Fracking Failures 2017

Oil and Gas Industry Environmental Violations in Pennsylvania

FRONTIER GROUP

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Executive Summary

Fracking is dirty and dangerous. From the very beginning of clearing a site for drilling, through the extraction, transport and delivery of natural gas, fracking poses significant risks to our air and water and to human health.

Even when drillers follow all the rules, fracking is a dirty and dangerous activity. Yet drilling companies also regularly violate laws and regulations meant to protect the environment and the public, magnifying the risk to our health and environment. Since the last *Fracking Failures* report in 2015, gas drillers across Pennsylvania have continued to violate laws with little consequence.

In Pennsylvania, fracking companies violate rules and regulations meant to protect the environment and human health on virtually a daily basis. Between January 1, 2008, and September 30, 2016, fracking companies together committed a combined total of 4,351 violations, or an average of 1.4 violations per day.

Despite the number of violations resulting from fracking operations across Pennsylvania—and the ensuing pollution, workplace accidents and threats to public health—enforcement has lagged far behind the level necessary to deter companies from breaking the rules. **Between 2008 and 2016, just 17 percent of violations of rules meant to protect the environment and public health at unconventional wells were accompanied with a fine.** When they were, the median fine was only $5,263.

These are violations of rules designed to protect the environment and public health, as opposed to administrative violations. These violations include:

- **Allowing toxic chemicals to flow off drilling sites and into soil and water**. On the night of January 11, 2014, a large Cabot tank holding fracking production fluid exploded during a routine inspection. The worker examining the tank was blown backwards and injured and nearly 3,000 gallons of contaminated water was spilled onto the well pad and surrounding soil.

- **Endangering drinking water**. Pennsylvania regulators have confirmed at least 283 cases of drinking water contamination due to drilling operations at fracking wells between 2007 and 2016. In one such case, Carrizo (Marcellus) LLC was cited for failing to properly restore a water supply that it had contaminated.

- **Polluting our rivers and streams**. In 2014, Range Resources was found responsible for leaking pollutants into soil and waterways in Washington County. In one violation, the company allowed fracking fluid to flow from a pipe, ultimately harming aquatic life in Brush Run in Hopewell Township, a stream designated by the state as “high quality,” the second-cleanest designation that a waterway can receive in the Commonwealth.

- **Disposing of waste improperly**. In one incident at an EXCO Resources well in Bell Township, Clearfield County, the company was cited for contaminating underground drinking water supplies after disposing of wastewater underground at a leaking injection well.

Table ES-1. Fracking Companies Most Frequently Cited for Violations of Rules Designed to Protect the Environment and Public Health, January 2008-September 2016

Company	Violations	Rank
Chesapeake Appalachia LLC	463	1
Cabot Oil & Gas Corporation	451	2
Chief Oil & Gas LLC	386	3
Range Resources Appalachia LLC	346	4
Talisman Energy USA Inc. (now Repsol)	209	5
XTO Energy Inc.	176	6
Anadarko E&P Onshore LLC	163	7
EQT Production Co.	162	8
Seneca Resources Corporation	156	9
SWEPI LP	140	10
Pennsylvania General Energy Company LLC	134	11
Southwestern Energy Production Company	123	12
East Resources Inc.	104	13
EXCO Resources PA LLC	91	14
WPX Energy Appalachia LLC	90	15
Ultra Resources Inc.	84	16
Chevron Appalachia LLC	78	17
Carrizo (Marcellus) LLC	77	18
EOG Resources Inc.	73	19
Atlas Resources LLC *(renamed Titan Energy after bankruptcy in September 2016)*	*71*	*20*
Total (Top 20 Violators)	**3,577**	
Total (All Violators)	**4,351**	

Defining "Fracking"

In this report, references to the effects of "fracking" 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.

The state of Pennsylvania designates wells as either conventional or unconventional. This report looks only at wells designated as unconventional, meaning natural gas is extracted through high-volume hydraulic fracturing. Hydraulic fracturing sometimes occurs at conventional wells, but it is typically less resource-intensive and, therefore, is excluded from consideration in this report.

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

- Subsidiaries of ExxonMobil and Shell, along with major players like Cabot and Chesapeake, rank among the top 10 for total violations.

- Pennsylvania-based companies ranking among the top violators include Warren County-based Pennsylvania General Energy, Pittsburgh-based EQT Production, Pittsburgh-based Atlas Resources (renamed Titan Energy after bankruptcy in September 2016), and East Resources, which was based in Warrendale until it was acquired by Royal Dutch Shell in 2010.

Both firms with many wells and firms with few wells rank poorly for number of violations when adjusted for the extent of their fracking activities in Pennsylvania.

- Chief Oil & Gas, based in Texas, drilled 291 wells between 2008 and September 2016 and was cited for 386 violations—more violations per well drilled (1.33) than any major driller. The company was followed by WPX Energy Appalachia of Oklahoma (90 violations for 77 wells drilled, a ratio of 1.17); JKLM Energy (16 violations for 19 wells drilled, or 0.84 violations for every drilled well); Cabot Oil & Gas of Houston (451 violations for 587 drilled wells, a ratio of 0.77); and Carrizo Marcellus (77 violations for 103 drilled wells, or 0.75 violations per well).

- Allegheny County's JKLM Energy ranked first with an average of 0.97 violations per active well per reporting period, another way of measuring the frequency of violations across companies of different sizes. Texas-based Anadarko averaged 0.45 violations per active well, followed by Penn Virginia Oil & Gas with an average of 0.23 violations per active well in each reporting period. Cabot Oil & Gas came in fourth with 0.22 violations per active well, and Chief Oil & Gas ranked fifth with 0.13 violations per active well averaged per reporting period.

The number of violations that received citations from state officials is likely lower than the actual number of infractions that occurred, because of Pennsylvania's historical pattern of conducting fewer inspections than state rules require, and because inspectors have regularly declined to issue violation notices when companies voluntarily agree to fix problems.

The sheer number and severity of risks posed by fracking operations make constructing an adequate regulatory regime for fracking and enforcing it at thousands of wells and other sites implausible. To protect the public, the Commonwealth should:

- **Impose a moratorium on any new well permits.** The analysis clearly demonstrates the fracking industry's failures to implement basic environmental protections at gas drilling sites, putting our air and water at risk. The only way to safeguard our health and environment is by stopping fracking, beginning with new wells.

- For existing wells, **Pennsylvania must adopt much more stringent protections and truly enforce them through**:

  - *Increased Mandatory Minimum Fines:* Increase the minimum fines for violations and create a tiered structure for repeat violators to provide a more effective deterrent.

  - *Permit Revocation for Repeat Offenders*: Companies that flagrantly disregard rules designed to protect the environment and public health should be required to halt drilling operations.

  - *Additional Environmental Inspectors*: Boost funding to allow more "cops on the beat" for fracking site inspections, with a goal of at least three inspections per site each year, including random inspections.

- *Monitoring Air Emissions and Water Pollution:* Institute a meaningful monitoring program for both air emissions and water pollution to ensure standards are being met. One mechanism for monitoring would be to use tracers, which can help pinpoint leaks and assess pollution.

- *Increased Transparency:* The state should collect and release more complete data on violations at fracking sites to the public. Better public engagement and transparency about violations should include online information allowing residents to easily find out about violations in their area, the associated fines, and the remediation efforts undertaken by the responsible company.

- *Ensuring Polluters, Not Taxpayers, Pay for Damage:* All drillers should be required to provide sufficient financial assurance to account for worst case scenarios and accidents. Insurance and bonding rules for fracking companies 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.

