. In other words, both public information and opportunity for public comment is greatly reduced.

3.2. State Laws

State laws regulating hydraulic fracturing operations are a patchwork of old and new rules, with important protections frequently absent or weakened by exemptions. As of September 2013, at least 28 states have some hydraulic fracturing within their borders, but far fewer than 28 states have strong laws on chemical disclosure and water and air quality monitoring around unconventional oil and gas operations (Bradner 2013; Kiparsky and Hein 2013; Richardson et al. 2013).

3.2.1. State Chemical Disclosure Laws

The simplest problem with state laws on chemical disclosure is that they frequently do not exist. Nine states with drilling inside their boundaries do not have any laws regulating disclosure of chemicals (Richardson et al. 2013). Some companies inside those states do voluntarily disclose information about the chemicals they use (FracFocus 2013). However, without a law making disclosure mandatory, it is impossible to verify the completeness and accuracy of the disclosures (see Box 7, p. 27).

As of September 2013, 17 states do have a chemical disclosure law of some kind, and two more have proposed—but not passed—disclosure laws (Bradner 2013; Richardson et al. 2013; Wernau 2013b). The laws, however, frequently fall short of full, public disclosure occurring in a timely and accessible manner.

Full Disclosure. State chemical disclosure laws require companies to disclose information about the chemicals they use in their hydraulic fracturing fluid, but vary significantly in how close those requirements come to “full” disclosure (Richardson et al. 2013). For purposes of risk assessment, disclosure ideally would require not only the identity of the chemical, but also its concentration and total volume used. Some states do require identification of all chemicals. Others do not subject all chemicals that a company uses to disclosure requirements—just the ones that the Occupational Safety and Health Administration already requires be listed on Material Safety Data Sheets. Some states, such as Wyoming, require only that the identity of the chemical be disclosed, while others, such as Arkansas, require the concentration, the volume, or both.

Additionally, state regulators aiming at full disclosure may want to look at the process of unconventional oil and gas development more broadly, rather than focusing narrowly on the hydraulic fracturing fluid, since hazardous chemicals are involved in other stages. Once wells are drilled, the wastewater that flows back up to the surface contains not only chemicals from the injected fluid, but also concentrations of salts, naturally occurring radioactive materials, or other hazardous materials from the subsurface created by chemical reactions with the injected fluid (BLM 2013) (see Section 1.1.).

Hazardous chemicals may also be used in other parts of the operation. A recent study of air quality around unconventional oil and gas wells in Colorado detected significant amounts of airborne methylene chloride, a chemical toxic to human beings in sufficient quantities (Song 2012). Methylene chloride is stored on well pads and is used as a cleaning agent. Although detected by air monitors, it did not have to be disclosed because the laws in Colorado cover

BOX 8

Policy Makers and Corporate Connections

Many government officials have, at some point in their careers, been affiliated with industry. While these affiliations do not necessarily present a conflict of interest, it is important to keep in mind that politicians may be inclined to maintain a good relationship with industry, either because of past connections, current political contributions, or the prospect of future jobs. One study found that between 2001 and 2011 the natural gas industry spent nearly \$750 million in federal lobbying and political contributions to members of Congress to fight regulatory oversight of hydraulic fracturing (Browning and Kaplan 2011). In some cases, connections to industry may raise questions about pro-industry policy decisions.



© Shutterstock.com/poliat

For example, New York State Senator Tom Libous was recently criticized for his attempts to block the passage of a bill that would extend a state moratorium on hydraulic fracturing for another two years. Claiming that he had nothing to gain from an end to the moratorium, Libous said he supported fracking because he believed it would be beneficial to the state. Critics noted that his wife's real estate company owns land where the rights to underground natural gas have already been leased to a drilling company, and the company is currently run by Libous's business partner and campaign contributor, Luciano Piccirilli (Klopott 2013).

In another case, in November 2012, former Pennsylvania Governor Edward G. Rendell told the *New York Post* that he personally urged New York Governor Andrew M. Cuomo to allow hydraulic fracturing in the state, saying "New York would be crazy not to lift the moratorium" (Campanile and Kriss 2012). In March 2013, Rendell wrote an op-ed in the *New York Daily News* in which he promoted natural gas as an important part of our nation's energy future. He criticized what he considered "a false choice" between fracking and environmental health, and emphasized the potential of natural gas development to create "great jobs for hardworking Americans" (Rendell 2013). It was later revealed that Rendell was a paid consultant at a private equity firm that had investments in natural gas—a conflict of interest that Rendell admitted he "should have disclosed" (Elliot 2013a). Further investigation showed that Rendell was also special counsel at the prominent energy law firm Ballard Spahr LLP, which represents oil and gas companies. Before Rendell was elected governor, he was a partner at the same law firm. Rendell's spokeswoman could neither confirm nor deny his involvement in cases concerning oil and gas development (Elliot 2013b).

Furthermore, in February 2013, the Public Accountability Initiative released a report that documented that Pennsylvania's two previous governors (Tom Ridge and Mark Schweiker) had strong ties to the natural gas industry. So has every secretary of environmental protection since the commonwealth's Department of Environmental Protection (DEP) was created. Among other findings, the report found that 20 DEP employees held jobs in the energy industry either before or after their DEP roles. The report concludes: "The revolving door data in this report raises troubling questions about the incentives that may be guiding public officials' oversight of fracking in Pennsylvania" (PAI 2013).

only the chemicals used to hydraulically fracture the well, not for other activities. Ohio recently considered including a provision in its bill regulating unconventional oil and gas development that would have required disclosure of all chemicals used throughout the entire drilling and extraction process, rather than solely in the hydraulic fracturing fluid, but that provision was excluded from the final version (Galbraith 2012). To date, comprehensive chemical disclosure, as only briefly considered in this case, is the exception rather than the rule among state disclosure laws.

Public Disclosure. Nearly every state law governing chemical disclosure related to unconventional oil and gas operations proposed or currently in effect contains an important limit on public disclosure: trade secret provisions, which allow a company to refrain from disclosing the identity of a chemical if it feels that disclosure would hurt the company's competitive position.

One of the only states with a proposed or enacted law without a trade secret provision is Alaska (Field et al. 2013; Gilmer 2013; Wiseman 2013b). In December 2012, the Alaska Oil and Gas Conservation Commission, Alaska's state regulator of oil and gas operations, proposed new rules for hydraulic fracturing with a chemical disclosure requirement that did not contain any exemption for trade secrets. As of October 2013, the proposal was in its second public comment period, after which the commission would decide whether to act on it. It may become the first chemical disclosure law in the nation, federal or state, without a trade secrets provision.

States have tried two different strategies to address potentially problematic issues of trade secret provisions. The first is to provide access to certain groups of people who have special responsibilities, such as medical professionals or state regulators. Most state laws require companies to disclose the identities of all chemicals to state regulators, even those declared trade secrets, so regulators have the information necessary to identify threats to public health. But there are exceptions; for example, Colorado does not give state regulators such access (Galbraith 2012). Similarly, most state laws have some provision that allows emergency responders and medical personnel access to information about chemicals declared as trade secrets. For example, Pennsylvania allows doctors who suspect a patient's symptoms may have been caused by exposure to hydraulic fracturing chemicals to get information from companies about the chemicals they used, so long as the doctors agree not to disclose the information to anyone else (Detrow 2012). In practice, however, such exceptions to trade secret provisions have not always operated smoothly. Doctors in Pennsylvania have



Trade secret provisions in chemical disclosure laws allow companies to withhold information about the chemicals used in hydraulic fracturing if they consider the information to be proprietary. The Alaska Oil and Gas Conservation Commission proposed new rules for hydraulic fracturing that have a chemical disclosure requirement without a trade secret provision. If passed, these rules may become the only chemical disclosure law in the nation without a trade secret exemption.

spoken of their own hesitation, delays, or nervousness in requesting information from companies, because of their uncertainty about the law's implications and associated legal requirements and their fear of adverse consequences from oil and gas companies. As a result, some doctors have reported being unable to provide their patients with full and proper care (Banerjee 2012) (see Box 6, p. 22).

A second strategy focuses on creating greater opportunity for input into how chemicals are designated trade secrets. In most states, trade secret designations are declared by companies without external review or the possibility of challenge. However, some states do have provisions that allow for either review or challenge. Wyoming, for example, allows state regulators to determine the legitimacy of a company's request to designate the identity of a chemical as a trade secret, and the company must show a factual basis for its request (Dlouhy 2012). Other laws allow certain ordinary citizens to challenge trade secret designations. For example, Texas allows landowners with wells either on their property or adjacent to it to challenge trade secret designations. Additionally, any department or agency of Texas with jurisdiction over a matter to which the trade secret is relevant also can challenge designations (Payne 2012). The practical effect of review and challenge provisions may not be large, since regulators often have limited capacity to adjudicate debates about trade secrecy (Vladeck 2009): as of 2011, Wyoming had granted 146 requests for trade secret exemptions and denied just two (Detrow 2011).

Timely and Accessible Disclosure. Even with chemical disclosure laws in place, information often is not readily accessible to the public within needed timeframes. Just six states require some form of disclosure before drilling occurs (Wernau 2013b; NRDC 2012). All other states with disclosure laws on the books require disclosure only after wells are completed.

Whether chemical information is disclosed before or after drilling, it may not be easy to access. Some laws, such as those in Pennsylvania, require the company to send paper records to the office of the state regulator, who then stores them on location (Detrow 2011). Anyone seeking access to the records must file a request through Pennsylvania's Right to Know system, posing time and resource barriers to interested parties.

Some states make the chemical information available online. Wyoming hosts the information on the state government's website. More commonly, state laws require companies to post information about the chemicals they use on the website FracFocus (Hall 2013; Wiseman 2013b). FracFocus has been criticized, however, for storing information in a way that is neither searchable nor downloadable in bulk, which makes systematic analysis of the data challenging (Konschnik 2013). FracFocus has recently updated the website in response to these criticisms, but how effective the changes will be remains to be seen (see Box 7, p. 27).

3.2.2. State Environmental Quality Monitoring Laws

A majority of states with unconventional oil and gas development inside their boundaries do not have laws requiring water or air quality monitoring near drilling sites. The laws that do exist are often weak or limited.

Water Quality Monitoring. More than half of all states with unconventional oil and gas development inside their borders have no laws requiring pre-drilling baseline testing of water quality near drilling sites or continued monitoring after drilling begins (Richardson et al. 2013; Wiseman and Gradijan 2011). In the states that do have such laws, testing programs can be voluntary rather than mandatory, and most focus on either baseline testing or continued monitoring of water quality, but not both. Additionally, states do not require testing for all of the same substances, or reporting in particular units, thus impeding the production of information that can be easily comparable across states.

Only eight states have passed or proposed laws requiring baseline measurements of water quality in nearby water bodies before drilling begins. The details of these laws vary significantly (Richardson et al. 2013; Wiseman 2013b; Intermountain Oil and Gas BMP Project 2012; Wiseman

and Gradijan 2011). Within testing programs, the most common approach is simply to require testing of some set of bodies of water within a certain distance of a well. For example, New York uses a 1,000-foot radius, while Ohio recently widened its radius from 300 feet to 1,500 feet, and West Virginia also changed its rebuttable presumption of contamination to water wells within 1,500 feet of an oil or gas well. The bodies of water that must be tested within that radius are different from state to state. Colorado's program has well operators test a maximum of four sources of groundwater around each site, while New York and Ohio have well operators test all water wells.

Instead of (or in addition to) requiring testing, some states, including Pennsylvania and West Virginia, establish a legal presumption that a company is responsible for contamination of groundwater that occurs within a specified radius of their well (Wiseman 2013a; Wiseman

A majority of states with unconventional oil and gas development inside their boundaries do not have laws requiring water or air quality monitoring near drilling sites. The laws that do exist are often weak or limited.

and Gradijan 2011). The company can prove otherwise by showing a baseline test that demonstrates the contamination existed before drilling. But in the absence of such data, the company is considered responsible. These laws create an incentive for companies to carry out baseline tests, and they protect landowners in cases where companies do not test.

Laws requiring water quality monitoring after drilling begins are even rarer. Just two states—Colorado and New York—appear to have programs of any kind (Intermountain Oil and Gas BMP Project 2012). Under Colorado's current voluntary sampling program, well operators take post-drilling samples in response to landowner complaints of a measureable or distinct change in water quality; Colorado has proposed, but not yet passed, a mandatory testing program. If implemented, the mandatory program would require companies to take two tests of water quality after drilling has been completed—one between 12 and 18 months, and another between 60 and 78 months. New York's proposed regulations have a specific schedule as well, requiring companies to test three months, six months, and 12 months after hydraulic fracturing operations have been completed for each well. Michigan requires monitoring systems to detect leakage from hydrocarbon or brine storage secondary containment areas (that is, areas with a second

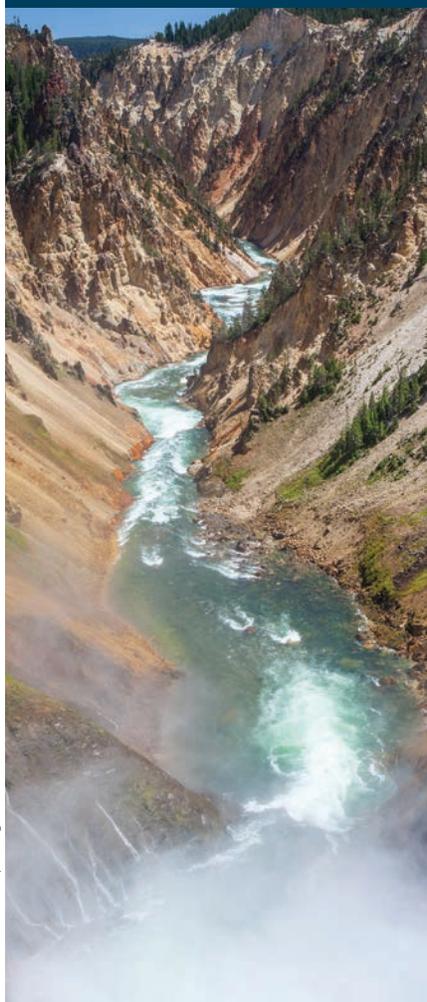
barrier or an outer wall of a double enclosure to contain any leak or spill from storage containers) (Michigan 2006).

Air Quality Monitoring. State laws for monitoring air quality around unconventional oil and gas development sites are rare. Although many states do regulate some aspects of air pollution at well sites, few to none require air monitoring specifically (Richardson et al. 2013). Most commonly, states regulate venting or flaring of gas. Some states restrict how many wells can be drilled in a given time period in a partic-

ular area, which can reduce the amount of air pollution at any one time. Despite the relative prevalence of regulations focused on air pollution, just two states have implemented any kind of program for monitoring air quality near drilling sites. Texas runs an air quality monitoring program in the Barnett Shale, and Pennsylvania has conducted some air quality monitoring in the Marcellus Shale, but not in a systematic and ongoing way (PADEP 2011; TCEQ 2011; Wiseman and Gradijan 2011; TCEQ 2010).

BOX 9

A Need for Comprehensive Laws



Currently the United States does not have the chemical disclosure laws or the water and air quality monitoring laws needed to advance scientific knowledge and inform public decision making on unconventional oil and gas development. People who live near unconventional oil and gas development lack information on potential exposures and risks; scientists and public health officials face challenges in gathering the data needed for studying potential risks.

And failures of legal protections in one area can create or impede efforts to address failures in another. For example, currently a group of landowners in Wyoming are suing the state government to remove exemptions for trade secrets from the state's chemical disclosure law (Zhorov 2013). Wyoming does not have a baseline water quality testing law, so landowners who live close to drilling sites and draw their drinking water from nearby sources have to conduct baseline tests of water quality themselves. Without these tests, they may not be able to prove that drilling operations were the cause of water contamination that might occur in the future. Yet in conducting those baseline tests, the landowners do not know all the chemicals they should test for because companies use the trade secrets provision in Wyoming's chemical disclosure law to avoid publicly disclosing some of the chemicals they use. In other words, the failure of laws to generate one kind of information (the identities of chemicals used in hydraulic fracturing) can prevent citizens from compensating for the failure of laws to generate another kind of information (useful and complete baseline water quality data).

Such situations, and the interlocking problems they involve, illustrate the complexity of the informational landscape on unconventional oil and gas development as well as the need for stronger, better-designed, and coordinated regulations to provide the kind and quality of data that citizens, policy makers, and scientists need.

CHAPTER FOUR

Right to Know in the Public Dialogue: Best Practices for Empowering Citizens



To make informed decisions about unconventional oil and gas development in their communities, citizens need access to reliable information about all the risks and benefits that such development could bring and to whom. An open dialogue can make for better decision making in affected communities.

The public has the right to know the known and potential risks and benefits of hydraulic fracturing and the industrial processes and practices accompanying it. The public needs evidence to make informed decisions about unconventional oil and gas development in its communities—information disclosed by industry and the government and information revealed through scientific research. As unconventional techniques for extracting oil and gas expand, lessons learned and best practices derived from experience in one region can play an especially important role in future decision making in other regions (EIA 2013).

To effectively inform public decision making, scientific evidence and information must be accessible, reliable, and flow from trusted channels. What information does the public need and actually receive? What role do special interests play in contextualizing information? Are state and

federal agencies doing enough to answer citizens' questions? Are academic institutions providing accessible information through their outreach and extension programs? Are popular media helping or hindering a more scientifically informed dialogue?

Scientific unknowns about some of the impacts of development have converged with a lack of comprehensive legal requirements and interference from special interests. The confluence of biased science, conflicted politicians, and misinformation in the public dialogue has produced a noisy environment that challenges citizens seeking reliable information, erecting hurdles to communities wanting to make science-informed decisions about unconventional oil and gas development in their localities. A recent report by the Pacific Institute found that the public dialogue around hydraulic fracturing is “marked by confusion and obfuscation” and that “a lack of credible and comprehensive data

and information is a major impediment” to assessing risks and making decisions (Cooley and Donnelly 2012).

Effective engagement in the public dialogue requires navigating through incomplete, competing, and often conflicting sources. Finding information necessitates sorting through search engine results that are not ranked in order by reliability. And assessing risks requires consciously practicing objectivity because sometimes the best science-informed sources may not tell people what they want to hear.

Moreover, risk perception complicates how the public receives information. Even reliable information—when conveyed through channels the public perceives to be untrustworthy—can fail to support an evidence-based public dialogue. A recent study by University of Michigan researchers found that merely providing technical informa-

tion would not empower communities. Rather, communication about shale energy development should “facilitate a process that leads to socially agreed upon decisions . . . by meaningfully involving the public early on in the policy-making and regulatory process” (Wolske, Hoffman, and Strickland 2013).

For communities facing oil or gas development, this section analyzes best practices that promote transparency and evidence-based decision making in today’s noisy information landscape. The examples discussed below serve as starting points for citizens in the search for reliable information from government, the media, stakeholder groups, and academia. Citizens and their local and national policy makers can build upon these models and navigational strategies as they work together to build trust and overcome barriers.

