



FRACKING FAILURES

Oil and Gas Industry Environmental Violations in Pennsylvania and What They Mean for the U.S.



Fracking Failures

Oil and Gas Industry Environmental Violations in Pennsylvania and What They Mean for the U.S.



Written by:

Jeff Inglis, Frontier Group

John Rumpler, Environment America Research & Policy Center

Winter 2015

Acknowledgments

The authors wish to thank Joanne Kilgour, director of Sierra Club Pennsylvania Chapter; Brook Lenker, director of FracTracker Alliance; and Maya van Rossum, the Delaware Riverkeeper, for their review and comments. Thanks also to Tony Dutzik and Gideon Weissman of Frontier Group for editorial support.

Environment New York Research & Policy Center gratefully thanks the Colcom Foundation for making this report possible.

The authors bear responsibility for any factual errors. The recommendations are those of Environment New York Research & Policy Center. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

© 2015 Environment New York Research & Policy Center



Environment New York Research & Policy Center is a 501(c)(3) organization. We are dedicated to protecting our air, water and open spaces. We investigate problems, craft solutions, educate the public and decision-makers, and help the public make their voices heard in local, state and national debates over the quality of our environment and our lives. For more information about Environment New York Research & Policy Center or for additional copies of this report, please visit www.environmentnewyorkcenter.org.

FRONTIER GROUP

Frontier Group provides information and ideas to help citizens build a cleaner, healthier, fairer and more democratic America. We address issues that will define our nation's course in the 21st century – from fracking to solar energy, global warming to transportation, clean water to clean elections. Our experts and writers deliver timely research and analysis that is accessible to the public, applying insights gleaned from a variety of disciplines to arrive at new ideas for solving pressing problems. For more information about Frontier Group, please visit www.frontiergroup.org.

Layout: To The Point Publications, tothepointpublications.com

Cover: Drilling operations at a Marcellus Shale site in Pennsylvania. Photo by Chuck Anderson, Earth and Environmental Systems Institute, Penn State University. The compliance status of wells at the facility depicted is unknown.

Table of Contents

Executive Summary	4
Introduction	7
Fracking Harms the Environment and Human Health	9
Fracking Contaminates Water.....	9
Fracking Consumes Vast Amounts of Water	10
Fracking Causes Air Pollution	10
Fracking Jeopardizes Human Health	11
Fracking Emits Global Warming Pollution	12
Fracking Threatens America’s Natural Heritage	12
Regulations Are Failing to Protect Health and the Environment from Fracking	12
Fracking Companies Are Violating Rules Meant to Protect the Environment and Human Health	15
Violations Pose Real Risks to Our Environment and Health	15
All Types of Fracking Companies Commit Environment-Damaging Violations	16
Violators Include Companies That Have Promised To Improve Their Environmental Performance	19
Top Violators Include All Sizes of Companies.....	20
Pennsylvania Violators Also Have Fracking Operations Across the Country.....	22
Policy Recommendations	23
Methodology	25
Appendix A: Assigned Violation Categories and Their DEP Codes	27
Appendix B: Top 20 Most-Cited Fracking Companies Ranked by Environmental and Health Violations, Their Parent Companies, and Their Other Operating Locations	32
Appendix C: States Where Pennsylvania’s Top 20 Most-Cited Fracking Companies Also Operate	34
Appendix D: Companies Active in Pennsylvania, January-June 2014	35
Notes	37

Executive Summary

Fracking is dirty. From the very beginning of clearing a site for drilling, through extraction, transport and delivery of finished products, fracking poses significant risks to our air and water and to human health. People who live and work near fracking sites are at greater risk for respiratory and neurological diseases.

Oil and gas industry spokespeople routinely maintain that the risks of fracking can be minimized by best practices and appropriate state regulation. Not only is this false – fracking is harmful even when drillers follow all the rules – but drillers also regularly violate essential environmental and public health protections, undermining their own claims. A look at recent data from Pennsylvania, where key industry players pledged to clean up their acts, illustrates the frequency with which companies still break the rules.

In Pennsylvania, fracking companies violate rules and regulations meant to protect the environment and human health on virtually a daily basis. Between January 1, 2011, and August 31, 2014, the top 20 of-fending fracking companies committed an average of 1.5 violations per day.

Fracking operators in Pennsylvania have committed thousands of violations of oil and gas regulations since 2011. These violations are not “paperwork” violations, but lapses that pose serious risks to workers, the environment and public health, including:

- **Allowing toxic chemicals to flow off drilling sites and into local soil and water.** In July 2012, for example, Chief Oil & Gas was cited by

the Pennsylvania Department of Environmental Protection (DEP) when the company allowed 4,700 gallons of hydrochloric acid to flow off of its drilling site in Leroy Township, Bradford County, and into nearby Towanda Creek, causing a fish kill.

- **Endangering drinking water through improper well construction.** Well problems, including leaks, contaminated drinking water supplies in as many as 243 cases across Pennsylvania between December 2007 and August 2014 – 81 of them between 2011 and 2014. In one such case Carrizo (Marcellus) LLC was cited for failing to properly restore a water supply its fracking activities had contaminated.
- **Dumping industrial waste into local waterways.** One operator, EQT Production, was cited twice in 2012 by the Pennsylvania Department of Environmental Protection (DEP) for violations at a well in Duncan Township, Tioga County, that polluted a local stream.
- **Otherwise disposing of waste improperly.** In one 2012 incident at an Exco Resources well in Bell Township, Clearfield County, the company was cited for contaminating underground drinking water supplies as a result of leaks from a well drilled for the specific purpose of injecting toxic waste underground.

The list of top violators in Pennsylvania includes large, multi-national oil and gas industry operators and smaller, locally owned firms – and companies that promised to exceed state safety standards. (See Table ES-1.)

- Subsidiaries of Exxon-Mobil and Shell, along with Cabot and Chesapeake, rank among the top 10 for total violations.
- These and other top violators also have fracking operations or own mineral rights that would allow for future fracking in 23 other states: Alaska, Arkansas, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Tennessee, Texas, Utah, Virginia, West Virginia, and Wyoming.
- Pennsylvania-based companies ranking among the top violators included Warren-based Pennsylvania General Energy, Pittsburgh-based EQT Production, Canonsburg-based CNX Gas (a subsidiary of Consol Energy), and Kittanning-based Snyder Bros., Inc.
- Top violators also include the four firms that told the public they would adhere to higher standards when they formed the Center for Sustainable Shale Development in 2013. Since then, those firms – EQT, Chevron Appalachia, Consol and Shell – have together committed at least 100 violations.

Both large and small firms rank highly for number of violations when adjusted for the size of their fracking activities in Pennsylvania.

- Atlas Resources, based in Pittsburgh, drilled 11 wells between 2011 and August 2014 (among companies with at least five wells drilled), and was cited for 13 violations – or 1.18 violations per well drilled, ranking first. The company was followed by Exco Resources of Dallas; Halcon Operating Company of Houston; Houston-based Carrizo; and Kittanning, Pennsylvania-headquartered Snyder Brothers.

Table ES-1. Pennsylvania’s 20 Most Frequently Cited Fracking Companies, Ranked by Number of Environmental and Health Violations, January 2011-August 2014

Company	Environmental and Health Violations	Rank
CABOT OIL & GAS CORP	265	1
CHESAPEAKE APPALACHIA LLC	253	2
RANGE RESOURCES APPALACHIA LLC	174	3
CHIEF OIL & GAS LLC	150	4
SWEPI LP	119	5
XTO ENERGY INC	113	6
ANADARKO E&P ONSHORE LLC	92	7
SOUTHWESTERN ENERGY PROD CO	88	8
WPX ENERGY APPALACHIA LLC	86	9
SENECA RESOURCES CORP	85	10 (tie)
CARRIZO (MARCELLUS) LLC	85	10 (tie)
EXCO RESOURCES PA LLC	82	12
EQT PRODUCTION CO	80	13 (tie)
PA GEN ENERGY CO LLC	80	13 (tie)
TALISMAN ENERGY USA INC	65	15
CHEVRON APPALACHIA LLC	63	16
ULTRA RESOURCES INC	52	17
EOG RESOURCES INC	38	18
CNX GAS CO LLC	36	19
SNYDER BROS INC	31	20

- Mieka, part of Texas-based Vadda Energy, ranked first for the average number of violations per well operated per reporting period (among companies operating at least five wells in at least one reporting period), with 0.46 violations per well per reporting period. The company was followed by Radnor, Pennsylvania-based Penn Virginia Oil and Gas; Enerplus Resources of Calgary, Alberta, Canada; Houston-based Carrizo (Marcellus) LLC; and XTO, a subsidiary of Irving, Texas-based ExxonMobil.

The number of violations that received citations from state officials is, in all likelihood, lower than the actual number of infractions, because of Pennsylvania’s consistent pattern of conducting fewer inspections than state rules require, and because inspectors regularly decline to issue violation notices when companies voluntarily agree to fix problems.

Studies in other states have shown similar problems of violations and environmental damage from fracking. There is little reason to believe, therefore, that fracking operations in Pennsylvania are substantively different from other states in their ability to cause harm or to commit repeated violations of health and safety laws.

The sheer number and severity of risks posed by fracking operations make constructing an adequate regulatory regime – much less enforcing it at thousands of wells and other sites – implausible. The industry’s persistent record of violations in Pennsylvania reinforces the case for the following policy recommendations:

- Banning fracking before it begins. As New York Governor Andrew Cuomo has determined, this is the most prudent course for states to protect the environment and public health.
- In states like Pennsylvania where widespread fracking is already under way, a moratorium on all new well permits to limit the damage. For existing wells, states must adopt much more stringent protections and truly enforce them.
- All local communities should have the right to reject fracking operations within their borders.
- Requiring drillers in states where fracking is already happening to post sufficient bonds and other financial assurance. Financial assurance rules should be designed to guarantee that the costs of any environmental or public health damage caused by fracking are borne by the drillers, not residents or the public.
- Closing loopholes that exempt fracking from key provisions of our federal environmental laws. Federal policymakers should protect America’s natural heritage by keeping fracking away from our national parks, national forests and sources of drinking water for millions of Americans.
- Collecting and releasing to the public more complete data on fracking. This would enable us to understand the full extent of the harm that fracking causes to our environment and health.

Introduction

At 6:45 on the morning of Tuesday, February 11, 2014, a group of fracking workers was about to begin a safety briefing at a fracking well site.¹ The three wells there, owned and operated by Chevron Appalachia, in Dunkard Township, Pennsylvania, southwest of Pittsburgh, had been drilled and fracked, and were about to begin producing natural gas.²

Before the safety meeting began, however, some workers reported hearing a hissing noise from one of the three wellheads.³ One of them, Ian McKee, a 27-year-old man engaged to be married and expecting a baby with his fiancée, walked over to investigate.⁴

The hissing noise was methane escaping from a damaged well. As McKee approached the well, it exploded. The explosion killed McKee instantly and produced enough heat to rupture and ignite a neighboring well, and to cause a propane truck nearby to explode.⁵ Another worker nearby on the well pad survived with minor injuries.⁶

For the next four days, the drilling site, located just a mile from an elementary school, became a blazing inferno of leaking methane and repeated explosions.⁷ Firefighting efforts were useless.⁸ And even after the fire burned itself out, the wells continued to vent between 10 million and 25 million cubic feet per day of methane, a potent global warming pollutant.⁹ It took 14 days to cap the two leaking wells.¹⁰

On March 18, 2014, the Pennsylvania Department of Environmental Protection (DEP) cited Chevron for nine violations in connection with the event, including “hazardous venting of gas,” failing to prevent explosion and fire, failing to maintain functioning equipment intended to prevent blowouts, and releasing “fugitive air contaminants without a permit.”¹¹ The company was also cited for leaking polluted fracking wastewater,¹² and for blocking DEP officials’ access to the site for two days following the explosion.¹³

Chevron was later revealed to have ignored repeated demands by the DEP for better air-quality monitoring and for frequent updates on the situation at the well.¹⁴ State officials also found the company had departed from standard procedures by allowing an inexperienced worker (who was not McKee) to work on the wellhead several days before the blast.¹⁵

The incident highlights the risks of fracking to the environment and to the health and safety of workers and the public. Ten months before Ian McKee’s death, however, Chevron had pledged to reduce those risks by upholding environmental and safety standards even more stringent than state requirements.