Introduction

Stacey Haney's home in western Pennsylvania had been in the family for more than 100 years. Her great-grandparents lived at the house on McAdams Road in Washington County and Stacey herself moved there in the late 1990s. The family's lawyer stated in court that the family never experienced negative health impacts from the home's well water and Stacey even used her well to provide water to the local church.[1] Until the fracking boom.

In court filings, Haney claimed that when Range Resources began fracking operations in 2009 just over a quarter mile from her home, McAdams Road turned into a magnet for heavy truck traffic, leading to extensive dust, diesel fumes and noise. The biggest impact of the drilling operations on the Haney family, however, became the chemicals in the air and in the family's well water, to which they attributed the nosebleeds, headaches, fatigue, skin rashes and difficulty breathing that became part of their lives. Stacey's doctor found elevated levels of toluene, benzene and arsenic in her toxicology tests, all chemicals that a 2015 study linked to contaminated well water from fracking chemical spills in the Marcellus shale area.[2] Eventually, Stacey and her kids abandoned the family home at the advice of her physician.[3]

Neighboring families, the Voyles and Kiskaddens, had similar stories and symptoms: after living healthily in Washington County for generations, the family members started getting rashes, stomach aches and nosebleeds and can no longer use their well water.[4]

In 2014, the Pennsylvania Department of Environmental Protection (DEP) fined Range Resources $4.15 million for violations at the wastewater impoundment near the Haneys' house and five others in Washington County. The fine, the largest the state had ever imposed on a gas company, cites violations including allowing flowback (used fracking fluid that returns to the surface) to leak into soil and groundwater. In addition to the fine, Range agreed to close five wastewater impoundments, including the one near the Haney home, and to upgrade two others.[5]

Violations of environmental and health safeguards —whether major ones like those committed by Range Resources in Washington County or the more common violations that occur on a near-daily basis in Pennsylvania's fracking counties —add to the risks and dangers fracking poses to citizens and the environment.

This report examines patterns of violations of rules designed to protect the environment and public health by companies involved in fracking in Pennsylvania. 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 extensive harm to the environment and the health of nearby communities—damage that has been documented in a variety of reports and studies. A review of 685 peer-reviewed studies found that the vast majority of scientific papers on fracking conclude that fracking poses public health risks, potential for water contamination, and air pollution.[6]

- **Fracking contaminates water:** Fracking poses major risks for our water supplies. Spills from trucks, leaks from wastewater impoundments or from other surface equipment like chemical storage containers and pipes, and well blowouts can release pollution to groundwater and surface water.

- **Fracking consumes vast amounts of water:** Each fracking well in Pennsylvania uses an average of 4.5 million gallons of water,[7] turning it into a toxic and radioactive soup that cannot be returned to the natural water cycle without extensive treatment. Between 2005 and 2015, fracking wells in Pennsylvania used 24 billion gallons of water.[8] That exceeds the amount of water consumed annually by the number of households in Pittsburgh, Allentown and Reading combined.[9]

- **Fracking causes air pollution:** More fracking in Pennsylvania has meant more air pollution. Between 2012 and 2013, the number of drilling sites increased 18 percent while total sulfur dioxide emissions (which contribute to acid rain and can cause asthma) near fracking sites increased nearly 60 percent. At the same time, emissions of volatile organic compounds (which contribute to the formation of smog and can cause nausea and throat irritation and damage the central nervous system) increased by nearly 20 percent. Emissions of particulate matter (which can cause heart attacks, asthma and respiratory problems) increased by 12 percent, and emissions of nitrogen oxides (which contribute to smog, and can aggravate asthma after long-term exposure) by 8 percent.[10]

- **Fracking emits global warming pollution:** Natural gas production, transportation and storage frequently results in major leaks of methane, a powerful greenhouse gas.[11] Researchers from Purdue, Cornell, the University of Colorado Boulder and the National Oceanic and Atmospheric Administration (NOAA) measured leakage over southwestern Pennsylvania in 2012 and estimated that 7 percent of gas produced in the region escapes into the atmosphere.[12]

- **Fracking jeopardizes human health:** Proximity to well pads has been associated with increases in a person's risk for respiratory and neurological problems, as well as elevated risk of birth defects.[13] One study from the University of Pennsylvania found that residents living in zip codes with the most fracking were nearly 30 percent more likely to be hospitalized for cardiology issues than residents in counties with no fracking.[14]

  The lead author of another study on air pollution in Susquehanna County told *U.S. News* that toxic air pollution, including elevated levels of benzene and formaldehyde, around fracking sites "is a significant public health risk,"

Forest in Pennsylvania cleared for a well and drilling equipment. Credit: The Downstream Project, Skytruth, and Lighthawk

that will "almost certainly" lead to more cancer in the impacted communities.[15]

- **Fracking endangers workers' health and safety:** According to the U.S. Occupational Safety and Health Administration (OSHA), the fatality rate for oil and gas workers is seven times higher than for other industries. Risks include explosions, chemical exposures and vehicle crashes.[16] For example, in 2010, Greg Bish, a 26-year-old from Ford City, died after accidentally causing an explosion while attempting to unthaw a valve on his tanker truck in freezing temperatures.[17]

  Many of the other threats to workers are quieter and more prolonged. OSHA has issued a hazard alert for workers at fracking sites due to concerns about the risk of workers contracting lung disease after inhaling silica dust produced during handling the sand that is injected, along with fluid, into fracking wells.[18]

  Despite the dangers, there is minimal oversight of workers' safety in Pennsylvania. In the decade after 2004, companies drilled nearly 9,500 fracking wells in the state. Yet only 254—less than 3 percent—were inspected by the Occupational Safety and Health Administration.[19]

- **Fracking threatens Pennsylvania's natural heritage:** Fracking transforms public lands and natural areas into industrial zones. According to a 2015 study, development of gas infrastructure in the Marcellus Shale region of Pennsylvania can harm up to 23 acres of land per well pad, reducing core forest area by up to 10 percent across the region studied.[20] As oil and gas companies expand fracking activities, national parks, national forests and other iconic landscapes are increasingly at risk.

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Fracking Imposes Significant Costs on Communities

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

Ruining Roads

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. Analysts at the RAND Corporation estimate that Pennsylvania roads sustain $13,000 to $23,000 worth of damage for each fracked well.[21]

Endangering Local Economies

Fracking imposes damage on the environment, public health and public infrastructure, with significant economic costs, especially in the long run after the initial rush of drilling activity has ended. Other negative impacts on local economies include:

- Reduced home values. A 2014 study found that Pennsylvania homes that depend on private groundwater lost an average of $33,000 in value when a shale well was drilled within nine-tenths of a mile.[22]

- 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, and by creating an explosion risk from methane.

- Natural gas infrastructure poses a risk of explosion. In April 2016, a natural gas pipeline exploded, destroying and damaging nearby homes and burning one man as he was trying to flee.[23]

- Increasing traffic—especially heavy truck traffic—has contributed to an increase in traffic crashes and fatalities. In northern Pennsylvania, vehicle crash rates were significantly higher in counties where unconventional gas drilling took place.[24]

Regulations Are Failing to Protect the Environment and Human Health

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.[25] While regulations may help, the risks of fracking are significant even when fracking companies follow the rules put in place to protect the environment and human health, and threats only increase when oil and gas companies break the rules.