FIGURE 4. CITIZENS’ SOURCES OF INFORMATION ON UNCONVENTIONAL OIL AND GAS DEVELOPMENT



4.1. Online Sources

First, in the search for reliable information and trustworthy sources on unconventional oil and gas development, it is important to note challenges in the search process itself. Many, if not most, Americans today get their information about unconventional oil and gas development by searching the Internet. In 2013, 85 percent of adults in the United States are online. Among younger adults aged 18 to 29, 98 percent are online (Pew Internet 2013). Between 2008 and 2013, Internet searches in the United States for the term fracking surged (Figure 5). Regionally, states most directly affected by drilling activities, moratoria, or other legislative actions saw the highest search volume index indicators. New York and Pennsylvania—two of the states most divided over the future status of hydraulic fracturing—ranked among the top 10 states based on how often fracking was searched relative to other, unrelated search terms and relative to other states. Related searches, such as “hydraulic fracturing,” “what is fracking,” “water fracking,” and “fracking gas” surged correspondingly; “fracking jobs” and “fracking economy” were not among the highest-ranked related searches (Google Trends 2013a).

As unconventional oil and gas development has increased, so has the public’s desire for more information. In particular, the most popular related searches suggest that people are looking for basic, factual information about the potential effects of unconventional oil and gas development on their health and their local environments. As they pursue basic facts, they must also confront and compare information

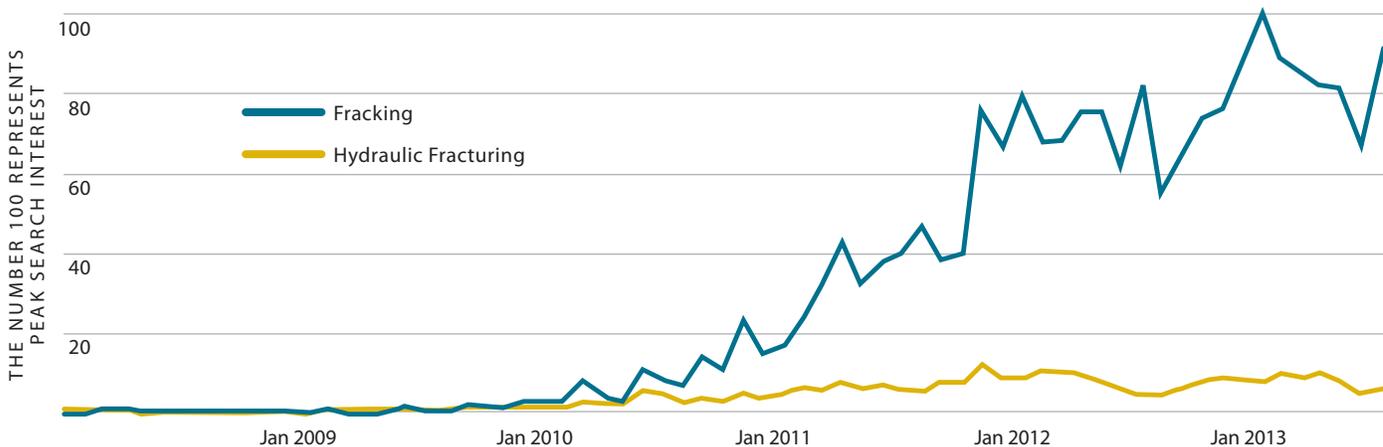
Between 2008 and 2013, Internet searches in the United States for the term fracking surged.

from sources with diverse perspectives, including some with whose points of view they may disagree. Here we explore obstacles people encounter in their search for answers, and highlight sites and people cutting through the challenges of online sources.

4.2. Government Resources

Federal agencies—the EPA, the USGS, and the BLM—along with state and local governments can be good sources of reliable information about unconventional oil and gas development, often providing clear, objective, and up-to-date answers to frequently asked questions (FAQ) about the process, risks, and benefits of hydraulic fracturing and its associated industrial processes. Ideally, such government information is region-specific when appropriate, easy to locate online, and updated regularly to include new scientific and legal information. The agencies may also include information about precautions the public should take to protect their health or their property, as well as resources for additional information. When government agencies produce materials with these characteristics, they not only make information clear and available but also gain the public’s trust as a reliable information source.

FIGURE 5. GOOGLE SEARCH TRENDS FOR THE WORDS “FRACKING” AND “HYDRAULIC FRACTURING”



In practice, government information can be limited in scope, hard to locate, or nonexistent. In 2011, the Shale Gas Subcommittee of the Secretary of Energy Advisory Board recommended creation of a public access portal to a variety of information from federal and state agencies, but that portal does not yet exist (Secretary of Energy Advisory Board 2011). In its absence, below are some tips for navigating government sources followed by examples of agencies, states, and municipalities that are on the right track.

Without refining online search terms to include agency names, citizens seeking to learn more about fracking may encounter, first and foremost, websites and articles of questionable accuracy and objectivity.

4.2.1. Federal Agencies

Since federal agencies have greater research capacity and data access than many state and municipal governments, citizens rely on federal agencies to help understand science-based policy issues related to natural resources and human

health, safety, and security. The three federal agencies most responsible for overseeing oil and gas development in the United States are the EPA, the USGS, and the BLM. The EPA regulates industrial activities that release pollutants into the environment. The USGS provides scientific analysis on natural resources and on the health of the environment. The BLM regulates oil and gas development on federal and tribal land.

Federal agencies usually provide objective, accessible information resources for the American public, but finding information from them online can take some effort. Using targeted search terms and having the patience to sift through online search results beyond the first few pages can help locate reliable government information. Without refining online search terms to include agency names, however, citizens seeking to learn more about fracking from government agencies may encounter, first and foremost, websites and articles of questionable accuracy and objectivity instead of objective, science-based information. News stories in popular media may or may not present accurate, up-to-date, sufficiently comprehensive scientific information. Special interests by their nature present scientific information in the context of a high-stakes policy debate, in which getting the science right may or may not serve their interests or be their primary goal. Even when special



© Flickr/chesapeakeclimate

Federal and state agencies can be good sources of information about unconventional oil and gas development. Federal agencies tend to have more comprehensive information about the technical processes and impacts of development, while states and municipalities generally have better localized information about when and where drilling occurs.

interests do present accurate scientific information, citizens may have difficulty approaching it objectively because of their own preexisting viewpoints on the issues represented by these interests.

Federal agencies do not generally appear in the top rankings in Internet search engine results unless their names or initials are included with search terms. Since fracking is the popular name by which the public knows the general enterprise of unconventional oil and gas development, the word fracking is searched for significantly more frequently than the more technical term hydraulic fracturing (Google Trends 2013b). But because government agencies employ the more technical terms hydraulic fracturing for the actual engineering process and unconventional shale gas development for the wider enterprise that includes drilling, wastewater disposal, and other associated engineering processes, searches for the more common term fracking do not readily (or quickly) turn up agency results. While the EPA did rank highly in a search of the term hydraulic fracturing, even this agency did not make it into the first five pages of a normalized Google search of the term fracking. In fact, not a single federal or state government website appeared in the first five pages of results in a Google search for the term fracking.

The public can take simple steps to refine search results and find agency information more efficiently. In turn, federal agencies should consider ways to maximize their own visibility to the public. Federal agency approaches to providing the public with information about fracking vary from very good to needing improvement. Below outlines what an interested citizen may encounter when searching for reliable information from the three federal agencies most responsible for overseeing oil and gas development: the EPA, the USGS, and the BLM.

The Environmental Protection Agency. The EPA stands out as the most visible and accessible source of information for citizens looking for basic or scientific information on hydraulic fracturing. A normalized Google search for hydraulic fracturing brings up the EPA's "Natural Gas Extraction—Hydraulic Fracturing" landing page as the second result. This is important for two reasons: 1) with the exception of a California state resource, the EPA is the only government agency that appears on the first page of Google search results, and 2) research has shown that most Internet users never view search engine results beyond the first page (Ruby 2010). Thus, the EPA may be the only federal government source a person will encounter when searching for information about hydraulic fracturing (EPA 2013).

Although the EPA could better anticipate and include questions in a traditional FAQ format on its hydraulic fracturing site, the agency does deliver appropriate and accessible information, along with links to more detailed information, in four key areas:

1. Improving scientific understanding
2. Providing regulatory clarity and protections against risks
3. Ensuring compliance
4. Promoting transparency and conducting outreach

In each of these areas, the EPA emphasizes its work in research, oversight, guidance, and rule making. In addition, the site provides opportunities for citizens to become engaged through reporting spills and commenting on study design.

The Environmental Protection Agency may be the only federal government source a person will encounter when searching for information about hydraulic fracturing.

The U.S. Geological Survey. The USGS provides some excellent resources for the public on its website. The USGS site includes an up-to-date, science-driven hydraulic fracturing FAQ visitors can click through (USGS 2013b). Most notably, the site includes multimedia features showcasing scientists who are working on understanding and describing the geological and other natural Earth systems involved in unconventional oil and gas extraction.

The multimedia features encourage the public to become engaged in both the science and policy making around unconventional oil and gas development. For example, the video gallery contains a congressional briefing entitled "Hydraulic Fracturing—the State of the Science," which is part of an ongoing series of briefings the USGS has been presenting on the theme of "Start with the Science." Members of the public can thus view USGS scientists speaking directly to members of Congress and their staffs about what they know and what they are learning.

Compared with the EPA, the USGS has a less visible presence in Internet search results for hydraulic fracturing—not appearing anywhere in the first five pages of a normalized Google search. As a result, USGS resources are much less likely to be utilized by the general public.



Federal agencies can be a reliable source of scientific information on hydraulic fracturing. The U.S. Geological Survey website features videos of scientists describing unconventional oil and gas development to policy makers (USGS 2013b).

Bureau of Land Management. Because it regulates activity on federal and Indian lands, the BLM is another federal agency that provides information on unconventional oil and gas development. In contrast to the EPA and the USGS websites, information on fracking is more difficult to access on the BLM website.

The BLM site does contain many pages with information on the science and policy of hydraulic fracturing and its associated activities, including an FAQ document (BLM 2013), but the information is scattered. This structure makes it difficult to quickly scan and identify what might be of greatest interest or relevance. While the BLM has a hydraulic fracturing landing page in the Colorado section of its website (BLM CO 2013a), the agency does not have a national hydraulic fracturing landing page as the EPA and USGS do.

Second, the BLM FAQ sheet and related pages have numerous problems that make them less than satisfactory as informational tools for the general public. The FAQ sheet was difficult to locate on the agency's website and incomplete as far as answering questions a concerned citizen would likely have. It also lacked a release date that would indicate the currency of the information (we surmised 2013 based on sources it cited), and appeared reliant upon special interests for key pieces of information (BLM CO 2013b). For example, on one of the agency's Colorado pages, Halliburton is listed along with the EPA under "Other National Resources" (BLM CO 2013b). Although the oil and gas industry can and does provide reliable resources, such as materials on the technical aspects of drilling and

BOX 10

What Makes a Good Government Information Source



For citizens to have trust in their policy makers and public officials, federal, state, and municipal agencies will need to openly and comprehensively discuss risks—real or perceived—that the general public associate with unconventional oil and gas development. Recent studies on risk perception in communities confronting choices about such development show that citizens worry about consequences, are uncertain about how costs and benefits will be distributed, and lack confidence in the willingness, ability, and effectiveness of their leaders to address the full range of their concerns (Christopherson, Frickey, and Rightor 2013). Comprehensive, science-based information that takes the public's concerns seriously promotes greater citizen engagement and participation in an evidence-based public dialogue and thereby engenders greater trust in the policy-making process.

To maximize value to the public, government sources of information should:

- be accurate and complete;
- be easy to locate and navigate;
- be easy to comprehend;
- address concerns and basic questions about where and how drilling is occurring or would occur;
- answer questions about health, environmental, social, and economic impacts that a community is likely to have;
- describe limitations, uncertainties, and knowledge gaps;
- respectfully acknowledge concerns of diverse stakeholders; and
- open further opportunities for citizens to become engaged in the political process.

extraction, industry resources are unlikely to provide the range of objective and comprehensive risk information in which citizens are interested.

4.2.2. State and Municipal Sources

State and municipal agencies are also important sources of scientific information about unconventional oil and gas development. Such sources provide regional and local information of more direct and immediate concern to citizens engaged in local community decision making or facing choices involving their own properties.

Although some state and municipal websites contain unbalanced or misrepresentative information when discussing community impacts, others instill trust by addressing their constituents' questions and making information relatively easy to locate. Maryland, for example, through its Marcellus Safe Drilling Initiative, is conducting studies on the impacts of unconventional oil and gas development and publicly reporting its findings and recommendations. Indeed, the public is invited to comment before the final report is released in 2014, and all meetings of the Marcellus Shale Advisory Commission, tasked with overseeing the initiative, are open to the public (MDE 2013).

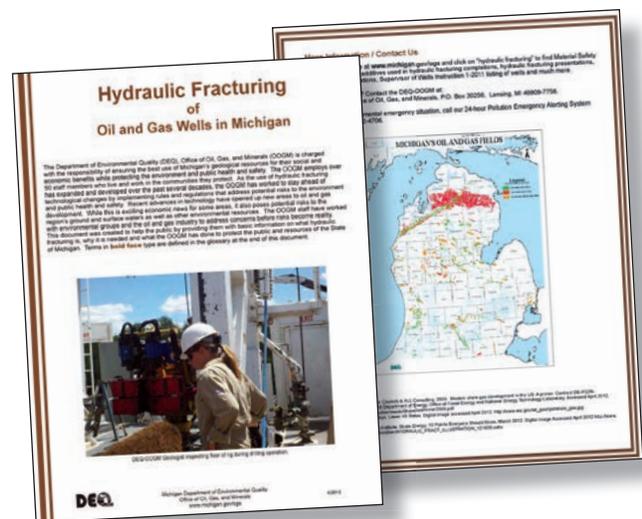
In general, state and municipal websites do a better job of addressing questions about where and how drilling occurs than in addressing questions about potential community impacts. This is especially true for states among the earliest to embrace unconventional oil and gas development. North Dakota, for example, provides basic scientific information about the geology and technology of unconventional oil and gas extraction, but has only limited information on environmental and human health impacts. North Dakota's "Oil and Gas Frequently Asked Questions" is nine pages long and answers 59 questions in seven categories: surface owner questions, mineral owner questions, regulatory questions, Bakken basics, royalties and tax questions, oil and gas production, and infrastructure questions. Only two of the 59 questions address environmental impacts, and only four address social and economic impacts (North Dakota 2013).

Pennsylvania also provides ample science-based public information resources, including fact sheets, interactive on-line tools, and links to other resources, such as the EPA, the USGS, and the Interstate Oil and Gas Commission. Its interactive tools allow users to locate well sites and inspection sites, as well as identify operator locations. Its fact sheets address such topics as methane leakage, injection wells for disposal and enhanced recovery, and orphaned wells. Like North Dakota, however, Pennsylvania is also limited in how it addresses spills, water and air pollution, drinking

water supplies, and socioeconomic impacts (Pennsylvania OOGM 2013).

State and municipal websites may leave out science-informed resources or misrepresent key information of public interest. The Michigan Department of Environmental Quality (DEQ), for example, offers its constituents two versions of its frequently asked questions on hydraulic fracturing activities—a four-page simple FAQ and an eight-page more technical version—both essentially covering the same ground (MDEQ 2013a; MDEQ 2013b). In some ways, both are excellent models; they briefly and clearly describe the geological reasons for hydraulic fracturing as well as the technical process itself. The longer version also includes a glossary of unfamiliar terms and a 24-hour hotline to report environmental emergencies.

However, both Michigan FAQ sheets have some flaws. The longer document includes a section called "Hydraulic Fracturing Concerns," which downplays the degree of scientific uncertainty surrounding water contamination and federal regulatory exemptions (MDEQ 2013a). The shorter document is dismissive about accidents, water contamination, and methane leakage (MDEQ 2013b). The FAQs leave two incorrect impressions on environmental and health risks: first, that the science is settled—when many uncertainties, in fact, remain—and, second, that regulatory loopholes at the federal level do not affect Michigan residents—which they do.



Many states and cities provide information on hydraulic fracturing for their residents. Although the comprehensiveness of this information varies across municipalities, it can be a good source of more regionally specific information on geology, laws, and choices that communities have.

BOX 11

Silencing Community Discussion of Fracking

Public discussion is a key component of community decision making on unconventional oil and gas development, but in the case of Sanford, New York, that discussion was briefly cut off.

In September 2012, the town board of Sanford passed a resolution banning the discussion of fracking during board meetings. According to the board, the topic was dominating public discussion, leaving no time for consideration of other issues. The board did, however, welcome written comments on the subject (Esch 2013b). Before the resolution, the town board held a pro-fracking position, leasing land to oil and gas companies and asking state lawmakers to remove New York's drilling moratorium (Dodd 2013). According to one resident, the town supervisor was one of a number of residents who signed leases with oil and gas companies that included signing bonuses worth millions of dollars (Esch 2013b).

Many residents were angered by the resolution, claiming it interfered with their ability to influence decisions that would significantly impact their lives (Dodd 2013). In February 2013, a local environmental group, Catskill Citizens for Safe Energy, and the Natural Resources Defense Council (NRDC) filed a lawsuit against the town, arguing that the ban on fracking discussions violated residents' First Amendment right to free speech (Dodd 2013). The director of the Department of State's Committee on Open Government opined that the town board was not required to allow any public discussion at its meetings. NRDC's attorney in the case argued that the board could not ban discussion of a specific topic (Esch 2013b). In April 2013, the Sanford town board repealed the resolution, and Catskill Citizens and NRDC dropped their lawsuit (NRDC 2013).



© Shutterstock/Lance Bellers

Among municipalities, Greeley, Colorado, stands out as having comprehensive information on its website that addresses questions citizens are likely to have about the science and about state and local laws (City of Greeley 2011). Greeley's FAQ sheet includes information about the community's preparedness to deal with emergencies resulting from hazardous materials. Like the other state examples cited here, however, Greeley's FAQ sheet sidesteps questions about the potential impact on water supplies. In answer to the question "How can fracking affect water supplies?" the document describes measures companies take to prevent leakage (such as ensuring the appropriate depth of steel casings and the concrete fillings used to protect the integrity of the wellbore) but does not directly answer the question.

The Greeley website also misrepresents the degree to which oil and gas companies' liability insurance will protect community residents in the event of property damage on their leased or nearby property. While the Greeley document states that drilling companies are required to carry liability insurance, general liability policies typically do

not cover hydraulic-fracturing-related damages caused by the toxic chemicals in wastewater and hydraulic fracturing fluid because of a standard exclusion clause called a "pollution exclusion" (Foggan and Siehndel 2011). As its name implies, the clause excludes liability from losses arising from pollutants escaping into the environment. Fracking-related damages that do not fall under the pollution exclusion, such as those related to methane leakage, increasingly do not meet the general liability criteria of bodily injury or property damage that is neither expected nor intended. To supplement general liability, companies can purchase environmental site liability (ESL) and operator's extra expense (OEE) insurance, which do cover losses due to exposure to pollutants. Some states are beginning to mandate additional coverage. Maryland, for example, now requires a minimum of \$1 million in pollution liability coverage above and beyond its requirements for comprehensive general liability (Maryland 2013). But most other states do not require these extra insurance policies (Foggan and Siehndel 2011).

4.3. Mainstream News Sources

One of the primary ways the public learns about unconventional oil and gas development is through mainstream news. Since many people may never look beyond news sources, an informed public dialogue depends on accurate and unbiased reporting. Journalists are faced with the task of getting the science and technology right, translating technical evidence for lay audiences, making sense of uncertainty, and sorting fact from misinformation in debates.

