



Dangerous and Close

**Fracking Near Pennsylvania's
Most Vulnerable Residents**



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Executive Summary

Using the extraction process known as hydraulic fracturing, gas companies are drilling near our communities, polluting our air and water, and risking the health of our children and other vulnerable populations. “Fracking” involves injecting water, sand and a mixture of chemicals at high pressures deep underground, breaking up rock formations to release natural gas. Blowouts, fires, and explosions can occur at well sites, and drilling and extraction can contaminate our air and water, putting the health and well-being of nearby citizens at risk. This is particularly true for Pennsylvania’s most

vulnerable residents: infants, school children, the elderly and those with weakened immune systems.

Gas drilling companies are exploiting the resources found in the Marcellus and other shale formations that extend beneath much of Pennsylvania. Just since the start of 2007, gas companies have drilled more than 9,100 fracking wells in the state and permits have been issued for thousands more.

Drilling companies are fracking for shale gas in close proximity to many vulnerable Pennsylvanians.

Figure ES-1: Hospitals, Schools, Child Care Providers and Nursing Care Facilities within One Mile of a Permitted Well Site (as of May 2015)

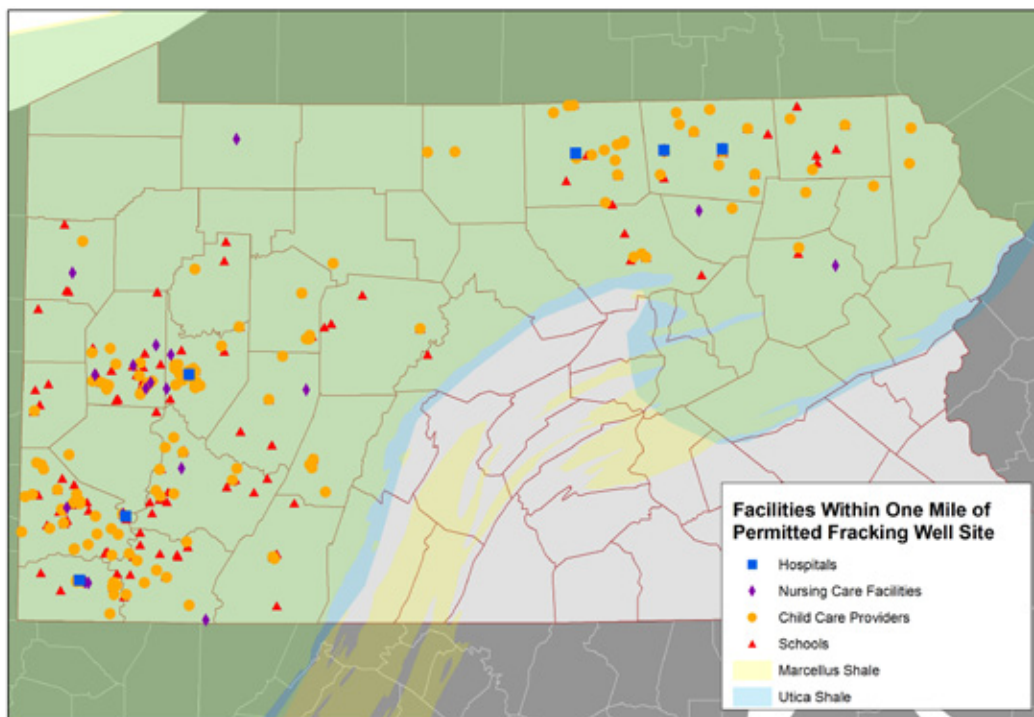
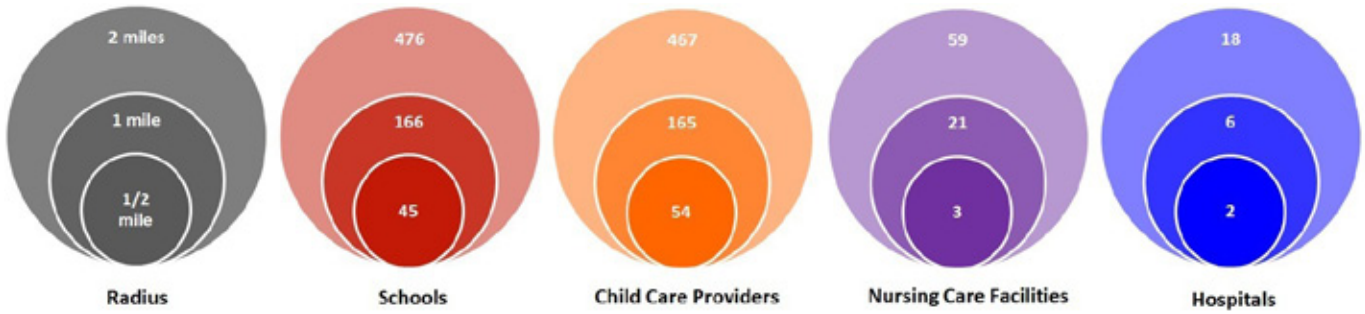


Figure ES-2: Proximity of Facilities Serving Vulnerable Populations to Permitted Well Sites



- There are 166 schools, 165 child care providers, 21 nursing care providers and six hospitals within a one-mile radius of permitted fracking well sites. (See Figures ES-1 and ES-2.)
- Approximately 53,000 Pennsylvania children under the age of 10 and 41,000 seniors 75 years of age and older live within one mile of a permitted fracking well site.
- Across the state, there are 52 schools, 51 child care providers, two nursing care facilities and two hospitals within one mile of natural gas compressor stations, which produce hazardous air pollution while moving gas to markets.
- Between 2001 and March 2015, the Pennsylvania Department of Environmental Protection (PA DEP) recorded almost 5,200 violations of regulations intended to protect public safety and the environment at fracking sites. Many have occurred in close proximity to vulnerable Pennsylvanians, including:
 - More than 220 violations at wells within one mile of a school;
 - 180 violations within one mile of a child care provider;
 - 28 violations within one mile of a nursing care facility; and
 - 13 violations within one mile of a hospital.

Drillers have rapidly expanded fracking and gas extraction efforts.

- Between 2007 and May 2015, Pennsylvania issued more than 19,300 permits for fracking sites.
- There were approximately 5,900 more permitted fracking well sites (which can contain several individual wells) in Pennsylvania in May 2015 than there were in May 2013. There were approximately 2,400 more wells.

Table ES-1: Proximity of Facilities Serving Vulnerable Populations to Permitted Well Sites

	Schools	Child Care Providers	Hospitals	Nursing Care Facilities
Half-Mile	45	54	2	3
One Mile	166	165	6	21
Two Miles	476	467	18	59

Table ES-2: Proximity of Facilities to Natural Gas Compressor Stations

Radius	Schools	Child Care Providers	Hospitals	Nursing Care Facilities
One Mile	52	51	2	2
Two Miles	207	205	6	23

- The gas industry has projected drilling on the order of 60,000 shale gas wells by 2030. Should this occur, gas extraction activity could move even closer to vulnerable populations, putting more people at risk.

Fracking jeopardizes the health and safety of nearby residents, especially infants, school children, the elderly and the sick.

- Residents living near fracking sites have long suffered from a range of health problems, including headaches, eye irritation, respiratory problems and nausea. Recent studies have linked residence near fracking sites to increased rates of certain illnesses, as well as to low birth-weight among newborns.
- Children are likely more vulnerable to the impacts of gas extraction because they are still developing and they tend to breathe more rapidly than adults. The elderly and the sick, meanwhile, have fewer defenses against pollution.

Fracking increases risks to public health and safety.