The experience of fracking to date suggests that no 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. In 2014, Concerned Health Professionals of New York, a group of health professionals opposed to fracking in New York State, undertook a meta-review of years of scientific literature, covering many aspects of fracking. The study concluded that "regulations are simply not capable of preventing harm."[26] In addition, regulatory agencies are often too understaffed, underfunded, and restricted to ensure effective oversight and enforcement that could prevent problems before they happen.

In Pennsylvania, fracking companies violate rules and regulations meant to protect the environment and human health on virtually a daily basis. Between January 1, 2008, and September 30, 2016, fracking companies committed a combined total of 4,351 violations, or 1.4 violations per day, on average.[27]

These are not administrative violations—they are violations of rules designed to protect Pennsylvania's environmental and public health from real and immediate harm. And those violations have been committed by a variety of drilling companies—large and small, local, national and international.

As this report documents, violations of rules designed to protect the environment and public health can lead to significant damage to waterways, natural lands and the health of nearby residents.

Fracking Violations Contaminate Water Supplies

For seven years, Jesse and Shirley Eakin's well water in Washington County had been dangerously contaminated: It smelled, was tinted yellow and carried so much sand that the faucets clogged. In 2009, after Atlas Energy began drilling near their home, the couple became alarmed when rashes and growths appeared on their skin after showering; a few years later, their vegetable garden died. Jesse reported to the Center for Public Integrity in 2016 that, over time, the soles of his shoes disintegrate from walking on his lawn. While waiting for water test results from the state, the Eakins depended on bottled water and paid for city water, rather than risking using their well water.[28]

The Eakins' story is echoed across Pennsylvania, where in some towns, dozens of households rely on bottled water brought in by volunteers or water companies by the truckload, or supplied by the oil and gas industry itself.[29] The DEP has

received more than 2,800 complaints of water problems in proximity to drilling operations, according to Center for Public Integrity analysis of DEP data, but the department has yet to formally determine the causes of many of those problems and most incidents have not resulted in a fine.[30]

The DEP has confirmed drinking water contamination by oil and gas drilling in at least 284 cases across the state between 2007 and 2016, including:[31]

- In March 2016, after nearly eight years of complaints and suits by local homeowners, Cabot Oil & Gas, one of Pennsylvania's biggest drillers, was found responsible for contaminating well water in Dimock, PA, and fined more than $4 million.[32] While the gas company had vehemently denied wrongdoing for years[33] and has stated they'll appeal the court's decision,[34] a federal investigation of the incident found that the company had allowed pollutants to leak into local groundwater, causing levels of chemicals—including arsenic, lead and methane—at nearby wells "high enough to affect health (27 private water wells), pose a physical hazard (17 private water wells) or make the water unsuitable for drinking."[35]

- In 2015, a drill bit got stuck 600 feet underground while JKLM Energy drilled a new gas well in Potter County. In an attempt to recover the drill bit, the fracking company poured 100 gallons of unapproved surfactant chemicals, diluted with water, into the hole. Numerous households complained about groundwater contamination, and in October 2016, the company was fined more than $472,000 for polluting six private drinking water supplies.[36]

One method of fracking waste disposal is the injection of the wastewater into wells deep underground, which puts aquifers at risk. In April 2011, EXCO Resources discovered that an injection well in Clearfield County had failed mechanical integrity and was leaking brine. The company continued to inject fracking brine underground at the well for five more months without notifying DEP.[37] EXCO was eventually forced to fix the well, with oversight by the U.S. Environmental Protection Agency, and pay nearly $160,000 in fines.[38]

In many cases, water supplies were so compromised that fracking companies were required to truck in replacement drinking water supplies for residents or construct new drinking water wells and some companies faced sanctions for failing to provide safe replacement drinking water for impacted communities.[39] WPX Energy Appalachia was cited three times over the course of six months in 2014, for example, for failing to properly restore a drinking water supply that its drilling had contaminated in Donegal, Westmoreland County. However, the company was never fined for these violations.[40]

Fracking spills happen at 5 to 20 percent of drill sites in the state, according to research from Cornell University's Water Resources Institute.[41] A full buildout of the Marcellus shale gas production could allow for as many as 100,000 wells in Pennsylvania, meaning as many as 20,000 new wells could have operational violations that one day threaten the environment and public health.[42] Those numbers do not include wells that may fail as they age, nor wells that are fracked more than once, nor wells tapping the Utica shale, which are already being drilled in Pennsylvania at depths below the Marcellus shale.[43]

Drilling Companies Pollute Local Waterways

At least 52 companies have been cited for pollution of Pennsylvania rivers and streams since 2008 as a result of drilling operations and wastewater storage.[44]

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.[45] As a condition of its permit, the company was required to control runoff to prevent pollution from entering the stream.[46]

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.[47] And in October 2012, the site suffered a spill of 420 gallons of fluid that had flowed up out of the well.[48] Neither incident resulted in a fine.

One well in Cameron County, operated by J-W Operating at the time, was cited on three separate occasions in little more than one week in 2009 (September 30—October 8) for discharging pollution into waterways.[49] This well also holds the title of the Pennsylvania fracking well with more violations than any other (21 total) between January 2008 and September 2016, all of which occurred between September 2009 and January 2011.[50]

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.[51] At one wastewater pond in Hopewell Township, the company allowed fracking fluid to flow from a pipe to the ground, ultimately harming aquatic life in Brush Run, a stream designated by the state as "high quality," the second-cleanest designation that a waterway can receive in the Commonwealth.[52] 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.[53]

The following month, in October 2014, state officials announced that EQT Production had operated an impoundment pond with as many as 200 holes in its lining.[54] 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.[55] 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.[56]

Beyond polluting waterways, fracking can consume millions of gallons of water per well. Excessive water withdrawals can reduce the local availability of clean water for wildlife and communities. Between 2009 and 2014, Range Resources did not record the quantity of water it was pulling from local rivers and streams for use in fracking operations, breaking its permitting requirements for drilling in Washington and Allegheny counties. Subsequent investigations found that the company had exceeded the maximum amount allowed in some instances. In 2015, Range Resources settled with the DEP and agreed to pay $1.75 million in a fine and money to support environmental mitigation in Allegheny County.[57]

Spills of Toxic Chemicals Threaten Nearby Communities

Dozens of companies were cited for polluting the environment between January 2008 and September 2016.[58]

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.[59] 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 up to 35,000 gallons per hour.[60] The flow lasted for 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.[61] The following month, fracking waste from another Carrizo well nearby flowed onto a neighboring miniature horse farm.[62] The company was later fined $192,000 for both instances.[63]

On the night of January 11, 2014, a large Cabot Oil & Gas tank holding fracking production fluid exploded during a routine inspection. The worker who had been examining the tank was blown backwards and injured, and nearly 3,000 gallons

of production water spilled onto the well pad and surrounding soil. Eleven months after the explosion, Cabot was fined $120,000.[64]

Wells Can Continue Polluting Long After Use

If companies fail to properly close, or plug, wells after their use, pollution, including toxic chemicals and other contaminants, can migrate to nearby aquifers and layers of earth around the well.[65] Many improperly plugged wells also leak significant amounts of methane into the atmosphere.[66]

The problem of not properly closing wells is widespread: for instance, EQT Production was cited 11 times in March 2015 alone for failing to plug wells it was no longer using.[67]

Unplugged wells are particularly a problem when companies struggle financially or go out of business, leaving taxpayers to pay for cleanup. 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 picking up the tab.[68] Through September 2016, Pennsylvania had listed nearly 9,000 abandoned or orphaned (wells abandoned before 1985) oil and gas wells that were unplugged, many of which predate the shale gas boom.[69]

As the gas boom begins to bust and many companies struggle financially, more wells may be abandoned, potentially before they are cleaned up. Drillers in Pennsylvania are required to post bonds before drilling as collateral in case a company can't fund the plugging of a well when it is done drilling. That way, if a company goes under and fails to clean up a well, the state can clean up the fracking site with the money posted by the company. However, the bonding requirement is far too low to cover the cost of site reclamation. Operators in Pennsylvania can use a $600,000 blanket bond to cover all of their wells statewide;[70] however, researchers have estimated that plugging a fracked well in Pennsylvania costs about $100,000 per well.[71] Therefore, if a company operates more than 1,000 wells, like Range Resources, that leaves a mere $600 for the cleanup of each well. The low bonding level could leave the state and taxpayers on the hook for cleanup.