The media practices considered below contribute to an informed public dialogue that supports evidence-based decision making. This media content analysis is intended to highlight strategies reporters have used to convey scientific information. While some story summary is necessary, we are more interested in how these stories convey information—their overarching strategies—than in their particular details. We offer these examples as models the public can look to for the kinds of characteristics to seek out in news stories when relying on general media as sources for scientific information.

4.3.1. Transparency in Information Sources

Investigative reporting about fracking can require locating, searching through, and synthesizing information from thousands of primary documents. Media outlets and the public should place high value on reporting that includes links and citations to primary sources so readers can verify accuracy of assertions for themselves.

Award-winning investigative journalist Tom Wilber believes, “Fighting for transparency in matters of overwhelming public interest is fundamental to the work of any journalist, and there is a critical need for transparency, and aggressive reporting, in matters related to the energy industry.” Through his experience as a reporter covering gas development in the Marcellus Shale, Wilber offers insights about the importance of access to information in the public dialogue about fracking. “Journalists,” he contends, “are not there to take sides, but to equip society . . . with the tools it needs for self-governance, and that begins with a spotlight on matters of public interest” (Wilber 2013).

The *New York Times* reporter Ian Urbina followed these principles when he researched and wrote his highly regarded “Drilling Down” series (Urbina 2012a) covering a range of topics from chemical disclosure, wastewater disposal, and well leases to truck traffic. The series raised important questions: What is the truth about water contamination? Why is the oil and gas industry exempt from federal laws governing drinking water, clean air, and even occupational standards for truck drivers? What should property owners know about gas well leases before signing them?

Each story in the series is connected to a digital document reader—accessible to the public by simply clicking a link—that contains the primary source documents. The document reader contains electronic copies of original documents including EPA records obtained through FOIA requests, leaked industry responses to evidence of water contamination, oil and gas leasing agreements from a number of states, and industry exemptions from trucking safety rules. While the documents have been annotated by *New York Times* staff for readers who only skim the thousands of pages, readers can access them in their entirety to freely and independently examine the information covered by these documents.

For example, while industry exemptions from EPA rules such as the Safe Drinking Water Act have drawn considerable attention, the final piece in the series, “Deadliest Danger Isn’t at the Rig but on the Road,” explains the lesser-known exemptions from the National Transportation Safety Board (NTSB) rules governing trucking. The subject of this story is compelling on its own: a truck driver working for the oil and gas industry in Ohio is killed when he falls asleep at the wheel 17 hours into his shift. But the document reader adds 79 additional pages of information that provide a much fuller picture of worker and road safety issues (Urbina 2012b). Included among the documents are the police report determining the cause of the accident, fed-

“Fighting for transparency in matters of overwhelming public interest is fundamental to the work of any journalist, and there is a critical need for transparency, and aggressive reporting, in matters related to the energy industry.”

eral highway regulators’ citations of the trucker’s company for safety violations the previous year, the NTSB’s objections to oil and gas industry exemptions from rules governing truckers’ shift lengths, public comments by truckers on the Federal Motor Carrier Safety Administration’s proposed rule changes to eliminate exemptions, and industry defenses of the exemptions.

The purpose of the story, along with its linked documents, was more to shed light on policies and their little-known consequences for communities than to call out bad actions. Communities contending with local fracking operations need information on matters involving road and worker safety, as they can have direct local impacts.

Even government employees involved in studying and regulating the oil and gas industry have turned to the *Times*

document reader to view information difficult to locate, track down, or obtain from other sources. *Times* technical staff have tracked the IP addresses of visitors to the document reader. As the series unfolded and awareness of its value increased, they noticed a steady uptick in the number of hits the document reader was receiving from government IP addresses (Urbina 2013).

Transparency of information sources engages the public as active investigators. With access to a reporter's primary sources, the public can engage firsthand with the evidence, and not be deceived when information is excerpted and repurposed by special interests.

Reporting on unanswered questions helps the public recognize and better navigate information gaps and diverse viewpoints in the decision-making process.

4.3.2. Coverage of Uncertainties

Reporting on scientific uncertainties promotes more informed decision making. Policy makers and the public are hungry for answers and concrete recommendations, yet many science-based questions about unconventional oil and gas development remain unanswered. Finding trustworthy information about uncertainties is particularly challenging, since both supporters of and opponents to unconventional oil and gas development tend to downplay or exaggerate knowledge gaps. Reporting on unanswered questions helps the public recognize and better navigate information gaps and diverse viewpoints in the decision-making process.

The National Public Radio (NPR) series “The Fracking Boom: Missing Answers” exhibits key strategies for media coverage of the scientific uncertainties surrounding unconventional oil and gas development (NPR 2012). These strategies include:

1. Creating a public space for scientists to speak about their work in their own words
2. Helping readers assess the scientists' credibility by identifying their credentials and funding sources
3. Focusing on what the science says and does not say without jumping to policy conclusions
4. Highlighting the need for more scientific research to answer unanswered questions
5. Encouraging the public to be objective and explore viewpoints with which they may disagree
6. Explaining—without exaggerating—the complex relationship between uncertainty and risk

The NPR website also provides multimedia interactive tools the public can use to explore the scientific uncertainties covered by the stories in more depth.

Elizabeth Shogren's “Fracking's Methane Trail: A Detective Story” demonstrates how a news outlet can create space for a scientist to speak publicly—and thus convey scientific information and discuss uncertainties in a reliable yet accessible manner. The story featured Gabrielle Petron, a scientist working for the National Oceanic and Atmospheric Administration (NOAA) who specializes in collecting and analyzing air pollution data. After finding unusually high levels of methane in air samples near Denver, she and her colleagues were able to track it by its chemical signature to oil and gas fields in northeastern Colorado. Throughout the story, Petron is quoted frequently, giving her a platform to speak directly to the public. The story also provides a bit of informal peer review by having other scientists uninvolved but familiar with Petron's work comment on and discuss Petron's research in their own words and in language accessible to the general public (Shogren 2012).

The story stays focused on what the science does or does not say without discussing policy implications. While Petron's research resolved some uncertainties—where the methane in the Denver air sample was coming from and how much higher it was than estimates had indicated—it brought up new questions: Why were estimates so low? Why are emissions not routinely measured more accurately? How much do pollution levels vary from one gas field to



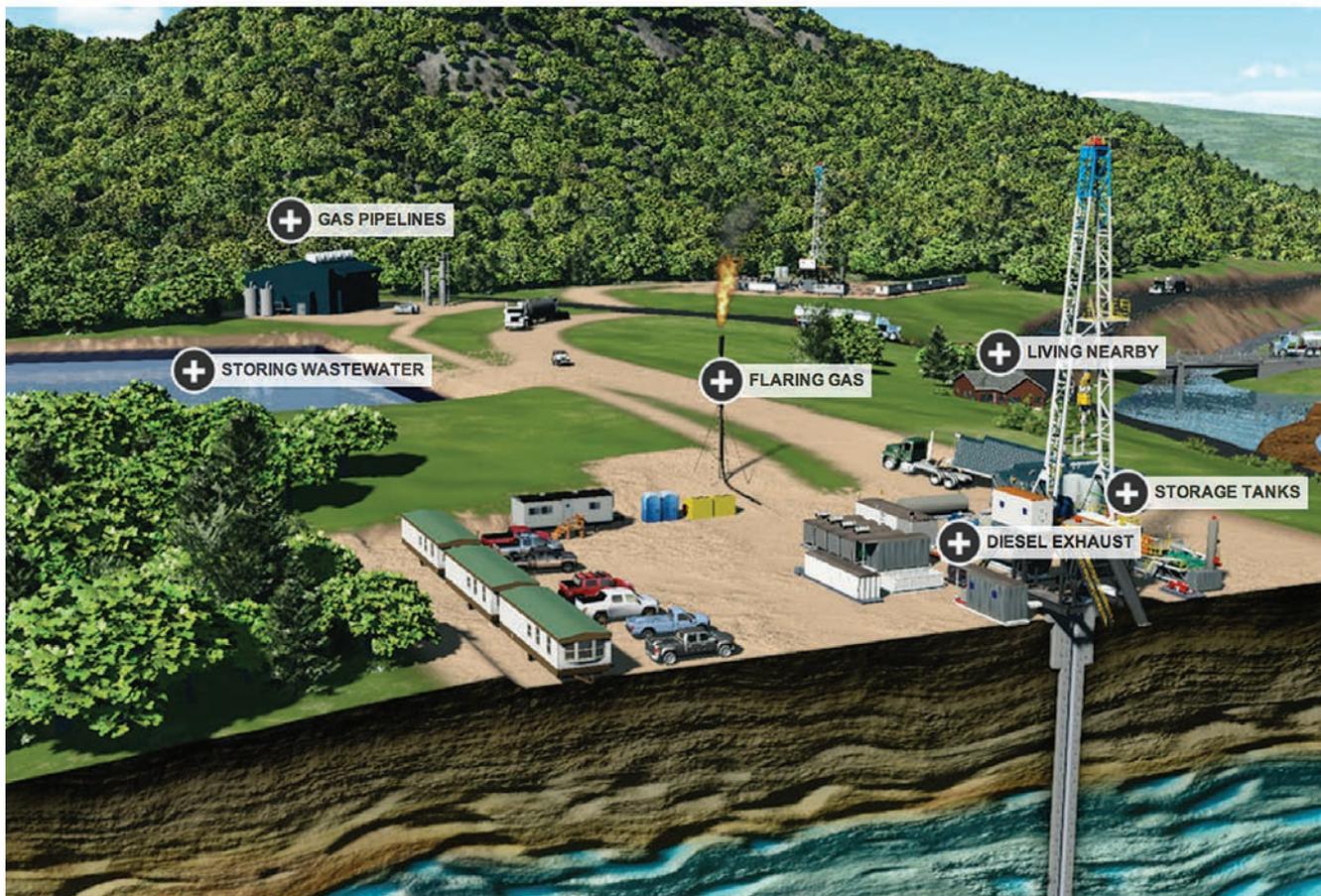
The public has a right to know about any uncertainties associated with potential impacts of unconventional oil and gas development in its communities. Understanding the knowns and unknowns can help communities make more informed decisions.

another? By asking these and other questions—the very questions researchers are asking—the story helps readers understand the scientific process.

Many uncertainties about methane emissions remain. Through the story, readers can begin to appreciate the role science and scientists play in answering questions that help inform good decision making. Petron's profile gives non-scientists a glimpse of what good evidence looks like to scientists and why it is important.

Complementing this and other stories on the NPR website is an interactive graphic (see below). It depicts a well site with its various components and is organized around three topic areas of uncertainty: air, water, and health (NPR 2012). The public can click on the different components and learn what is known and unknown, while also learning the scientific and technological basics about hydraulic fracturing.

Uncertainty remains an ongoing challenge for scientists and citizens alike—in both science and policy making. When looking to news sources for information about the science involved in the fracking debate, the public should look for stories that neither stoke nor dismiss concerns but accurately represent the work scientists are doing to advance understanding and reduce uncertainties. Citizens should recognize the role their own biases and preconceptions can play when evaluating information, particularly when uncertainty is high. It is important to strive for objectivity by examining diverse viewpoints and being open to robust scientific evidence. Public engagement with scientists' work promotes recognition of the importance of reliable, long-term data in resolving uncertainties, which can have a positive impact on the lives of people by supporting informed, evidence-based decisions.



This interactive graphic on NPR's website summarizes what scientists do and do not know about the risks to air, water, and public health from unconventional oil and gas development. Notably, the graphic effectively communicates uncertainty about such risks (NPR 2012).

4.3.3. Accurate Presentation of Scientific Information

In the public debate, economic issues compete for attention with air quality, water quality, water use, chemical disclosure, road safety, and other science-driven issues. Although science is not the only element that drives decision making on unconventional oil and gas development, it should be represented accurately and considered appropriately relative to other salient issues such as job creation.

The *Wall Street Journal* (WSJ) covers unconventional oil and gas development primarily as an economic issue, although it does include some coverage of science. Excluding opinion pieces, the paper covered pertinent scientific issues to the extent they arose within business or politics. In such cases, the articles included:

- Factual statements and statistics from federal and other peer-reviewed science
- Quotes from relevant scientists speaking about their work in appropriate contexts
- Coverage of technological innovations underreported elsewhere

In “Well Sealing Cited in Leaks, Not Fracking,” the WSJ cites the methane leakage research of a key player in the scientific discussion around unconventional oil and gas development: Robert B. Jackson, Nicholas Professor of Global Environmental Change at Duke University. The brief story highlights the study’s implications for industry, but also cites its findings: that 82 percent of 141 wells tested had elevated levels of methane. The report quotes Jackson directly stating the study shows that “poor casing and cementing problems are the simplest explanations” for the

Although science is not the only element that drives decision making on unconventional oil and gas development, it should be represented accurately and considered appropriately relative to other salient issues such as job creation.

contamination, rather than the process of hydraulic fracturing itself. Jackson’s conclusion is an important scientific takeaway—especially for the industry—as it suggests that, in theory, such problems can be mitigated through better engineering and well construction (Gold 2013).

The WSJ’s coverage also highlights technological innovations underreported elsewhere, particularly business opportunities arising through science-based approaches to meeting new consumer demands. Shelly Banjo’s “Clothing the Well-Dressed



Communities making decisions about unconventional oil and gas development must consider the accompanying risks. Different information sources report and weigh risk differently, but mainstream news sources and other stakeholders in the public conversation can help communities understand the risks and benefits involved.

Fracker—Retailers, Manufacturers Envision a Gold Rush in Duds for Workers in Booming Oil and Gas Fields” considers how clothing manufacturers have turned to innovative fabrics and technologies to meet the demands of oil and gas workers for protective clothing that is flame resistant, durable, and also more lightweight than traditional fire gear and can double as casual wear off the work site. In a public dialogue replete with pro- and anti-fracking interests, such intriguing science-driven innovations easily get lost. Innovative clothing design may not be as important as other science-based concerns involving larger segments of the public, yet protective clothing is an element of occupational safety relevant for oil and gas workers, investors, and multiple industries (Banjo 2013).

4.4. Navigating Information about Risk

One of the biggest challenges communities face in making decisions about unconventional oil and gas development is sorting through and assessing the reliability of information about risk. Different information sources report and weigh risk differently; similarly, segments of the public receive and view risk information differently. There is a rich literature on risk perception (Fischhoff 1993; Slovic 1987), which explores how different segments of the public view risk and the factors important to each. Understanding these differences can be informative and helpful as stakeholders come together to engage in public dialogue and decision making around fracking.

Special interests and other stakeholders play an important role in the public dialogue because they often highlight different concerns and elements in the complex decisions

communities must make. At the same time, information from these different sources may not always be the most reliable and trustworthy. What should citizens and policy makers do when information from one seemingly reliable source conflicts with information from another? Below we discuss best practices for navigating through materials from different stakeholder groups in the fracking debate, to obtain and understand their perspectives while also steering clear of misinformation.

4.4.1. Gauging Reliability in a Landscape of Misinformation

Key stakeholders in the public conversation on unconventional oil and gas development—both supporters and opponents—can be good sources of information. Supporters' materials can provide clear and concise descriptions of the technology and engineering involved in oil and gas extraction. Opponents frequently provide information about risks and public interest concerns that do not receive much attention elsewhere.

FIGURE 6. HURDLES TO SCIENCE-INFORMED DECISION MAKING ON FRACKING



The rapid growth of unconventional oil and gas development has outpaced the public's ability to make informed decisions about the best way to ensure healthy, prosperous communities. Understanding the barriers and how to overcome them can empower communities to make more evidence-based decisions about fracking.

But information on all sides of the issue can be “cherry-picked” or skewed. Misinformation is rarely present in the pure form of entirely false statements or fabricated evidence. It comes in varying degrees of seriousness and can include half-truths, misleading phrases or images, distortions of numbers and statistics, omissions of key points, misrepresentations of research, and quotes taken out of context (Brown 2012). Even when no misinformation is present, many factors influence how information reaches and is received by citizens. According to science communication experts, cultural values (Kahan 2013), media and social context (Sheufole 2013), and language choices (Ross 2013) all play a role.

The following questions can help citizens gauge the reliability and objectivity of information sources, particularly those representing stakeholder groups:

- Does the source cite primary sources or experts with relevant knowledge?
- Can a reader or listener clearly distinguish facts from opinions and preferences?
- Is the purpose of the source to provide general information, further scholarship, or offer a public service?
- Does the source mention limitations, uncertainties, and counter-evidence?
- Does the source make it easy to identify its funding sources, affiliations, and ideological or policy position?

Pro-fracking materials often downplay, dismiss, or ignore information and concerns about risks to human health or the environment.

A “yes” to all or most of the questions below suggests the source may contain misinformation and may not be a reliable source of information on risks:

- Are individuals without scientific expertise, such as politicians, presented as the primary authorities on scientific questions?
- Did any individuals or entities with apparent conflicts of interest that were not fully disclosed contribute to this research, or are they listed as providing financial support?
- Is the purpose of the source to persuade you of a predetermined point of view or to sell a product or service?
- Does the source omit or dismiss conflicting information, analysis, or points of view?

- Is anecdotal rather than scientific evidence featured most prominently?

4.4.2. Downplaying Risk

Pro-fracking materials often downplay, dismiss, or ignore information and concerns about risks to human health or the environment—often in subtle ways—even when the material cites scientific information that presents a more nuanced or uncertain picture. Pro-fracking materials typically highlight economic benefits to both communities and individuals, but may fail to raise or address other concerns. Materials from industry sources generally have an explicitly persuasive intent to promote industry interests. Although industry can be a trustworthy source of technical information about oil and gas extraction—which can help the public understand the process—its materials are unlikely to raise or highlight health and safety risks or other matters of public concern.

While economic opportunities are an important consideration in decision making, the public should approach with caution materials that tout opportunities without presenting reliable data to support such claims, or without acknowledgment of uncertainties and risks. One can see examples of how half-truth and deflection can misrepresent or downplay risks or avoid an issue altogether on the Energy in Depth website, a project of the Independent Petroleum Association of America. The website suggests that fracking has gone on safely for decades: “The history of fracturing technology’s safe use in America extends all the way back to the Truman administration” (Energy in Depth 2013). And this is true in the narrow case of the process of hydraulic fracturing for oil. But, as discussed in Section 1, recent innovations such as horizontal (directional) drilling, the adaptation of hydraulic fracturing for natural gas, plus the full suite of operations including wastewater disposal, transportation, and storage, accompanied by the recent widespread expansion of oil and gas development, have created new risks in new places. The Energy in Depth website refers to all the new developments only as “opportunities” without alluding to the risks and concerns associated with this larger set of today’s potential problems.

Another noteworthy misrepresentation on the Energy in Depth site relates to loopholes in federal and state regulation. As discussed in Section 3, hydraulic fracturing operations carry exemptions from major federal legislation—including the Clean Air Act, the Clean Water Act, and the Safe Drinking Water Act—and state regulation is currently insufficient. On its FAQ page, Energy in Depth misrepresents those regulatory gaps. In answering the question about federal loopholes, it redirects attention to the existence of state regulations and suggests that state laws are both adequate and adequately enforced: “States have regulated the fracturing process for

more than six decades now, and by any legitimate measure have compiled an impressive record of enforcement in that time” (Energy in Depth 2013).