- Fires at well sites can present an immediate safety threat to nearby residents, occasionally resulting in evacuations of homes and businesses and even fatalities among well workers.

- Fracking brings with it the potential for spills, blowouts and well failures that contaminate groundwater supplies. According to analysis of Pennsylvania Department of Environmental Protection (PA DEP) records by the *Scranton Times-Tribune*, oil and gas development damaged the water supplies of at least 161 homes, farms, churches and businesses in the state between 2008 and the fall of 2012.

- Fracking creates health-threatening air pollution. Volatile compounds in natural gas formations and diesel engine exhaust contribute to the formation of soot and smog pollution, which reduces lung function among healthy people, triggers asthma attacks, and has been linked to increases in school absences, hospital visits and premature death.
- Fracking also creates increased truck traffic, which in turn raises the risk of accidents, and creates excessive noise and light, which can disturb sleep patterns and increase the risk of high blood pressure, heart attacks and strokes.

In order to protect the public and especially the Commonwealth’s children, elderly and sick, Pennsylvania should issue a moratorium on additional fracking operations – at least until the following measures are in place:

- Require a minimum setback of one mile for all fracking operations and associated infrastruc-

ture relative to schools, child care providers, hospitals and nursing care facilities.

- Ban the use of fracking waste pits and toxic chemicals in fracking fluid.
- Increase sanctions on oil and gas companies for violations committed near schools, child care providers, hospitals and nursing care facilities to better safeguard vulnerable populations. Fines or other sanctions should increase in proportion to the number of violations committed by a company, and in inverse proportion to the distance between the violation and a community of vulnerable Pennsylvanians. The more violations a driller is responsible for, or the closer those violations are to children, the elderly or the sick, the greater the consequence should be.

- Ramp up enforcement – including regular inspections and mandatory penalties – to ensure that drillers are following important laws and regulations intended to protect the public from the harms caused by fracking.

In addition, Pennsylvanians should at least be granted the protection of the nation’s core environmental laws, from which oil and gas drillers are currently exempt. The federal government should apply key elements of the Resource Conservation and Recovery Act, the Safe Drinking Water Act, the Clean Air Act, the Clean Water Act, and the National Environmental Policy Act to gas extraction just as it would regulate any potential threat to public health or the environment. In particular, wastewater from fracking should be regulated under the same rules that apply to hazardous waste produced by other industries.

Defining “Fracking”

Throughout this report, we refer to “fracking” as including all of the activities needed to bring a well into production using high-volume hydraulic fracturing, to operate that well, to process the gas or oil produced from that well, and to deliver the gas 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 high-volume hydraulic fracturing in oil and gas extraction.

Introduction

High-volume hydraulic fracturing has expanded rapidly across Pennsylvania in recent years. In less than a decade, more than 9,000 fracking wells have been drilled throughout the Commonwealth.

The location of current and proposed “fracking” wells threatens to bring the dangers of fracking directly into many people’s daily lives. More and more families, for example, are learning about plans to develop wells near their children’s schools.¹ Some schools and hospitals source their drinking water from wells near potential fracking locations that could become polluted due to leakage from wastewater spills or poor well construction. Students could also be harmed by air pollution from nearby drilling operations. As a result, some families are actively challenging drilling plans in front of zoning boards, or forming community groups dedicated to opposing proposed fracking operations near local schools.²

People across Pennsylvania recognize the potential harm that fracking can cause to them and their loved ones. They are particularly concerned when oil and gas drilling takes place in close proximity to their most vulnerable family members.

Yet, fracking near vulnerable populations in Pennsylvania – infants, school children, the elderly and the sick – is all too common. Hundreds of schools, child care providers, hospitals and nursing homes are alarmingly close to fracking operations, putting the Pennsylvanians in their care at risk. This report catalogs the continued spread of fracking across the Commonwealth and the growing number of schools, child care providers, hospitals and nursing homes that now exist within a short distance of permitted well sites.

Fracking is encroaching on the places where we live, teach and care for one another. This report serves as a reminder of the unacceptable dangers of fracking, its potential to harm Pennsylvanians, and the need to bring this risky form of drilling to an end.

Fracking Is Occurring Close to Vulnerable Populations

The combination of hydraulic fracturing and horizontal drilling has enabled gas companies to exploit natural gas deposits underneath much of Pennsylvania. Since the start of 2007, companies have drilled more than 9,100 fracking wells in the Commonwealth.³

Fracking operations are intensive industrial activities involving diesel-powered machinery, the use of large volumes of chemicals, and the storage of vast amounts of wastewater. In most circumstances, communities seek to keep industrial activities

far away from day care facilities, schools, hospitals and homes due to the disruption they create and the environmental and safety dangers they pose.

However, drilling for shale gas is occurring in close proximity to many vulnerable Pennsylvanians. Across the Commonwealth, as of May 2015, there were 166 schools, 165 child care providers, 21 nursing care facilities and six hospitals within one mile of permitted fracking well sites. (See Figure 1.) Table 1 details the numbers by facility.

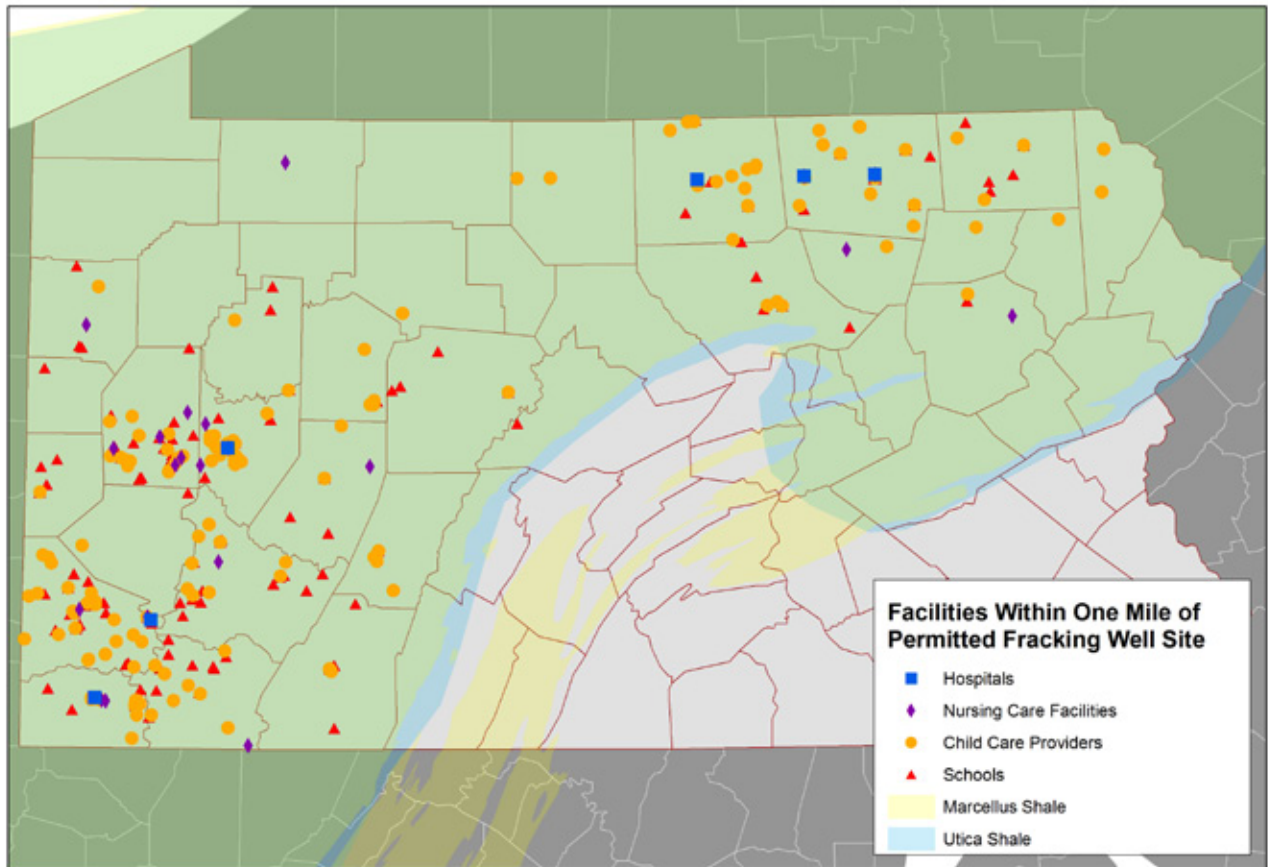
Table 1: Number of Facilities within One-Half, One and Two Miles of a Permitted Fracking Well Site