In April 2013, Chevron Appalachia had been among several companies that announced – to great fanfare – their participation in the Center for Sustainable Shale Development (CSSD), a coalition of



A fluid retaining basin at a Marcellus Shale site in Pennsylvania.

drilling companies and environmental organizations focused on finding ways to reduce the environmental and public health threats posed by fracking.¹⁶ Companies receiving CSSD certification pledge they are meeting and will continue to uphold strong standards of environmental responsibility.¹⁷

This report examines patterns of violations of environmental and health safeguards by companies involved in fracking in Pennsylvania. The risks posed

by fracking are similar across the country, and many of the companies involved are currently drilling, or have plans to drill, in other states. The continued violation of key laws by a variety of companies – large and small, local and multinational, and even ones that had pledged to do better – demonstrates both the inherent risks of fracking and the extreme difficulty of regulating it in ways sufficient to protect the public and the environment.

Fracking Harms the Environment and Human Health

Fracking has done a lot of harm to the environment – damage that has been documented in a variety of reports and studies, including the Environment America Research & Policy Center report *Fracking by the Numbers*.¹⁸

Fracking Contaminates Water

Drilling poses major risks for our water supplies, including potential underground leaks of toxic chemicals and contamination of groundwater. There are at least 243 documented cases of contaminated drinking water supplies across Pennsylvania between December 2007 and August 2014 due to fracking activities, according to the Pennsylvania Department of Environmental Protection (DEP).¹⁹ Many of those cases required fracking companies to truck in replacement drinking water supplies for residents, construct new drinking water wells, or otherwise modify their existing water wells to make the water drinkable again.²⁰ Hundreds of other complaints of water problems in proximity of drilling have been

received by the DEP but the department has yet to formally determine the causes of many of those cases.²¹

Many, perhaps most, of those cases did not result in DEP citing the companies in question for violations of the state's fracking rules.²² Companies that failed to provide safe replacement drinking water for neighbors did at times face sanctions. In November 2012, for example, Carrizo (Marcellus) LLC was cited for failing to properly restore a drinking water supply that its drilling had contaminated in Forest Lake Township, Susquehanna County.²³

In February 2011, workers for Flatirons Development, a Denver-based company, were drilling the firm's first fracked well in Pennsylvania. The well was being drilled through the geological layer containing an aquifer when water began spewing from the Flatirons well – and stopped coming out of a nearby well supplying drinking water to the residents of Brockway Borough, in Jefferson County.²⁴

Defining “Fracking”

When we refer to “fracking,” we include all of the activities needed to bring a shale gas or oil well into production using high-volume hydraulic fracturing (fracturing operations that use at least 100,000 gallons of water), to operate that well, and to deliver the gas or oil produced from that well to market. The oil and gas industry often uses a more restrictive definition of “fracking” that includes only the actual moment in the extraction process when rock is fractured – a definition that obscures the broad changes to environmental, health and community conditions that result from the use of fracking in oil and gas extraction.

After the Flatirons well was drilled, the Brockway well's water became cloudy and discolored.²⁵ Local watershed protection advocates objected to the Flatirons well's continued operation.²⁶ In June 2014, a state legislator also expressed concerns over water quality in the area.²⁷ Faced with this opposition, in August 2014, the company agreed to shut its well down.²⁸

Between six and seven percent of all fracking wells develop leaks shortly after being drilled that could contaminate nearby well water or aquifers.²⁹ In Pennsylvania, where as many as 100,000 wells could be drilled in the Marcellus shale, that means at least 5,000 new wells would be pollution risks. And with as many as another 100,000 wells projected in the rest of the Marcellus in other states, at least another 5,000 wells would leak underground.³⁰ Those numbers do not include wells that may fail as they age, nor wells that get fracked more than once, nor wells in the Utica shale region, which are already being drilled in Pennsylvania at depths below the Marcellus shale.³¹ Fracking is linked to contaminated drinking water supplies in at least 12 other states, in addition to Pennsylvania.³²

Beyond affecting drinking water supplies, fracking also produces vast amounts of toxic wastewater that must be stored, transported and ultimately disposed of – posing the threat of water contamination at each step. In 2012 alone, Pennsylvania fracking wells produced 1.2 billion gallons of wastewater.³³ Nationwide, that figure for 2012 was 280 billion gallons of toxic wastewater.³⁴

Fracking Consumes Vast Amounts of Water

Fracking consumes between tens of thousands and millions of gallons of water per well, turning it into a toxic and radioactive soup that cannot be returned to the natural water cycle without extensive treatment. At the same time, excessive water withdrawals can reduce the local availability of clean water for wildlife and humans.

Each fracking well in Pennsylvania uses an average of 4.5 million gallons of water.³⁵ Between 2005 and 2012, fracking wells in Pennsylvania used 30 billion gallons of water.³⁶ Altogether, fracking wells across the U.S. used 250 billion gallons of water between 2005 and 2012.³⁷

Fracking-related water demand may also lead to calls for increased public spending on water infrastructure. Texas, for example, adopted a State Water Plan in 2012 that calls for \$53 billion in investments in the state water system, including \$400 million to address unmet needs in the mining sector (which includes hydraulic fracturing) by 2060.³⁸ Fracking is projected to account for 42 percent of water use in the Texas mining sector by 2020.³⁹

Fracking Causes Air Pollution

Air pollutants are released during at least 15 different parts of the oil and gas development process.⁴⁰ Many of the chemicals used in fracking are known air pollutants, and wastewater produced from fracking operations includes volatile compounds that can evaporate into the air, and have been linked to human health problems.⁴¹ Leaking or vented natural gas can also contain toxic chemicals such as toluene and xylenes, which can cause breathing difficulty, and benzene, which can cause leukemia – even at low levels of exposure.⁴²

A 2010 study by the Pennsylvania Department of Environmental Protection found elevated levels of ethane, propane and benzene – all toxics associated with fracking – “in the air near Marcellus Shale drilling operations.”⁴³ Similar problems have been documented in Texas and Arkansas.⁴⁴

Impoundment ponds where fracking waste water is stored are also sources of air pollution, as chemicals evaporate from the open-air pits.⁴⁵ In addition, increased truck traffic needed to service the drilling sites contributes to air pollution.⁴⁶

Concerns about air pollution from fracking have been raised not only in Pennsylvania, but also in Colorado, Ohio and Texas.⁴⁷

Fracking Jeopardizes Human Health

In light of the air and water pollution from fracking, it should come as no surprise that a growing number of scientific studies are linking the drilling practice with various health risks. Proximity to well pads has been associated with increases in a person’s risk for respiratory and neurological problems, as well as birth defects.⁴⁸ Cancer-causing chemicals are used at one-third of all fracking sites in the country, according to an analysis of fracking companies’ self-reported disclosures.⁴⁹ The top three chemicals used in fracking – naphthalene, benzyl chloride and formaldehyde – are all carcinogens.⁵⁰ They are also toxic to human reproductive, neurological, respiratory and gastrointestinal systems.⁵¹

More than three-quarters of the chemicals used in fracking can, at varying dosage levels, harm skin, eyes, breathing, digestion and liver functions.⁵² More than half can damage the nervous system.⁵³ And more than one-third are potential disruptors of the

endocrine system – affecting neurological and immune system function, reproduction, and fetal and child development.⁵⁴

Air pollutants at fracking sites include volatile organic compounds (VOCs) such as benzene, xylene and toluene, which can cause varied health problems, from eye irritation and headaches to asthma and cancer.⁵⁵ Other chemicals released to the air also harm human health. (See Table 1.)

Investigations and analysis in Pennsylvania by the online journalism site ProPublica and the non-profit group Earthworks have linked fracking operations to significant damage to nearby residents’ health.⁵⁷ The ProPublica study found similar problems in three other states: Colorado, Texas and Wyoming.⁵⁸

In Pennsylvania, the Earthworks study examined 55 households reporting health problems near gas facilities, and found elevated levels of toxic contaminants in their homes, and in turn, widespread unexpected illnesses (such as liver disease in someone who does not drink alcohol).⁵⁹

Table 1. Recognized Health Effects of Air Emissions from Natural Gas Activities⁵⁶

	Pulmonary	Neurologic	Reproductive	Dermal	Hematologic
Particulate Matter	X			X	
Hydrogen Sulfide	X	X		X	
Ozone	X				
Carbon Monoxide		X	X		
Nitrogen Oxides (NOx)	X				
Sulfur Dioxide	X				
Volatile Organic Compounds (VOCs)	X	X	X	X	X
Benzene, Toluene, Ethylene and Xylenes (BTEX)	X	X	X	X	X
Naturally Occurring Radioactive Materials (NORMs)			X	X	X



Flaring in Scott Township, Lawrence County, Pennsylvania.

Fracking activity puts the health and safety of the industry's workers at risk, and in some cases has tragically led to death. The National Institute for Occupational Safety and Health has raised concerns about the risk of workers contracting lung disease after inhaling silica dust produced during handling of the sand that is injected, along with fluid, into fracking wells. The research prompted the U.S. Occupational Safety and Health Administration to issue a hazard alert for workers at fracking sites.⁶⁰

Fracking Emits Global Warming Pollution

Methane is an extremely powerful greenhouse gas – 86 times more potent than carbon dioxide over a 20-year period, and 34 times more powerful over a 100-year period.⁶¹ Methane leaks into the atmosphere are large and common from fracking well and storage facilities, both as a result of intentional discharges and unintentional leaks.⁶²

Fracking Threatens America's Natural Heritage

Fracking transforms rural and natural areas into industrial zones. This development threatens national parks and national forests, damages the integrity of landscapes and habitats, and contributes to water pollution problems that threaten aquatic ecosystems.

Before drilling can begin, land must be cleared of vegetation and leveled to accommodate drilling equipment, gas collection and processing equipment, and vehicles. Additional land must be cleared for roads to the well site, as well as for any pipelines and compressor stations needed to deliver gas to market. A study by the Nature Conservancy of fracking infrastructure in Pennsylvania found that well pads average 3.1 acres and related infrastructure damages an additional 5.7 acres.⁶³

Often, this development occurs on remote and previously undisturbed wild lands. As oil and gas companies expand fracking activities, national parks, national forests and other iconic landscapes are increasingly at risk.

In addition, governments may be forced to spend tax money to clean up orphaned wells – wells that were never properly closed and whose owners, in many cases, no longer exist as functioning business entities. Though oil and gas companies face a legal responsibility to plug wells and reclaim drilling sites, they have a track record of leaving the public holding the bag.⁶⁴

Regulations Are Failing to Protect Health and the Environment from Fracking

Supporters of fracking say its harm to the environment can be reduced, minimized, or even eliminated by enacting strong rules and regulations, and by the use of industry-determined best practices.⁷¹ However, the experience of fracking to date suggests that no

Fracking Imposes Significant Costs on Communities

As with prior extractive booms, the fracking oil and gas rush disrupts local communities and imposes a wide range of immediate and long term costs on them.

Ruining Roads

As a result of its heavy use of publicly available infrastructure and services, fracking imposes both immediate and long-term costs on taxpayers.

The trucks required to deliver water to a single fracking well cause as much damage to roads as 3.5 million car journeys, putting massive stress on roadways and bridges not constructed to handle such volumes of heavy traffic. In 2010, Pennsylvania estimated that repairing roads affected by Marcellus Shale drilling would cost \$265 million.⁶⁵

Endangering Local Economies

A 2008 study by the firm Headwaters Economics found that areas of the country that have relied on fossil-fuel extraction for growth are doing worse economically than their peers, with less-diversified economies, a less-educated workforce, and greater disparities in income.⁶⁶

Other negative impacts on local economies include:

- Downward pressure on home values. One Texas study found that homes valued at more than \$250,000 and located within 1,000 feet of a well site lost 3 to 14 percent of their value.⁶⁷
- Harm to agriculture, both directly through damage to livestock from exposure to fracking fluids, and indirectly through economic changes that undermine local agricultural economies.

Threatening Public Safety

Fracking harms public safety by increasing traffic in rural areas where roads are not designed for such high volumes, by creating an explosion risk from methane, and by increasing earthquake activity.

- A 2011 survey by Pennsylvania State Impact in eight counties found that 911 calls had increased in seven of them, with the number of calls increasing in one county by 49 percent over three years, largely due to an increase in incidents involving heavy trucks.⁶⁸
- Methane contamination of well water poses a risk of explosion if the gas builds up inside homes. In both Pennsylvania and Ohio, homes have exploded after high concentrations of methane inside the buildings were ignited by a spark.⁶⁹
- On New Year's Eve in 2011 – shortly after Ohio began accepting increasing amounts of wastewater from Pennsylvania – a 4.0 earthquake shook Youngstown, Ohio. Seismic experts at Columbia University determined that pumping fracking wastewater into a nearby injection well caused the earthquake.⁷⁰ Earthquakes triggered by injection well wastewater disposal have happened in Oklahoma, Arkansas, Texas, Ohio and Colorado.