While it is technically true that some states, such as Michigan, have better regulated unconventional oil and gas development, other states, such as Pennsylvania, have been much less effective in regulating and enforcement: 3,025 rule violations and \$3.5 million in fines between 2009 and 2012 are not indicators of an effective regulatory structure (Amico et al. 2013). And calling out state regulations, effective or otherwise, does not address the legitimate public concern about exemptions to federal laws.

Misleading images that are associated with scientific findings can tarnish the perceived credibility of actual science.

4.4.3. Exaggerating Risk

Just as some stakeholders and special interests minimize risk, others can and have exaggerated risks to mobilize public sentiment against unconventional oil and gas development. These stakeholders may skip over nuances, uncertainties, limitations, and caveats of scientific studies or quote sections out of context as evidence to support claims that the research may not. Word choices may be made to exacerbate existing negative perceptions about corporations, fossil fuels, and environmental degradation when the science may indicate otherwise or be inconclusive. Conversely, reliable scientific information may be presented in a manner or context that causes members of the public still trying to make up their minds to distrust the objectivity of this material—and hence the credibility of the science.

Parts of filmmaker Josh Fox’s documentaries *Gasland* and *Gasland II*, for example, illustrate such misrepresentations. While the film deserves praise for raising awareness, generating citizen engagement, and bringing some of the science behind the impacts of drilling to light, the film also includes and sensationalizes some misinformation.

For example, *Gasland*’s iconic image was tap water catching on fire because of methane content supposedly the result of hydraulic fracturing. The iconic image is replicated even more dramatically in *Gasland II*, with flames coming out of a garden hose. While unconventional oil and gas development does pose risks of methane contamination of drinking water, both portrayed instances of flammable water were found not to have been caused by shale gas development. In the original film, the gas was found to have been naturally occurring

BOX 12

Academia as an Information Source

Although many academic resources are geared toward technical rather than general audiences, some universities are taking steps to engage and empower the public as partners in the delivery and even the production of information related to unconventional oil and gas development. The Marcellus Center for Outreach and Research at Pennsylvania State College, for example, coordinates efforts by researchers in different fields across the university and facilitates the dissemination of the information to stakeholder groups including the general public. The Marcellus Center not only supports research on shale gas development but also on workforce needs and training, community and demographic shifts, and the need for government services. It also serves as a resource for information on state regulations and tax revenues related to the industry (Marcellus Center 2013). Even at universities that do not have such programs, citizens can reach out to experts to seek information and guidance (see Box 13, p. 53).

Even at universities that do not have programs with a public education component, citizens can reach out to experts to seek information.

An increasing number of researchers are utilizing community-based participatory research (CBPR) to work with communities to build trust, understanding, and participation in research studies. Empowering citizens as active partners in the research process provides numerous benefits to research findings and public health intervention outcomes, such as numerous additional opportunities for data collection and more open communication between researchers and the public. In addition, community participation builds and strengthens the capacity of community residents to address future health and environmental risks through education, outreach, and training (AHRQ 2003).



(CDNR 2008). For the hose fire shown in the sequel, a Texas court found that the hose had been attached to a gas vent, not a water line, and “was done not for scientific study but to provide local and national news media with a deceptive video calculated to alarm the public into believing the water was burning” (Lipsky vs. Durant, Carter, Coleman, LLC et al. 2012).

The imagery used in the films seemed more geared toward provoking fear than creating understanding of the facts. In the public conversation, misleading images that are associated with scientific findings can tarnish the perceived credibility of actual science. Studies on such persuasive tactics have raised ethical concerns over the sensationalized manipulation of shared values—in this case, the importance of water in our lives—to motivate an audience to take a particular action (Ross 2013).

By emphasizing the importance of factual information and putting a price on the risks, insurance provides a concrete framework to discuss concerns outside of the often politically and ideologically charged debate between pro- and anti-fracking interests.

In another example of opponents’ use of misinformation, the group Americans Against Fracking combines accurate and inaccurate statements on its “Get the Facts” page without citing sources, making it difficult to discern fact and opinion. Some statements are supported by research (e.g., “Communities in these regions face an onslaught of heavy truck traffic—often either laden with dangerous chemicals used in drilling and fracking or with the resulting toxic waste”), but other statements are not similarly supported (e.g., “Scientists now believe that natural gas is likely worse than coal in terms of driving global climate change in the coming decades”) (Americans Against Fracking 2013).

4.4.4. Insuring Risk

The insurance industry depends on objective, up-to-date scientific information about unconventional oil and gas development in order to understand, evaluate, and price the risks accurately. But the insurance perspective is rarely a part of the public conversation, even though the public has a vested interest in knowing whether oil and gas companies

have adequate liability insurance and whether home owners’ policies protect against fracking-related damages.

By emphasizing the importance of factual information and putting a price on the risks, insurance provides a concrete framework to discuss concerns outside of the often politically and ideologically charged debate between pro- and anti-fracking interests.

Some insurers have concluded that unconventional oil and gas development poses too many risks. In July 2012, Nationwide Mutual Insurance Company made national news, albeit briefly, when an internal memo was leaked to the press. It stated: “After months of research and discussion, we have determined that the exposures presented by hydraulic fracturing are too great to ignore. Risks involved with hydraulic fracturing are now prohibited for General Liability, Commercial Auto, Motor Truck Cargo, Auto Physical Damage and Public Auto (insurance) coverage” (Esch 2012).

Responding in defense of its position against oil and gas industry criticism, Nationwide cited a lack of access to information: “Insurance works when a carrier can accurately price the coverage to match the risks. When information and claims experience are not available to fully understand the scope of a given risk, carriers aren’t able to price protection that would be fair to both the customer and the company” (Nationwide Mutual Insurance Company 2012).

Many other insurers do provide supplements to general liability protection, including specialty products such as environmental site liability coverage that cost more. In all cases, industry reports show that insurers are looking carefully at the most up-to-date scientific information when anticipating potential damages and making cost determinations. They look at many of the same issues that are of concern to communities: risks to water supplies, risks to surrounding land use, chemical exposure, and earthquakes (Willis Energy Market Review 2012). While citizens and communities should not make their decisions based on the profit margins of the insurance industry, the insurance perspective should play a greater role in the public dialogue.

CHAPTER FIVE

Toward Improved Dialogue and Decision Making



More comprehensive laws governing hydraulic fracturing at the federal, state, and local level can help drive us toward a more transparent and informed discussion on unconventional oil and gas development in the United States.

The rapid growth of unconventional oil and gas development has outpaced the public's ability to make informed, evidence-based decisions about the best way to ensure healthy, prosperous communities. The public has a right to know about the impacts—positive or negative—that unconventional oil and gas development may have. Citizens have a right to understand the uncertainties and limitations of our scientific knowledge. They have a right to know what is, can, or should be covered by regulations. And they have a right to be engaged in the discussion. Ultimately, citizens need to be empowered with the information needed to make informed decisions about unconventional oil and gas development in their communities.

The best available science about the effects of hydraulic fracturing, wastewater disposal, and other activities on communities should inform decision makers and the public. Robust and ongoing scientific research is needed to understand the environmental and public health impacts associated with unconventional oil and gas development, spanning all the processes from hydraulic fracturing to the disposal of hazardous waste. Science can inform communities about such effects, but research must be fast-tracked and made publicly accessible.

Inappropriate corporate interference in the science and policy-making process must be addressed. Protection of public health and well-being should take priority over

private special interests. The exemptions that allow companies to keep vital information about their activities secret must be lifted. Federal, state, and local governments should make information accessible to researchers, decision makers, and the public. Greater transparency, more oversight, and more comprehensive laws and regulations at all levels are necessary in order to protect public health and the environment.

Protection of public health and well-being should take priority over special interests. The exemptions that allow companies to keep vital information about their activities secret must be lifted.

We believe the following steps can help guide us toward a more transparent, science-informed dialogue and decision-making process on unconventional oil and gas development in the United States:

- Loopholes in federal environmental legislation that exempt oil and gas development should be closed. Major exemptions exist in several federal laws including the Safe Drinking Water Act, the Clean Water Act, the Clean Air Act, and the Toxic Release Inventory of the Emergency Planning and Community Right-To-Know Act. Strengthening these laws would allow the federal government to better protect the public from risks associated with unconventional oil and gas development, and to provide better oversight and assistance to states and municipalities (which often have limited resources).
- The chemical composition, volume, and concentration of all hydraulic fracturing fluids used in each specific locality should be disclosed, including chemicals considered proprietary; this information should be made available to the public online before drilling can begin. Further, the chemical composition of flowback and other wastewater in every locality should be publicly disclosed. Public safety should be prioritized over company trade secrets, as it has been for other regulated industries.
- Companies should be required to collect and publicly disclose two key sets of data: First, they should conduct baseline studies of air, water, and soil quality before drilling begins; second, there must be ongoing monitoring of air, water, and soil quality during and after extraction activities. Such concrete data will allow scientists to quantify the short-term and long-term effects of unconventional oil and gas development, help hold those responsible for pollution in communities accountable, and empower citizens with trustworthy information on their environmental quality.
- Federal agencies and state and municipal governments should:
 - collect representative and robust environmental and health data for affected communities or require companies to do so;
 - conduct comprehensive studies to assess the health and environmental risks;
 - make the data, research results, and other information related to unconventional oil and gas production publicly accessible; and
 - engage citizens and address their concerns about the impacts of unconventional oil and gas development in a meaningful way.



The public has a right to know about all the risks and benefits that could come with unconventional oil and gas development. Greater transparency in industry operations and government decision making are needed for a science-informed dialogue.

BOX 13

A Toolkit for Community Decision Making



Along with this report, we have developed a toolkit for active citizens and policy makers faced with decisions about unconventional oil and gas development in their communities. By providing practical advice and resources, the toolkit helps citizens identify critical questions to ask, and obtain the scientific information they need to weigh the prospects and risks in order to make the best decisions for their community.

To make sound decisions about unconventional oil and gas development, we need independent science to play a stronger role in informing public dialogue. The toolkit can aid informed public discussions and decision making about fracking in communities by helping citizens to:

- identify critical issues about the potential impacts of fracking in their area and be able to search for answers;
- distinguish reliable information from misinformation—and help their neighbors and local decision makers do the same;
- communicate with scientists, media, policy makers, and local groups to be a part of the public discussion; and
- learn about and engage with the key actors in their community to influence oil and gas policy making at a local and state level.

To read or print the toolkit, go to www.ucsusa.org/HFtoolkit.



References

- Agency for Healthcare Research and Quality (AHRQ). 2003. The role of community-based participatory research. Creating partnerships, improving health. AHRQ publication no. 03-0037. United States Department of Health & Human Services. June. Online at <http://archive.ahrq.gov/research/cbprrole.htm>. Accessed August 22, 2013.
- Agency for Toxic Substances & Disease Registry (ATSDR). 2004. Interaction profile for toxic substances: Benzene, toluene, ethylbenzene, and xylenes (BTEX). May. Online at <http://www.atsdr.cdc.gov/interactionprofiles/ip05.html>. Accessed August 18, 2013.
- Airgas. 2013. Material Safety Data Sheet: Methane. Online at <http://www.airgas.com/documents/pdf/001033.pdf>, accessed July 30, 2013.
- Alvarez, R.A., S.W. Pacala, J.J. Winebrake, W.L. Chameides, and S.P. Hamburg. 2012. Greater focus needed on methane leakage from natural gas infrastructure. *Proceedings of the National Academy of Sciences* 109:6435–6440. Online at <http://www.pnas.org/content/109/17/6435>. Accessed September 6, 2013.
- American Petroleum Institute (API). 2013. Comments of API and ANGA on EPA's request for information to inform hydraulic fracturing research related to drinking water resources. Online at <http://www.api.org/policy-and-issues/policy-items/hf/comments-api-anga-to-epa>. Accessed August 18, 2013.
- Americans Against Fracking. 2013. Research/facts. Online at <http://www.americansagainstfracking.org/get-the-facts/>. Accessed August 22, 2013.
- Amico, C., D. DeBelius, S. Detrow, and M. Stiles. 2013. Shale play: Natural gas drilling in Pennsylvania. State Impact Pennsylvania. National Public Radio. Online at <http://stateimpact.npr.org/pennsylvania/drilling/>. Accessed July 11, 2013.
- Augustine, N.R., R.R. Colwell, and J.J. Duderstadt. 2012. *A review of the processes of preparation and distribution of the report "Fact-based regulation for environmental protection in shale gas development."* Review prepared at the request of the University of Texas at Austin. November 30. Online at <http://www.utexas.edu/news/PDF/Review-of-report.pdf>. Accessed September 6, 2013.
- Bamberger, M., and R.E. Oswald. 2012. Impact of gas drilling on human and animal health. *New Solutions*. 22(1):51–77. doi:10.2190/NS.22.1.e.
- Banerjee, N. 2013. Internal EPA report highlights disputes over fracking and well water. *Los Angeles Times*. July 27. Online at <http://www.latimes.com/news/nationworld/nation/la-na-epa-dimock-20130728,0,4847442.story>. Accessed August 20, 2013.
- Banerjee, N. 2012. Pennsylvania law on fracking chemicals worries doctors. *Los Angeles Times*. April 21. Online at <http://articles.latimes.com/2012/apr/21/nation/la-na-adv-fracking-doctors-20120422>. Accessed September 7, 2013.
- Banjo, S. 2013. What the well-dressed fracker is wearing. *The Wall Street Journal*. May 15. Online at <http://online.wsj.com/article/SB10001424127887323798104578453310080203022.html>. Accessed July 3, 2013.
- Battelle. 2012. *Review of EPA hydraulic fracturing study plan EPA/600/R11/122, November 2011*. June. Online at http://www.velaw.com/UploadedFiles/VESite/E-comms/final_epa_study_plan_review_061112.pdf. Accessed September 8, 2013.
- Bell, T.E. 2013. "There's gas in them thar shales!" Shale gas recovery 101. *The Bent*. 104(3):22–27, 61. Summer. Online at <http://tbp.org/pubs/Features/Su13Bell.pdf>. Accessed August 22, 2013.
- Boyer, E.W., et al. 2012. *The impact of Marcellus gas drilling on rural drinking water supplies*. The Center for Rural Pennsylvania. March. Online at http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2012.pdf. Accessed September 8, 2013.
- Bradbury, J., M. Obeiter, L. Draucker, W. Wang, and A. Stevens. 2013. *Clearing the air: Reducing upstream greenhouse gas emissions from U.S. natural gas systems*. Washington, DC: World Resources Institute. Online at http://pdf.wri.org/clearing_the_air_full_version.pdf. Accessed September 8, 2013.
- Bradner, T. 2013. State oil and gas commission mulls tough new regs on fracking. *Alaska Journal of Commerce*. April 4. Online at <http://www.alaskajournal.com/Alaska-Journal-of-Commerce/March-Issue-5-2013/State-oil-and-gas-commission-mulls-tough-new-regs-on-fracking/>. Accessed September 8, 2013.
- Bredfeldt, T. 2013. Public health risks in shale gas development. Discussion presentation. Presented at the Workshop on Risks of Unconventional Shale Gas Development, May 30–31, Washington, DC. National Research Council. Online at http://sites.nationalacademies.org/xpiedi/groups/dbasesite/documents/webpage/dbase_083487.pdf. Accessed September 19, 2013.
- Breiner, A. 2013. "Frack gag" bans children from talking about fracking, forever. *ClimateProgress*. August 2. Online at <http://thinkprogress.org/climate/2013/08/02/2401591/frack-gag-for-kids/>. Accessed August 26, 2013.
- Breitling Oil and Gas. 2012. US shale faces water, transparency complaints. October 4. Online at <http://www.breitlingoilandgas.com/us-shale-faces-water-transparency-complaints/>. Accessed August 21, 2013.
- Bridge, I. 2009. Crystalline silica: A review of the dose response relationship and environmental risk. *Air Quality and Climate Change* 43(1):17–23. Online at <http://www.superquarry.org.au/wp-content/uploads/2011/02/Bridge-2009-environmental-silicosis-risk045.pdf>. Accessed September 8, 2013.
- Brittingham, M. 2013. Ecological risks of shale gas development. Presented at the Workshop on Risks of Unconventional Shale Gas Development, May 30–31, Washington, DC. National Research Council. Online at http://sites.nationalacademies.org/xpiedi/groups/dbasesite/documents/webpage/dbase_083489.pdf. Accessed September 8, 2013.
- Brown, D.A. 2012. Ethical analysis of disinformation campaign's tactics: (1) Think tanks, (2) PR campaigns, (3) astroturf groups, and (4) cyber-bullying attacks. *Ethics and Climate*. Online at http://blogs.law.widener.edu/climate/2012/02/10/ethical_analysis_of_disinformation_campaigns_tactics_1_think_tanks_2_pr_campaigns_3_astroturf_groups/. Accessed September 8, 2013.
- Browning, J., and A. Kaplan. 2011. *Deep drilling, deep pockets in Congress*. Washington, DC: Common Cause. November 10. Online at <http://www.commoncause.org/atfjcfj%7Bfb3c17e2-cdd1-4df6-92be-bd4429893665%7D/DEEP%20DRILLING%20DEEP%20POCKETS%20NOV%202011.PDF>. Accessed September 8, 2013.
- Bureau of Land Management (BLM). 2013. *Oil and gas; hydraulic fracturing on federal and Indian lands. Supplemental notice of proposed rulemaking and request for comment*. U.S. Department of the Interior. 43 CFR Part 3160. 4310-84P. Online at http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directoratel/public_affairs/hydraulicfracturing.Par.91723.File.tmp/HydFrac_SupProposal.pdf. Accessed August 20, 2013.
- Bureau of Land Management, Colorado (BLM CO). 2013a. Hydraulic fracturing. Online at http://www.blm.gov/colst/en/BLM_Programs/oilandgas/Hydraulic_Fracturing.html. Accessed August 2, 2013.
- Bureau of Land Management, Colorado (BLM CO). 2013b. Science of hydraulic fracturing. Online at http://www.blm.gov/colst/en/BLM_Programs/oilandgas/Hydraulic_Fracturing/Hydraulic_Fracturing_Science.html. Accessed August 2, 2013.
- Burton, G.A., K.J. Nadelhoffer, and K. Presley. 2013. *Hydraulic fracturing in the state of Michigan: Environment/ecology technical report*. University of Michigan. September 3. Online at <http://graham.umich.edu/media/files/HF-04-Environment-Ecology.pdf>. Accessed September 6, 2013.