	Schools	Child Care Providers	Hospitals	Nursing Care Facilities
Half-Mile	45	54	2	3
One Mile	166	165	6	21
Two Miles	476	467	18	59

Defining “Fracking”

Throughout this report, we refer to “fracking” as including all of the activities needed to bring a well into production using high-volume hydraulic fracturing, to operate that well, to process the gas or oil produced from that well, and to deliver the gas 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 high-volume hydraulic fracturing in oil and gas extraction.

Figure 1: Hospitals, Schools, Child Care Providers and Nursing Care Facilities within One Mile of a Permitted Well Site (as of May 2015)



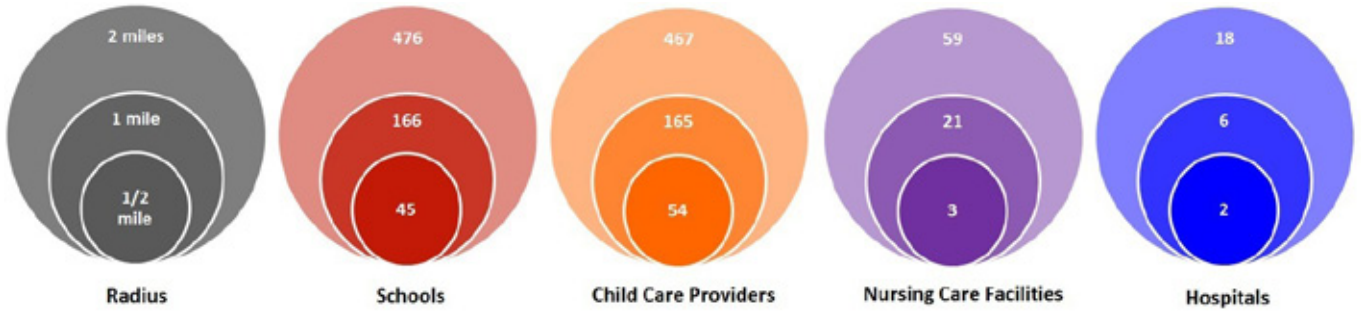
In addition, there were 52 schools, 51 child care providers, two nursing care facilities and two hospitals within one mile of natural gas compressor stations, which produce hazardous air pollution while moving gas to markets. (See Table 2.)

The results of this analysis provide a conservative and limited snapshot of the many ways in which vulnerable populations may be exposed to risks from fracking. Other potential sources of risk, such as proximity to gas pipelines, must be considered to provide a comprehensive view. (See Methodology and Data Sources on page 30.)

Table 2: Proximity of Vulnerable Populations to Natural Gas Compressor Stations

Radius	Schools	Child Care Providers	Hospitals	Nursing Care Facilities
One Mile	52	51	2	2
Two Miles	207	205	6	23

Figure 2: Number of Facilities Near Permitted Well Sites

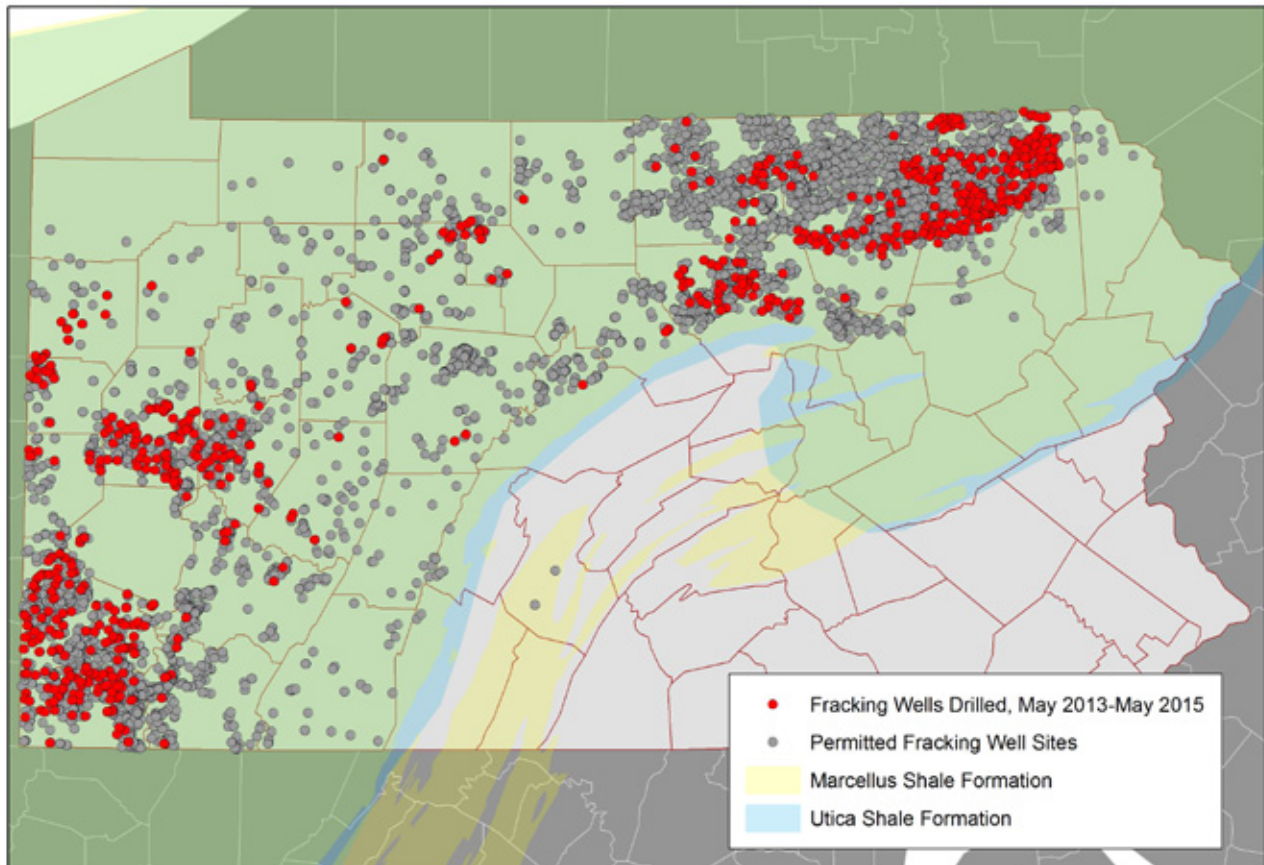


Fracking Has Spread Rapidly in Pennsylvania

The Marcellus Shale formation underlies southern New York, most of Pennsylvania, eastern Ohio, West Virginia, and western Maryland at

depths of 5,000 to 9,000 feet.⁴ The Utica Shale formation lies largely beneath the Marcellus, though extraction of oil and gas from the Utica formation has yet to start in earnest. For years, the fossil fuels locked within these shale formations beneath Pennsylvania were presumed to

Figure 3: Fracking Wells Drilled, May 2013-May 2015



be inaccessible. In the early 2000s, however, rising prices for fossil fuels and the marriage of two previously existing technologies – horizontal drilling and hydraulic fracturing – enabled the gas industry to tap fossil fuels locked in previously difficult-to-reach rock formations.