A drill pad in southwestern Pennsylvania during fracking operations.

regulatory regime is capable of fully protecting the public – both due to the inherent risks of fracking and the oil and gas industry’s long track record of violating even the most basic environmental, health and safety standards.

A recent meta-review of years of scientific literature studying many aspects of fracking concluded that “regulations are simply not capable of preventing harm.”⁷² This is because the number of wells keeps

growing, the researchers wrote, and because there are so many factors – including “the subterranean geological landscape itself” – that are outside the realm of human control.⁷³

More importantly, though, any defense of fracking assumes that fracking companies will actually follow all the rules. As this report documents, they don’t. Not even companies that promise to exceed state standards regularly obey existing regulations.

Fracking Companies Are Violating Rules Meant to Protect the Environment and Human Health

The risks of fracking are significant even when fracking companies follow the rules and regulations put in place to protect the environment and human health. The threats to the environment increase when frackers break the rules.

In Pennsylvania, fracking companies violate rules and regulations meant to protect the environment and human health on virtually a daily basis. Between January 1, 2011, and August 31, 2014, the 20 most-cited companies together committed an average of 1.5 violations per day.⁷⁴

Moreover, these are not mere “paperwork” violations – they are violations that put Pennsylvania’s environmental and public health at real risk. And those violations have been committed by a variety of drilling companies – large and small, local, national and international.

Violations Pose Real Risks to Our Environment and Health

Violations of environmental, public health and safety rules can lead to significant damage to waterways, natural lands and the health of nearby residents.

Industrial Waste Is Dumped Into Local Waterways

A total of 28 companies have been cited for discharge of pollution into Pennsylvania rivers and streams since 2011.⁷⁵

In September 2014, Range Resources was deemed responsible for leaking hazardous fracking-related fluids into soil and water from six wastewater impoundment ponds in Washington County.⁷⁶

At one pond in Cecil Township, the fracking fluid harmed aquatic life in Brush Run, a stream designated by the state as “high quality,” the state’s second-highest level of waterway protection.⁷⁷ As part of the settlement, Range Resources agreed to completely stop using several of its impoundment ponds, and to pay \$4.1 million in fines.⁷⁸

An EQT well in Duncan Township, Tioga County, holds the infamous title of the Pennsylvania fracking well with more violations than any other between January 2011 and August 2014.⁷⁹ Among other problems, the owner of the well was cited for mishandling fracking waste liquid on four separate occasions from May through September 2012.⁸⁰ On two of those occasions, the well was also cited for discharging industrial waste (which can include “drill cuttings, oil, brine, and/or silt”) into a nearby spring.⁸¹

Toxic Chemicals Flow off Drilling Sites and Into the Surrounding Environment

Dozens of companies were cited for failing to prevent pollution between January 2011 and August 2014.⁸²

In 2011 Chief Oil and Gas was allowed to drill a fracking well 40 feet from wetlands adjoining Towanda Creek, in Leroy Township, Bradford County.⁸³ As a

condition of its permit, the company was required to control runoff to prevent pollution from entering the stream.⁸⁴ It did not comply with that requirement.

In July 2012, 4,700 gallons of hydrochloric acid overflowed the containment area around the drilling pad and polluted the stream, killing fish in Towanda Creek.⁸⁵ And in October 2012, the site suffered a spill of 420 gallons of fluid that had flowed up out of the well.⁸⁶

In March 2013, a wellhead owned by Carrizo burst in Tunkhannock, Wyoming County, releasing hundreds of thousands of gallons of fracking wastewater into the local environment and nearby wetlands, and causing the evacuation of several nearby homes.⁸⁷ The official report indicated that bolts within the wellhead were too loose and became unfastened, allowing a liquid mixture of water, sand, hydrochloric acid and other hazardous chemicals to spew out of the wellhead at a rate of between 25,000 and 35,000 gallons per hour.⁸⁸

The flow lasted for as long as 18 hours, during which the road leading to the site was blocked off and several families living nearby were asked to evacuate for fear that methane gas could also escape the well and explode.⁸⁹

As a result of the incidents described above, Chief and Carrizo were cited for violating rules requiring frackers to prevent pollution, among other violations.⁹⁰

Waste Is Stored and Disposed of Improperly

There have been 35 companies cited for violations of waste handling rules since 2011.⁹¹

In October 2014, state officials announced that EQT Production had operated an impoundment pond with as many as 200 holes in its lining.⁹² The leaks, found in May 2012 at the pond in Duncan Township, Tioga County, released as many as 500 gallons of toxic fracking wastewater, contaminating Rock Run,

a high quality trout-fishing stream, among other waters, and killing trees and other nearby plants.⁹³ The leaks and damage also led to EQT being charged with six criminal misdemeanors for violations of the state's Fish and Boat Code and assessed a \$4.5 million civil fine.⁹⁴

One method of fracking waste disposal is the injection of the wastewater into wells deep underground. This method of disposal has been shown to contaminate aquifers, as Exco Resources did in 2011, operating an injection well in Bell Township, Clearfield County, for four months after discovering it was leaking.⁹⁵ The company was forced to fix the well and pay \$160,000 in fines.⁹⁶

Wells Are Not Properly Plugged After Use

EQT Production was cited 10 times in 2013 alone for failing to plug wells it was no longer using.⁹⁷ Plugging wells is important for long-term protection of groundwater supplies because it helps prevent pollution, including toxic chemicals and other contaminants, from migrating to nearby aquifers and other geologic layers from the wells.⁹⁸ Many improperly plugged wells also leak significant amounts of methane into the atmosphere.⁹⁹

All Types of Fracking Companies Commit Environment-Damaging Violations

In all, 54 companies were cited for environmental and health violations in Pennsylvania between January 2011 and August 2014.

It is not just big companies, nor just small ones, that violate Pennsylvania's fracking rules. Neither is it only companies based out of state, nor only ones with local headquarters.

The biggest violator was Cabot Oil & Gas Corporation, based in Houston, which was cited for 265 violations,

including polluting surface and groundwater, by the Pennsylvania DEP from January 2011 through August 2014.¹⁰⁰ (See Table 2.) Other top violators include international household names like Shell and Chevron, well-known fracking companies like Range Resources and Chesapeake, and firms known well in Pennsylvania like Pennsylvania General Energy and Consol (CNX Gas).¹⁰¹

Some of the largest oil companies in the world are among Pennsylvania’s most frequent violators:

- **Cabot Oil and Gas Corporation**, based in Houston, is a member of the Standard and Poor’s 500.¹⁰³ With 265 violations between January 2011 and August 2014, Cabot leads the list of Pennsylvania’s frequent offenders.¹⁰⁴

Table 2. Pennsylvania’s 20 Most Frequently Cited Fracking Companies, Ranked by Number of Environmental and Health Violations, January 2011-August 2014¹⁰²

Company	Environmental and Health Violations	Rank
CABOT OIL & GAS CORP	265	1
CHESAPEAKE APPALACHIA LLC	253	2
RANGE RESOURCES APPALACHIA LLC	174	3
CHIEF OIL & GAS LLC	150	4
SWEPI LP	119	5
XTO ENERGY INC	113	6
ANADARKO E&P ONSHORE LLC	92	7
SOUTHWESTERN ENERGY PROD CO	88	8
WPX ENERGY APPALACHIA LLC	86	9
SENECA RESOURCES CORP	85	10 (tie)
CARRIZO (MARCELLUS) LLC	85	10 (tie)
EXCO RESOURCES PA LLC	82	12
EQT PRODUCTION CO	80	13 (tie)
PA GEN ENERGY CO LLC	80	13 (tie)
TALISMAN ENERGY USA INC	65	15
CHEVRON APPALACHIA LLC	63	16
ULTRA RESOURCES INC	52	17
EOG RESOURCES INC	38	18
CNX GAS CO LLC	36	19
SNYDER BROS INC	31	20

- **Chesapeake Energy**, based in Oklahoma City, says on its website that it is “the second-largest producer of natural gas” in the country.¹⁰⁵ Its subsidiary Chesapeake Appalachia received the second-highest number fracking violations in recent Pennsylvania history, with 253.¹⁰⁶
- **SWEPI** is a subsidiary of global petroleum giant Royal Dutch Shell with corporate headquarters in The Hague, The Netherlands.¹⁰⁷ It is fifth on the list of most frequent offenders, with 119 violations.¹⁰⁸
- **XTO Energy** has been, since 2010, a subsidiary of Irving, Texas-based ExxonMobil, “the world’s largest publicly traded international oil and gas company.”¹⁰⁹ XTO racked up 113 violations between January 2011 and August 2014.¹¹⁰

Major, multinational firms aren’t the only ones to violate the law. Four Pennsylvania-headquartered companies are on the top 20 list:

- **Pennsylvania General Energy**, headquartered in the northwestern Pennsylvania city of Warren, has 80 violations, tying it for 13th on the list.¹¹¹
- **EQT Production**, based in Pittsburgh, also has 80 violations and is tied for 13th on the list. In addition, EQT operates the well in Pennsylvania most often cited for violations. Located in Duncan Township, Tioga County, this single well had 19 violations from January 2011 through August 2014.¹¹² The company has another troublesome well in Duncan Township, which has 10 violations.¹¹³

The Actual Number of Violations of Environmental and Health Standards in Pennsylvania Is Likely Higher

This report analyzes notices of violation issued by the Pennsylvania Department of Environmental Protection in response to violations of environmental and public health rules under the state’s Oil and Gas Act.

It is likely that the number of *actual* violations is much higher than state records indicate, for two reasons. First, air pollution violations are handled, reported, and enforced by a different arm of the Pennsylvania DEP from oil and gas well violations, and as such are not included in this analysis.¹¹⁶

Second, Pennsylvania’s basic environmental laws are inadequately enforced.

A 2012 Earthworks report found that Pennsylvania oil and gas regulators conducted fewer than 20 percent of the inspections state rules required.¹¹⁷ Another Earthworks report two years later revealed that Pennsylvania regulators don’t meet their own standards for inspection frequency.¹¹⁸

A 2014 report from the state’s Auditor General said the state DEP was caught unprepared for the sudden increase in fracking activity, and found that, despite adding personnel to the well inspection staff, the DEP was unable to provide regular, consistent monitoring of fracking activity.¹¹⁹

The Pennsylvania DEP also has a regular practice of not issuing violation notices if companies voluntarily agree to address problems found by inspectors – including in cases as severe as contaminating drinking water supplies.¹²⁰

Other states have had enforcement difficulties at least as severe as Pennsylvania’s. A series of reports by Earthworks in 2012 revealed that violations in Colorado, New Mexico, New York, Ohio and Texas are also likely underreported because those states also all have too few inspectors for the number of wells, and are unable to inspect the majority of their active wells.¹²¹

- **CNX Gas**, a subsidiary of Canonsburg-based giant Consol Energy, is 19th on the list, with 36 violations.¹¹⁴
- **Snyder Brothers**, based in Kittanning, is 20th on the list, with 31 violations.¹¹⁵

Violators Include Companies That Have Promised to Improve Their Environmental Performance

In April 2013, several of Pennsylvania’s largest fracking companies – EQT, Chevron Appalachia, Consol and Shell – formed the Center for Sustainable Shale Development (CSSD), promising not only that “safe, sustainable shale resource development” was possible, but that they would do it of their own accord.¹²²

Photo: Ken Skipper, U.S. Geological Survey.



A drill rig at a Marcellus Shale production site in Pennsylvania.