- Campanile, C. 2012. Ex-Pa. Gov. Rendell to Gov. Cuomo: Fracking would be good for New York State. *New York Post*. November 30. Online at <http://nypost.com/2012/11/30/ex-pa-gov-rendell-to-gov-cuomo-fracking-would-be-good-for-new-york-state/>. Accessed September 8, 2013.
- Carbone, M., Y.I. Baris, P. Bertino, S. Comertpay, A.U. Dogan, G. Gaudino, S. Jube, S. Kanodia, C.R. Partridge, H.I. Pass, Z.S. Rivera, I. Steele, M. Tuncer, S. Way, H. Yang, A. Miller. 2011. Erionite exposure in North Dakota and Turkish villages with mesothelioma. *Proceedings of the National Academy of Sciences* 108(33):13618–13623. August 16. doi: 10.1073/pnas.1105887108. Online at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3158231/>. Accessed August 16, 2013.
- Cathles, L.M., L. Brown, M. Taam, and A. Hunter. 2012. A commentary on “The greenhouse-gas footprint of natural gas in shale formations” by R.W. Howarth, R. Santoro, and A. Ingraffea. *Climatic Change*. Online at <http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/FINAL%20Short%20Version%2010-4-11.pdf>. Accessed September 8, 2013.
- Christopherson, S., C. Frickey, and N. Rightor. 2013. *A vote of ‘no confidence’: Why local governments take action in response to shale and gas development*. City and regional planning working paper. Ithaca, NY: Cornell University. June. Online at http://www.greenchoices.cornell.edu/downloads/development/shale/marcellus/Vote_of_No_Confidence_WT.pdf. Accessed September 8, 2013.
- Christopherson, S., and N. Rightor. 2011. A comprehensive economic impact analysis of natural gas extraction in the Marcellus Shale. Working paper. Ithaca, NY: Cornell University.
- Center for American Progress, The, and OMB Watch (CAP). 2004. *Special interest takeover: The Bush administration and the dismantling of public safeguards*. For The Citizens for Sensible Safeguards Coalition. May. Online at <http://www.americanprogress.org/lefsispecialinterests.pdf>. Accessed September 8, 2013.
- City of Greeley, Colorado. 2011. *Oil & gas development frequently asked questions*. July 13. Online at <http://greeleygov.com/CommunityDevelopment/Documents/Planning/Forms%20and%20Handouts/Oil%20and%20Gas%20FAQ.pdf>. Accessed June 13, 2013.
- Clark, C.E., and J.A. Veil. 2009. *Produced water volumes and management practices in the United States*. Argonne National Laboratory Environmental Science Division. For U.S. Department of Energy Office of Scientific and Technical Information. September. Online at <http://www.ipd.anl.gov/anlpubs/2009/07/64622.pdf>. Accessed September 8, 2013.
- Colborn, T., C. Kwiatkowski, K. Schultz, and M. Bachran. 2011. Natural gas operations from a public health perspective. *Human and Ecological Risk Assessment: An International Journal*. 17(5):1039–1056. October. Online at <http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/fracking%20chemicals%20from%20a%20public%20health%20perspective.pdf>. Accessed September 8, 2013.
- Colorado Department of Natural Resources (CDNR). 2008. Letter to Mike W. Markham concerning water quality analytical results for domestic water well (permit #63252). September 30. Online at http://www.eenews.net/assets/2011/02/10/document_gw_01.pdf. Accessed July 10, 2013.
- Connor, K., and R. Galbraith. 2013. *Industry partner or industry puppet? How MIT’s influential study of fracking was authored, funded, and released by oil and gas industry insiders*. Public Accountability Initiative. March. Online at http://public-accountability.org/wp-content/uploads/industry_partner_or_industry_puppet.pdf. Accessed September 8, 2013.
- Considine, T., R., Watson, R. Entler, and J. Sparks. 2009. *An emerging giant: Prospects and economic impacts of developing the Marcellus Shale natural gas play*. Pennsylvania State University College of Earth & Mineral Sciences. Department of Energy and Mineral Engineering. Online at <http://marcelluscoalition.org/wp-content/uploads/2010/05/EconomicImpactsOfDevelopingMarcellus.pdf>. Accessed September 8, 2013.
- Cooley, H., and K. Donnelly. 2012. *Hydraulic fracturing and water resources: Separating the frack from the fiction*. Pacific Institute. June. Online at http://www.pacinst.org/wp-content/uploads/2013/02/full_report35.pdf. Accessed August 21, 2013.
- Costanzo, C., and T.W. Kelsey. 2012. Marcellus Shale and local collection of state taxes: What the 2011 Pennsylvania tax data say. Pennsylvania State University Center for Economic and Community Development. Online at <http://www.marcellus.psu.edu/resources/PDFs/MSTax2012.pdf>. Accessed August 21, 2013.
- Davies, P. 2012. Sand surge. *Fedgazette*. The Federal Reserve Bank of Minneapolis. July. Online at http://www.minneapolisfed.org/pubs/fedgaz/12-07/sand_surge_fedgazette_july_2012.pdf. Accessed September 8, 2013.
- Department of State (DOS). 1948. United States information and educational exchange act of 1948. January 27. Online at <http://www.state.gov/documents/organization/177574.pdf>. Accessed September 14, 2013.
- Detrow, S. 2012. Fracking disclosure: Colorado’s compromise is Pennsylvania’s controversy. National Public Radio. StateImpact Pennsylvania. June 7. Online at <http://stateimpact.npr.org/pennsylvania/2012/06/07/fracking-disclosure-colorados-compromise-is-pennsylvanias-controversy/>. Accessed September 8, 2013.
- Detrow, S. 2011. Wyoming grants 146 “trade secret” exemptions for fracking chemicals. National Public Radio. StateImpact Pennsylvania. August 25. Online at <http://stateimpact.npr.org/pennsylvania/2011/08/25/wyoming-grants-146-trade-secret-exemptions-for-fracking-chemicals/>. Accessed September 8, 2013.
- DiCosmo, B. 2013. Industry criticizes EPA fracking study ahead of planned peer review. *InsideEPA*. May 3. Online at <http://insideepa.com/Inside-EPA-General/Public-Content-ACC/industry-criticizes-epa-fracking-study-ahead-of-planned-peer-review/menu-id-1026.html>. Accessed September 8, 2013.
- DiGiulio, D.C., R.T. Wilkin, C. Miller, and G. Oberley. 2011. *Investigation of ground water contamination near Pavillion, Wyoming*. Draft. U.S. Environmental Protection Agency. Online at http://www2.epa.gov/sites/production/files/documents/EPA_ReportOnPavillion_Dec-8-2011.pdf. Accessed September 8, 2013.
- Dlouhy, J.A. 2012. Environmentalists challenge trade secret protections for hydraulic fracturing. *Fuel Fix*. March 26. Accessed September 8, 2013.
- Dobb, E. 2013. The new oil landscape. *National Geographic*. March. Online at <http://ngm.nationalgeographic.com/2013/03/bakken-shale-oil/dobb-text>. Accessed September 8, 2013.
- Dodd, S. 2013. Town board to residents: Shut up about that darn fracking thing, willya? *OnEarth*. February 12. Natural Resources Defense Council. Online at <http://www.onearth.org/blog/town-board-to-residents-shut-up-about-fracking>. Accessed September 8, 2013.
- Ebersole, J. 2012. Williston no. 1 in sales tax revenue. *Williston Herald*. July 20. Online at http://www.willistonherald.com/news/williston-no-in-sales-tax-revenue/article_17bb2c7a-d285-11e1-9ecb-0019bb2963f4.html. Accessed September 8, 2013.
- Ecowatch. 2013. Feds charge man in fracking wastewater dumping case. February 5. Online at <http://ecowatch.com/2013/fracking-wastewater-dumping-case/>. Accessed August 24, 2013.
- Efstathiou, J., Jr. 2012. Frackers fund university research that proves their case. *Bloomberg*. July 23. Online at <http://www.bloomberg.com/news/2012-07-23/frackers-fund-university-research-that-proves-their-case.html>. Accessed September 8, 2013.
- Efstathiou, J., Jr., and M. Drajem. 2013. Drillers silence fracking claims with sealed settlements. *Bloomberg Businessweek*. June 6. Online at <http://www.businessweek.com/news/2013-06-06/drillers-silence-u-dot-s-dot-water-complaints-with-sealed-settlements#p1>. Accessed August 26, 2013.

- Eligon, J. 2013. An oil town where men are many, and women are hounded. *The New York Times*. January 15. Online at http://www.nytimes.com/2013/01/16/us/16women.html?pagewanted=1&r=1&_r=1&_r=1. Accessed September 9, 2013.
- Elliot, J. 2013a. More than a matter of opinion: Ed Rendell's plea for fracking fails to disclose industry ties. *ProPublica*. March 28. Online at <http://www.propublica.org/article/ed-rendell-new-york-fracking-op-ed-disclosure>. Accessed September 9, 2013.
- Elliot, J. 2013b. Another layer to Rendell's fracking connections. *ProPublica*. April 8. Online at <http://www.propublica.org/article/another-layer-to-rendells-fracking-connections>. Accessed September 9, 2013.
- Ellis, B. 2011. Crime turns oil boomtown into Wild West. *CNNMoney*. October 26. Online at http://money.cnn.com/2011/10/26/pf/America_boomtown_crime/index.htm. Accessed September 9, 2013.
- Energy in Depth. 2013. Just the facts. Independent Petroleum Association of America. Online at <http://energyindepth.org/just-the-facts/>. Accessed July 12, 2013.
- Energy in Depth. 2012. Hydraulic fracturing: Experience shows process is fundamentally safe. Independent Petroleum Association of America. Online at http://energyindepth.org/wp-content/uploads/2013/04/EID_Nevada_fact_sheet-final.pdf. Accessed July 12, 2013.
- Energy Information Administration (EIA). 2013. *Annual energy outlook 2013. With projections to 2040*. Washington, DC: U.S. Department of Energy. DOE/EIA-0383(2013). April. Online at <http://www.eia.gov/forecasts/aeo/pdf/0383%282013%29.pdf>. Accessed August 21, 2013.
- Entrekin, S., M. Evans-White, B. Johnson, and E. Hagenbuch. 2011. Rapid expansion of natural gas development poses a threat to surface waters. *Frontiers in Ecology and the Environment* 9(9):503–511. October 6. doi:10.1890/10053. Online at <http://www.cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/Entrekin%20et%20al%20Frontiers%20in%20Ecology%20and%20the%20Environment.pdf>. Accessed September 9, 2013.
- Environmental Protection Agency (EPA). 2013a. Natural gas extraction—hydraulic fracturing. July 12. Online at <http://www2.epa.gov/hydraulicfracturing>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2013b. Particulate matter (PM). March 18. Online at <http://www.epa.gov/airquality/particlepollution/index.html>. Accessed July 31, 2013.
- Environmental Protection Agency (EPA). 2013c. EPA's study of hydraulic fracturing and its potential impact on drinking water resources. August 21. Online at <http://www.epa.gov/hfstudy>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2013d. *EPA needs to improve air emissions data for the oil and natural gas production sector*. Office of the Inspector General. Report no. 13-P-0161. February 20. Online at <http://www.epa.gov/oig/reports/2013/20130220-13-P-0161.pdf>. Accessed July 31, 2013.
- Environmental Protection Agency (EPA). 2013e. Wyoming to lead further investigation of water quality concerns outside of Pavillion with support of EPA. June 20. Online at <http://yosemite.epa.gov/opaladmpress.nsf/20ed1dfa1751192e8525735900400c30/dcf7dcb471dcfe1785257b90007377bf?OpenDocument>. Accessed August 20, 2013.
- Environmental Protection Agency (EPA). 2013f. Ground level ozone. August 14. Online at www.epa.gov/glo/index.html. Accessed September 14, 2013.
- Environmental Protection Agency (EPA) 2012a. Emergency Planning and Community Right-To-Know Act (EPCRA). June 27. Online at <http://www.epa.gov/agriculture/lcra.html>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA) 2012b. Safe Drinking Water Act (SDWA). March 6. Online at <http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA) 2012c. Underground Injection Control Program. September 12. Online at <http://water.epa.gov/type/groundwater/uic/index.cfm>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA) 2012d. Regulation of hydraulic fracturing under the Safe Drinking Water Act. May 4. Online at http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydroreg.cfm. Accessed September 14, 2013.
- Environmental Protection Agency (EPA) 2012e. *Permitting guidance for oil and gas hydraulic fracturing activities using diesel fuels—draft: Underground Injection Control Program guidance #84*. EPA 816-R-12-004. May. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2012f. *Study of the potential impacts of hydraulic fracturing on drinking water resources. Progress report*. EPA 601/R-12/011. December. Online at www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2012g. Memorandum. New project notification. July 17. Online at http://www.epa.gov/oig/reports/notificationMemos/newStarts_07-17-12_Region_6_Range_Resources.pdf. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2012h. EPA's air rules for the oil & natural gas industry. Summary of key changes to the new source performance standards. Online at <http://www.epa.gov/airquality/oilandgas/pdfs/20120417changes.pdf>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 2012i. What are the six common air pollutants? April 20. Online at <http://www.epa.gov/airquality/urbanair/>. Accessed August 24, 2013.
- Environmental Protection Agency (EPA). 2004. Evaluation of impacts to underground sources of drinking water by hydraulic fracturing of coalbed methane reservoirs study (2004). Online at http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethane.
- Environmental Protection Agency (EPA). 1987a. Report to Congress. Management of wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy. Vol. 1. EPA/530-SW-88-003. December. Online at http://www.nytimes.com/interactive/us/drilling-down-documents-7.html?_r=0#document/p1a27935. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). 1987b. Report to Congress. Management of wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy. Vol. 1. EPA/530-SW-88-003. December. Online at <http://nepis.epa.gov/Exe/ZyNET.exe/9100W11P.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1986+Thru+1990&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A\zyfiles\Index%20Data\86thru90\Txt\00000025\9100W11P.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h&-&MaximumDocuments=1&FuzzyDegr ee=0&ImageQuality=r75g8/r75g8/x150y150g16i425&Display=p|&DefSee kPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL#>. Accessed September 14, 2013.
- Environmental Protection Agency (EPA). No date. Overview of greenhouse gases: Methane emissions. Online at <http://epa.gov/climatechange/ghgemissions/gases/ch4.html>. Accessed August 24, 2013.

- Esch, M. 2013a. New York fracking study: Groups question industry-associated consultants' involvement. Associated Press. *Huffington Post*. April 26. Online at http://www.huffingtonpost.com/2013/04/26/new-york-fracking-study_n_3163140.html. Accessed September 9, 2013.
- Esch, M. 2013b. Sanford, New York fracking discussion ban prompts lawsuit from environmental groups. Associated Press. *Huffington Post*. February 12. Online at http://www.huffingtonpost.com/2013/02/12/sanford-new-york-fracking_n_2669476.html. Accessed September 9, 2013.
- Esch, M. 2012. US insurer won't cover gas drill fracking exposure. Associated Press. *U.S. News & World Report*. July 12. Online at http://www.usnews.com/news/business/articles/2012/07/12/us-insurer-wont-cover-gas-drill-fracking-exposure?_cid=related-links:TOP. Accessed July 11, 2013.
- FACT. 2013. People. Online at <http://www.fact-corp.com/people.html>. Accessed September 5, 2013.
- FACT. 2011. Brief information about FACT Inc. founder Fred Aminzadeh. Online at http://www.fact-corp.com/uploads/1/0/1/8/10183844/fred_aminzadeh.pdf. Accessed August 26, 2013.
- Field, T., E. Fink, S. Ghosh, L. Lessig, D. Levine, L.P. Loren, M.L. Lyndon, F. Pasquale, M.L. Rustad, and T. Sichelman. 2013. Letter to Commissioner Cathy P. Foerster, Alaska Oil & Gas Conservation Commission re: Second revised notice of proposed changes in the regulations of the Alaska Oil and Gas Conservation Commission dated January 17, 2013, specifically 20 AAC 25.283, Hydraulic Fracturing.
- Fischhoff, B., A. Bostrom, and M.J. Quadrel. 1993. Risk perception and communication. *American Review of Public Health* 14:183–203. Online at <http://rcfp.pbworks.com/f/RiskPerceptionAndCommunication.pdf>. Accessed September 9, 2013.
- Fish and Wildlife Service (FWS). 2013. Endangered and threatened wildlife and plants; endangered species status for diamond darter. Final rule. *Federal Register* 78(144):45074–45095. July 26. Online at <http://www.gpo.gov/fdsys/pkg/FR-2013-07-26/html/2013-17938.htm>. Accessed August 20, 2013.
- Foggan, L.A., and K.C. Siehndel. 2011. Litigation looms, but general liability coverage should generally not be at stake in hydrofracturing liability claims. *Mealey's Litigation Report: Insurance*. September 14. Online at http://www.americanbar.org/content/dam/aba/administrative/litigation/materials/sac_2012/15-2_litigation_looms_foggan.authcheckdam.pdf. Accessed July 31, 2013.
- Food & Water Watch. 2011. *Exposing the oil and gas industry's false jobs promise for shale gas development. How methodological flaws grossly exaggerate jobs projections*. Washington, DC. November. Online at <http://documents.foodandwaterwatch.org/doc/FalseJobsPromiseReport.pdf>. Accessed August 25, 2013.
- Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz, and R. Van Dorland. 2007. Changes in atmospheric constituents and in radiative forcing. In *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller. Cambridge, UK: Cambridge University Press. Online at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf>. Accessed September 9, 2013.
- FracFocus. 2013a. FracFocus 2.0. Hundreds of companies. Thousands of wells. Online at <http://fracfocus.org/>. Accessed July 12, 2013.
- FracFocus. 2013b. Hydraulic fracturing: The process. Online at <http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process>. Accessed September 9, 2013.
- FracTracker. 2013. Exploring data, sharing perspectives, and mapping impacts of the oil and gas industry. Online at <http://www.fractracker.org/>. Accessed September 9, 2013.
- Freyman, M., and R. Salmon. 2013. Hydraulic fracturing & water stress: Growing competitive pressures for water. Ceres. Online at http://www.circleofblue.org/waternews/wp-content/uploads/2013/05/Ceres_Fracking_Water_042613.pdf. Accessed August 24, 2013.
- Galbraith, K. 2012. Seeking disclosure on fracking. *The New York Times*. May 30. Online at http://www.nytimes.com/2012/05/31/business/energy-environment/seeking-disclosure-on-fracking.html?_r=1. Accessed September 9, 2013.
- Garvin, S.M. 2011. Letter to Michael Krancer, acting secretary, Pennsylvania Department of Environmental Protection. March 7. Online at http://www.epa.gov/region3/marcellus_shale/PADEP_Marcellus_Shale_030711.pdf. Accessed August 20, 2013.
- Gasland. 2013. Fracking FAQs. Online at <http://www.gaslandthemovie.com/whats-fracking>. Accessed July 10, 2013.
- Gilbert, D., and R. Gold. 2012. EPA backpedals on fracking contamination. *The Wall Street Journal*. April 1. Online at <http://online.wsj.com/article/SB10001424052702303404704577313741463447670.html#articleTabs%3Darticle>. Accessed September 9, 2013.
- Gilmer, E.M. 2013. Fracking trade secrets would get no protection under draft Alaska rule. *EnergyWire*, January 3. Online at <http://www.eenews.net/stories/1059974249>. Accessed September 9, 2013.
- Gold, R. 2013. Well sealing cited in leaks, not fracking. *The Wall Street Journal*. June 25. Online at <http://online.wsj.com/article/SB10001424127887323998604578567853193607238.html>. Accessed July 3, 2013.
- Goldenberg, S. 2013. A Texan tragedy: Ample oil, no water. *The Guardian*. August 11. Online at <http://www.theguardian.com/environment/2013/aug/11/texas-tragedy-ample-oil-no-water>. Accessed August 28, 2013.
- Google Trends. 2013a. Web search interest: Fracking. United States, Jan 2008–Jun 2013. Online at <http://www.google.com/trends/explore?q=fracking#q=fracking&geo=US&date=1%2F2008%2066m&cmpt=q>. Accessed June 7, 2013.
- Google Trends. 2013b. Web search interest: Fracking, hydraulic fracturing. United States, Jan 2008–Jun 2013. Online at <http://www.google.com/trends/explore?q=fracking#q=fracking%20%20hydraulic%20fracturing&geo=US&date=1%2F2008%2066m&cmpt=q>. Accessed June 12, 2013.
- Government Accountability Office (GAO). 2012. *Oil and gas. Information on shale resources, development, and environmental and public health risks*. GAO-12-732. September. Accessed September 14, 2013.
- Government Accountability Office (GAO). 2005. *Storm water pollution. Information needed on the implications of permitting oil and gas construction activities*. GAO-05-240. February. Online at <http://www.gao.gov/assets/250/245272.pdf>. Accessed September 14, 2013.
- Greene, S. 2008. Oil secret has nasty side effect. *The Denver Post*. July 24. Online at http://www.denverpost.com/news/ci_9976257. Accessed September 9, 2013.
- Gregory, K.B., R.D. Vidic, and D.A. Dzombak. 2011. Water management challenges associated with the production of shale gas by hydraulic fracturing. *Elements* 7(3):181–186. The Mineralogical Society of America. doi: 10.2113/gselements.7.3.181. Online at <http://elements.geoscienceworld.org/content/7/3/181.abstract>. Accessed September 9, 2013.