To produce natural gas from a fracking well, a drilling company must first drill a vertical well into the shale formation. Then, drilling operators cut horizontal branches into the shale, radiating outward as much as 5,000 feet to reach sections of rock away from the central well.⁵ Once the wells are drilled, operators pump water containing sand and a mixture of chemicals into the ground at high pressure. The water forces its way into cracks in the rock, widening them, and the sand holds those cracks open wide enough for gas to escape. After drilling a well, operators can repeat the process of hydraulic

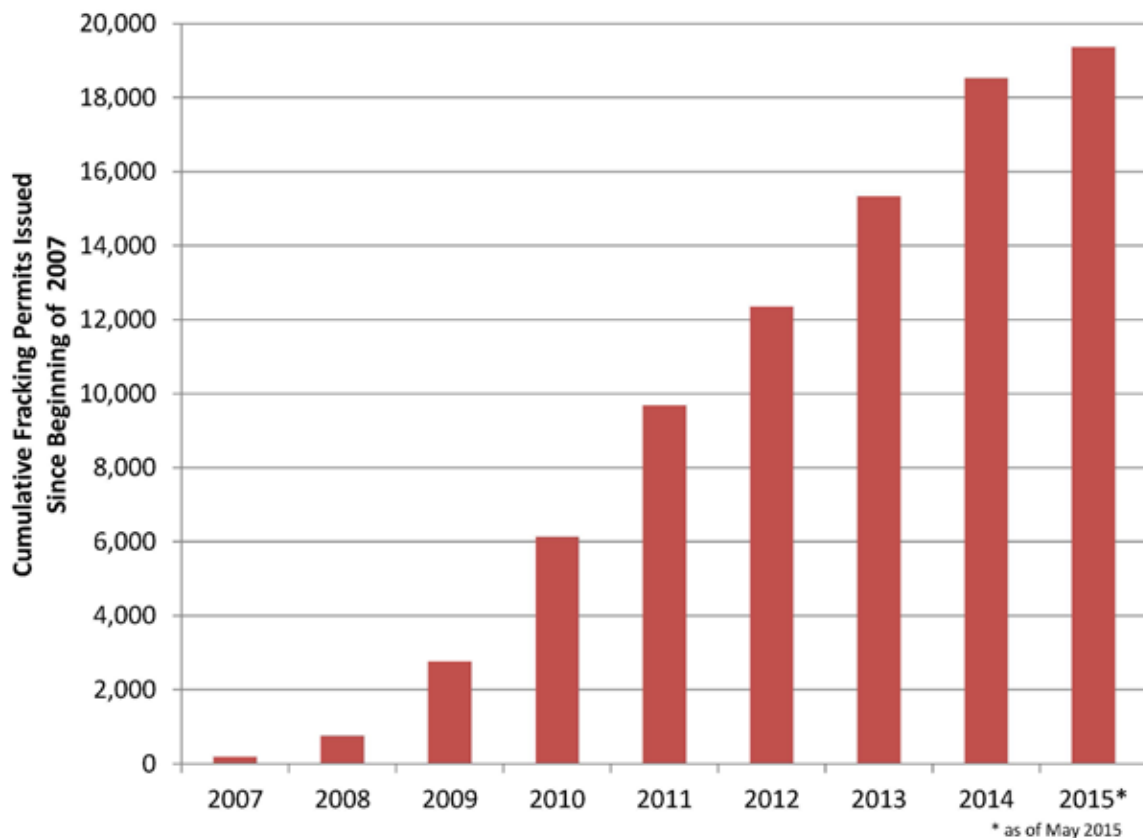
fracturing to boost gas production anywhere from 1-10 years after the well begins operation.⁶

The oil and gas industry has moved quickly to develop Pennsylvania’s shale gas resources. Since 2007, the industry has drilled more than 9,100 fracking wells in the Commonwealth, and permits have been issued for thousands more. Just between the end of May 2013 and mid-May 2015, gas companies drilled more than 2,400 new fracking wells.⁷

Gas drilling companies drilled the first test well into Marcellus Shale in 2004.⁸ Gas extraction began in earnest in 2007. Development of the Utica Shale remains only in the early stages.⁹ Statewide, since the beginning of 2007, Pennsylvania has issued more than 19,300 permits for fracking wells.¹⁰ (See Figure 4.)

If oil and gas drillers have their way, tens of thousands of new fracking wells will be drilled across the

Figure 4: Cumulative Fracking Well Permits Issued in Pennsylvania as of May 2015¹¹



Commonwealth in the coming decades. By 2030, Pennsylvania could see up to 60,000 wells extracting resources from the Marcellus Shale alone.¹²

Proximity of Fracking to Children

Children are more vulnerable to the impacts of gas extraction, and indeed all pollution, because they are still developing. Their respiratory, immune and nervous systems are more susceptible to damage from toxic chemicals. Children tend to breathe more rapidly than adults and are also more likely to play outdoors, where they can be exposed to dangerous substances in the air. Finally, children have less ability to detoxify dangerous chemicals compared to adults.¹³

Short-term exposure to hazardous pollutants could cause acute distress, with symptoms including difficulty breathing, wheezing, watery or itchy eyes, rashes or headaches. Very high exposures could cause nausea, vomiting, lack of coordination or more serious impacts.¹⁴

Children may be exposed to sustained, low levels of mixtures of different chemicals over long periods of time – which may not produce obvious symptoms

right away. Exposure to low levels of many of the chemicals used in or generated by gas extraction activities could contribute to a variety of health effects, including asthma, cancer, birth defects, damage to the reproductive system and impaired brain development.¹⁵