All Types of Fracking Companies Commit Environment-Damaging Violations

In all, 79 companies were cited for violations of rules and regulations meant to protect the environment and human health in Pennsylvania between January 2008 and September 2016.

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 ones with local headquarters.

The biggest violator was Chesapeake Appalachia, based in Oklahoma City, which was cited for 463 violations, including polluting surface and groundwater, by the Pennsylvania DEP from January 2008 through September 2016.[72] (See Table 1.) Other top violators include international household names like Shell, Exxon and Chevron, well-known companies like Range Resources and Cabot Oil & Gas, and local firms like Pennsylvania General Energy (Warren) and EQT Production (Pittsburgh).[73]

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.[75] With 451 violations between January 2008 and September 2016, Cabot comes in second on the list of Pennsylvania's frequent offenders. Over the same time period, the company only received six fines from the DEP, totaling $384,600.[76]
- **XTO Energy** racked up 176 violations between January 2008 and September 2016 but was fined just eight times for a total of $294,000.[77] In 2010, XTO became a subsidiary of ExxonMobil, the world's largest publicly traded international oil and gas company.[78]
- **SWEPI** is a subsidiary of global petroleum giant Royal Dutch Shell with corporate headquarters in The Hague, The Netherlands.[79] It is tied for tenth on the list of most frequent offenders, with 134 violations. SWEPI has only been fined twice in the last eight years, for a total of $24,500.[80]

Major multinational firms aren't the only ones to violate the law**.** Seven Pennsylvania-headquartered companies are on the top 20 list, including:

- **Pittsburgh-based EQT Production** had 162 violations and comes in eighth on the list. The company was fined nine times, totaling $118,000. In addition, EQT operates the well tied for second-most-cited for violations in Pennsylvania. Located in Duncan Township, Tioga County, this single well has received 19 violations, all in 2012. None of the violations at this well ever resulted in a fine.[81]
- **Pennsylvania General Energy**, headquartered in the northwestern Pennsylvania city of Warren, has 134 violations, coming in 11th on the list. The company was fined just three times for a total of $120,000.[82]

Table 1. Fracking Companies with the Most Violations of Rules Meant to Protect the Environment and Public Health, Ranked, January 2008-September 2016[74]

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Seneca Resources Corporation	156	9
SWEPI LP	140	10
Pennsylvania General Energy Company LLC	134	11
Southwestern Energy Production Company	123	12
East Resources Inc.	104	13
EXCO Resources PA LLC	91	14
WPX Energy Appalachia LLC	90	15
Ultra Resources Inc.	84	16
Chevron Appalachia LLC	78	17
Carrizo (Marcellus) LLC	77	18
EOG Resources Inc.	73	19
Atlas Resources LLC *(renamed Titan Energy after bankruptcy in September 2016)*	*71*	*20*
Total (Top 20 Violators)	**3,577**	
Total (All Violators)	**4,351**	

Top Violators Include Companies of All Sizes

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

- The number of wells drilled by that company since 2008.[90]
- The number of wells the company operated during the time period since 2008.

The two measures were used in order to reflect the fact that fracking wells sometimes change ownership after they have been drilled. For both measures, we limited the comparisons only to those firms with significant activity during this period. (See Methodology.)

Compared with the number of wells drilled between January 2008 and September 2016 (see Table 2), the list of most frequent violators included:

- **Chief Oil & Gas**, based in Dallas, tops the list with 291 wells drilled and 386 citations—or 1.33 violations per well drilled. Chief has been repeatedly cited for failing to take appropriate pollution prevention measures, as well as for spills of toxic fluids.[91]
- **WPX Energy Appalachia**, based in Oklahoma, ranks second for violations per well drilled

The Actual Number of Historical Violations of Rules Designed to Protect the Environment and Human Health in Pennsylvania Is Likely Higher

This report analyzes notices of violation issued by the Pennsylvania Department of Environmental Protection in response to violations of rules and regulations meant to protect the environment and public health.

It is likely that the number of *actual* violations of state regulations since 2008 is much higher than records indicate. 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.[83]

Second, Pennsylvania's basic environmental laws have historically been inadequately enforced as the Department of Environmental Protection was underfunded for many years. In 2016, DEP Secretary John Quigley said that since 2008, the agency was underequipped after years of budget cuts: In eight years, the DEP lost nearly 700 positions, more than half of which conducted inspections and processed permits.[84]

A 2012 Earthworks report found that Pennsylvania oil and gas regulators conducted fewer than 20 percent of the inspections state rules required.[85] Two years later, Earthworks revealed that Pennsylvania regulators weren't meeting their own standards for inspection frequency.[86]

An extensive six-month investigation in 2015 by PennLive, a central Pennsylvania news source,[87] found that the Department of Environmental Protection had failed in many cases to issue fines to fracking sites known to be leaking, excluded certain results from water tests, kept inadequate records, and issued 90 percent fewer fines in 2014 (issuing just 18 that year) compared to 2009 (with a peak of 246 fines).[88]

The Pennsylvania DEP also historically had a practice of not issuing violation notices if companies voluntarily agreed to address problems found by inspectors—including in cases as severe as contaminating drinking water supplies.[89]

Table 2. Top 20 Companies with the Most Violations Meant to Protect the Environment or Public Health, Per Well Drilled, January 2008-September 2016[94]

Company	Violations at Wells Since 2008	Number of Wells Drilled Since 2008	Violations Per Well Drilled	Rank
Chief Oil & Gas LLC	386	291	1.326	1
WPX Energy Appalachia LLC	90	77	1.169	2
JKLM Energy LLC	16	19	0.842	3
Cabot Oil & Gas Corporation	451	587	0.768	4
Carrizo (Marcellus) LLC	77	103	0.748	5
Pennsylvania General Energy Company LLC	134	181	0.740	6
Triana Energy LLC	13	18	0.722	7
XTO Energy Inc.	176	264	0.667	8
EXCO Resources PA LLC	91	150	0.607	9
BLX Inc.	6	11	0.545	10
Chesapeake Appalachia LLC	463	915	0.506	11
Inflection Energy (PA) LLC	25	56	0.446	12
Energy Corporation Of America	49	122	0.402	13
EOG Resources Inc.	73	183	0.399	14
Seneca Resources Corporation	156	399	0.391	15
Anadarko E&P Onshore LLC	163	444	0.367	16
Snyder Brothers Inc.	36	104	0.346	17
Range Resources Appalachia LLC	346	1100	0.315	18
Talisman Energy USA Inc. (now Repsol)	209	671	0.311	19
Atlas Resources LLC *(renamed Titan Energy after bankruptcy in September 2016)*	71	234	0.303	20

with 77 wells drilled and 90 health and environment violations, or 1.17 violations per well drilled.[92]

- **JKLM Energy** only drilled 19 wells over the period but received 16 violations, coming in third with 0.84 violations per drilled well.