Table 3. Environmental and Health Violations by Members of the Center for Sustainable Shale Development, July 2013-August 2014¹²⁸

Company	Environmental and Health Violations
SWEPI LP	39
EQT PRODUCTION CO	28
CHEVRON APPALACHIA LLC	27
CNX GAS CO LLC	6

The group said it had developed standards it claimed are more stringent than legal and regulatory requirements, setting 15 specific performance goals for operators “that are protective of air quality, water resources and climate.”¹²³ An expert analysis commissioned by the Delaware Riverkeeper Network found the CSSD performance standards deficient and often duplicative of existing requirements and practices, and concluded that they do not set a high standard of protection for the environment or affected communities.¹²⁴

And Pennsylvania DEP records show that since promising to exceed state standards, those four companies – all among the state’s most frequent violators – have failed to uphold state requirements at least 100 times.¹²⁵

The most frequent offender among these four since the April 2013 announcement of CSSD’s formation is the Royal Dutch Shell subsidiary known as SWEPI.¹²⁶ (See Table 3.) But all four have committed violations since their commitment to the CSSD. In June 2013, months after promising to look after the environment, CNX was cited for dumping industrial waste into the very waters it had promised to protect as a member of CSSD.¹²⁷

Top Violators Include All Sizes of Companies

Larger firms that drill or operate many wells may violate the law more frequently simply as a result of being more active. To correct for this, we compared the number of violations by company with:

- The number of wells drilled by that company since 2011.¹²⁹
- The number of wells the company operated since 2011.

In both cases, we limited the comparisons only to those firms with significant fracking activity during this period. (See Methodology.)

Viewed by number of wells drilled between January 2011 and August 2014 (see Table 4), the list included:

- **Atlas Resources**, based in Pittsburgh, drilled 11 wells during that period, and was cited for 13 violations – or 1.18 violations per well drilled, topping the list. Atlas has been repeatedly cited for failing to take appropriate pollution prevention measures, as well as for spills of toxic fluids.¹³⁰

Table 4. Top 20 Companies with the Most Environmental and Health Violations Per Well Drilled, January 2011-August 2014¹³⁵

Company	Violations At Wells Drilled Since 2011	Number of Wells Drilled Since 2011	Violations Per Well Drilled	Rank
ATLAS RESOURCES LLC	13	11	1.18	1
EXCO RESOURCES PA LLC	48	72	0.67	2
HALCON OPR CO INC	4	7	0.57	3
CARRIZO (MARCELLUS) LLC	51	93	0.55	4
SNYDER BROS INC	26	55	0.47	5
CHIEF OIL & GAS LLC	98	212	0.46	6
WPX ENERGY APPALACHIA LLC	51	114	0.45	7
CABOT OIL & GAS CORP	124	306	0.41	8
PA GEN ENERGY CO LLC	45	112	0.40	9
SENECA RESOURCES CORP	50	188	0.27	10
XTO ENERGY INC	43	174	0.25	11
ALPHA SHALE RES LP	7	30	0.23	12
SWEPI LP	85	391	0.22	13
SOUTHWESTERN ENERGY PROD CO	63	308	0.20	14
EQT PRODUCTION CO	71	350	0.20	15
INFLECTION ENERGY (PA) LLC	8	41	0.20	16
RANGE RESOURCES APPALACHIA LLC	104	566	0.18	17
CHESAPEAKE APPALACHIA LLC	90	539	0.17	18
TRIANA ENERGY LLC	2	12	0.17	19
CHEVRON APPALACHIA LLC	52	320	0.16	20

- **Exco Resources**, based in Dallas, was second, with 72 wells drilled and 48 health and environment violations, or 0.67 violations per well drilled.¹³¹
- **Halcon Operating Company**, based in Houston, drilled just seven wells but had four violations, putting it third on the list.¹³²
- **Carrizo (Marcellus) LLC**, owned by Houston-based Carrizo Oil and Gas, drilled 93 wells and had 51 environmental and health violations, ranking fourth.¹³³
- **Snyder Brothers**, based in Kittanning, Pennsylvania, was fifth, with 26 violations and 55 wells drilled.¹³⁴
- **Mieka**, part of Texas-based Vadda Energy, is at the top of the list with 0.46 average violations per active well per reporting period. The company has had problems properly controlling erosion at its well sites.¹³⁶

When factoring in the number of wells in active production (see Table 5), top violators also include large and small, locally based and international firms:

Table 5. Top 20 Companies with the Highest Average Number of Environmental and Health Violations Per Active Well Per Reporting Period, January 2011-June 2014¹⁴¹

Company	Average Wells Operating Per Reporting Period	Environmental and Health Violations Per Active Well	Rank
MIEKA LLC	4.43	0.46	1
PENN VIRGINIA OIL & GAS CORP	5.00	0.26	2
ENERPLUS RES (USA) CORP	6.57	0.22	3
CARRIZO (MARCELLUS) LLC	80.57	0.21	4
XTO ENERGY INC	151.14	0.20	5
RICE DRILLING B LLC	35.86	0.18	6
CHIEF OIL & GAS LLC	140.86	0.16	7
CABOT OIL & GAS CORP	298.57	0.15	8
STONE ENERGY CORP	7.71	0.14	9
HALCON OPR CO INC	5.80	0.12	10
PA GEN ENERGY CO LLC	117.86	0.11	11
TRIANA ENERGY LLC	21.14	0.11	12
ULTRA RESOURCES INC	62.00	0.11	13
WPX ENERGY APPALACHIA LLC	160.57	0.10	14
ANTERO RESOURCES CORP	4.14	0.09	15
SOUTHWESTERN ENERGY PROD CO	179.43	0.09	16
ALPHA SHALE RES LP	22.43	0.08	17
SENECA RESOURCES CORP	178.25	0.07	18
TANGLEWOOD EXPL LLC	11.00	0.06	19
EXCO RESOURCES PA LLC	296.14	0.06	20

- **Penn Virginia Oil & Gas**, based in Radnor, Pennsylvania, ranked second with 0.26 average violations per active well per reporting period. The company also operated just five wells in the first half of 2014.¹³⁷
- **Enerplus Resources (USA)**, a subsidiary of Enerplus Resources, based in Calgary, Alberta, Canada, was third with 0.22 average violations per active well per reporting period. The company operated seven wells in the first half of 2014.¹³⁸
- **Carrizo (Marcellus) LLC**, owned by Houston-based Carrizo Oil and Gas, ranked fourth with 0.21 average violations per active well per reporting period. Carrizo reported operations at 101 Pennsylvania fracking wells in the first six months of 2014.¹³⁹
- **XTO**, the ExxonMobil subsidiary, is fifth with one violation per every five wells operating. It reported operating 238 wells in the first six months of 2014.¹⁴⁰

Pennsylvania Violators Also Have Fracking Operations Across the Country

Many of the companies violating Pennsylvania's rules protecting the environment and human health from the worst harms of fracking also operate in other places around the country.¹⁴²

Of the 20 companies that are Pennsylvania's most frequent violators, 17 are part of companies with fracking operations in at least one other state – and two, XTO Energy and EOG Resources, operate in 10 or more other states. (See Appendix B for details on which companies operate in which states, and Appendix C to see which states are home to which companies.)

According to their respective websites, some of these companies are in just a few states, such as Cabot, Pennsylvania's most-cited company, which also operates in Texas and West Virginia. But others have vast nationwide presences: The parent company of Chesapeake Appalachia, the state's second most-cited fracking firm, has fracking operations in Colorado, Kansas, Louisiana, Ohio, Oklahoma, Texas, West Virginia and Wyoming. And XTO Energy, a subsidiary of ExxonMobil (Pennsylvania's sixth most-cited company) has fracking operations in 16 other states.

These and other top violators also have fracking operations or mineral rights that would allow for future fracking in 23 other states: Alaska, Arkansas, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Tennessee, Texas, Utah, Virginia, West Virginia, and Wyoming.

Policy Recommendations

Fracking is an inherently polluting practice. Given the scale and severity of fracking's myriad impacts, constructing and implementing a regulatory regime sufficient to protect the environment and public health from dirty drilling seems unlikely. Moreover, the notion of strictly enforcing such safeguards at tens of thousands of wells – plus compressor stations, pipelines, processing plants and waste disposal sites – is highly implausible.

The evidence bears this out. As demonstrated in this report, fracking operators in Pennsylvania regularly violate essential environmental and public health protections. Even key industry players who have pledged to clean up their acts are still breaking the rules and damaging the environment. Moreover, such violations merely scratch the surface, since state officials are only inspecting a fraction of fracking wells and Pennsylvania lacks some of the most basic rules that could reduce fracking damage – like bans on waste pits or bars on the use of toxic chemicals in fracking fluid.

This is hardly a problem unique to Pennsylvania. Fracking operators have racked up hundreds of violations in other states as well, and many violators in Pennsylvania have leases to drill in several other states.

The continued violations by fracking operators serve to underscore a key reason why the drilling practice cannot be made safe: Constructing rules that address the sheer number and severity of risks posed by

fracking – much less enforcing those rules at thousands of wells and other sites – is impracticable at best. Accordingly, banning fracking before it begins – as has been done in New York state – is the most prudent course for states to protect the environment and public health.

In states like Pennsylvania where widespread fracking is already under way, a moratorium on all new permits and wells is in order – at least until all of the following measures are permanently in place:

- Dramatically ramp up enforcement – including regular inspections and penalties sufficiently certain and severe that it no longer pays to pollute;
- Require drillers to post sufficient financial assurance to guarantee that the costs of any environmental or public health damage caused by fracking are borne by fracking operators, not the public; and
- Adopt much more stringent protections – including bans on waste pits, bars on the use of toxic chemicals in fracking fluid, adequate buffer zones, and bans on fracking in state forests and parks.

The record of persistent violations also belies any notion that citizens should have to exclusively rely on state agencies or officials to protect their health and environment from dirty drilling. Accordingly,

- All local communities must be granted clear authority to reject or restrict dirty drilling within their borders; and
- Federal policymakers should close the loopholes exempting fracking from key provisions of our nation's environmental laws and protect America's natural heritage by keeping fracking away from

our national parks, national forests, and sources of drinking water for millions of Americans.

Finally, more complete data on fracking should be collected and made available to the public, enabling us to understand the full extent of the harm that fracking causes to our environment and health.

Photo: William Avery Hudson



A fracking well site in Franklin Township near Montrose and Dimock.

Methodology

Basic Information

The data in this report represent violations of environmental and health protection regulations at “unconventional” (i.e., fracking) wells in Pennsylvania from 1 January 2011 through 31 August 2014.¹⁴³

Data were downloaded from the Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297. Violation, well activity and production reporting data were downloaded on 18 September 2014.

Violation Information

Violations are those reported in the state’s “Oil and Gas Compliance Report” database. These data were searched for in the database with a query specifically returning “inspections with violations only.” The result was downloaded as a CSV file,¹⁴⁴ opened in Microsoft Excel to better handle comma-delimited text, and then imported into Microsoft Access. Data downloaded were for unconventional wells only.

This file had multiple records for many violations, reflecting various stages of addressing the problem, including notices of violation, administrative orders, cessation orders, consent orders and consent assessment of civil penalties. We filtered out these duplicates by counting violations based only on each violation’s unique ID number.

In addition to specifying specific violations, the downloaded file also sorted them into categories: “administrative” or “environmental health and safety.” We discarded Pennsylvania’s categorization as inconsistent and inadequate, and instead ourselves divided the violations into two categories: “administrative” or “environmental and health,” based on the definitions listed in Appendix A.

The data presented in this report include only environmental and health violations, not administrative violations. Compliance with administrative rules is very important – failure to comply with administrative rules can conceal other types of violations and deny the public access to critical information about drilling practices in their communities. However, to emphasize the immediate hazards posed by fracking to communities, this report focuses solely on violations with the direct potential to threaten the environment and public health.

Wells Drilled Data

The state’s “Wells Drilled by Operator” data were downloaded in a CSV file.¹⁴⁵

Oil and Gas Production Data

These data were found from the “Oil and Gas Production Reports” section of the Pennsylvania’s DEP’s website, accessing the “Statewide Data Downloads” page and downloading CSV files for each reporting

period.¹⁴⁶ All of the files for the time period in question were downloaded – including those labeled “Unconventional wells,” “Conventional wells,” “without Marcellus” or “Marcellus Only.” Despite their file names, most of the files contained information about both conventional and unconventional wells. We deleted anything that was marked with an “N” in the “Unconventional” column.

Determining Operators Responsible for Violations

For each violation, the operator responsible was named in the Oil and Gas Compliance Report.

Assessing Violations Per Well Drilled

From the “Wells Drilled By Operator” data, we extracted all wells whose construction began between 1 January 2011 and 31 August 2014, according to the well’s spud date, the date on which drilling operations began. The violations at those wells were counted by operator, and compared with the number of wells reported drilled by each of those companies during the same period. Some companies did not drill any wells; others who did drill wells were not cited for any violations.