- Groat, C.G., and T.W. Grimshaw. 2012. *Fact-based regulation for environmental protection in shale gas development*. Austin, TX: The Energy Institute. University of Texas. February. Online at http://www.velaw.com/UploadedFiles/VEsite/Resources/ei_shale_gas_reg_summary1202%5B1%5D.pdf. Accessed August 26, 2013.
- Hall, K.B. 2013. Hydraulic fracturing: Trade secrets and the mandatory disclosure of fracturing water composition. *Idaho Law Review* 49:399–435. Online at <http://www.uidaho.edu/~lmedia/Files/orgs/Law/law-review/2013-symposium/Hydraulic-Fracturing-Trade-Secrets.ashx>. Accessed August 20, 2013.
- Hallowich, Stephanie and Chris Hallowich v. Range Resources Corporation; Williams Gas/Laurel Mountain Midstream; Markwest Energy Partners, LP; Markwest Energy Group, LLC; and Pennsylvania Department of Environmental Protection. 2011. In the Court of the Common Pleas of Washington County, Pennsylvania. Civil Division. Transcript. Online at <http://ae3b703522cf9ac6c40a-32964bea949fe02d45161cf7095bfea9.r89.cf2.rackcdn.com/2013/211/626/pg-settlement-hearing-transcript.pdf>. Accessed August 27, 2013.
- Haluszczak, L.O., A.W. Rose, and L.R. Kump. 2012. Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. *Applied Geochemistry* 28:55–61. Online at <http://www.sciencedirect.com/science/article/pii/S0883292712002752>. Accessed September 14, 2013.
- Hamburger, T., and A.C. Miller. 2004a. Investigation of drilling regulations is urged. *Los Angeles Times*. October 15. Online at <http://www.latimes.com/news/nationworld/la-na-frac15oct15,1,3468974.story>. Accessed September 14, 2013.
- Hamburger, T., and A.C. Miller. 2004b. Halliburton's interests assisted by White House. *Los Angeles Times*. October 14. Online at <http://articles.latimes.com/2004/oct/14/nation/na-frac14>. Accessed August 30, 2013.
- Hamilton, J. 2012. Town's effort to link fracking and illness falls short. National Public Radio. May 16. Online at <http://www.npr.org/2012/05/16/152204584/towns-effort-to-link-fracking-and-illness-falls-short>. Accessed June 26, 2013.
- Harrison, S.S. 1985. Contamination of aquifers by overpressuring the annulus of oil and gas wells. *Groundwater* 23(3):317–324. May–June. Online at <https://info.ngwa.org/GWOL/pdf/851535002.PDF>. Accessed September 14, 2013.
- Harrison, S.S. 1983. Evaluating system for ground-water contamination hazards due to gas-well drilling on the glaciated Appalachian Plateau. *Groundwater* 21(6):689–700. Online at <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.1983.tb01940.x/abstract>. Accessed September 14, 2013.
- Hastings, M. 2011. Another runaway general: Army deploys psy-ops on U.S. senators. *Rolling Stone*. February 23. Online at <http://www.rollingstone.com/politics/news/another-runaway-general-army-deploys-psy-ops-on-u-s-senators-20110223>. Accessed September 14, 2013.
- Helms, L. 2012. Director's cut. NDIC Department of Mineral Resources. December 17. Online at <https://www.dmr.nd.gov/oilgas/directorscut/directors-cut-2012-12-17.pdf>. Accessed August 24, 2013.
- Hopey, D. 2011. Range Resources, Mount Pleasant Township at odds over well sites. *Pittsburgh Post-Gazette*. April 6. Online at <http://www.post-gazette.com/stories/local/state/range-resources-mount-pleasant-township-at-odds-over-well-sites-292252/>. Accessed September 14, 2013.
- Horn, S. 2013. "Frackademia" strikes again at USC with "Powering California" study release. *DeSmogBlog*. March 14. Online at <http://www.desmogblog.com/2013/03/14/frackademia-strikes-again-usc-powering-california-study>. Accessed September 14, 2013.
- Horn, S. 2012. Frackademia: Controversial SUNY Buffalo Shale Institute's reputation unraveling. *DeSmog Blog*. October 11. Online at <http://www.desmogblog.com/2012/09/19/frackademia-the-brewing-suny-buffalo-shale-resources-society-institute-storm>. Accessed August 31, 2013.
- Howarth, R., D. Shindell, R. Santoro, A. Ingraffea, N. Phillips, and A. Townsend-Small. 2012. Methane emissions from natural gas systems. Background paper for the National Climate Assessment (NCA). Reference no. 2011-0003. Online at <http://www.eeb.cornell.edu/howarth/Howarth%20et%20al.%20--%20National%20Climate%20Assessment.pdf>. Accessed September 14, 2013.
- Hunt, S. 2013. Hauler illegally dumped fracking waste, state says. *The Columbus Dispatch*. June 5. Online at <http://www.dispatch.com/content/stories/local/2013/06/05/hauler-illegally-dumped-fracking-waste-state-says.html>. Accessed August 24, 2013.
- Independent Oil & Gas Association of New York (IOGANY). 2013. Letter to Hon. Andrew M. Cuomo. April 22. Online at <http://www.scribd.com/doc/137334508/Letter-from-IOGA-of-New-York-to-Governor-Andrew-Cuomo-Regarding-Natural-Gas-Development>. Accessed September 6, 2013.
- Intermountain Oil and Gas BMP Project. 2012. Summary of groundwater sampling rules. Online at <http://www.oilandgasbmps.org/workshops/COGCCgroundwater/Summary%20table%20of%20State%20Water%20Sampling%2011%2021%2012.pdf>. Accessed September 14, 2013.
- Jackson, R.B., A. Vengosh, T.H. Darrah, N.R. Warner, A. Down, R.J. Poreda, S.G. Osborn, K. Zhao, and J.D. Kan. 2013. Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *Proceedings of the National Academy of Sciences* 110(28):11250–11255. doi:10.1073/pnas.1221635110. Online at <http://www.pnas.org/content/early/2013/06/19/1221635110.full.pdf+html>. Accessed August 21, 2013.
- Jacquet, J.B. 2013. Risks to communities from shale gas development. Presented at the Workshop on Risks of Unconventional Shale Gas Development, May 30–31, Washington, DC. National Research Council. Online at http://sites.nationalacademies.org/xpiedi/groups/dbasesite/documents/webpage/dbase_083401.pdf. Accessed September 15, 2013.
- Javers, E. 2011. Oil executive: Military-style "psy ops" experience applied. CNBC. November 8. Online at <http://www.cnbc.com/id/45208498>. Accessed September 15, 2013.
- Kahan, D. 2013. Science literacy & cultural polarization: It doesn't happen *just* with global warming, but it also doesn't happen for *all* risks. Why? The Cultural Cognition Project at Yale Law School. June 13. Online at <http://www.culturalcognition.net/blog/2013/6/13/science-literacy-cultural-polarization-it-doesnt-happen-just.html>. Accessed July 12, 2013.
- Kargbo, D.M., R.G. Wilhelm, and D.J. Campbell. 2010. Natural gas plays in the Marcellus Shale: Challenges and potential opportunities. *Environmental Science & Technology* 44:5679–5684. Online at <http://pubs.acs.org/doi/pdf/10.1021/es903811p>. Accessed September 15, 2013.
- Kelly, S. 2013a. Faster drilling, diminishing returns in shale plays nationwide? *DeSmogBlog.com*. April 29. Online at <http://www.desmogblog.com/2013/04/29/faster-drilling-lower-returns-shale-plays-nationwide>. Accessed August 24, 2013.
- Kelly, S. 2013b. Another Pennsylvania wastewater treatment plant accused of illegally disposing radioactive fracking waste. *DeSmogBlog.com*. July 18. Online at <http://www.desmogblog.com/2013/07/17/another-pennsylvania-wastewater-treatment-plant-accused-illegally-disposing-fracking-radioactive-waste>. Accessed August 24, 2013.
- Kelsey, T.W., M. Shields, J.R. Ladlee, M. Ward, T.L. Brundage, L.L. Michael, and T.B. Murphy. 2012. *Economic impacts of Marcellus Shale in Bradford County: Employment and income in 2010*. Marcellus Shale Education & Training Center. January. Online at http://www.marcellus.psu.edu/resources/PDFs/EI_Bradford.pdf. Accessed August 21, 2013.

- Kemball-Cook, S., A. Bar-Ilan, J. Grant, L. Parker, J. Jung, W. Santamaria, J. Mathews, and G. Yarwood. 2010. Ozone impacts of natural gas development in the Haynesville Shale. *Environmental Science & Technology* 44(24):9357–9363. Online at <http://pubs.acs.org/doi/abs/10.1021/es1021137>. Accessed September 15, 2013.
- Keranen, K.M., H.M. Savage, G.A. Abers, and E.S. Cochran. 2013. Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 M_w 5.7 earthquake sequence. *Geology* 41(6):699–702. doi:10.1130/G34045.1. Online at <http://geology.gsapubs.org/content/early/2013/03/26/G34045.1.abstract>. Accessed September 15, 2013.
- King, G.E. 2012. Hydraulic fracturing 101: What every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells. SPE 152596. Society of Petroleum Engineers. Online at http://fracfocus.org/sites/default/files/publications/hydraulic_fracturing_101.pdf. Accessed August 24, 2013.
- Kiparsky, M., and J.F. Hein. 2013. *Regulation of hydraulic fracturing in California: A wastewater and water quality perspective*. Wheeler Institute for Water Law and Policy. University of California Berkeley School of Law. April. Online at http://www.law.berkeley.edu/files/ccelp/Wheeler_Hydraulic_Fracturing_April2013.pdf. Accessed August 21, 2013.
- Klopott, F. 2013. N.Y. Senate fracking backer tied to firm with gas lease. Bloomberg. May 9. Online at <http://mobile.bloomberg.com/news/2013-05-09/n-y-senate-fracking-backer-tied-to-firm-with-gas-lease.html>. Accessed September 15, 2013.
- Konschnik, K., M. Holden, and A. Shasteen. 2013. *Legal fractures in chemical disclosure laws. Why the voluntary chemical disclosure registry FracFocus fails as a regulatory compliance tool*. Harvard Law School. Environmental Law Program. April 23. Online at <http://blogs.law.harvard.edu/environmentallawprogram/files/2013/04/4-23-2013-LEGAL-FRACTURES.pdf>. Accessed September 15, 2013.
- Krauss, C. 2011. In North Dakota, flames of wasted natural gas light the prairie. *The New York Times*. September 26. Online at http://www.nytimes.com/2011/09/27/business/energy-environment/in-north-dakota-wasted-natural-gas-flickers-against-the-sky.html?_r=2&. Accessed July 17, 2013.
- Kresse, T.M., N.R. Warner, P.D. Hays, A. Down, A. Vengosh, and R.B. Jackson. 2012. *Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas, 2011*. United States Geological Survey. Scientific investigations report 2012-5273. Online at <http://pubs.usgs.gov/sir/2012/5273/sir2012-5273.pdf>. Accessed September 15, 2013.
- Kusnetz, N. 2012. North Dakota turns blind eye to dumping of fracking waste in waterways and farmland. *InsideClimate News*. June 8. Online at <http://insideclimatenews.org/news/20120608/oil-companies-north-dakota-boom-gas-drilling-fracking-wastewater-waterways-pollution-dumping-grounds>. Accessed August 24, 2013.
- Kusnetz, N. 2011. Fracking chemicals cited in congressional report stay underground. ProPublica. April 18. Online at <http://www.propublica.org/article/fracking-chemicals-cited-in-congressional-report-stay-underground>. Accessed September 15, 2013.
- Legal Environmental Assistance Foundation, Inc. v. United States Environmental Protection Agency*. 1997. U.S. Court of Appeals for the Eleventh Circuit. No. 00-10381. Online at http://www.epa.gov/ogwdw/uic/pdfs/cbmstudy_attach_uic_11th_circuit_decision.pdf. Accessed August 20, 2013.
- Legere, L. 2011. Cabot argues to resume drilling in Dimock as tests show surges of methane in water wells. *The Scranton Times-Tribune*. October 19. Online at <http://thetimes-tribune.com/news/gas-drilling/cabot-argues-to-resume-drilling-in-dimock-as-tests-show-surges-of-methane-in-water-wells-1.1220204#axzz1fmqcRIJc>. Accessed September 15, 2013.
- Levy, M. 2011. Fracking towns see crime, carousing surge amid gas boom. *York Daily Record*. October 27. Online at http://www.ydr.com/ci_19201110. Accessed September 15, 2013.
- Licata, A. 2009. Natural gas drilling threatens trout in Pennsylvania (and other Appalachian states). *Field & Stream*. July 24. Online at <http://www.fieldandstream.com/articles/fishing/trout-fishing/where-fish-trout/2009/07/natural-gas-extraction-threatens-appalachian>. Accessed August 25, 2013.
- Lipsky, Steven and Shyla vs. Durant, Carter, Coleman, LLC et al.* 2012. 43rd Judicial District. Parker County, Texas. February 16. Online at <http://www.barnetshalenews.com/documents/2012/legal/Court%20Order%20Denial%20of%20Lipsky%20Motion%20to%20Dismiss%20Range%20Counterclaim%202-16-2012.pdf>. Accessed July 10, 2013.
- Liroff, R.A. 2011. *Extracting the facts: An investor guide to disclosing risks from hydraulic fracturing operations*. Interfaith Center on Corporate Responsibility and Investor Environmental Health Network. Falls Church, VA. Online at <http://www.iehn.org/publications/reports/frackguidance.php>. Accessed September 15, 2013.
- Lustgarten, A. 2013. EPA's abandoned Wyoming fracking study one retreat of many. ProPublica. July 3. Online at <http://stateimpact.npr.org/texas/2013/07/03/epas-abandoned-wyoming-fracking-study-one-retreat-of-many/>. Accessed September 15, 2013.
- Lustgarten, A. 2009. Officials in three states pin water woes on gas drilling. ProPublica. April 26. Online at <http://www.propublica.org/article/officials-in-three-states-pin-water-woes-on-gas-drilling-426>. Accessed September 15, 2013.
- Lutz, B.D., A.N. Lewis, and M.W. Doyle. 2013. Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development. *Water Resources Research* 49(2):647–656. Online at <http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20096/abstract?deniedAccessCustomisedMessage=&userIsAuthenticated=false>. Accessed September 15, 2013.
- Lyman, S., and H. Shorthill, 2013. *2012 Uintah Basin winter ozone & air quality study. Final report*. Document no. CRD13-320.32. Commercialization and Regional Development. Utah State University. February 1. Online at http://rd.usu.edu/files/uploads/ubos_2011-12_final_report.pdf. Accessed September 15, 2013.
- Macmillan, L. 2013. A snapshot of drilling on a park's margin. *The New York Times*. March 1. Online at http://green.blogs.nytimes.com/2013/03/01/a-snapshot-of-drilling-on-a-parks-margins/?_r=0. Accessed August 25, 2013.
- Magyar, R. 2010. Ex-Penn State professor receives more oil & gas industry funding. Examiner.com. August 17. Online at <http://www.examiner.com/article/ex-penn-state-professor-receives-more-oil-gas-industry-funding>. Accessed September 15, 2013.
- Manning, R. 2013. Bakken business: The price of North Dakota's fracking boom. *Harper's Magazine*. March. Online at <http://harpers.org/archive/2013/03/bakken-business/>. Accessed September 15, 2013.
- Martin, M. 2012. The boom and bust of fracking. National Public Radio. December 13. Online at <http://www.npr.org/2012/12/13/167165906/the-boom-and-bust-of-fracking>. Accessed August 20, 2013.
- Maryland. 2013. Senate Bill 854. Environment—gas and oil drilling—financial assurance. February 7. Online at <http://mgaleg.maryland.gov/2013RS/bills/sb/sb0854f.pdf>. Accessed September 4, 2013.
- Maryland Department of the Environment (MDE). 2013. Marcellus Shale safe drilling initiative. Online at <http://www.mde.state.md.us/programs/land/mining/marcellus/pages/index.aspx>. Accessed August 21, 2013.
- Massachusetts Institute of Technology (MIT). No date. *The future of natural gas: An interdisciplinary MIT study*. Online at http://mitei.mit.edu/system/files/NaturalGas_Report.pdf. Accessed August 26, 2013.