- **Cabot Oil & Gas**, based in Houston, drilled 587 wells and had 451 violations, putting it fourth on the list.[93]

- **Carrizo (Marcellus)** drilled 103 wells and was cited 77 times for violations intended to protect the environment.

When factoring in the number of active wells operated by a company (see Table 3), top violators also include large and small, locally based and international firms:

- **JKLM Energy LLC**, based in Sewickley, tops the list with an average of 0.97 violations per active well. The company is a small operator, running an average of just eight wells during each semiannual reporting period. Still, the company has had repeated problems properly constructing and operating wells and was cited for polluting water, including groundwater contamination.[95]

- **Anadarko E&P Onshore LLC**, based in Texas, ranked second with 0.45 violations per well. The company has operated an average of 288 wells in each six-month period.[96]

- **Penn Virginia Oil & Gas Corp.,** was third with 0.23 violations per well. The company had an average of active six wells in each six-month period since beginning operation in Pennsylvania in 2009.[97]

- **Cabot Oil & Gas Corp.**, from Houston, ranked fourth with 0.22 violations per active well. The company is one of the largest operators in the state, operating an average of 323 wells in each period since 2008.[98]

- **Chief Oil & Gas**, is fifth with 0.13 violations per active well. It reported operating an average of 178 wells per six-month reporting period.[99]

Table 3. Top 20 Companies with the Highest Average Number of Violations of Rules Meant to Protect the Environment or Public Health, Per Active Well Per Six-Month Reporting Period, January 2008-September 2016[100]

Company	Average Wells Operating Per Six-Month Period	Violations Per Active Well	Rank
JKLM Energy LLC	8	0.972	1
Anadarko E&P Onshore LLC	288	0.446	2
Penn Virginia Oil & Gas Corporation	6	0.226	3
Cabot Oil & Gas Corporation	323	0.220	4
Chief Oil & Gas LLC	178	0.127	5
Rice Drilling B LLC	66	0.110	6
XTO Energy Inc.	146	0.100	7
Pennsylvania General Energy Company LLC	103	0.091	8
Inflection Energy (PA) LLC	54	0.089	9
Talisman Energy USA Inc.	461	0.072	10
Carrizo (Marcellus) LLC	71	0.071	11
Seneca Resources Corporation	221	0.059	12
EXCO Resources PA LLC	146	0.045	13
WPX Energy Appalachia LLC	124	0.041	14
Burnett Oil Co. Inc.	5	0.041	15
Snyder Brothers Inc.	67	0.040	16
Energy Corporation Of America	97	0.038	17
EQT Production Co.	279	0.037	18
EOG Resources Inc.	150	0.036	19
Chesapeake Appalachia LLC	891	0.033	20

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.[101]

Of the 20 companies that are Pennsylvania's most frequent violators, nearly all of them have drilling operations in at least one other state—and three, Atlas Resources (renamed Titan Energy after bankruptcy in September 2016), XTO Energy and EOG Resources, operate in 10 or more other states. (See Appendix C for details on which companies operate in which states, and Appendix D to see which states are home to which companies.)

According to their respective websites, some of these companies have a vast nationwide presence themselves or through their parent company, like Pennsylvania's most-cited company, Chesapeake Energy, which has fracking operations in Louisiana, Ohio, Oklahoma, Pennsylvania, Texas and Wyoming.

Altogether, the top violators also have operations in 21 other states that could allow for more fracking across the country: Alaska, Arkansas, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Tennessee, Texas, Utah, Virginia, West Virginia, and Wyoming.

Enforcement Has Not Been Sufficient to Deter Violations

Despite the number of violations and tragedies resulting from fracking operations across Pennsylvania, enforcement has lagged far behind the level necessary to deter companies from breaking the rules. **Between 2008 and 2016, just 17 percent of violations of regulations designed to protect the environment and human health at unconventional wells were accompanied by a fine and when they were, the median fine was only $5,263.**[102]

Furthermore, enforcement has varied markedly over time, particularly depending on the

Violations Beyond the Fracking Well

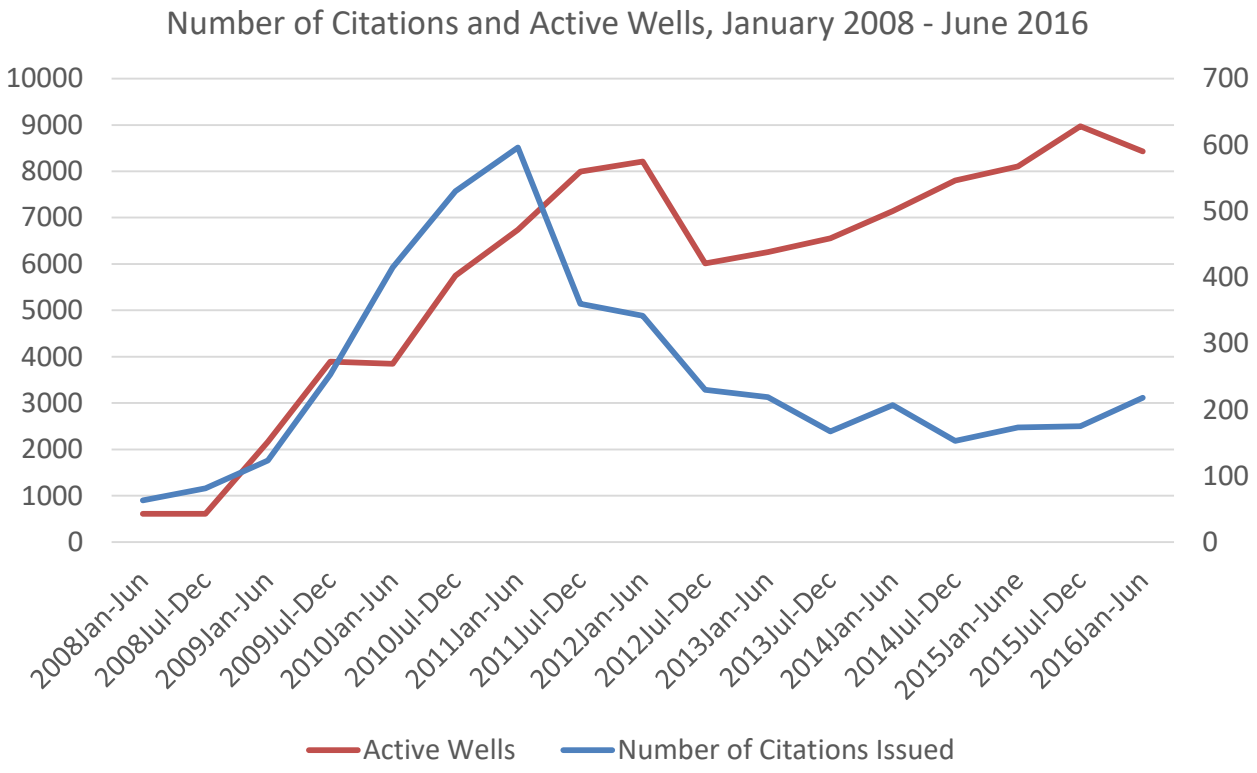
For this report, we endeavored to include only violations at wells with high-volume hydraulic fracturing, so we used Pennsylvania's database on violations at unconventional wells. However, the dataset excludes many violations occurring across the oil and gas extraction process that cannot be attributed to any particular well, and, therefore, are not included in the violation totals presented throughout the report.