For ranking purposes, we focused on the most active companies in the state by excluding from the rankings all companies who drilled fewer than five wells over the period. That includes 36 companies and excludes the 50 who drilled four or fewer wells.

Assessing Violations Per Active Well

The data identifying which companies had how many violations in each time period were combined with

the data of which companies reported wells operating in that time period.

To arrive at an overall determination of the number of violations per active well, we calculated for each reporting period the number of environmental and health violations that company received and the number of that company’s wells reporting production activity.

Those numbers were used to calculate a violations per active well ratio for that reporting period. The ratios for all periods in which the company reported production activity were averaged, to come up with an overall average ratio for the company.

For example, Mieka received no violations between January and June 2011, a period during which it operated three wells, for a ratio of zero violations per well operated. The same was true from July to December 2011. Between January and June 2012, the company received seven violations and operated five wells, a ratio of 1.4. In the second half of 2012, it received no violations and operated five wells, another ratio of zero. In the first half of 2013, it received one violation and operated five wells, a ratio of 0.2; the second half of 2013 saw it receive two violations and operate five wells, for a ratio of 0.4. In the first half of 2014, Mieka received six violations and operated five wells, a ratio of 1.2. Averaging those ratios gives Mieka 0.46 average violations per active well per reporting period.

For ranking purposes, we focused on the most active companies in the state by excluding from the rankings all companies that never operated more than five wells in any time period. That includes 58 companies and excludes the 28 companies that never had more than five wells active in any given reporting period.

Appendix A: Assigned Violation Categories and Their DEP Codes

The boldface text is the category assigned by the researchers. The Pennsylvania Department of Environmental Protection violation codes (bulleted items) are assigned by DEP.

Administrative

- 102.5NPDES - Failure to obtain an NPDES [National Pollutant Discharge Elimination System] Permit for Stormwater Discharges Associated With a Construction Activity.
- 105GEN - Encroachment-General
- 105IMP - Failure to implement Encroachment Plan
- 201A - Failure to have permit on site during drilling
- 201F - Failure to notify DEP, landowner, political subdivision, or coal owner 24 hrs prior to commencement of drilling
- 201G - Failure to post permit number, operator name, address, telephone number in a conspicuous manner at the site during drilling
- 201H - Failure to properly install the permit number, issued by the department, on a completed well.
- 201TAG - Failure to install, in a permanent manner, the permit number on a completed well
- 203TAG - Failure to affix, in a permanent manner, a registration number on a well within 60 days of registration
- 210H - Failure to properly install the permit number, issued by the department, on a completed well.
- 212CMPLRPT - Failure to submit completion report within 30 days of completion of well
- 212PRODRPT - Failure to submit annual production report
- 212WELLRCD - Failure to submit well record within 30 days of completion of drilling
- 287.54A - Person or municipality has not performed waste analysis or no copy submitted to the Department.
- 301 - Failure of storage operator to maintain and/or submit required information, such as maps, well records, integrity testing informatio [sic], pressure data
- 51017 - Administrative Code-General
- 601.101 - O&G Act 223-General. Used only when a specific O&G [Oil & Gas] Act code cannot be used
- 78.122 - Drillers Log not on site
- 78.124 - Failure to submit plugging certificate 30 days after well plugged
- 78.51(H) - Failure to report receipt of notice from a landowner, water purveyor or affected person that a water supply has been affected by pollution or diminution, to the Department within 24 hours of receiving the notice.

- 78.57 - Failure to post pit approval number
- 78.57PITAPPR - Failure to obtain pit approval/permit
- 78.65(3) - Failure to submit or submitting an inadequate well site restoration report within 60 days of restoration of the well site
- 79.11 - Conservation well located less than 330' [feet] from lease or unit line without waiver.
- ACT214GEN - Coal & Gas Resources Coordination Act 214 - General
- ACT359GEN - Oil & Gas Conservation Law - General
- OGA 3211(F1) - Failure to notify DEP or surface landowner or local political subdivision 24 hours prior to commencement of drilling. Failure to electronically notify DEP. Failure to re-notify DEP.
- OGA 3211(F2) - Failure to notify DEP 24 hours prior to cementing casing strings, pressure testing of production casing, stimulation of well or plugging of an unconventional well.
- OGA 3211(G) - Failure to post the well permit number and the operator's name, address and phone number at the well site during construction of the access road, site preparation and during drilling, operating or alteration of well.
- OGA 3211(H) - Failure to install, in a permanent manner, the permit number on a completed well.
- OGA 3211(M) - Failure to obtain an approved water management plan for withdrawing or using water during the drilling or hydraulic fracture stimulation of an unconventional well.
- OGA 3218.3 - Failure to properly maintain transportation/disposal records for unconventional well wastewater. Failure to make such records available upon request.
- OGA 3220(C) - Failure to notify DEP, the coal operator, lessee and owner prior to plugging a well and submit a plat.
- OGA 3222(A) - Failure to submit annual conventional well production report.
- OGA 3222(B) - Failure to submit well record / completion report.

Environmental and Health

- 102.11 - Failure to design, implement or maintain BMPs [best management practices] to minimize the potential for accelerated erosion and sedimentation.
- 102.22 - Failure to achieve permanent stabilization of earth disturbance activity.
- 102.4 - Failure to minimize accelerated erosion, implement E&S [erosion & sedimentation] plan, maintain E&S [erosion & sedimentation] controls. Failure to stabilize site until total site restoration under OGA [Oil & Gas Act] Sec 206(c)(d)
- 102.4HQBMP - Failure to implement Special Protection BMPs [best management practices] for HQ [high quality] or EV [exceptional value] stream.
- 102.4INADPLN - E&S [erosion & sedimentation] Plan not adequate
- 102.4NOPLAN - No E&S [erosion & sedimentation] plan developed, plan not on site
- 105.11 - Person constructed, operated, maintained, modified, enlarged or abandoned a water obstruction or encroachment but failed to obtain Chapter 105 permit.
- 105.11 - Water obstruction or encroachment constructed, operated, maintained, modified, enlarged or abandoned without a 105 permit.
- 105.44 - Failure to implement work according to specifications in 105 Permit.
- 105.44 - Permittee has failed to perform work according to specifications as approved.
- 105NOPERMIT - Encroachment without Permit or Waiver

- 201E - Failure to comply with terms and conditions of permit
- 201I - Drilling with an expired permit
- 201PRMT - Drilling, altering, or operating a well without a permit
- 205A - Drilling w/in 200 ft of building or water well w/o variance
- 205B - Drilling w/in 100 ft of surface water or wetland w/o variance
- 206C - Failure to restore well site within nine months after completion of drilling, failure to remove all pits, drilling supplies and equipment not needed for production.
- 206D - Failure to restore site w/in 9 months of plugging well
- 206REST - Failure to restore site w/in 9 months of completion of drilling or plugging
- 208A - Failure to restore a water supply affected by pollution or diminution
- 209BOP - Inadequate or improperly installed BOP [blowout preventer], other safety devices, or no certified BOP [blowout preventer] operator
- 210IMPRPLUG - Failure to plug zones having borne gas, oil, or water
- 210UNPLUG - Failure to plug a well upon abandonment
- 301CSL - Stream discharge of IW [industrial waste], includes drill cuttings, oil, brine and/or silt
- 301UNPMTIW - Industrial waste was discharged without permit.
- 307CSL - Discharge of industrial waste to waters of Commonwealth without a permit.
- 401 CSL - Discharge of polluttional [sic] material to waters of Commonwealth.
- 401CAUSEPOLL - Polluting substance(s) allowed to discharge into Waters of the Commonwealth.
- 401CSL - Discharge of polluttional [sic] material to waters of Commonwealth.
- 402611 - Failure to meet effluent limits of permit
- 402CSL - Failure to adopt pollution prevention measures required or prescribed by DEP by handling materials that create a danger of pollution.
- 402CSL B - Failure to meet requirements of permit, rules and regulations, or order of DEP.
- 402POTNLPOLL - There is a potential for polluting substance(s) reaching Waters of the Commonwealth and may require a permit.
- 509 - Failure to comply w/ order, CO&A [consent order & agreement], hindrance to personnel, misrepresentation under OGA [Oil & Gas Act]
- 6018.301 - Operator has mismanagement [sic] Residual Waste.
- 6018.301 - Residual Waste is mismanaged.
- 6018.302A - Unlawful Management of RSW [residual waste]
- 6018.610 8II - Unlawful transfer of RSW [residual waste]
- 6018.610-2 - Person or municipality operates a facility without a permit.
- 6018.610-4 - Handles solid waste contrary to rules and regulations, or orders of the Department, or any permit condition, or in any manner as to create a public nuisance.
- 691.1 - Clean Streams Law-General. Used only when a specific CLS [sic; Clean Streams Law] code cannot be used
- 691.401WPD - Failure to prevent sediment or other pollutant discharge into waters of the Commonwealth.

- 691.402 - Potential to pollute waters of the Commonwealth
- 691.402WPP - Site conditions present a potential for pollution to waters of the Commonwealth.
- 78.11 - Well drilled or operated without a permit or registration from DEP.
- 78.12 - Oil or gas well drilled, altered or operated not in accordance with a permit or the regulations.
- 78.51(A) - Failure to restore or replace an impacted water supply.
- 78.53 - Failure to implement and maintain BMPs [best management practices] in accordance with Chapter 102.
- 78.54 - Failure to properly control or dispose of industrial or residual waste to prevent pollution of the waters of the Commonwealth.
- 78.55 - No Control and Disposal/PPC [prevention, preparedness, contingency] plan or failure to implement PPC [prevention, preparedness, contingency] plan
- 78.56(1) - Pit and tanks not constructed with sufficient capacity to contain polluttional substances.
- 78.56(2) - Failure to maintain 2' [feet] of freeboard in an impoundment.
- 78.56(3) - Impoundment not structurally sound, impermeable, 3rd party protected.
- 78.56FRBRD - Failure to maintain 2' [feet] freeboard in an impoundment
- 78.56LINER - Improperly lined pit
- 78.56PITCNST - Impoundment not structurally sound, impermeable, 3rd party protected, greater than 20" [inches] of seasonal high ground water table
- 78.57C2 - Failure to construct properly plug, frac, brine pits
- 78.6 - Tophole water discharge does not meet standards
- 78.60B - Tophole water discharged improperly
- 78.61A - Improper pit disposal of drill cuttings from above the casing seat
- 78.62 - Improper encapsulation of waste
- 78.64 - Inadequate containment of oil tank
- 78.65(1) - Rat hole not filled
- 78.65(2) - Failure to restore site within 30 days of permit expiration when well not drilled
- 78.66A - Failure to report release of substance threatening or causing pollution
- 78.66BRINE - Failure to report a reportable release of brine to DEP within 2 hours.
- 78.73A - Operator shall prevent gas and other fluids from lower formations from entering fresh groundwater.
- 78.73B - Excessive casing seat pressure
- 78.74 - Hazardous well venting
- 78.81D1 - Failure to maintain control of anticipated gas storage reservoir pressures while drilling through reservoir or protective area
- 78.81D2 - Failure to case and cement properly through storage reservoir or storage horizon
- 78.83A - Diameter of bore hole not 1 inch greater than casing/casing collar diameter
- 78.83COALCSG - Improper coal protective casing and cementing procedures
- 78.83GRNDWTR - Improper casing to protect fresh groundwater
- 78.84 - Insufficient casing strength, thickness, and installation equipment

- 78.85 - Inadequate, insufficient, and/or improperly installed cement
- 78.86 - Failure to report defective, insufficient, or improperly cemented casing w/in 24 hrs or submit plan to correct w/in 30 days
- 79.12CW - Insufficient casing, BOP [blowout preventer], cement or wait on cement to prevent waste from conservation well.
- 91.33A - Failure to notify DEP of pollution incident. No phone call made forthwith
- 91.33B - Failure to take measures to mitigate spill impact and/or clean up w/in 15 days
- 91.33POLLINC - Pollution incident was not reported to DEP.
- 91.34A - Failure to take all necessary measures to prevent spill. Inadequate diking, potential pollution
- 91.35IMPOUND - Adequate impoundment freeboard was not maintained.
- 92.3 - Discharge of pollutants from a point source into surface waters without NPDES [National Pollutant Discharge Elimination System] permit.
- CSL201BYPASS - Untreated or inadequately treated sewage was discharged
- CSL301BYPASS - Industrial waste was discharged without a permit
- CSL401CAUSPL - Polluting substance(s) allowed to discharge into Waters of the Commonwealth
- CSL402POTPOL - There is a potential for polluting substance(s) reaching Waters of the Commonwealth and may require a permit
- OGA 3211(A) - Drilling or altering a well without a well permit or no copy of the well permit at the well site.
- OGA 3216(A) - Failure to restore disturbed land surface of a well site.
- OGA 3216(C) - Failure to fill all pits used to contain produced fluids or industrial wastes and remove unnecessary drilling supplies/equipment not needed for production within 9 months from completion of drilling of well.
- OGA 3218(A) - Failure to restore or replace a public or private water supply affected by a well operator.
- OGA 3219 - Failure to use casing of sufficient strength and other safety devices to prevent blowouts, explosions and fires.
- OGA 3220(A) - Failure to plug the well upon abandoning it.
- OGA 3258(B) - Failure to provide free and unrestricted access.
- OGA 3259(1) - Drilling, altering or operating a well without a permit. Failure to comply with rules or regulations adopted under the 2012 Oil and Gas Act, DEP order, or a term or condition of the well permit.
- OGA 3259(3) - Refuse, obstruct, delay or threaten a DEP agent or employee.
- OGA3218.2(A) - Failure to design and construct unconventional well site to prevent spills to the ground surface and off well site.
- OGA3218.2(C) - Failure to use containment systems for (1) drilling mud, (2) hydraulic oil, (3) diesel fuel, (4) drilling mud additives, (5) hydraulic fracturing additives, (6) hydraulic fracturing flowback.
- OGA3259(2) - Conducting a drilling or production activity that is contrary to the 2012 Oil and Gas Act, 25 Pa. Code Chapter 78, DEP order, or a term or condition of the well permit.
- SWMA301 - Failure to properly store, transport, process or dispose of a residual waste.