Population

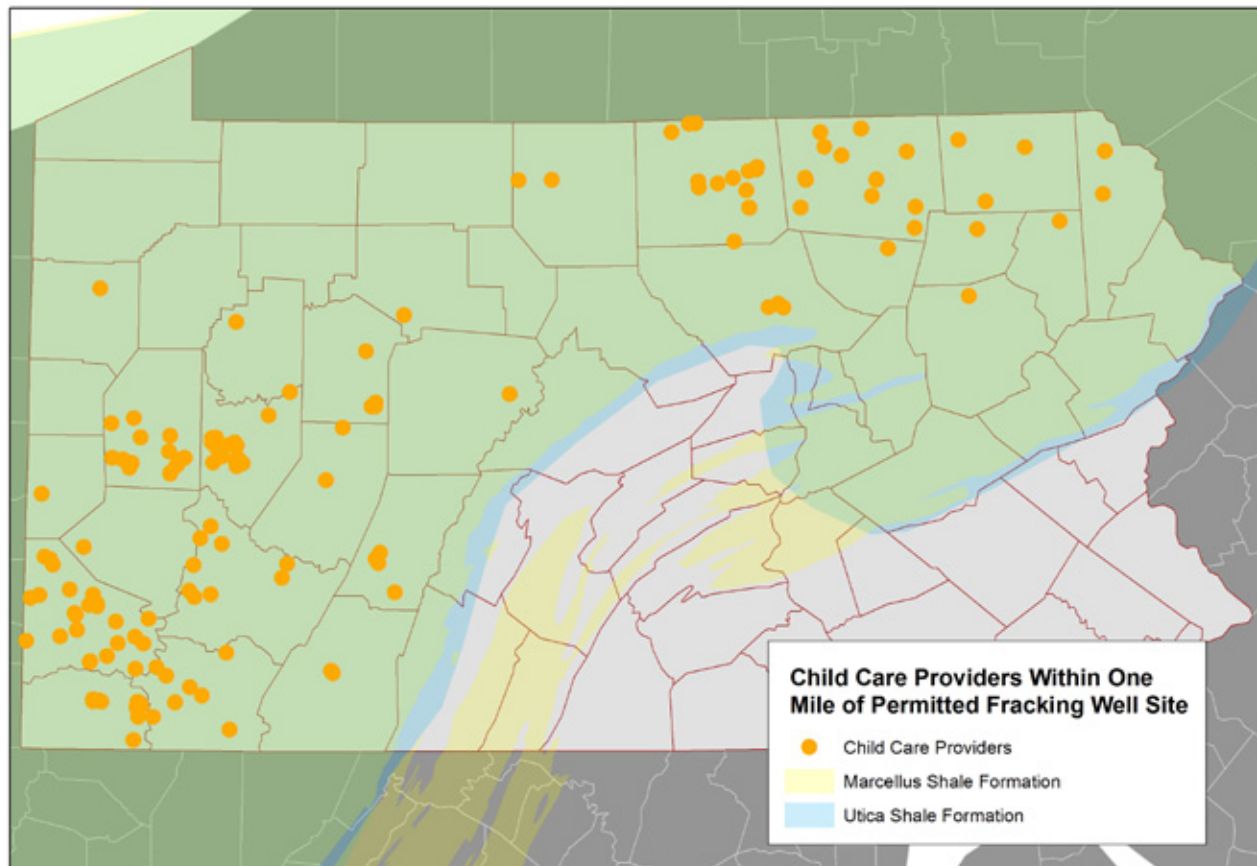
Tens of thousands of Pennsylvania children live in close proximity to fracking operations. According to estimates based on data from the 2010 Census, approximately 53,000 Pennsylvania children under the age of 10, and 25,000 children under the age of five, live within one mile of a permitted shale drilling site.

Counties in western Pennsylvania that have experienced extensive drilling activity are among those with the most children living in proximity to fracking. In Washington County, the estimated number of children under 10 living within a mile of a permitted well site exceeds 8,000. Butler, Westmoreland and Fayette counties in western Pennsylvania and Bradford County in northeastern Pennsylvania each have more than 4,000 children living within a mile of permitted well sites. (See Table 3.)

Table 3. Estimated Number of Children Living within a Mile of a Permitted Fracking Well Site¹⁶

County	Under age 5	Age 5-9	Total children under age 10
Washington	3,843	4,322	8,165
Butler	2,729	3,238	5,967
Westmoreland	2,412	2,731	5,143
Bradford	2,337	2,322	4,659
Fayette	1,914	2,195	4,109
Greene	1,435	1,543	2,978
Susquehanna	1,420	1,552	2,972
Armstrong	1,434	1,438	2,872
Tioga	1,181	1,242	2,423
Allegheny	858	966	1,824

Figure 5: Child Care Providers within One Mile of a Permitted Fracking Well Site, May 2015



Child Care Providers

There are more than 8,000 child care providers in Pennsylvania, including both day care centers and family-run day care providers in private homes. Almost 2,700 of these providers are located in areas overlying the Marcellus Shale formation.¹⁷

There are 467 day care facilities within two miles of permitted fracking well sites in Pennsylvania, and 165 within one mile. Within a half-mile, there are 54 day care facilities. (See Figure 5.)

The Clean Air Council maintains a list of coordinates and addresses for 512 natural gas compressor stations across Pennsylvania.¹⁸ There are 205 child care facilities located within two miles of these stations statewide. Within one mile, the number is 51.

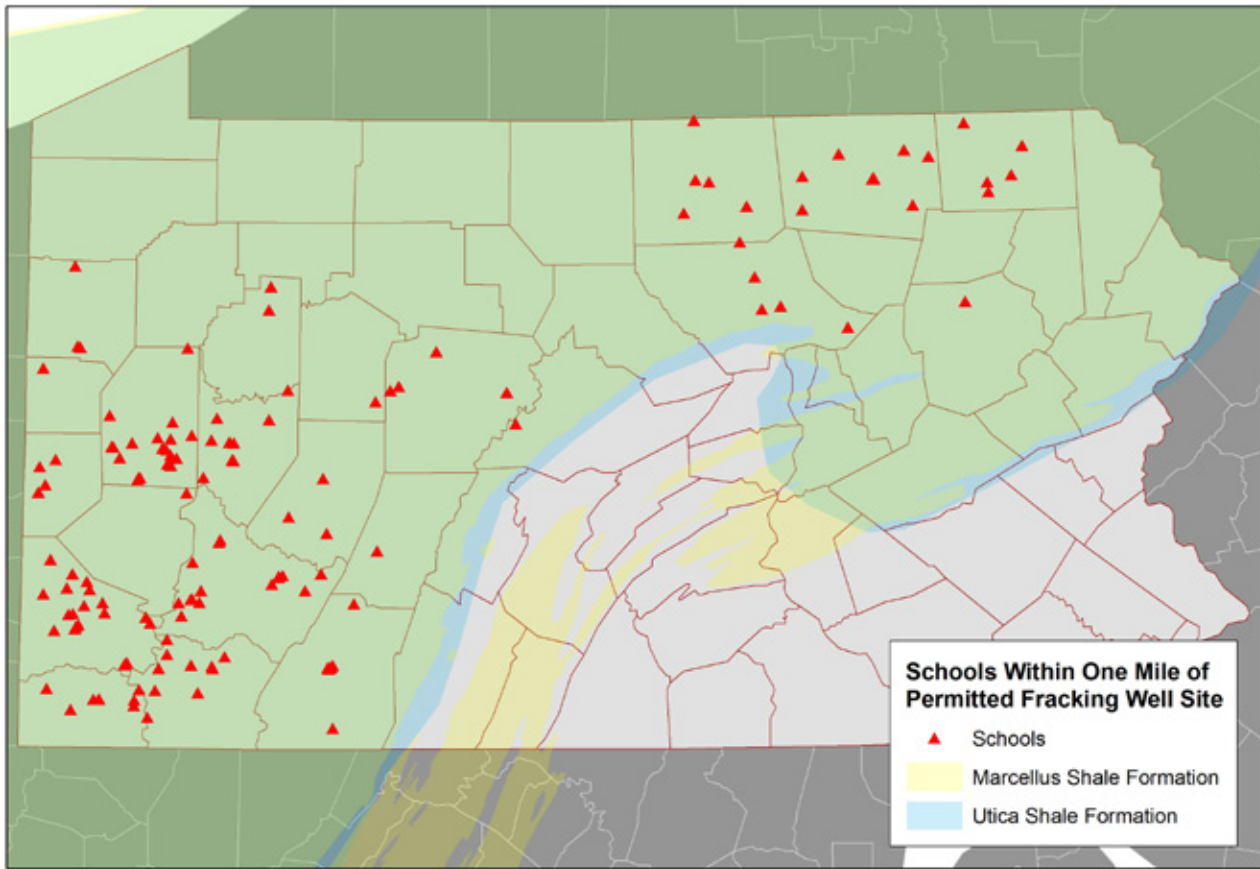
Schools

There are almost 6,000 K-12 schools in Pennsylvania. More than 2,300 of these schools are located in the broad swath of land overlying the Marcellus Shale formation. Children at school facilities that rely on well water can be particularly vulnerable to gas extraction-related water contamination.