We identified more than 600 additional environmental violations that were issued at locations other than unconventional well heads, including at impoundment ponds and pipelines. Pennsylvania's tracking system makes it difficult to directly attribute these specific violations to fracking, but they represent other sources of oil and gas operations that present a risk to environmental and public health. These violations include the $4.15 million fine mentioned earlier in the report that was assessed to Range Resources for multiple faulty impoundments. They also include a nearly $1 million penalty against Vantage Energy for multiple violations at one of its Greene County wells, including a landslide that impacted local streams and a spill of two truckloads of fracking wastewater into the streams impacted by the landslide.

administration. For example, the number of violations issued declined markedly between 2011 and 2014, under Governor Corbett, even as fracking activity in the state increased dramatically (see Figure 1).

DEP Secretary John Quigley stated at a Senate Appropriations Committee budget hearing in 2016 that the agency had 670 fewer staff than eight years prior. In addition to asking for restored agency funding, Secretary Quigley outlined new processes that he hoped would increase the number of oil and gas inspections, including the transition to tablets from clipboards, which he stated could double productivity of DEP inspectors.[103]

Figure 1. Number of Violations of Rules Meant to Protect the Environment and Public Health Issued Over Time, Compared to Active Wells, Per Period, Between January 2008 and June 2016[105]



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 energy seems impossible. Moreover, the notion of enforcing such safeguards at tens of thousands of wells—plus compressor stations, pipelines, processing plants and waste disposal sites—is implausible.

The evidence bears this out. As demonstrated in this report, fracking operators in Pennsylvania regularly violate essential rules designed to protect the environment and public health. Even key corporations that have pledged to clean up their act continue to break the rules and damage the environment. Moreover, such violations merely scratch the surface, since the agency responsible for fracking oversight has been ill-equipped to inspect all the wells and Pennsylvania lacks some of the most basic rules that could reduce fracking damage—including rules around well-construction and fracking waste disposal that are currently being litigated and increased setbacks for drilling operations.

The sheer number and severity of risks posed by fracking operations make constructing an adequate regulatory regime for fracking—say nothing of enforcing it at thousands of wells and other sites—implausible. Accordingly, the Commonwealth should:

- **Impose a moratorium on any new well permits.** The analysis in this report clearly demonstrates the fracking industry's failures to implement basic environmental protections at gas drilling sites, putting our air and water at risk. The only way to safeguard our health and environment is by stopping fracking, beginning with new wells.
- For existing wells, **Pennsylvania must adopt much more stringent protections and truly enforce them through**:
    - *Increased Mandatory Minimum Fines:* Increase the minimum fines for violations and create a tiered structure for repeat violators to provide a more effective deterrent.
    - *Permit Revocation for Repeat Offenders*: Companies that flagrantly disregard environmental and public health rules should be required to halt drilling operations.
    - *Additional Environmental Inspectors*: Boost funding to allow more "cops on the beat" for fracking site inspections, with a goal of at least three inspections per site each year, including random inspections.
    - *Monitoring Air Emissions and Water Pollution:* Institute a meaningful monitoring program for both air emissions and water pollution to ensure standards are being met. One mechanism for monitoring would be to use tracers, which can help pinpoint leaks and assess pollution.
    - *Increased Transparency:* The state should collect and release more complete data on violations at fracking sites to the public. Better public engagement and transparency about violations should include online information allowing residents to easily find out about violations in their area, the associated fines, and the remediation efforts undertaken by the responsible company.

- *Ensuring Polluters, Not Taxpayers, Pay for Damage:* All drillers should be required to provide sufficient financial assurance to account for worst case scenarios and accidents. Insurance and bonding rules for fracking companies 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.

Methodology

The data in this report represent violations of environmental regulations at "unconventional" (i.e., fracking) wells in Pennsylvania from 1 January 2008 through 1 December 2016.[106]

Data were downloaded from the Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, at http://www.dep.pa.gov/DataandTools/Reports/Oil%20and%20Gas%20Reports/Pages/default.aspx. Violation, well activity and production reporting data were downloaded on 12 December 2016.

Violation Information

Violations are those reported in the state's "Oil and Gas Compliance Report" database. These data were identified through a query returning "inspections with violations only" at unconventional wells. The result was downloaded as a CSV file,[107] opened in Microsoft Excel to better handle comma-delimited text, and then imported into Microsoft Access.

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.

(As noted in the report, the number of violations may be higher than the number of violation notices given because the Pennsylvania DEP historically would not issue violation notices if companies voluntarily agreed to address problems.[108] This also excludes environmental violations that were issued at locations other than unconventional well heads, including at impoundment ponds and pipelines.)

In addition to specifying particular 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 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 violations of rules and regulations intended to protect the environment and public health, 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 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.[109]

Oil and Gas Production Data

These data were found in the "Oil and Gas Production Reports" section of the Pennsylvania DEP's website by accessing the "Statewide Data

Downloads" page and downloading CSV files for each reporting period.[110] 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 "N" or "No" 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 2008 and 30 September 2016 (the last full report available at the time of download for all data required), according to the well's spud date. 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 10 wells over the period. That includes 41 companies and excludes the 34 who drilled 10 or fewer wells.

Assessing Violations Per Active Well

The data identifying violations by company in each time period were combined with data on well operations during the same time period to arrive at the number of violations per active well.

We calculated, for each reporting period, the number of environmental and health violations that each company received and the number of that company's wells reporting production activity.

Over the timeframe of this analysis (January 2008—September 2016), the Department of Environmental Protection used several different reporting periods. In order to more accurately compare active wells per time period, the DEP's reporting periods as posted online were normalized into six-month periods (January—June; July—December):

- Jan.—June 2008: Based on violations committed and all unconventional well records from Jan.—Dec. 2008 (Annual O&G, with Marcellus).
- July—Dec. 2008: Based on violations committed and all unconventional well records from Jan.—Dec. 2008 (Annual O&G, with Marcellus).
- Jan.—June 2009: Based on violations committed and all unconventional well records from Jan.—Dec. 2009 (Annual O&G, with Marcellus).
- July—Dec. 2009: Based on violations committed and all unique unconventional well records listed in Jan.—Dec. 2009 (Annual O&G, with Marcellus) and in Jul 2009 - Jun 2010 (Marcellus Only, 12 months).
- Jan.—June 2010: Based on violations committed and all unconventional records from Jul. 2009—Jun. 2010 (Marcellus Only, 12 months), combined with Jan - Dec 2010 (Annual O&G, without Marcellus). This includes a unique reporting period in the DEP's records, which covers 12 months starting in July and overlaps with another reporting period. In order to be conservative, we included all wells listed in either reporting period.
- July—Dec. 2010: Based on violations committed and all unconventional well records from Jul.—Dec. 2010 and from Jan.—Dec. 2010 (Annual O&G, without Marcellus).
- For 2011, 2012, 2013 and 2014, the 6-month time periods of Jan.—Jun. and Jul.—Dec.

were used. Any unconventional wells that were accidentally reporting in the year-long reporting periods designated "Without Marcellus" or "Conventional," were included in the respective six-month periods.

- For 2015, the monthly reporting periods were combined into six-month periods (Jan.—June and Jul.—Dec) and an average was taken to arrive at one number for the six-month period.

- For 2016, the monthly reporting periods were combined into a six-month period (Jan.—June) and a three-month period (July—Sept) and an average was taken to arrive at one number for each period.

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 active wells were averaged over the entire time span covered by the analysis to come up with an overall average for the company.