Appendix B

Top 20 Most-Cited Fracking Companies Ranked by Environmental and Health Violations, Their Parent Companies, and Their Other Operating Locations¹⁴⁷

Rank	Company	Environmental and Health Violations, Jan. 2011-Aug. 2014	Corporate Parent	Website	Headquarters Location	States of Operation ¹⁴⁸
1	CABOT OIL & GAS CORP	265	Cabot Oil & Gas Corporation	cabotog.com	Houston, Texas	Pennsylvania, Texas, West Virginia
2	CHESAPEAKE APPALACHIA LLC	253	Chesapeake Energy ¹⁴⁹	chk.com	Oklahoma City, Oklahoma	Colorado, Kansas, Louisiana, Ohio, Oklahoma, Pennsylvania, Texas, West Virginia, Wyoming
3	RANGE RESOURCES APPALACHIA LLC	174	Range Resources	rangeresources.com	Fort Worth, Texas	Kentucky, Maryland, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, West Virginia
4	CHIEF OIL & GAS LLC	150	Chief Oil & Gas LLC	chiefog.com	Dallas, Texas	Pennsylvania
5	SWEPI LP	119	Royal Dutch Shell ¹⁵⁰	shell.com	The Hague, The Netherlands	Louisiana, Ohio, Pennsylvania, Wyoming ¹⁵¹
6	XTO ENERGY INC	113	ExxonMobil	xtoenergy.com	Irving, Texas	Alaska, Arkansas, Colorado, Kansas, Louisiana, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Utah, West Virginia, Wyoming
7	ANADARKO E&P ONSHORE LLC	92	Anadarko Petroleum	anadarko.com	The Woodlands, Texas	Colorado, Kansas, Louisiana, Pennsylvania, Texas, Utah, Wyoming

Continued on page 33

Continued from page 32

Rank	Company	Environmental and Health Violations, Jan. 2011-Aug. 2014	Corporate Parent	Website	Headquarters Location	States of Operation ¹⁴⁸
8	SOUTHWESTERN ENERGY PROD CO	88	Southwestern Energy	swn.com	Houston, Texas	Arkansas, Colorado, Pennsylvania, Texas, West Virginia
9	WPX ENERGY APPALACHIA LLC	86	WPX Energy	wpxenergy.com	Tulsa, Oklahoma	Colorado, New Mexico, North Dakota
10	SENECA RESOURCES CORP	85	National Fuel Gas Company	natfuel.com	Williamsville, New York	California, New York, Pennsylvania
11	CARRIZO (MARCELLUS) LLC	85	Carrizo Oil & Gas Inc	carrizo.com	Houston, Texas	Colorado, Ohio, Pennsylvania, Texas
12	EXCO RESOURCES PA LLC	82	Exco Resources Inc	excoresources.com	Dallas, Texas	Louisiana, Pennsylvania, Texas, West Virginia
13	EQT PRODUCTION CO	80	EQT Corporation	eqt.com	Pittsburgh, Pennsylvania	Kentucky, Ohio, Pennsylvania, Virginia, West Virginia
14	PA GEN ENERGY CO LLC	80	Pennsylvania General Energy	penngeneralenergy.com	Warren, Pennsylvania	Pennsylvania
15	TALISMAN ENERGY USA INC	65	Talisman Energy Inc	talisman-energy.com	Calgary, Alberta, Canada	New York, Pennsylvania, Texas
16	CHEVRON APPALACHIA LLC	63	Chevron Corporation	chevron.com	San Ramon, California	Michigan, Ohio, Pennsylvania, Texas
17	ULTRA RESOURCES INC	52	Ultra Petroleum Corporation ¹⁵²	ultrapetroleum.com	Houston, Texas	Pennsylvania, Wyoming
18	EOG RESOURCES INC	38	EOG Resources Inc	eogresources.com	Houston, Texas	Colorado, Louisiana, Montana, New Mexico, Ohio, Oklahoma, Pennsylvania, Texas, Utah, West Virginia, Wyoming
19	CNX GAS CO LLC	36	Consol Energy	consolenergy.com	Canonsburg, Pennsylvania	Indiana, Illinois, Kentucky, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia
20	SNYDER BROS INC	31	Snyder Brothers Inc	snyderbrothersinc.com	Kittanning, Pennsylvania	Pennsylvania

Appendix C

States Where Pennsylvania's Top 20 Most-Cited Fracking Companies Also Operate¹⁵³

State	Companies Operating ¹⁵⁴
Alaska	ExxonMobil
Arkansas	ExxonMobil, Southwestern Energy
California	National Fuel Gas Company
Colorado	Chesapeake Energy, ExxonMobil, Anadarko Petroleum, Southwestern Energy, Carrizo Oil & Gas Inc, EOG Resources
Indiana	Consol Energy
Illinois	Consol Energy
Kansas	Chesapeake Energy, ExxonMobil, Anadarko Petroleum
Kentucky	Range Resources, EQT Corporation, Consol Energy
Louisiana	Chesapeake Energy, Royal Dutch Shell, ExxonMobil, Anadarko Petroleum, Exco Resources Inc, EOG Resources
Maryland	Range Resources
Michigan	Chevron Corporation
Montana	ExxonMobil, EOG Resources
New Mexico	ExxonMobil, WPX Energy, EOG Resources
New York	ExxonMobil, National Fuel Gas Company, Talisman Energy Inc, Consol Energy
North Dakota	ExxonMobil, WPX Energy
Ohio	Chesapeake Energy, Range Resources, Royal Dutch Shell, ExxonMobil, Carrizo Oil & Gas Inc, EQT Corporation, Chevron Corporation, EOG Resources, Consol Energy
Oklahoma	Chesapeake Energy, Range Resources, ExxonMobil, EOG Resources
Tennessee	Consol Energy
Texas	Cabot Oil & Gas Corporation, Chesapeake Energy, Range Resources, ExxonMobil, Anadarko Petroleum, Southwestern Energy, Carrizo Oil & Gas Inc, Exco Resources Inc, Talisman Energy Inc, Chevron Corporation, EOG Resources
Utah	ExxonMobil, Anadarko Petroleum, EOG Resources
Virginia	Range Resources, EQT Corporation, Consol Energy
West Virginia	Cabot Oil & Gas Corporation, Chesapeake Energy, Range Resources, ExxonMobil, Southwestern Energy, Exco Resources Inc, EQT Corporation, EOG Resources, Consol Energy
Wyoming	Chesapeake Energy, Royal Dutch Shell ¹⁵⁵ , ExxonMobil, Anadarko Petroleum, Ultra Petroleum Corporation, EOG Resources

Appendix D

Companies Active in Pennsylvania, January-June 2014¹⁵⁶

Company	Wells Operating	Rank
RANGE RESOURCES APPALACHIA LLC	891	1
CHESAPEAKE APPALACHIA LLC	858	2
SWEPI LP	632	3
CHEVRON APPALACHIA LLC	582	4
TALISMAN ENERGY USA INC	511	5
CABOT OIL & GAS CORP	434	6
EQT PRODUCTION CO	413	7
ANADARKO E&P ONSHORE LLC	364	8
EXCO RESOURCES PA LLC	350	9
SOUTHWESTERN ENERGY PROD CO	315	10
CNX GAS CO LLC	301	11
ATLAS RESOURCES LLC	258	12
SENECA RESOURCES CORP	239	13
XTO ENERGY INC	238	14
CHIEF OIL & GAS LLC	225	15
WPX ENERGY APPALACHIA LLC	183	16
EOG RESOURCES INC	175	17
PA GEN ENERGY CO LLC	156	18
ENERGY CORP OF AMER	112	19
RE GAS DEV LLC	110	20
CARRIZO (MARCELLUS) LLC	101	21
SNYDER BROS INC	94	22
RICE DRILLING B LLC	75	23
DOMINION TRANS INC	73	24
VANTAGE ENERGY APPALACHIA II LLC	69	25
MDS ENERGY LTD	63	26
ULTRA RESOURCES INC	56	27
HILCORP ENERGY CO	47	28
INFLECTION ENERGY LLC	39	29
ALPHA SHALE RES LP	35	30 (tie)

Continued on page 36

Continued from page 35

Company	Wells Operating	Rank
PENNENERGY RESOURCES LLC	35	30 (tie)
CITRUS ENERGY CORP	34	32
NOBLE ENERGY INC	31	33
TRIANA ENERGY LLC	20	34
TENASKA RES LLC	13	35
BLX INC	12	36
EM ENERGY PA LLC	11	37 (tie)
HUNT MARCELLUS OPERATING CO LLC	11	37 (tie)
ENDEAVOUR OPERATING CORP	9	39 (tie)
REDMILL DRILLING	9	39 (tie)
STONE ENERGY CORP	8	41
ENERPLUS RES (USA) CORP	7	42 (tie)
HALCON OPR CO INC	7	42 (tie)
TEXAS KEYSTONE INC	7	42 (tie)
JJ BUCHER PRODUCING CORP	6	45
BURNETT OIL CO INC	5	46 (tie)
MIEKA LLC	5	46 (tie)
NORTHEAST NATURAL ENERGY LLC	5	46 (tie)
PENN VIRGINIA OIL & GAS CORP	5	46 (tie)
T & F EXPLORATION LP	4	50
CAMPBELL OIL & GAS INC	3	51 (tie)
FLATIRONS DEVELOPMENT LLC	3	51 (tie)
SM ENERGY CO	3	51 (tie)
ALLIANCE PETROLEUM CORP	2	54 (tie)
ANTERO RESOURCES CORP	2	54 (tie)
BAKER GAS INC	2	54 (tie)
SAMSON RES CO	2	54 (tie)
TRUE OIL LLC	2	54 (tie)
WILLIAM MCINTIRE COAL OIL & GAS	2	54 (tie)
AMER OIL & GAS LLC	1	60 (tie)
DL RESOURCES INC	1	60 (tie)
GREAT OAK ENERGY INC	1	60 (tie)
GREAT PLAINS OPER LLC DBA GREAT MTN OPER	1	60 (tie)
JM BEST INC	1	60 (tie)
THE PRODUCTION CO LLC	1	60 (tie)
WILMOTH INTERESTS INC	1	60 (tie)

Notes

1. Marie Cusick and Katie Colaneri, "Worker Still Missing After Southwestern Pa. Gas Well Explosion," *Pennsylvania State Impact*, 13 February 2014; Pennsylvania Department of Environmental Protection, *After Action Review Department of Environmental Protection Incident Response Chevron Appalachia LLC – Lanco 7H Well Fire, Dunkard Township, Greene County*, 6 August 2014.

2. Marie Cusick and Katie Colaneri, "Worker Still Missing After Southwestern Pa. Gas Well Explosion," *Pennsylvania State Impact*, 13 February 2014.