Statewide, there are 476 schools within two miles of permitted fracking well sites. Almost 170 schools are within one mile, and 45 are within a half-mile. A permitted fracking well site may contain more than one fracking well. (See Figure 6.)

There are more than 200 schools within two miles of natural gas compressor stations. There are more than 50 within one mile.

Figure 6: Schools within One Mile of a Permitted Shale Well Site, as of May 2015



Children at facilities in close proximity to wells or compressor stations are vulnerable to air pollution exposure.

Proximity of Fracking to the Elderly and Sick

The elderly and the sick have reduced tolerance for pollution exposure. Older adults have weaker immune systems and more difficulty breaking down toxins in the body, potentially increasing the risks posed by exposure to environmental pollutants.¹⁹

Those with pre-existing health problems are also at increased risk. For example, people with pre-existing cardiovascular disease are more likely to suffer a heart attack or a stroke after exposure to elevated levels of soot pollution,

such as that from a diesel truck or a drilling rig.²⁰ In one study, within hours of exposure to soot levels called “moderate” by the U.S. Environmental Protection Agency, people were 34 percent more likely to suffer a stroke.²¹

Population

Tens of thousands of Pennsylvania seniors live in the shadow of fracking well sites. According to estimates based on data from the 2010 Census, approximately 41,000 Pennsylvanians aged 75 and older – including 12,000 people 85 years of age and older – live within one mile of a permitted fracking well site.

As is the case with children (see page 13), the greatest number of elderly living in close proximity to fracking are in western Pennsyl-

Table 4. Estimated Number of Seniors 75 Years and Older Living within a Mile of a Permitted Fracking Well Site²²

County	Age 75 to 84	Age 85 and up	Total seniors 75 and up
Washington	4,829	2,239	7,068
Butler	3,198	1,492	4,690
Westmoreland	3,212	1,280	4,493
Fayette	2,368	1,006	3,374
Bradford	2,153	865	3,017
Armstrong	1,733	753	2,486
Greene	1,516	640	2,156
Susquehanna	1,482	520	2,002
Tioga	1,265	471	1,736
Allegheny	1,108	404	1,512

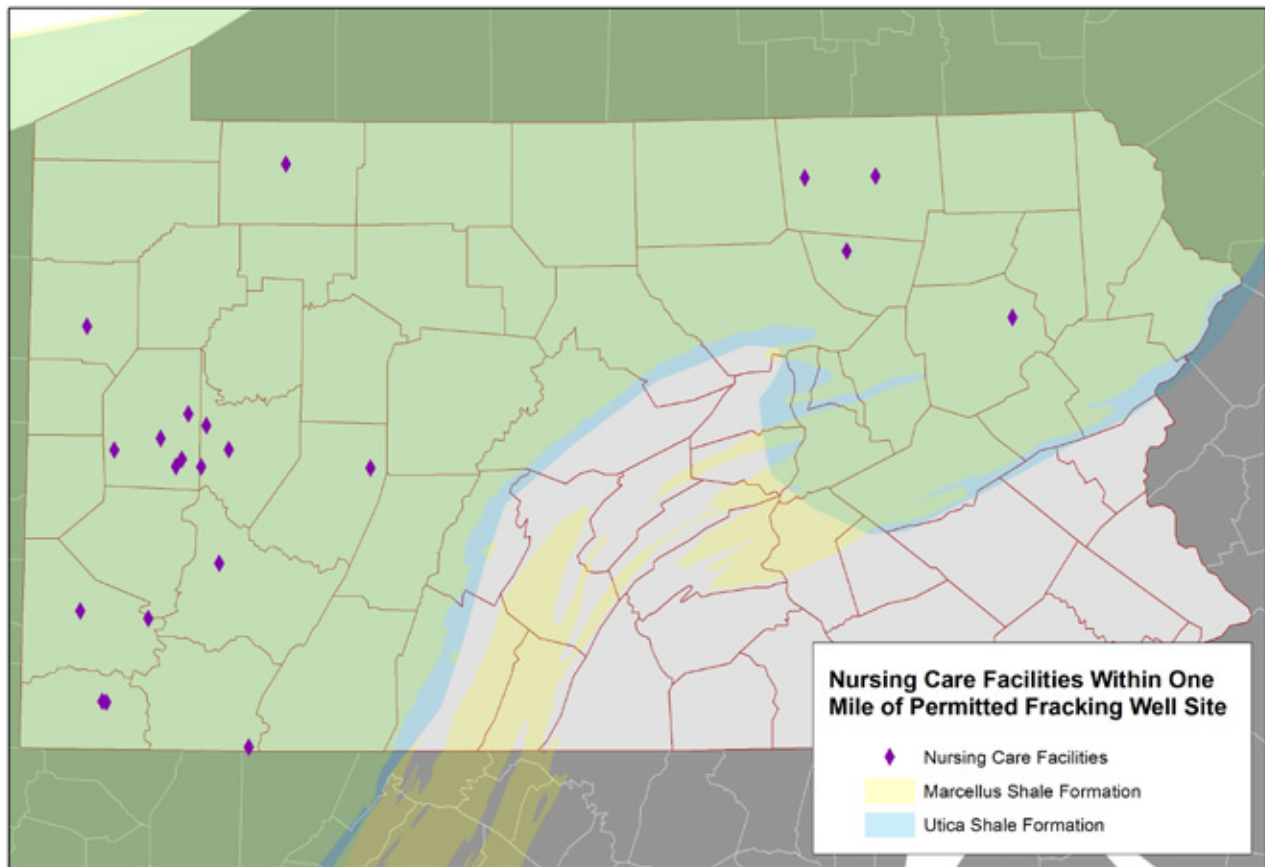
vania, with Washington, Butler, Westmoreland and Fayette counties, along with Bradford County in northeastern Pennsylvania, serving as home to more than 3,000 seniors 75 years of age and older living within a mile of a permitted fracking well site. (See Table 4.)

Nursing Care Facilities

Across the Keystone State, there are 687 nursing care facilities. Fifty-nine of those are within a two miles of a permitted fracking well site. An additional 21 are within one mile, and three nursing homes are within a half-mile of Pennsylvanian fracking well sites.

Twenty-three nursing homes are within two miles of natural gas compressor stations. Two are within one mile.

Figure 7: Nursing Care Facilities within One Mile of a Permitted Fracking Well Site