For example, Inflection Energy started operating its first fracking wells in Pennsylvania in 2014. The company had 51 active wells in July—December 2014 and received no violations, for a ratio of zero violations per operated well. It had 54 active wells in January—June of 2015, with no violations again. In July—December 2015, the company received 20 violations for 56 wells, for a ratio of 0.36 violations per active well. In January—June 2016, Inflection was cited twice while operating 56 active wells (a ratio of 0.036), and 3 times with 55 active wells in July—September 2016 (0.055 violations per active well). Averaged together, those ratios give Inflection Energy an average ratio of 0.089 violations per active well per reporting period, ranking the company ninth on this scale.

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 10 wells in any time period. We also focused on companies currently still operating in the state, excluding any companies that did not have more than 10 active wells at any point in 2016. That includes 46 companies and excludes the 93 companies that neither had more than 10 wells active in any given reporting period nor active wells in 2016. This also, by nature of the analysis, may exclude companies that had drilled wells under a prior name and merged into or were acquired by one of the included companies.

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
- 102.5(c) - PERMIT REQUIREMENTS—Person conducting earth disturbance activity associated with oil and gas activities involving 5 acres or more of earth disturbance over the life of the project failed to obtain an E & S Permit prior to commencing the earth disturbance activity.
- 102.5(m)4 - PERMIT REQUIREMENTS—GENERAL PERMITS—Person failed to comply with the terms and conditions of the E & S Control General Permit.
- 102.7(c) - PERMIT TERMINATION—Permittee failed to remain in compliance with permit terms and conditions on the project site until receiving written approval of the notice of termination (NOT) from the Department or conservation district.
- 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 pollultional [sic] material to waters of Commonwealth.
- 401CAUSEPOLL - Polluting substance(s) allowed to discharge into Waters of the Commonwealth.
- 401CSL - Discharge of pollultional [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(a) - PITS AND TANKS FOR TEMPORARY CONTAINMENT - Operator failed to contain pollutional substances and wastes from the drilling, altering, completing, recompleting, servicing and plugging the well, including brines, drill cuttings, drilling muds, oils, stimulation fluids, well treatment and servicing fluids, plugging and drilling fluids other than gases in a pit, tank or series of pits and tanks.

- 78.56(1) - Pit and tanks not constructed with sufficient capacity to contain pollutional 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
- 78.57(a) - CONTROL, STORAGE AND DISPOSAL OF PRODUCTION FLUIDS - Operator failed to collect the brine and other fluids produced during operation, service and plugging of the well in a tank, pit or a series of pits or tanks, or other device approved by the Department or Operator discharged brine or other fluids on or into the ground or into waters of the Commonwealth.
- 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
- 78.85(a)5 - CASING AND CEMENTING - CEMENT STANDARDS - Operator failed prevent gas flow in the annulus and use gas block additives and low fluid loss slurries in areas of known shallow gas producing zones.
- 78.86 - Failure to report defective, insufficient, or improperly cemented casing w/in 24 hrs or submit plan to correct w/in 30 days
- 78.91(a) - PLUGGING - GENERAL PROVISIONS - Upon abandoning a well, the owner or operator failed to plug the well to stop the vertical flow of fluids or gas within the well bore under 25 Pa. Code ?? 78.92 ? 78.98 or an approved alternate method.
- 79.12CW - Insufficent 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
- 91.33(A) - INCIDENTS CAUSING OR THREATENING POLLUTION - Failure to notify the Department of an accident or other activity or incident, a toxic substance or another substance which would endanger downstream users of the waters, result in pollution or create a danger of pollution of the waters of this Commonwealth, or would damage property.
- 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
- CSL 401 - PROHIBITION AGAINST OTHER POLLUTIONS - Discharged substance of any kind or character resulting in pollution of Waters of the Commonwealth.
- CSL 402(b) - POTENTIAL POLLUTION - Conducting an activity regulated by a permit issued pursuant to Section 402 of The Clean Streams Law to prevent the potential of pollution to waters of the Commonwealth without a permit or contrary to a permit issued under that authority by the Department.
- 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 3215(A) - Failure to maintain gas/oil well distances restrictions from a building, private water well or from a water well, surface water intake, reservoir, water extraction point of water purveyor without DEP variance or written consent of owner or water purveyor.
- 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 3217(A) - Failure to control and dispose of brines produced from the drilling, alteration or operation of a well consistent with the Clean Streams Law.
- OGA3218.2(A) - Failure to design and construct unconventional well site to prevent spills to the ground surface and off well site.
- 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(2I) - 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:

Companies That Drilled Five or More Unconventional Wells in Pennsylvania Between January 2008 and September 2016[113]

Company	Wells Drilled	Rank
Range Resources Appalachia LLC	1100	1
Chesapeake Appalachia LLC	915	2
SWEPI LP	691	3
Talisman Energy USA Inc. (now Repsol)	671	4
EQT Production Co.	659	5
SWN Production Co. LLC	598	6
Cabot Oil & Gas Corporation	587	7
Anadarko E&P Onshore LLC	444	8
Chevron Appalachia LLC	425	9
Seneca Resources Corporation	399	10
CNX Gas Co LLC	351	11
Chief Oil & Gas LLC	291	12
XTO Energy Inc.	264	13
Atlas Resources LLC (Renamed Titan Energy in September 2016)	234	14
RE Gas Dev LLC	227	15
Rice Drilling B LLC	199	16
EOG Resources Inc.	183	17
Pennsylvania General Energy Company LLC	181	18
EXCO Resources PA LLC	150	19
Energy Corporation Of America	122	20
Snyder Brothers Inc.	104	21
Carrizo (Marcellus) LLC	103	22

Company	Wells Drilled	Rank
Hilcorp Energy Co	101	23
Vantage Energy Appalachia II LLC	93	24
WPX Energy Appalachia LLC	77	25
MDS Energy Development LLC	60	26 (tie)
Noble Energy Inc.	60	26 (tie)
PennEnergy Resources LLC	57	28
Inflection Energy (PA) LLC	56	29
EM Energy PA LLC	54	30
Warren E & P Inc.	39	31
Alpha Shale Resources LP	34	32
Vantage Energy Appalachia LLC	23	33
LPR Energy LLC	21	34
JKLM Energy LLC	19	35
Triana Energy LLC	18	36
Hunt Marcellus Operating Co LLC	14	37
Tenaska Resources LLC	13	38
Apex Energy (PA) LLC	12	39
BLX Inc.	11	40 (tie)
Samson Exploration LLC	11	40 (tie)
Halcon Operating Co. Inc.	7	42
Northeast Natural Energy LLC	6	43 (tie)
Penn Virginia Oil & Gas Corporation	6	43 (tie)
Burnett Oil Co. Inc.	5	45 (tie)
Redmill Drilling	5	45 (tie)

Appendix C:

Top 20 Companies Ranked by Violations of Rules Meant to Protect the Environment and Public Health[111]