3. Pennsylvania Department of Environmental Protection, *After Action Review Department of Environmental Protection Incident Response Chevron Appalachia LLC – Lanco 7H Well Fire, Dunkard Township, Greene County*, 6 August 2014.

4. See note 1.

5. Killed McKee instantly: David Dekok, "Death at Pennsylvania Gas Well Blamed on Human Error, Poor Supervision," *Reuters.com*, 6 August 2014; nearby well and truck: Molly Born and Sean Hamill, "Greene County Shale Well Continues Burning," *Pittsburgh Post-Gazette*, 12 February 2014.

6. Worker nearby: Pennsylvania Department of Environmental Protection, *Summary of Bureau of Investigations Information Gathering Efforts Chevron Lanco Pad A Gas Well Fire*, 6 August 2014; minor injuries: Katie Colaneri, "Crews Cap Leaking Chevron Gas Well that Started Fire in Southwest Pa.," *Pennsylvania State Impact*, 24 February 2014.

7. Near a local school: Marie Cusick and Katie Colaneri, "Worker Still Missing After Southwestern Pa. Gas Well Explosion," *Pennsylvania State Impact*, 13 February 2014; repeated explosions: Pennsylvania Department of Envi-

ronmental Protection, *After Action Review Department of Environmental Protection Incident Response Chevron Appalachia LLC – Lanco 7H Well Fire, Dunkard Township, Greene County*, 6 August 2014.

8. Laura Legere, "With Fire Out, Crews Move Toward Capping Wells at Greene County Explosion Site," *Pennsylvania State Impact*, 17 February 2014; Marie Cusick and Katie Colaneri, "DEP: Crews Making Progress on Well Fire in Southwest Pa., Worker Still Missing," *Pennsylvania State Impact*, 13 February 2014.

9. Katie Colaneri, "Crews Cap Leaking Chevron Gas Well that Started Fire in Southwest Pa.," *Pennsylvania State Impact*, 24 February 2014; Laura Legere, "With Fire Out, Crews Move Toward Capping Wells at Greene County Explosion Site," *Pennsylvania State Impact*, 17 February 2014.

10. Katie Colaneri, "Crews Cap Leaking Chevron Gas Well that Started Fire in Southwest Pa.," *Pennsylvania State Impact*, 24 February 2014.

11. Pennsylvania Department of Environmental Protection, *Notice of Violation* (letter to Chevron Appalachia LLC), 18 March 2014.

12. Ibid.

13. Katie Colaneri, "Chevron Blocked Access to DEP After Fatal Well Fire in Southwest Pa.," *Pennsylvania State Impact*, 9 April 2014.

14. Pennsylvania Department of Environmental Protection, *Summary of Bureau of Investigations Information Gathering Efforts Chevron Lanco Pad A Gas Well Fire*, 6 August 2014.

15. Not McKee: David Dekok, "Death at Pennsylvania Gas Well Blamed on Human Error, Poor Supervision," *Reuters.com*, 6 August 2014; all other facts in this sentence:

Pennsylvania Department of Environmental Protection, *Summary of Bureau of Investigations Information Gathering Efforts Chevron Lanco Pad A Gas Well Fire*, 6 August 2014.

16. "CSSD: Environmental Cred for Appalachian Shale Producers," *WVNStv.com*, 25 April 2013; promise: Center for Sustainable Shale Development, *Center for Sustainable Shale Development*, accessed at www.sustainables shale.org, 15 October 2014.

17. Ibid.

18. Elizabeth Ridlington, Frontier Group, and John Rumpler, Environment America Research & Policy Center, *Fracking by the Numbers*, October 2013, available at www.frontiergroup.org/reports/fg/fracking-numbers.

19. The Pennsylvania Department of Environmental Protection has confirmed 243 cases of water supply contamination as a result of fracking activities; due to redactions in the supporting documents, it is not possible to tell how many were due to failures of fracking wells, as opposed to other potential causes such as wastewater spills or wells going dry. Pennsylvania Department of Environmental Protection, *Water Supply Determination Letters*, 29 August 2014, available at files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf.

20. Pennsylvania Department of Environmental Protection, *Water Supply Determination Letters*, 29 August 2014, available at files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf.

21. Laura Legere, "Sunday Times Review of DEP Drilling Records Reveals Water Damage, Murky Testing Methods," *Scranton Times-Tribune*, 19 May 2013.

22. Laura Legere, "DEP Releases Updated Details on Water Contamination Near Drilling Sites," *Pittsburgh Post-Gazette*, 9 September 2014.

23. Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, *Oil and Gas Reports*, accessed at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297, 18 September 2014 (violation 653937).

24. "DEP Issues Drilling Permit for Gas Well in Snyder Twp.," *Nashua Telegraph*, 26 May 2013.

25. Ibid.

26. Pennsylvania state senator Joe Scarnati, *Statement on Flatirons Ending Marcellus Drilling Operations at Brandon-Day Well* (press release), 11 August 2014.

27. "Scarnati Seeks Denial of Flatirons Permit," *Tri-County Sunday*, 22 June 2014.

28. See note 26.

29. Anthony Ingraffea, Physicians Scientists and Engineers for Healthy Energy, *Fluid Migration Mechanisms Due to Faulty Well Design and/or Construction: An Overview and Recent Experiences in the Pennsylvania Marcellus Play*, January 2013.

30. Anthony Ingraffea, Physicians Scientists and Engineers for Healthy Energy, *Fluid Migration Mechanisms Due to Faulty Well Design and/or Construction: An Overview and Recent Experiences in the Pennsylvania Marcellus Play*, January 2013. The study's projections for Marcellus well numbers included New York, which banned fracking in December 2014.

31. Ibid.

32. Amy Mall, "Incidents Where Hydraulic Fracturing Is a Suspected Cause of Drinking Water Contamination" (blog post), *NRDC Switchboard*, 28 February 2014.

33. See note 18.

34. Ibid.

35. David Baker, "Fracking in California Takes Less Water," *San Francisco Chronicle*, 8 September 2012.

36. See note 18.

37. Ibid.

38. Texas Water Development Board, *Water for Texas: 2012 State Water Plan*, January 2012.

39. Based on projected water use for production of oil and gas from shale, tight gas and tight oil formations from Texas Water Development Board, *Current and Projected*

Water Use in the Texas Mining and Oil and Gas Industry, June 2011.

40. Tanja Srebrotnjak and Miriam Rotkin-Ellman, Natural Resources Defense Council, *Fracking Fumes: Air Pollution from Hydraulic Fracturing Threatens Public Health and Communities*, December 2014.

41. U.S. House of Representatives, Committee on Energy and Commerce, *Chemicals Used in Hydraulic Fracturing*, April 2011.

42. Gabe Rivin, "Fracking Regulators Won't Create Rules for Air Pollution," *North Carolina Health News*, 29 July 2014.

43. Pennsylvania Department of Environmental Protection, *Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report*, 1 November 2010.

44. Texas: Shannon Ethridge, Texas Commission on Environmental Quality, *Memorandum to Mark R. Vickery Re: Health Effects Review of Barnett Shale Formation Area Monitoring Projects*, 27 January 2010; Arkansas: Arkansas Department of Environmental Quality, *Emissions Inventory and Ambient Air Monitoring of Natural Gas Production in the Fayetteville Shale Region*, 22 November 2011.

45. Seth Shonkoff, Jake Hays and Madelon Finkel, "Environmental Public Health Dimensions of Shale and Tight Gas Development," *Environmental Health Perspectives*, August 2014.

46. Ibid.

47. Colorado: David Kelly, University of Colorado – Denver, *Study Shows Air Emissions Near Fracking Sites May Pose Health Risk* (press release), 19 March 2012; Ohio: Policy Matters Ohio, *Fracking in Carroll County, Ohio: An Impact Assessment*, 10 April 2014; Texas: Mike Ludwig, "Eco-Investigators Say Fracking Air Pollution Is Poisoning Families in Texas," *Truthout.org*, 23 September 2013.

48. Respiratory and neurological problems: Peter M. Rabinowitz, et al., "Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania," *Environmental Health Perspectives*, 10 September 2014 and Physicians for Social

Responsibility, Environmental Health Policy Institute, *Health Risk Assessment of Natural Gas Drilling in Colorado*, accessed at www.psr.org/environment-and-health/environmental-health-policy-institute/responses/health-risk-assessment-of-natural-gas-drilling-colorado.html, 6 October 2014; birth defects: Lisa McKenzie et al., "Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado," *Environmental Health Perspectives*, April 2014.

49. David Manthos, SkyTruth, *Cancer-Causing Chemicals Used in 34% of Reported Fracking Operations*, 22 January 2013.

50. Ibid.

51. Ibid.

52. See note 45.

53. Ibid.

54. Chemicals are endocrine disruptors: Seth Shonkoff, Jake Hays and Madelon Finkel, "Environmental Public Health Dimensions of Shale and Tight Gas Development," *Environmental Health Perspectives*, August 2014; what endocrine disruptors do: National Institute of Environmental Health Sciences, *Endocrine Disruptors*, accessed at www.niehs.nih.gov/health/topics/agents/endocrine/, 10 December 2014.

55. L.M. McKenzie, et al., "Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources," *Science of the Total Environment*, 424: 79-87, 1 May 2012.

56. Based on data from Leslie A. Walleigh MD MPH, Southwest Pennsylvania Environmental Health Project, *Health Concerns from Unconventional Gas Extraction* (PowerPoint presentation), 20 July 2012, available at www.nw-sofa.org/wp-content/uploads/2013/11/Health-Concerns-from-Unconventional-Gas-Extraction2loedits1.pdf.

57. Abrahm Lustgarten and Nicholas Kusnetz, "Science Lags as Health Problems Emerge Near Gas Fields," *ProPublica*, 16 September 2011; Nadia Steinzor, Earthworks, Wilma Subra, Subra Company, and Lisa Sumi, *Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania*, October 2012.

58. Abrahm Lustgarten and Nicholas Kusnetz, "Science Lags as Health Problems Emerge Near Gas Fields," *ProPublica*, 16 September 2011.
59. Nadia Steinzor, Earthworks, Wilma Subra, Subra Company, and Lisa Sumi, *Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania*, October 2012.
60. U.S. Occupational Safety and Health Administration, *Hazard Alert: Worker Exposure to Silica During Hydraulic Fracturing*, accessed at www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html, 27 October 2014.
61. Gunnar Myhre, Drew Shindell, et al., Intergovernmental Panel on Climate Change, "Anthropogenic and Natural Radiative Forcing," *Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2013.
62. Center for Sustainable Shale Development, *Performance Standards*, accessed at www.sustainableshale.org/performance-standards, 15 October 2014; A.R. Brandt, et al., "Methane Leaks From North American Natural Gas Systems," *Science*, 14 February 2014.
63. Nels Johnson, et al., The Nature Conservancy, *Pennsylvania Energy Impacts Assessment, Report 1: Marcellus Shale Natural Gas and Wind*, 15 November 2010.
64. Tony Dutzik, Benjamin Davis and Tom Van Heeke, Frontier Group, and John Rumpler, Environment America Research & Policy Center, *Who Pays the Costs of Fracking? Weak Bonding Rules for Oil and Gas Drilling Leave the Public at Risk*, July 2013.
65. Scott Christie, Pennsylvania Department of Transportation, *Protecting Our Roads*, testimony before the Pennsylvania House Transportation Committee, 10 June 2010.
66. Headwaters Economics, *Fossil Fuel Extraction as a County Economic Development Strategy: Are Energy-Focused Counties Benefiting?*, revised 11 July 2009.
67. Integra Realty Resources, *Flower Mound Well Site Impact Study*, prepared for Town of Flower Mound (Texas), 17 August 2010.
68. Scott Detrow, "Emergency Services Stretched in Pennsylvania's Top Drilling Counties," *Pennsylvania State Impact*, 11 July 2011.
69. Abrahm Lustgarten, "Officials in Three States Pin Water Woes on Gas Drilling," *ProPublica*, 26 April 2009.
70. Charles Choi, "Confirmed: Fracking Practices to Blame for Ohio Earthquakes," *NBC News*, 4 September 2013.
71. See, for example, an opinion piece by fracking industry leader Chris Faulkner, "The Misdeeds of a Few Companies Don't Warrant Fracking Bans," *Wall Street Journal*, 15 August 2014, and an opinion piece by former Pennsylvania secretary of the environment John Hanger, "If You Care About the Environment, You Should Welcome Natural Gas Fracking," *Guardian*, 8 July 2013.
72. Sheila Bushkin-Bedient et al., Concerned Health Professionals of New York, *Compendium of Scientific, Medical, and Media Findings Demonstrating the Risks and Harms of Fracking (Unconventional Gas and Oil Extraction)*, 2nd edition, 11 December 2014.
73. *Ibid.*
74. Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, *Oil and Gas Reports*, accessed at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297, 18 September 2014.
75. Pollution discharge rules are indicated by violation rules: 301CSL - Stream discharge of IW, includes drill cuttings, oil, brine and/or silt; 301UNPMTIW - Industrial waste was discharged without permit; 307CSL - Discharge of industrial waste to waters of Commonwealth without a permit; 401 CSL - Discharge of polluttional [sic] material to waters of Commonwealth; 401CAUSEPOLL - Polluting substance(s) allowed to discharge into Waters of the Commonwealth; 401CSL - Discharge of polluttional [sic] material to waters of Commonwealth; 402611 - Failure to meet

effluent limits of permit; 92.3 - Discharge of pollutants from a point source into surface waters without NPDES permit; CSL201BYPASS - Untreated or inadequately treated sewage was discharged; CSL301BYPASS - Industrial waste was discharged without a permit; CSL401CAUSPL - Polluting substance(s) allowed to discharge into Waters of the Commonwealth.