- Mauter, M.S. 2013. Operational risk issues in shale gas development: Response to “Understanding and mitigating risks associated with well construction and hydraulic fracturing.” Presented at the Workshop on Risks of Unconventional Shale Gas Development, May 30–31, Washington, DC. National Research Council. Online at http://sites.nationalacademies.org/xpdiol/groups/dbassessite/documents/webpage/dbasse_083465.pdf. Accessed September 15, 2013.
- McCurdy, S.E. 2012. Silica sand processing—water quantity and quality. Presented at Conference on the Silica Sand Resources of Minnesota and Wisconsin, October 1–3, Brooklyn Park, MN. *Program and Abstracts* 97–106. Precambrian Research Center, University of Minnesota and Society for Mining, Metallurgy & Exploration. Online at <http://www.d.umn.edu/prc/workshops/12%20SS%20Workshop/Program%20AbstractsC.pdf>. Accessed September 15, 2013.
- McDonnell, T. 2012. Fracking 101: The cozy relationship between the natural-gas industry and academic researchers. *The Atlantic*. July 30. Online at <http://www.theatlantic.com/technology/archive/2012/07/fracking-101-the-cozy-relationship-between-the-natural-gas-industry-and-academic-researchers/260501/>. Accessed September 15, 2013.
- McFeeley, M. 2013. Three reasons why the Obama administration shouldn't use FracFocus.org in its new fracking disclosure rule. Switchboard, Natural Resources Defense Council. April 10. Online at http://switchboard.nrdc.org/blogs/mcfeeley/three_reasons_why_the_obama_ad.html. Accessed September 15, 2013.
- McKenzie, L.M., R.Z. Witter, L.S. Newman, and J.L. Adgate. 2012. Human health risk assessment of air emissions from development of unconventional natural gas resources. *Science of the Total Environment* 424: 79–87. doi:10.1016/j.scitotenv.2012.02.018. Online at <http://icogg.state.co.us/library/setbackstakeholdergroup/Presentations/Health%20Risk%20Assessment%20of%20Air%20Emissions%20From%20Unconventional%20Natural%20Gas%20-%20HMcKenzie2012.pdf>. Accessed September 15, 2013.
- McLeod, R. 2011. \$and dollars—Mining frac sand in the River Valley. *Big River Magazine*. July–August. Online at <http://www.bigrivermagazine.com/fracsand.pdf>. Accessed August 25, 2013.
- Michaels, C., J.L. Simpson, and W. Wegner. 2010. *Fractured communities: Case studies of the environmental impacts of industrial gas drilling*. Riverkeeper. September. Online at <http://www.riverkeeper.org/wp-content/uploads/2010/09/Fractured-Communities-FINAL-September-2010.pdf>. Accessed September 15, 2013.
- Michigan. 2010. *Michigan's oil and gas regulations*. Michigan Department of Environmental Quality. Online at <http://cdm16110.contentdm.oclc.org/cdm/ref/collection/p16110coll2/id/30266>. Accessed August 20, 2013.
- Michigan Department of Environmental Quality (MDEQ). 2013a. Hydraulic fracturing of oil and gas wells in Michigan. April 20. Online at http://www.michigan.gov/documents/deq/Hydraulic_Fracturing_In_Michigan_423431_7.pdf. Accessed August 1, 2013.
- Michigan Department of Environmental Quality (MDEQ). 2013b. Questions and answers about hydraulic fracturing in Michigan. Online at http://www.michigan.gov/documents/deq/deq-FINAL-frack-QA_384089_7.pdf. Accessed June 13, 2013.
- Minnesota Department of Health. 2009. Wellhead protection issues related to mining activities. August. Online at <http://www.health.state.mn.us/divs/eh/water/swp/mining.pdf>. Accessed September 15, 2013.
- Minnesota Environmental Quality Board. 2013. *Report on silica sand. Final report*. State of Minnesota Department of Natural Resources, Division of Ecological and Water Resources. March 20. Online at <http://www.eqb.state.mn.us/documents/23.%20March%20Final%20Silica%20Sand%20report.pdf>. Accessed September 15, 2013.
- Molofsky, L.J., J.A. Connor, A.S. Wylie, T. Wagner, and S.K. Farhat. 2013. Evaluation of methane sources in groundwater in northeastern Pennsylvania. *Groundwater* 51(3):333–349. Online at <http://onlinelibrary.wiley.com/doi/10.1111/gwat.12056/pdf>. Accessed September 15, 2013.
- Mooney, C. 2011. The truth about fracking. *Scientific American*. October 19. Online at <http://www.scientificamerican.com/article.cfm?id=the-truth-about-fracking>. Accessed August 31, 2013.
- Moore, C.W., B. Zielinska, and R.B. Jackson. 2013. Air impacts of shale gas extraction and distribution. Presented at Workshop on Risks of Unconventional Shale Gas Development, May 30–31, Washington, DC. Online at http://sites.nationalacademies.org/DBASSE/BECS/DBASSE_083187. Accessed September 15, 2013.
- Myers, T. 2012. Potential contaminant pathways from hydraulically fractured shale to aquifers. *Groundwater* 50(6):872–882. Online at <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.2012.00933.x/abstract>. Accessed September 15, 2013.
- National Academy of Sciences. 2013. Workshop on risks of unconventional shale gas development. May 30–31. Online at http://sites.nationalacademies.org/DBASSE/BECS/DBASSE_083187#.Ud3KEG3fLYg. Accessed July 10, 2013.
- National Energy Technology Laboratory (NETL). 2010. *Cost and performance baseline for fossil energy plants, Volume 1: Bituminous coal and natural gas to electricity*. Revision 2. November. DOE/NETL-2010/1397. United States Department of Energy. Online at http://www.netl.doe.gov/energy-analyses/pubs/BitBase_FinRep_Rev2.pdf. Accessed August 21, 2013.
- National Energy Technology Laboratory (NETL). 2009. *Modern shale gas development in the United States: A Primer*. United States Department of Energy. April. Online at http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf. Accessed August 21, 2013.
- National Park Service (NPS). 2008. *Potential development of the natural gas resources in the Marcellus Shale. New York, Pennsylvania, West Virginia, and Ohio*. December. Online at http://www.nps.gov/frhi/parkmgmt/upload/GRD-M-Shale_12-11-2008_high_res.pdf. Accessed August 20, 2013.
- National Public Radio (NPR). 2012. The fracking boom: Missing answers. Special series. August 2, 2011 to May 15, 2012. Online at <http://www.npr.org/series/151930969/science-and-the-fracking-boom-missing-answers>. Accessed June 26, 2013.
- National Research Council. 2013. Induced seismicity potential in energy technologies. Washington, DC: The National Academies Press. Online at http://www.nap.edu/catalog.php?record_id=13355#. Accessed September 15, 2013.
- Natural Resources Defense Council (NRDC). 2013. New York town repeals fracking gag order after free speech lawsuit. Press release, April 17. Online at <http://www.nrdc.org/medial/2013/130417.asp>. Accessed September 15, 2013.
- Natural Resources Defense Council (NRDC). 2012. Comments on proposed rule on oil and gas; well stimulation, including hydraulic fracturing, on federal and state lands. September 10. Online at http://docs.nrdc.org/energy/files/ene_12091101a.pdf. Accessed September 15, 2013.
- Nationwide Mutual Insurance Company. 2012. Nationwide statement regarding concerns about hydraulic fracturing. Press release, July 13. Online at <http://www.nationwide.com/about-us/071312-nw-statement-on-fracking.jsp>. Accessed July 12, 2013.
- Navarro, M. 2012a. Institute's gas drilling report leads to claims of bias and concern for a university's image. *The New York Times*. June 11. Online at http://www.nytimes.com/2012/06/12/nyregion/university-at-buffalo-faces-scrutiny-over-gas-drilling-report.html?_r=1&. Accessed September 15, 2013.

- Navarro, M. 2012b. SUNY Buffalo shuts down its institute on drilling. *The New York Times*. November 19. Online at http://www.nytimes.com/2012/11/20/nyregion/suny-buffalo-will-end-controversial-fracking-institute.html?_r=3&. Accessed September 15, 2013.
- New Mexico Oil Conservation Division (NMOCD). 2008. Cases where pit substances contaminated New Mexico's ground water. September 12. Online at <http://www.emmrd.state.nm.us/ocd/documents/GWImpactPublicRecordsSixColumns20081119.pdf>. Accessed August 20, 2013.
- New York State Department of Environmental Conservation (NYSDEC). 2011. *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program. Well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus Shale and other low-permeability gas reservoirs*. September 30. Preliminary revised draft. Online at <http://www.dec.ny.gov/data/dmn/ogprdsgeisfull.pdf>. Accessed August 21, 2013.
- New York Times, The. 2011. Documents: Leaked industry e-mails and reports. Drilling down. Online at http://www.nytimes.com/interactive/us/natural-gas-drilling-down-documents-4.html?_r=0#document/p86/a24469. Accessed August 24, 2013.
- Nicot, J.P., R.C. Reedy, R.A. Costley, and Y Huang. 2012. *Oil & gas water use in Texas: Update to the 2011 mining water use report*. Prepared for the Texas Oil & Gas Association, Austin, Texas. September. Online at http://www.twdb.state.tx.us/publications/reports/contracted_reports/doc/0904830939_2012Update_MiningWaterUse.pdf. Accessed September 15, 2013.
- Nicot, J.P., and B.R. Scanlon. 2012. Water use for shale-gas production in Texas, U.S. *Environmental Science & Technology* 46(6):3580–3586. Online at <http://pubs.acs.org/doi/abs/10.1021/es204602t>. Accessed September 15, 2013.
- North Dakota. 2013. Oil and gas frequently asked questions. Online at <https://cms.oilresearch.nd.gov/image/cache/bg-015-033-faq.pdf>. Accessed June 13, 2013.
- Obeiter, M. 2012. How the EPA's new oil and gas standards will reduce greenhouse gas emissions. WRI Insights. May 9. Online at <http://insights.wri.org/news/2012/05/how-epas-new-oil-and-gas-standards-will-reduce-greenhouse-gas-emissions>. Accessed September 15, 2013.
- Occupational Safety & Health Administration (OSHA). 2013. Statement of Dr. David Michaels, assistant secretary of labor. Crystalline silica notice of proposed rulemaking. August 23. Online at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=24615. Accessed August 25, 2013.
- Occupational Safety & Health Administration (OSHA) and the National Institute of Occupational Safety and Health. 2012. Worker exposure to silica dust during hydraulic fracturing. *OSHA-NIOSH Hazard Alert*. June. Online at https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.pdf. Accessed August 16, 2013.
- Ohio Department of Natural Resources, Division of Mineral Resources Management. 2008. *Report on the investigation of the natural gas invasion of aquifers in Bainbridge Township of Geauga County, Ohio*. September 1. Online at http://s3.amazonaws.com/propublica/assets/natural_gas/ohio_methane_report_080901.pdf. Accessed September 15, 2013.
- Ohio Shale Coalition. 2012. *An analysis of the economic potential for shale formations in Ohio. Prepared by faculty and staff from the following universities: Cleveland State University, The Ohio State University, Marietta College*. Online at http://urban.csuohio.edu/publications/center/center_for_economic_development/Ec_Impact_Ohio_Utica_Shale_2012.pdf. Accessed August 26, 2013.
- Oil and Gas Accountability Project (OGAP). 2005. *Our drinking water at risk. What EPA and the oil and gas industry don't want us to know about hydraulic fracturing*. Earthworks. April. Online at <http://www.earthworkSACTION.org/files/publications/DrinkingWaterAtRisk.pdf>. Accessed August 21, 2013.
- Olmstead, S.M., L.A. Nuehlenbachs, J.S. Shih, Z. Chu, and A.J. Krupnick. 2013. Shale gas development impacts on surface water quality in Pennsylvania. *Proceedings of the National Academy of Sciences* 110(13):4962–4967. doi:10.1073/pnas.1213871110. Online at <http://www.pnas.org/content/early/2013/03/06/1213871110.full.pdf+html>. Accessed September 15, 2013.
- Osborn, S.G., A. Vengosh, N.R. Warner, and R.B. Jackson. 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proceedings of the National Academy of Sciences* 108(20):8172–8176. Online at <http://www.nicholas.duke.edu/cgcp/pnas2011.pdf>. Accessed September 15, 2013.
- Papoulias, D., and A. Velasco. 2013. Histopathological analysis of fish from Acorn Fork Creek, Kentucky, exposed to hydraulic fracturing fluid releases. *Southeastern Naturalist* 12(4):92–111. Online at <http://www.eaglehill.us/SENAonline/articles/SENA-sp-4/18-Papoulias.shtml>. Accessed August 30, 2013.
- Payne, J. 2012. Fracking update. Dallas Bar Association. May. Online at <http://www.dallasbar.org/content/fracking-update>. Accessed September 15, 2013.
- Pennsylvania Department of Environmental Protection (PADEP). 2011. *Northeastern Pennsylvania Marcellus Shale short-term ambient air sampling report*. January 12. Accessed August 20, 2013.
- Pennsylvania Department of Environmental Protection (PADEP). 2009. Accessed September 15, 2013.
- Pennsylvania Department of Environmental Protection (PADEP). 2000. *Pennsylvania's plan for addressing problem abandoned wells and orphaned wells*. Document no. 550-0800-001. April 10. Online at <http://www.elibrary.dep.state.pa.us/dsweb/Get/Version-48262/>. Accessed August 20, 2013.
- Pennsylvania Office of Oil and Gas Management (OOGM). 2013. Public resources. Proposed oil and gas surface regulations. Pennsylvania Department of Environmental Protection. Online at http://www.portal.state.pa.us/portal/server.pt/community/public_resources/20303. Accessed June 13, 2013.
- Perry, S.L. 2012a. Addressing the societal costs of unconventional oil and gas exploration and production: A framework for evaluating short-term, future, and cumulative risks and uncertainties of hydrofracking. *Environmental Practice* 14(4):352–65. December. Online at <http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8789189>. Accessed September 15, 2013.
- Perry, S.L. 2012b. Development, land use, and collective trauma: The Marcellus Shale gas boom in rural Pennsylvania. *Culture, Agriculture, Food, and Environment* 34(1):80–90. June. Online at <http://onlinelibrary.wiley.com/doi/10.1111/j.2153-9561.2012.01066.x/pdf>. Accessed September 15, 2013.
- Petron, G., G. Frost, B.R. Miller, A.I. Hirsch, S.A. Montzka, A. Karion, M. Trainer, C. Sweeney, A.E. Andrews, L. Miller, J. Kofler, A. Bar-Ilan, E.J. Dlugokencky, L. Patrick, C.T. Moore, Jr., T.B. Ryerson, C. Siso, W. Kolodzey, P.M. Lang, T. Conway, P. Novelli, K. Masarie, B. Hall, D. Guenther, D. Kitzis, J. Miller, D. Welsh, D. Wolfe, W. Neff, and P. Tans. 2012. Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. *Journal of Geophysical Research: Atmospheres* 117(D4). doi:10.1029/2011JD016360. Online at http://www.fossil.energy.gov/programs/gasregulation/authorizations/2013_applications/SC_Ex_13_04_lngPart_2.pdf. Accessed September 15, 2013.
- Pew Internet. 2013. Trend data (adults). Demographics of Internet users. Pew Research Center. Online at <http://www.pewinternet.org/Static-Pages/Trend-Data-%28Adults%29/Whos-Online.aspx>. Accessed June 10, 2013.

- Phillips, S. 2012. Pennsylvania doctors worry over fracking “gag rule”. National Public Radio. May 17. Online at <http://www.npr.org/2012/05/17/152268501/pennsylvania-doctors-worry-over-fracking-gag-rule>. Accessed September 15, 2013.
- Phillips, S. 2011. Burning question: What would life be like without the Halliburton loophole? StateImpact. Pennsylvania. National Public Radio. December 5. Online at <http://stateimpact.npr.org/pennsylvania/2011/12/05/burning-question-what-would-life-be-like-without-the-halliburton-loophole/>. Accessed September 15, 2013.
- Plushnick-Masti, R. 2013. EPA changed course after oil company protested. Associated Press. January 16. Yahoo! News. Online at <http://news.yahoo.com/epa-changed-course-oil-company-protested-082012084.html>. Accessed September 15, 2013.
- Powering California. 2013. *The Monterey Shale & California's economic future*. A research study conducted by the USC Price School of Public Policy, USC Global Energy Network, University of Southern California in association with The Communications Institute. Los Angeles. Online at http://communicationsinstitute.org/Monterey_Shale_Report_Final_130328.pdf. Accessed August 26, 2013.
- Public Accountability Initiative (PAI). 2013. *Fracking and the revolving door in Pennsylvania*. February. Online at <http://public-accountability.org/wp-content/uploads/Fracking-and-the-Revolving-Door-in-Pennsylvania.pdf>. Accessed August 27, 2013.
- Rahm, B.G., and S.J. Riha. 2011. Toward strategic management of shale gas development: Regional, collective impacts on water resources. *Environmental Science & Policy* 17:12–23. Online at <http://cce100.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/ESP%20Strategic%20Management%202012.pdf>. Accessed September 16, 2013.
- Railroad Commission of Texas. 2012. Railroad commissioners: “EPA’s vacate order in Range case confirms Railroad Commission findings based on scientific evidence.” Press release, March 30. Online at <http://www.rrc.state.tx.us/pressreleases/2012/033012.php>. Accessed August 20, 2013.
- Redden, M. 2013. Scott Walker’s sand grab: Wisconsin wants a piece of the fracking boom, no matter who gets hurt. *New Republic*. August 21. Online at <http://www.newrepublic.com/article/114320/frac-sand-mining-wisconsin-rides-fracking-boom>. Accessed August 25, 2013.
- Rendell, E. 2013. Why Cuomo must seize the moment on hydrofracking. *New York Daily News*. March 27. Online at <http://www.nydailynews.com/opinion/yes-fracking-n-y-article-1.1299789>. Accessed September 16, 2013.
- Richardson, N., M. Gottlieb, A. Krupnick, and H. Wiseman. 2013. *The state of state shale gas regulation*. Washington, DC: Resources for the Future. June. Online at http://www.rff.org/rffdocuments/RFF-Rpt-StateofStateRegs_Report.pdf. Accessed September 16, 2013.
- Rodriguez, G., and C. Ouyang. 2013. *Air emissions characterization and management for natural gas hydraulic fracturing operations in the United States*. Ann Arbor, MI: University of Michigan. Graduate master’s project report. April. Online at http://deepblue.lib.umich.edu/bitstream/handle/2027.42/97418/Air%20Emissions%20Hydraulic%20Fracturing_04-23-2013.pdf?sequence=1. Accessed September 16, 2013.
- Rosenfeld, S. 2012. Towns that dare to face up to fracking industry pay a hefty price. *AlterNet*. October 19. Online at <http://www.alternet.org/fracking/towns-dare-face-fracking-industry-pay-hefty-price>. Accessed September 16, 2013.
- Ross, D. 2013. Common topics and commonplaces of environmental rhetoric. *Written Communication* 30(1):91–131. January. Online at <http://wxc.sagepub.com/content/30/1/91>. Accessed September 16, 2013.
- Rowan, E.L., M.A. Engle, C.S. Kirby, and T.F. Kraemer. 2011. *Radium content of oil- and gas-field produced waters in the northern Appalachian Basin (USA): Summary and discussion of data*. U.S. Geological Survey. Scientific investigations report 2011–5135. Online at <http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf>. Accessed September 16, 2013.
- Royal Society, The, and The Royal Academy of Engineering. 2012. *Shale gas extraction in the UK: A review of hydraulic fracturing*. June. Online at http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/shale-gas/2012-06-28-Shale-gas.pdf. Accessed September 16, 2013.
- Royte, E. 2013. This is your town on fracking. *OnEarth*. Online at <http://www.onearth.org/articles/2013/07/fracking-boom-brings-pollution-health-problems-drunken-driving-and-other-problems-t>. Accessed August 16, 2013.
- Rozell, D.J., and S.J. Reaven. 2012. Water pollution risk associated with natural gas extraction from the Marcellus Shale. *Risk Analysis* 32(8):1382–93. August. doi:10.1111/j.1539-6924.2011.01757.x. Online at <http://www.ncbi.nlm.nih.gov/pubmed/22211399>. Accessed September 16, 2013.
- Ruby, D. 2010. The value of Google result positioning. *Chitika Online Advertising Network*. May 25. Online at <http://chitika.com/insights/2010/the-value-of-google-result-positioning/>. Accessed June 11, 2013.
- Ryan, P.H., M. Dihle, S. Griffin, C. Partridge, T.J. Hilbert, R. Taylor, S. Adjei, and J.E. Lockey. 2011. Erionite in road gravel associated with interstitial and pleural changes—an occupational hazard in western United States. *Journal of Occupational and Environmental Medicine* 53(8):892–898. doi:10.1097/JOM.0b013e318223d44c. August. Accessed August 16, 2013.
- Schaeffer, E., and A. Kron. 2012. *Petition to add the oil and gas extraction industry, Standard Industrial Classification Code 134, to the list of facilities required to report under the Toxics Release Inventory*. Environmental Integrity Project. October 24. Online at http://www.earthworksaction.org/files/publications/2012.10.24_TRI_Petition_FINAL.pdf. Accessed September 16, 2013.
- Scheufele, D. 2013. A brave new (online) world: Emerging technologies at the intersection of science, policy, and rapidly changing media environment. Presented at New Tools for Science Policy: A Breakfast Seminar Series, March 8, Washington, DC. Consortium for Science, Policy & Outcomes. Online at <http://vimeo.com/61369334>. Accessed July 12, 2013.
- Schierow, L-J. 2012. The Emergency Planning and Community Right-to-Know Act (EPCRA): A summary. Congressional Research Service. Report for Congress. RL32683. April 5. Online at <http://www.fas.org/sgp/crs/misc/RL32683.pdf>. Accessed September 16, 2013.
- Schiffman, R. 2013. “Frackademia”: How Big Gas bought research on hydraulic fracturing. *The Guardian*. January 9. Online at <http://www.theguardian.com/commentisfree/2013/jan/09/fracking-big-gas-university-research>. Accessed August 26, 2013.
- Schramm, E. 2011. What is flowback, and how does it differ from produced water? The Institute for Energy & Environmental Research in Northeastern Pennsylvania. Online at <http://energy.wilkes.edu/pages/205.asp>. Accessed August 24, 2013.
- Schrope, M. 2012. Fracking outpaces science on its impact. *Environment Yale*. Yale School of Forestry and Environmental Studies. Online at <http://environment.yale.edu/envystories/fracking-outpaces-science-on-its-impact>. Accessed September 16, 2013.
- Secretary of Energy Advisory Board (SEAB). 2011. *Shale Gas Production Subcommittee. Second ninety-day report*. United States Department of Energy. November 18. Online at http://www.shalegas.energy.gov/resources/111811_final_report.pdf. Accessed August 25, 2013.
- Shogren, E. 2012. Fracking’s methane trail: A detective story. National Public Radio. May 17. Online at <http://www.npr.org/2012/05/17/151545578/frackings-methane-trail-a-detective-story>. Accessed June 26, 2013.