Rank	Company	Violations, Jan 2008 - Sept 2016	Corporate Parent	Website	U.S. Headquarters Location	U.S. States of Operation
1	Chesapeake Appalachia LLC	463	Chesapeake Energy	chk.com	Oklahoma City, Oklahoma	Louisiana, Ohio, Oklahoma, Pennsylvania, Texas, Wyoming
2	Cabot Oil & Gas Corporation	451	Cabot Oil & Gas Corporation	cabotog.com	Houston, Texas	Pennsylvania, Texas, West Virginia
3	Chief Oil & Gas LLC	386	Chief Oil & Gas LLC	chiefog.com	Dallas, Texas	Pennsylvania
4	Range Resources Appalachia LLC	346	Range Resources	rangeresources.com	Fort Worth, Texas	Oklahoma, Pennsylvania, Texas, Louisiana
5	Talisman Energy USA Inc. (now Repsol)	209	Repsol Oil & Gas	repsol.com	Houston, Texas	Alaska, Kansas, Louisiana, New York, Oklahoma, Pennsylvania, Texas
6	XTO Energy Inc.	176	ExxonMobil	xtoenergy.com	Fort Worth, Texas	Arkansas, Colorado, Kansas, Louisiana, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Utah, West Virginia, Wyoming
7	Anadarko E&P Onshore LLC	163	Anadarko Petroleum	anadarko.com	The Woodlands, Texas	Colorado, Utah, Wyoming, Pennsylvania, Texas
8	EQT Production Co.	162	EQT Corporation	eqt.com	Pittsburgh, Pennsylvania	Kentucky, Ohio, Pennsylvania, Texas, Virginia, West Virginia
9	Seneca Resources Corporation	156	National Fuel Gas Company	natfuel.com/seneca	Houston, Texas	California, Kansas, New York, Pennsylvania
10	SWEPI LP	140	Royal Dutch Shell	shell.us	Houston, Texas	Pennsylvania, New York, Ohio, California
11	PA Gen Energy Co. LLC	134	Pennsylvania General Energy	penngeneralenergy .com	Warren, Pennsylvania	Pennsylvania
12	Southwestern Energy Production Company	123	Southwestern Energy	swn.com	Houston, Texas	Pennsylvania, West Virginia, Arkansas

Rank	Company	Violations, Jan 2008 - Sept 2016	Corporate Parent	Website	U.S. Headquarters Location	U.S. States of Operation
13	East Resources Inc. (acquired 2010)	104	Acquired by Royal Dutch Shell in 2010	shell.us/about-us/projects-and-locations/appalachia-pennsylvania.html	Warrendale, Pennsylvania (formerly)	Pennsylvania, Ohio, New York
14	EXCO Resources PA LLC	91	EXCO Resources Inc.	excoresources.com	Dallas, Texas	Texas, Louisiana, Pennsylvania, West Virginia
15	WPX Energy Appalachia LLC	90	WPX Energy	wpxenergy.com	Tulsa, Oklahoma	New Mexico, Texas, North Dakota, Colorado, Pennsylvania (formerly)
16	Ultra Resources Inc.	84	Ultra Petroleum Corporation	ultrapetroleum.com	Houston, Texas	Wyoming, Utah, Pennsylvania
17	Chevron Appalachia LLC	78	Chevron Corporation	chevron.com	Philadelphia, Pennsylvania	Pennsylvania, Texas, California, New Mexico, Oklahoma, Colorado, Wyoming, West Virginia
18	Carrizo (Marcellus) LLC	77	Carrizo Oil & Gas Inc.	carrizo.com	Houston, Texas	Texas, Ohio, Colorado, Pennsylvania, West Virginia, New York
19	EOG Resources Inc.	73	EOG Resources Inc.	eogresources.com	Houston, Texas	Montana, North Dakota, Wyoming, Utah, Colorado, Oklahoma, Pennsylvania, West Virginia, Texas, Louisiana, New Mexico, Ohio
20	Atlas Resources LLC (renamed Titan Energy after bankruptcy in September 2016)	71	Titan Energy LLC	titanenergyllc.com	Pittsburgh, Pennsylvania	Alabama, Arkansas, Texas, New Mexico, Pennsylvania, Oklahoma, Colorado, Ohio

Appendix D:

States Where Pennsylvania's Top 20 Most-Cited Fracking Companies Also Operate[112]

State	Companies Operating
Alaska	Repsol
Arkansas	ExxonMobil, Southwestern Energy, Titan Energy (formerly Atlas Resources)
California	National Fuel Gas Company, Royal Dutch Shell
Colorado	WPX Energy, Carrizo Oil & Gas Inc., EOG Resources Inc., ExxonMobil, Anadarko Petroleum, Titan Energy (formerly Atlas Resources)
Indiana	CONSOL Energy
Illinois	CONSOL Energy
Kansas	Repsol, ExxonMobil, National Fuel Gas Company, Southwestern Energy
Kentucky	EQT Corporation, CONSOL Energy
Louisiana	Chesapeake Energy, EXCO Resources Inc., EOG Resources
Montana	ExxonMobil, EOG Resources
New Mexico	ExxonMobil, WPX Energy, EOG Resources, Titan Energy (formerly Atlas Resources), L.P
New York	ExxonMobil, National Fuel Gas Company, Royal Dutch Shell, Repsol
North Dakota	ExxonMobil, WPX Energy, EOG Resources Inc.
Ohio	Chesapeake Energy, ExxonMobil, Royal Dutch Shell, Carrizo Oil & Gas Inc., EOG Resources Inc., Chevron Corporation, Titan Energy (formerly Atlas Resources), CONSOL Energy
Oklahoma	Chesapeake Energy, Range Resources, ExxonMobil, EOG Resources, Titan Energy (formerly Atlas Resources), Repsol
Tennessee	CONSOL Energy
Texas	Chesapeake Energy, Cabot Oil & Gas Corporation, Range Resources, Repsol, ExxonMobil, EQT Corporation, Anadarko Petroleum, WPX Energy, EXCO Resources Inc., Carrizo Oil & Gas Inc., EOG Resources Inc., Titan Energy (formerly Atlas Resources)
Utah	ExxonMobil, Anadarko Petroleum, EOG Resources, Ultra Petroleum Corporation

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80 See note 27.

81 Well number 117-21148: See note 27.

82 See note 27.

83 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.

84 *Governor's Proposed Fiscal Year 2016/2017 Budget,* Testimony of Secretary John Quigley, Pennsylvania Department of Environmental Protection, before Senate Appropriations Committee Budget Hearing, 25 February 2016.

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86 See note 45.

87 PA Media Group, "About PennLive," accessed at www.thepamediagroup.com/about-us/our-brands/pennlive on 30 June 2016.

88 Wallace McKelvey, "DEP Reorganization Meant Less Oversight of Marcellus Shale Drillers," *PennLive,* 19 October 2015, archived at web.archive.org/web/20151121092648/http://www.pennlive.com/midstate/index.ssf/2015/10/dep_reorganization_resulted_in_1.html#incart_river_home on 30 June 2016.

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

90 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 2008. 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.

91 See note 27.

92 Ibid.

93 Ibid.

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

95 See note 27.

96 Ibid.

97 Ibid.

98 Ibid.

99 Ibid.

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

101 Unless otherwise noted, all information about a company and their operations was accessed at each respective company's website on 28 June 2016.

102 See note 27.

103 *Governor's Proposed Fiscal Year 2016/2017 Budget,* Testimony of Secretary John Quigley, Pennsylvania Department of Environmental Protection, before Senate Appropriations Committee Budget Hearing, 25 February 2016.

104 Marcellus Drilling News, "Vantage Energy Fined $1M for Multiple Errors at Greene County Site," 23 December 2014.

105 See note 27.

106 "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, 20 June 2016.

107 See note 27.

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

109 See note 27.

110 Ibid.

111 Violations: Pennsylvania Department of Environmental Protection, Office of Oil and Gas

Management, *Oil and Gas Reports*, accessed at www.dep.pa.gov/DataandTools/Reports/Oil%20and%20Gas%20Reports/Pages/default.aspx, December 2016; unless otherwise noted, all information about a company was accessed at each respective company's website on 27 December 2016.

112 Unless otherwise noted, all information about a company and their operations was accessed at each respective company's website on 28 June 2016.

113 See note 27.