76. Don Hopey, "Range Resources to Pay \$4.15M Penalty," *Pittsburgh Post-Gazette*, 18 September 2014.

77. Fracking fluid in Brush Run and Brush Run designated "high quality": Don Hopey, "Range Resources to Pay \$4.15M Penalty," *Pittsburgh Post-Gazette*, 18 September 2014; "high quality" protection level: Pennsylvania Department of Environmental Protection, *Stream Redesignations*, accessed at www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/stream_redesignations/553982, 8 October 2014.

78. See note 76.

79. Its American Petroleum Institute well number is 117-21148.

80. See note 74.

81. Ibid.

82. Ibid.

83. Earthworks Oil and Gas Accountability Project, *Blackout in the Gas Patch*, August 2014.

84. Ibid.

85. Scott Detrow, "4,700 Gallons of Acid Spill at Bradford County Drilling Site," *Pennsylvania State Impact*, 5 July 2012.

86. See note 74. It is unclear from state records how much, if any, of this material reached Towanda Creek.

87. Pennsylvania Department of Environmental Protection, *DEP Fines Carrizo (Marcellus) LLC \$192,044 for 2013 Well Control Incident and a Spill in Wyoming County* (press release), 18 June 2014.

88. Pennsylvania Department of Environmental Protection, *DEP Fines Carrizo (Marcellus) LLC \$192,044 for 2013 Well Control Incident and a Spill in Wyoming County* (press release), 18 June 2014; Laura Legere, "Wyoming County Well Malfunction Causes Spill, Evacuation," *Scranton Times-Tribune*, 15 March 2013; Brendan Gibbons, "Driller Fined Nearly \$200K for Two Wyoming County Spills," *Citizens Voice*, 19 June 2014.

89. Road blocked off: Laura Legere, "Wyoming County Well Malfunction Causes Spill, Evacuation," *Scranton Times-Tribune*, 15 March 2013; flow from 6 p.m. March 13 through noon March 14: Brendan Gibbons, "Driller Fined Nearly \$200K for Two Wyoming County Spills," *Citizens Voice*, 19 June 2014. Contemporary reports disagree on the number of families given evacuation notices. The range is from four (Laura Legere, "Wyoming County Well Malfunction Causes Spill, Evacuation," *Scranton Times-Tribune*, 15 March 2013) to seven (Sofia Ojeda, "Update: Fracking Fluid Leak in Wyoming County," *WNEP.com*, 15 March 2013).

90. Pollution prevention rules are indicated by violation codes: 102.4HQBMP - Failure to implement Special Protection BMPs for HQ or EV stream; 402CSL - Failure to adopt pollution prevention measures required or prescribed by DEP by handling materials that create a danger of pollution; 402POTNLPOLL - There is a potential for polluting substance(s) reaching Waters of the Commonwealth and may require a permit; 691.401WPD - Failure to prevent sediment or other pollutant discharge into waters of the Commonwealth; 691.402 - Potential to pollute waters of the Commonwealth; 691.402WPP - Site conditions present a potential for pollution to waters of the Commonwealth; 78.54 - Failure to properly control or dispose of industrial or residual waste to prevent pollution of the waters of the Commonwealth; 78.55 - No Control and Disposal/PPC plan or failure to implement PPC plan; 78.56(1) - Pit and tanks not constructed with sufficient capacity to contain pollutorial substances; 78.56(2) - Failure to maintain 2' of freeboard in an impoundment; 78.56FRBRD - Failure to maintain 2' freeboard in an impoundment; 78.64 - Inadequate containment of oil tank; 78.73A - Operator shall prevent gas and other fluids from lower formations from entering fresh groundwater; 91.34A - Failure to take all necessary measures to prevent spill. Inadequate

diking, potential pollution; CSL402POTPOL - There is a potential for polluting substance(s) reaching Waters of the Commonwealth and may require a permit; OGA3218.2(A) - Failure to design and construct unconventional well site to prevent spills to the ground surface and off well site; OGA3218.2(C) - Failure to use containment systems for (1) drilling mud, (2) hydraulic oil, (3) diesel fuel, (4) drilling mud additives, (5) hydraulic fracturing additives, (6) hydraulic fracturing flowback.

91. Waste handling rules are indicated by violation codes: 6018.301 - Operator has mismanagement Residual Waste; 6018.301 - Residual Waste is mismanaged; 6018.302A - Unlawful Management of RSW; 6018.610 8II - Unlawful transfer of RSW; 6018.610-4 - Handles solid waste contrary to rules and regulations, or orders of the Department, or any permit condition, or in any manner as to create a public nuisance; 78.6 - Tophole water discharge does not meet standards; 78.60B - Tophole water discharged improperly; 78.61A - Improper pit disposal of drill cuttings from above the casing seat; 78.62 - Improper encapsulation of waste; SWMA301 - Failure to properly store, transport, process or dispose of a residual waste.

92. Stephanie Ritenbaugh, "EQT, DEP Take Their Cases to Court Over 2012 Flowback Leak," *Pittsburgh Post-Gazette*, 7 October 2014; Michael Rubinkam, "Record \$4.5M Fine Pursued Against Gas Driller," *Associated Press The Big Story*, 7 October 2014; Katie Colaneri, "DEP Seeks Record Fine Against Gas Driller as AG Files Criminal Charges," *Pennsylvania State Impact*, 7 October 2014.

93. Ibid.

94. Donald Hentz Jr., Pennsylvania Office of the Attorney General, *Affidavit of Probable Cause for Issuance of an Arrest Warrant* (against defendant EQT Production Company), 30 September 2014; Stephanie Ritenbaugh, "EQT, DEP Take Their Cases to Court Over 2012 Flowback Leak," *Pittsburgh Post-Gazette*, 7 October 2014; Katie Colaneri, "DEP Seeks Record Fine Against Gas Driller as AG Files Criminal Charges," *Pennsylvania State Impact*, 7 October 2014.

95. U.S. Environmental Protection Agency, *Exco Resources to Pay Penalty for Safe Drinking Water Act Violations in Clearfield County, Pa.* (press release), 12 April 2012.

96. Ibid.

97. See note 74.

98. Dan Frosch, "Wyoming May Act to Plug Abandoned Wells as Natural Gas Boom Ends," *New York Times*, 24 December 2013.

99. Mary Kang et al., "Direct Measurements of Methane Emissions from Abandoned Oil and Gas Wells in Pennsylvania," *Proceedings of the National Academy of Sciences*, 8 December 2014.

100. Number of violations: see note 74; drinking water contamination: Jim Polson, "Cabot Cited for Faults in Fracked Well After Gas Fouls Water," *Bloomberg Businessweek*, 11 January 2012.

101. See note 74.

102. Ibid.

103. Cabot Oil and Gas Corporation, *About Cabot*, accessed at www.cabotog.com/about-cabot, 14 October 2014.

104. See note 74.

105. Chesapeake Energy, *Chesapeake Energy Corporation*, accessed at www.chk.com/Pages/default.aspx, 14 October 2014.

106. See note 74.

107. "S&P Affirms Ratings on Ultra Petroleum (UPL) Following SWEP LP Deal," *Street Insider*, 19 August 2014.

108. See note 74.

109. Since 2010: Noah Brenner, "ExxonMobil and XTO Complete Merger," *Upstream*, 25 June 2010; world's largest: ExxonMobil, *About Us*, accessed at corporate.exxonmobil.com/en/company/about-us, 14 October 2014.

110. See note 74.

111. Ibid.

112. See note 79.

113. See note 74; its American Petroleum Institute well number is 117-20725.

114. See note 74.

115. Ibid.

116. Pennsylvania Department of Environmental Protection, Bureau of Air Quality, *BAQ Functions*, accessed at www.portal.state.pa.us/portal/server.pt/community/general_information/21814/baq_functions/1888693, 23 December 2014.

117. Earthworks Oil and Gas Accountability Project, *Enforcement Report: Pennsylvania Department of Environmental Protection*, September 2012.

118. See note 83.

119. Eugene DePasquale, Pennsylvania Auditor General, *DEP's Performance in Monitoring Potential Impacts to Water Quality from Shale Gas Development, 2009-2012*, 21 July 2014.

120. See note 22.

121. Earthworks, *Enforcement Report: Colorado Oil and Gas Conservation Commission*, March 2012; Earthworks, *Enforcement Report: New Mexico Oil and Gas Conservation Division*, May 2012; Earthworks, *Enforcement Report: New York State Department of Environmental Conservation*, July 2012; Earthworks, *Enforcement Report: Ohio Division of Oil and Gas Resources Management*, September 2012; Earthworks, *Enforcement Report: Texas Railroad Commission*, September 2012.

122. Formation date and members: "CSSD: Environmental Cred for Appalachian Shale Producers," *WVNStv.com*, 25 April 2013; promise: Center for Sustainable Shale Development, *Center for Sustainable Shale Development*, accessed at www.sustainableshale.org, 15 October 2014.

123. Center for Sustainable Shale Development, *Performance Standards*, accessed at www.sustainableshale.org/performance-standards, 15 October 2014.

124. Delaware Riverkeeper Network, *Unsafe & Unsustainable: Experts Review the Center for Sustainable Shale Development's Performance Standards for Shale Gas Development*, December 2014.

125. See note 74.

126. Ibid.

127. The violation number is 672880.

128. See note 74.

129. Note that this figure includes all violations by a given company at the wells it owned and that were drilled (by any company) since the beginning of 2011. In other words, violations at a well that a company owned at the time of the violation, even if it did not drill the well, are counted in the numerator of this measure.

130. See note 74.

131. Ibid.

132. Ibid.

133. Ibid.

134. Ibid.

135. Ibid. See Methodology for definition of "Environmental and Health Violations" and for methods of calculation and ranking.

136. See note 74.

137. Ibid.

138. Ibid.

139. Ibid.

140. Ibid.

141. See note 135.

142. "Operations" includes buying up property and mineral rights for prospective future fracking wells.

143. "Unconventional" is the same as "fracking" per Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, *Report Instructions for Well Inventory Report*, accessed at files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/HelpDocs/Permitted_Well_Inventory_Report_Help.pdf, 18 September 2014.

144. See note 74.

145. Ibid.

146. Ibid.

147. Environmental and health violations: see note 74; unless otherwise noted, all information about a company was accessed at each respective company's website on 20 October 2014.

148. See note 142.

149. U.S. Environmental Protection Agency, Energy Company to Pay \$3.2 Million Penalty to Resolve Clean Water Violations in West Virginia / Chesapeake Appalachia LLC to Spend Estimated \$6.5 Million to Restore Areas Damaged by Natural Gas Extraction (press release), 19 December 2013.

150. Anya Litvak, "Shell Concentrating its Marcellus Holdings, Sells off Other Shale Assets," Pittsburgh Post-Gazette, 14 August 2014.

151. Ibid.

152. Bloomberg Businessweek, Company Overview of Ultra Resources Inc., accessed at investing.businessweek.com/research/stocks/private/snapshot.asp?privcapId=26654732, 2 October 2014.

153. Unless otherwise noted, all information about a company was accessed at each respective company's website on 20 October 2014.

154. See note 142.

155. See note 150.

156. See note 74.