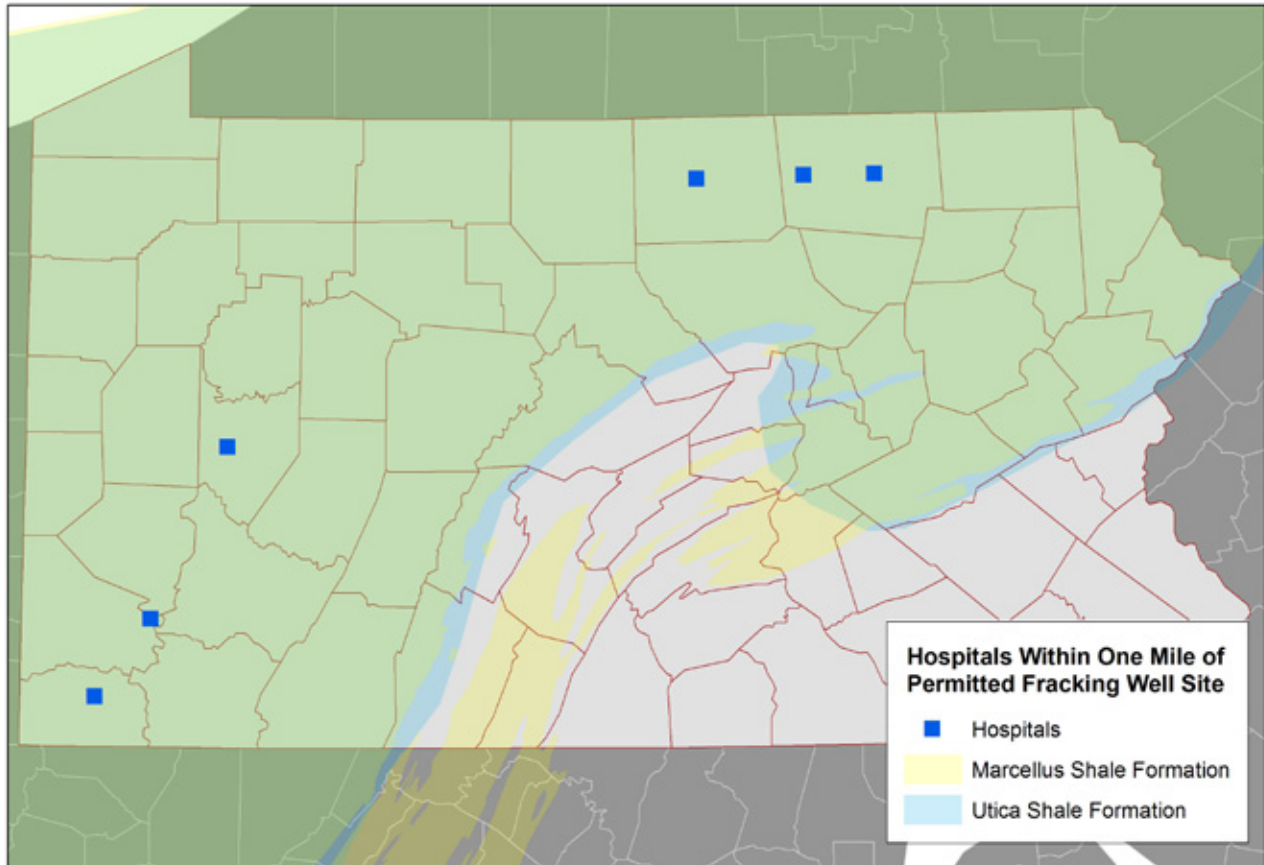
Hospitals

Statewide, 113 of the Pennsylvania's 253 hospitals are in the Marcellus Shale region. Eighteen hospitals are within two miles of permitted fracking well sites, and six hospitals are within one mile. Within a half-mile of such sites, there

are two hospitals. A fracking well site may contain more than one fracking well. (See Figure 8.)

Six hospitals are within two miles of natural gas compressor stations. Two hospitals are within one mile.

Figure 8: Hospitals within One Mile of a Permitted Shale Well Site



Environmental and Safety Violations at Fracking Well Sites in Pennsylvania

Fracking in close proximity to schools, day care centers and hospitals risks exposing vulnerable people to air and water pollution and other impacts. Many of these risks would be present

even if gas drillers obeyed oil and gas regulations to the letter. Unfortunately, many drillers don't follow the rules – leading to an even greater potential for damage.

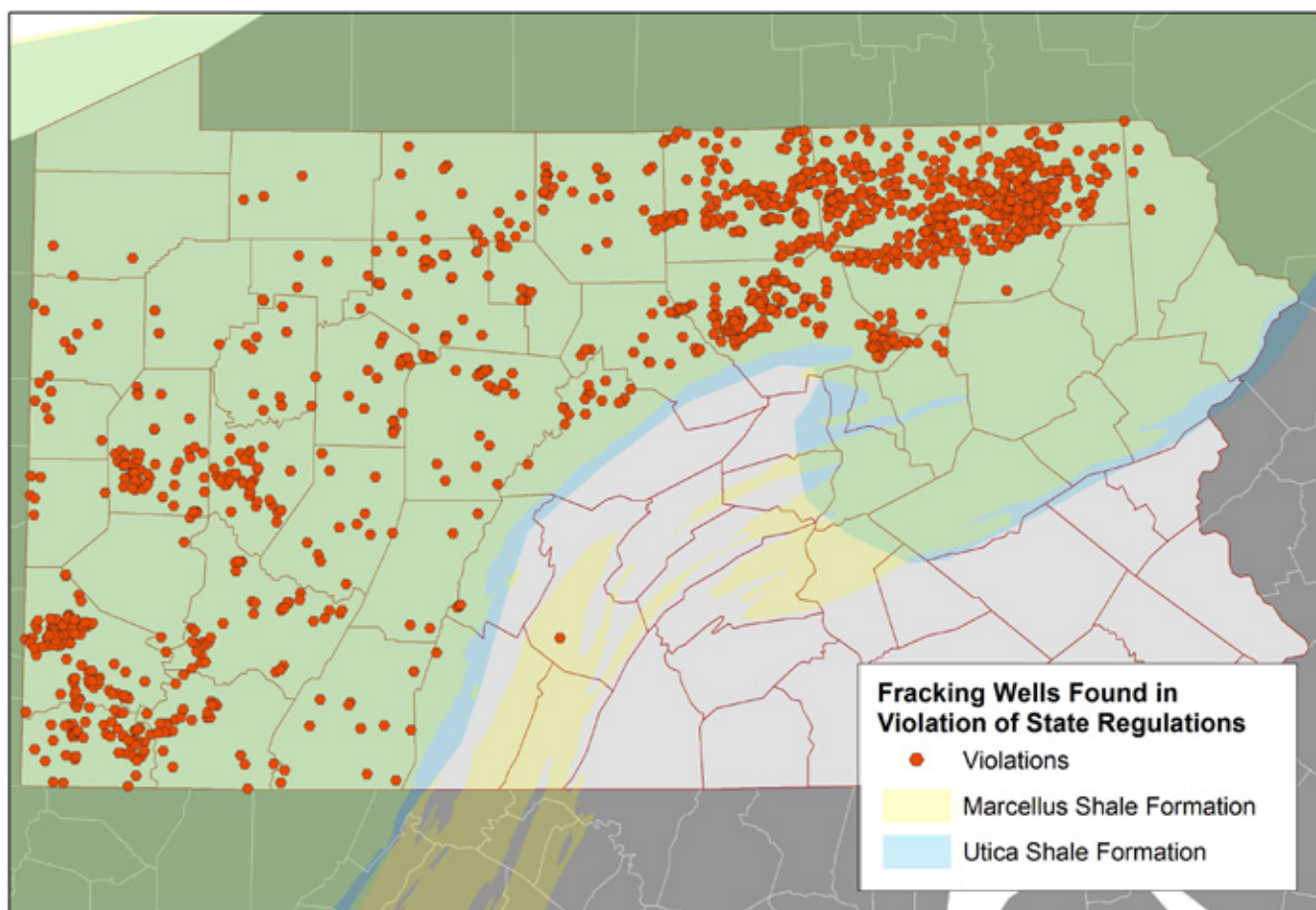
Between 2001 and March 2015, the Pennsylvania Department of Environmental Protection (PA DEP) recorded almost 5,200 violations of

regulations intended to protect the environment.²³ A violation implies that a drilling company was caught breaking a rule intended to protect Pennsylvania's natural resources or the health and safety of the public. Violations may indicate improper well construction, poor waste disposal, lack of preparedness for an accident, or an actual leak or spill. PA DEP only records violations at the well site, so traffic and road safety violations by chemical, water and waste haulers are not included in these figures.

Many of those violations took place in close proximity to vulnerable Pennsylvanians:²⁴ (See Figure 9.)

- More than 220 violations at wells took place within one mile of a school;
- 180 violations took place within one mile of a child care provider;
- 28 violations took place within one mile of a nursing care facility; and
- 13 violations took place within one mile of a hospital.