- Sieminski, A. 2013. *Outlook for shale gas and tight oil development in the U.S.* Presentation for Deloitte Energy Conference, May 21. Energy Information Administration. United States Department of Energy. Online at http://www.eia.gov/pressroom/presentations/sieminski_05212013.pdf. Accessed September 14, 2013.
- Skone, T.J. 2012. *Role of alternative energy sources: Natural gas technology assessment.* United States Department of Energy. National Energy Technology Laboratory. DOE/NETL-2012/1539. June 30. Online at <http://www.netl.doe.gov/energy-analyses/pubs/NGTechAssess.pdf>. Accessed September 16, 2013.
- Slovic, P. 1987. Perception of risk. *Science* 236(4799):280–285. April 17. Online at <http://www.ncbi.nlm.nih.gov/pubmed/3563507>. Accessed September 9, 2013.
- Song, L. 2012. First study of its kind detects 44 hazardous air pollutants at gas drilling sites. InsideClimate News. December 3. Online at <http://insideclimatenews.org/news/20121203/natural-gas-drilling-air-pollution-fracking-colorado-methane-benzene-endocrine-health-NMHC-epa-toxic-chemicals>. Accessed September 16, 2013.
- Soraghan, M. 2013. Former Pa. Gov. Rendell pressed EPA in Range pollution case, emails show. EnergyWire. February 5. Online at <http://www.eenews.net/stories/1059975812>. Accessed September 16, 2013.
- Soraghan, M. 2012. Diesel still used to “frack” wells, FracFocus data show. EnergyWire. August 17. Online at <http://www.eenews.net/stories/1059968900>. Accessed September 16, 2013.
- StateImpact Pennsylvania. 2013. Dimock, PA: “Ground zero” in the fight over fracking. National Public Radio. Online at <http://stateimpact.npr.org/pennsylvania/tag/dimock/>. Accessed September 16, 2013.
- Susquehanna River Basin Commission (SRBC). 2012. 64 water withdrawals for natural gas drilling and other uses suspended to protect streams. Press release, July 16. Online at <http://www.srb.com/newsroom/NewsReleasePrintFriendly.aspx?NewsReleaseID=90>. Accessed August 21, 2013.
- Texas Commission on Environmental Quality (TCEQ). 2011. *Health effects evaluation of Region 4 Carbonyl Monitoring Project, November 6 – 10, 2010, sampling for carbonyl compounds in Dish and Fort Worth, Texas.* Interoffice memorandum. February 24. Online at http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/healthEffects/2011.02.24-CarbonylMonitoringProject.pdf. Accessed August 20, 2013.
- Texas Commission on Environmental Quality (TCEQ). 2010. A commitment to air quality in the Barnett Shale. *Natural Outlook*. Fall. Online at <http://www.tceq.texas.gov/publications/pd/020/10-04/a-commitment-to-air-quality-in-the-barnett-shale>. Accessed August 20, 2013.
- Texas Commission on Environmental Quality (TCEQ). 2009. Health effects review of ambient air monitoring data collected by Wolf Eagle environmental engineers and consultants for Dish, TX. Interoffice memorandum. October 27. Online at http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/healthEffectsReview.pdf. Accessed August 20, 2013.
- Tiemann, M., and A. Vann. 2013. Hydraulic fracturing and Safe Drinking Water Act regulatory issues. Congressional Research Service. Report for Congress. R41760. January 10. Online at <http://www.fas.org/sgp/crs/misc/R41760.pdf>. Accessed August 20, 2013.
- Tollefson, J. 2013. Methane leaks erode green credentials of natural gas. *Nature*. January 2. Online at <http://www.nature.com/news/methane-leaks-erode-green-credentials-of-natural-gas-1.12123>. Accessed September 16, 2013.
- Tompkins County Council of Governments (TCCOG). 2011. *Community impact assessment: High volume hydraulic fracturing.* Rhinebeck, NY: Tompkins County. December 15. Online at http://www.tompkins-co.org/tccog/gas_drilling/TCCoG_Community_Impact_Assessment_12-15-11%20Final.pdf. Accessed August 21, 2013.
- Tracy, T. 2012. U.S. to set rules for fracking on federal land. *The Wall Street Journal*. May 3. Online at <http://online.wsj.com/article/SB10001424052702303877604577382460699241978.html>. Accessed September 16, 2013.
- Tripathi, S.K. 2012. A letter from UB President Satish K. Tripathi. University at Buffalo. The State University of New York. November 19. Online at <http://www.buffalo.edu/news/news-releases.host.html/content/shared/www/news/private/2012/11/13820.html>. Accessed September 16, 2013.
- TruckGauge. 2011. Why fracking is important to you. November 11. Online at <http://www.truckgauge.com/2011/11/11/why-fracking-is-important-to-you/>. Accessed August 25, 2013.
- Tsou, W. 2012. The big secret? Fracking fluids. Environmental Health Policy Institute. Physicians for Social Responsibility. Online at <http://www.psr.org/environment-and-health/environmental-health-policy-institute/responses/the-big-secret-fracking-fluids.html>. Accessed September 16, 2013.
- United States Geological Survey (USGS). 2013a. Welcome to the Interactive Energy Atlas for EERMA [Energy and Environment in the Rocky Mountain Area]. Online at <http://my.usgs.gov/leermal/>. Accessed September 16, 2013.
- United States Geological Survey (USGS). 2013b. Hydraulic fracturing. September 12. Online at <http://energy.usgs.gov/OilGas/UnconventionalOilGas/HydraulicFracturing.aspx>. Accessed September 16, 2013.
- United States Geological Survey (USGS). 2012. *Water quality studied in areas of unconventional oil and gas development, including areas where hydraulic fracturing techniques are used, in the United States.* USGS Powell Center for Analysis and Synthesis. April. Accessed August 20, 2013.
- United States House of Representatives (USHR). 2013. Subcommittee on Environment and Subcommittee on Energy. Joint hearing—lessons learned: EPA’s investigations of hydraulic fracturing. House Committee on Science, Space, and Technology. July 24. Online at <http://science.house.gov/hearing/subcommittee-environment-and-subcommittee-energy-joint-hearing-lessons-learned-epa%E2%80%99s>. Accessed August 27, 2013.
- United States House of Representatives (USHR). 2002. *Weird science: The Interior Department’s manipulation of science for political purposes.* Prepared by the Democratic Staff Committee on Resources. December 17. Online at http://grc.gcsu.edu/files/geog4400/DofInterior_weird_science.pdf. Accessed July 30, 2013.
- United States Senate (USS). 2013. Full committee forum: Shale development: Best practices and environmental concerns. Committee on Energy & Natural Resources. Online at <http://www.energy.senate.gov/public/index.cfm/2013/5/full-committee-forum-shale-development-best-practices-and-environmental-concerns>. Accessed August 27, 2013.
- Upton, J. 2013. EPA abandons investigation into fracking pollution. Grist. June 21. Online at <http://grist.org/news/epa-abandons-investigation-into-fracking-pollution/>. Accessed September 16, 2013.
- Urbina, I. 2013. *The New York Times* Drilling Down series. Public lecture at New York University. April 17. Online at <http://www.youtube.com/watch?v=z6dZaOtRrio>. Accessed June 25, 2013.
- Urbina, I. 2012a. Drilling down. *The New York Times* series. February 27, 2011 to May 15, 2012. Online at http://www.nytimes.com/interactive/us/DRILLING_DOWN_SERIES.html?_r=0. Accessed June 25, 2013.
- Urbina, I. 2012b. Deadliest danger isn’t at the rig but on the road. *The New York Times*. May 14. Online at <http://www.nytimes.com/2012/05/15/us/for-oil-workers-deadliest-danger-is-driving.html>. Accessed July 3, 2013.
- Urbina, I. 2011. A tainted water well, and concern there may be more. *The New York Times*. August 3. Online at <http://www.nytimes.com/2011/08/04/us/04natgas.html>. Accessed July 11, 2013.

- Vidic, R.D., S.L. Brantley, J.M. Vandebossche, D. Yoxheimer, and J.D. Abad. 2013. Impact of shale gas development on regional water quality. *Science* 340(6134). doi:10.1126/science.1235009. Online at <http://www.sciencemag.org/content/340/6134/1235009.abstract>. Accessed September 16, 2013.
- Vladeck, D.C. 2009. Information access—Surveying the current legal landscape of federal right-to-know laws. *The Environmental Law Reporter* 38(8):10773–10788. Online at <http://law.vanderbilt.edu/files/archive/Vladeck-2009.pdf>. Accessed September 16, 2013.
- Waeckerlin, E. 2012. EPA enforcement and fracking—Why Superfund and why now? *Fracking Insider*. February 21. Online at <http://www.frackinginsider.com/regulatory/when-one-thinks-of-a/>. Accessed September 16, 2013.
- Warner, N.R., R.B. Jackson, T.H. Darrah, S.G. Osborn, A. Down, K. Zhao, A. White, and A. Vengosh. 2012. Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. *Proceedings of the National Academy of Sciences* 109(30):11961–11966. Online at <http://lateson.com/us/r/www.pnas.org/content/109/30/11961.full>. Accessed September 16, 2013.
- Warner, N.R., T.M. Kresse, P.D. Hays, A. Down, J.D. Karr, R.B. Jackson, and A. Vengosh. 2013. Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville Shale development, north-central Arkansas. *Applied Geochemistry* 35:207–220. Online at <http://biology.duke.edu/jacksonlag2013.pdf>. Accessed September 16, 2013.
- Wernau, J. 2013a. “Gasland Part II” tour to launch in Normal. *Chicago Tribune*. May 19. Online at http://articles.chicagotribune.com/2013-05-19/business/ct-biz-0519-gasland-movie--20130519_1_fracking-oil-and-gas-industries-second-film. Accessed July 10, 2013.
- Wernau, J. 2013b. Gov. Quinn signs bill to regulate fracking. *Chicago Tribune*. June 17. Online at http://articles.chicagotribune.com/2013-06-17/business/chi-quinn-fracking-bill-20130617_1_fracking-fracturing-our-environment-many-environmental-advocates. Accessed September 16, 2013.
- Western Reserve Land Conservancy. 2013. *Uncommon ground for the common good*. Online at <http://www.wrlandconservancy.org/pdf/UNCOMMONGROUNDFINAL.pdf>. Accessed August 25, 2013.
- Wilber, T. 2013. Audiences at public talks show texture of fracking debate. *Shale Gas Review*. May 21. Online at <http://tomwilber.blogspot.com/2013/05/audiences-at-public-talks-show-texture.html>. Accessed June 25, 2013.
- Williams, H.F.L., D.L. Havens, K.E. Banks, and D.J. Wachal. 2008. Field-based monitoring of sediment runoff from natural gas well sites in Denton County, Texas, USA. *Environmental Geology* 55:1463–1471. Online at http://www.math.unt.edu/~williams/GEOG_3350/enviongeolpaper.pdf. Accessed September 16, 2013.
- Willis Energy Market Review. 2012. *All fracked up? Just how concerned should energy insurers be about hydraulic fracturing?* Online at http://www.willis.com/Documents/publications/Industries/Energy/10396_EMR%202012_Complete.pdf. Accessed July 12, 2013.
- Williston Community Profile. 2013. North Dakota Department of Commerce. Online at <http://www.business.nd.gov/searchCenter/Community/profile.asp?Page=1&FIPS=86220>. Accessed September 16, 2013.
- Williston, North Dakota. 2012. *Williston impact statement*. Online at http://www.willistonnd.com/usrimages/Williston_Impact_Statement.pdf. Accessed August 20, 2013.
- Wisconsin Department of Natural Resources. 2012. *Silica sand mining in Wisconsin*. January. Online at <http://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf>. Accessed August 20, 2013.
- Wiseman, H.J. 2013a. Hydraulic fracturing and information forcing. *Furthermore* 74:86–97. *Ohio State Law Journal* online supplement. Online at <http://moritzlaw.osu.edu/students/groups/oslj/files/2013/06/Furthermore.Wiseman.pdf>. Accessed August 20, 2013.
- Wiseman, H.J. 2013b. The private role in public fracturing disclosure and regulation. *Harvard Business Law Review Online* 3:49–66. Accessed August 20, 2013.
- Wiseman, H.J. 2013c. Risk and response in fracturing policy. 84 U. COLO. L. REV. 758–61, 766–70, 788–92. Online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2017104. Accessed September 16, 2013.
- Wiseman, H. 2009. Untested waters: The rise of hydraulic fracturing in oil and gas production and the need to revisit regulation. *Fordham Environmental Law Review* 20:115–171. Online at <http://www.law.uh.edu/faculty/thester/courses/Emerging%20Tech%20202011/Wiseman%20on%20Fracking.pdf>. Accessed September 16, 2013.
- Wiseman, H.J., and F. Gradijan. 2011. Regulation of shale gas development, including hydraulic fracturing. Social Science Research Network. Online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1953547. Accessed September 16, 2013.
- WKYC. 2013. Unions: “Fracking” jobs aren’t local. February 14. Online at <http://www.wkyc.com/news/article/283726/421/Unions-Fracking-jobs-arent-local>. Accessed August 24, 2013.
- Wolf Eagle Environmental. 2009. *Town of Dish, Texas. Ambient air monitoring analysis. Final report*. September 15. Online at http://townofdish.com/objects/DISH_-_final_report_revised.pdf. Accessed September 16, 2013.
- Wolske, K., A. Hoffman, and L. Strickland. 2013. *Hydraulic fracturing in Michigan integrated assessment: Public perceptions technical report*. September 3. Online at <http://graham.umich.edu/media/files/HF-08-Public-Perceptions.pdf>. Accessed September 9, 2013.
- Wright, P.R., P.B. McMahon, D.K. Mueller, and M.L. Clark. 2012. *Groundwater-quality and quality-control data for two monitoring wells near Pavillion, Wyoming, April and May 2012*. Reston, VA: United States Geological Survey (USGS). Data series 718. Online at http://pubs.usgs.gov/ds/718/DS718_508.pdf. Accessed August 20, 2013.
- Wyoming Oil and Gas Conservation Commission (WOGCC). *Well bore integrity—Final report*. June 20. Online at http://content.govdelivery.com/attachments/WYGOV/2013/06/20/file_attachments/220046/Additional%2B%2BPavillion%2BAnalysis%2B%2BTesting.pdf. Accessed September 16, 2013.
- Zelman, J. 2011. Mayor Calvin Tillman leaves Dish, Texas fearing “fracking” effects on family’s health. *Huffington Post*. February 24. Online at http://www.huffingtonpost.com/2011/02/24/mayor-calvin-tillman-leav_n_827478.html. Accessed September 16, 2013.
- Zhorov, I. 2013. Fracking chemical disclosure decision appealed to WY Supreme Court. Wyoming Public Media. April 17. Online at <http://wyomingpublicmedia.org/post/fracking-chemical-disclosure-decision-appealed-wy-supreme-court>. Accessed July 30, 2013.
- Zielinska, B., E. Fujita, and D. Campbell. 2011. *Monitoring of emissions from Barnett Shale natural gas production facilities for population exposure assessment. Final report to the National Urban Air Toxics Research Center*. NUATRC number 19. Online at <https://sph.uth.edu/mleland/attachments/DRI-Barnett%20Report%2019%20Final.pdf>. Accessed September 16, 2013.
- Zoback, M.D. 2012. Managing the seismic risk posed by wastewater disposal. *Earth. American Geosciences Institute*. April 17. Online at <http://www.earthmagazine.org/article/managing-seismic-risk-posed-wastewater-disposal>. Accessed September 16, 2013.

TOWARD AN EVIDENCE-BASED FRACKING DEBATE

Science, Democracy, and Community Right to Know in Unconventional Oil and Gas Development

The rapid growth of unconventional oil and gas development—commonly known as “fracking”—has outpaced the public’s ability to make informed, evidence-based decisions about the best way to ensure healthy, prosperous communities with this industry as a next-door neighbor. This dizzying pace of expansion has limited the time researchers have had to study unconventional oil and gas development and its impacts. And it has limited the time decision makers and citizens have had to effectively manage the development in their communities. Scientific unknowns about some of the impacts of development have converged with a lack of comprehensive legal requirements and interference in the science and policy process by special interests. The confluence of biased science, conflicted politicians, and misinformation in the public dialogue has produced a noisy environment that challenges citizens seeking reliable information, erecting hurdles to communities wanting to make science-informed decisions.

The public has a right to know about the impacts—positive or negative—that unconventional oil and gas development may have. Citizens have a right to understand the uncertainties and limitations of our scientific knowledge. They have a right

to know what is, can, or should be covered by regulations. And they have a right to be engaged in the discussion. Ultimately, citizens need to be empowered with the information needed to make informed decisions about unconventional oil and gas development in their communities.

The best available science about the effects of hydraulic fracturing, wastewater disposal, and other activities on communities should inform decision makers and the public. Inappropriate corporate interference in the science and policy-making process must be addressed. Protection of public health and well-being should take priority over private special interests. The exemptions that allow companies to keep vital information about their activities secret must be lifted. Federal, state, and local governments should make information accessible to researchers, decision makers, and the public. Greater transparency, more oversight, and more comprehensive laws and regulations at all levels are necessary in order to guide us toward a more transparent, science-informed dialogue and decision-making process on unconventional oil and gas development in the United States.



©2013 Trudy E. Bell

Union of Concerned Scientists

This report is available online at www.ucsusa.org/HFreport

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet’s most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

National Headquarters
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

Washington, DC, Office
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

West Coast Office
2397 Shattuck Ave., Ste. 203
Berkeley, CA 94704-1567
Phone: (510) 843-1872
Fax: (510) 843-3785

Midwest Office
One N. LaSalle St., Ste. 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751