Figure 9: Pennsylvania Fracking Wells Found in Violation of State Regulations (January 2001 – May 2015)



Change Since 2010 in Pennsylvania

Drilling companies are expanding the amount of fracking and gas extraction in close proximity to vulnerable populations. Since PennEnvironment Research & Policy Center first published a similar analysis in 2011 using fracking well permit data from 2007 through the end of 2010, the number of child care providers and hospitals in close proximity to well sites has increased substantially.

Since the end of 2010, the state has issued more than 13,200 fracking well permits and more than 6,200 wells have been drilled.²⁶ Between the end of May 2013 and May 2015, Pennsylvania issued almost 5,900 additional shale gas drilling permits, and 2,400 additional wells were drilled.²⁷ Within one mile of those recently drilled wells are 35 schools, 38 child care providers, three nursing care facilities and no hospitals.²⁸

Table 5. Number of Schools, Child Care Providers, Hospitals and Nursing Care Facilities within One Mile of a Permitted Fracking Well Site²⁵

	Child Care Providers	Hospitals	Nursing Care Facilities
2015	165	6	21
2010	104	2	N/A

Note: An accurate comparison of schools is not possible due to a change in Pennsylvania's school database.

Fracking Jeopardizes the Health and Safety of Nearby Residents

Fracking endangers the health of all Pennsylvanians, but the most vulnerable among us are at particular risk. Drilling operations can cause fires, explosions and blowouts (an uncontrolled release of oil or gas from a well). They can pollute local water supplies with toxic chemicals, or with radioactive contaminants dislodged from deep underground. They create air pollution through emissions from diesel trucks and engines, evaporation from wastewater storage ponds, and flaring of harmful gases. These impacts threaten public health – especially the health of vulnerable children, sick people and the elderly, who have fewer defenses against exposure to pollution.

Fracking Exposes Nearby Residents to Pollution and Safety Risks

Extracting gas or oil from shale deposits poses significant risks to public health and safety. Fires, explosions, truck traffic and noise can affect people close to the fracking site, while water contamination and air pollution present both a localized and more widespread danger. Residents living near fracking sites have long suffered from a range of health problems, including headaches, eye irritation, respiratory problems and nausea, with children, the elderly and the sick at even greater risk.

Safety Risks from Well Blowouts, Traffic and Noise

Well Blowouts

Blowouts are the uncontrolled release of gas, oil or water from a well. Blowouts can result in fires, creating an immediate health threat for anyone in the area – including burns, smoke inhalation or exposure to especially high concentrations of air pollution. Several high-profile blowouts and fires in the past several years illustrate the risk.

- A well worker lost his life in a natural gas fire that burned for five days in February 2014 at a Chevron well in Greene County.²⁹ An investigation into the cause of the explosion and subsequent blaze concluded that a mechanical failure was at least partly responsible for allowing gas to escape and ignite.³⁰
- A March 2013 blowout in Washington Township, Wyoming County, released natural gas and hundreds of thousands of gallons of wastewater. Authorities, worried about a potential explosion, evacuated nearby houses until Carrizo Oil and Gas could control the well.³¹ (Just a matter of weeks later, another well owned by the same company in the very same township spilled 9,000 gallons of

flowback fluid – the portion of fracking fluid that returns to the surface following hydraulic fracturing – onto the ground and street next to the drilling site. The fluid ultimately flowed into a nearby farmhouse basement and garage.)³²

- In April 2011, a well on the Morse Farm in Leroy Township, Bradford County, blew out during the hydraulic fracturing process. The well, owned by Chesapeake Energy, spilled thousands of gallons of chemicals, contaminating nearby farm fields and Towanda Creek, a tributary of the Susquehanna River. Emergency officials evacuated at least seven families.³³

Explosions also can happen at other steps in the natural gas extraction process. For example, a compressor station that moves natural gas in pipelines in Susquehanna County exploded in March 2012. The explosion damaged the building housing the compressor and rattled homes up to a half-mile away.³⁴ Such incidents are not uncommon. Slightly more than one year later, Susquehanna County was the scene of yet another compressor station explosion.³⁵

Truck Traffic

Fracking requires the transportation of massive amounts of water, sand and chemicals to and from well sites. Based on data from the town of Bradford, Pennsylvania, each well requires 800-1,000 truck trips for sand and water delivery during the fracking process. Including well pad development, well drilling, and extraction adds several hundred more trips for a total of as many as 1,650 truck trips per well.³⁶

It is well established that increased traffic volume leads to more accidents and thus to more injuries or deaths.³⁷ States at the heart of the fracking boom have seen an increase in deadly traffic accidents. A May 2014 Associated Press analysis found that traffic fatalities in six drilling states had quadrupled since 2004 at a time when traffic accidents nationwide

were trending down. In Pennsylvania's drilling counties, in particular, traffic fatalities increased 4 percent between 2009 and 2013, even as the rest of the state experienced a 19 percent *decrease*.³⁸

Noise and Light

Fracking turns quiet rural communities or plots of land into small industrial zones. Well construction, drilling, fracking, the accompanying truck traffic and the ongoing operation of machinery generate significant levels of local noise and light.

Excessive amounts of noise can harm nearby residents. In Finleyville, Pennsylvania, one resident complained of his home constantly vibrating from nearby drilling with noise reaching 75 decibels – as loud as running a vacuum cleaner.³⁹ Possible impacts of elevated noise exposure include high blood pressure, interrupted sleep, cognitive impairment and increased risk of cardiovascular health events such as strokes or heart attacks.⁴⁰ Drilling operations persist 24 hours per day and seven days per week, causing unnatural levels of light that can disrupt peoples' natural biological rhythms. Such disruptions are linked to sleep disturbances and depression.⁴¹

Drinking Water Pollution

Fracking can pollute both groundwater and surface waterways such as rivers, lakes and streams that serve as the drinking water supply for nearby and downstream communities. In rural areas, where the bulk of fracking takes place, residents may rely on well water or surface water for household and agricultural use.

In Pennsylvania, an analysis of Pennsylvania Department of Environmental Protection (PA DEP) records by the Scranton *Times-Tribune* found that oil and gas development damaged the water supplies for at least 161 homes, farms, churches and businesses between 2008 and the fall of 2012. In one case, the PA DEP presumed responsibility on the part of a driller for

contamination – including barium, strontium, salts and methane gas – in the water supply of a home that was 600 feet away from a well. Barium levels rose to more than 20 times higher than the maximum level considered safe in drinking water regulations.⁴²

Across the Commonwealth, there were 243 documented cases of contaminated drinking water supplies between December 2007 and August 2014 due to fracking activities, according to PA DEP.⁴³ An analysis published in the *Proceedings of the National Academy of Sciences* found that drinking water wells at Pennsylvania residences within 1 kilometer (about 0.6 miles) of a fracking well site were more likely to be contaminated with methane and ethane gas. Homes within 1 kilometer of wells had methane and ethane levels that were six and 23 times higher than homes further away, respectively.⁴⁴

Fracking has polluted drinking water sources in a variety of ways:

- Spills and well blowouts have released fracking chemicals and flowback into both groundwater and surface water.⁴⁵
- Waste pits containing toxic fracking wastewater have frequently failed.⁴⁶
- Faulty well construction has caused methane and other substances to find their way into groundwater.⁴⁷ Between 6 and 7 percent of all fracking wells develop leaks shortly after being drilled that could contaminate nearby well water or aquifers.⁴⁸

Recent studies have suggested that fracking may also pose a longer-term threat of groundwater contamination. One study used computer modeling to conclude that natural faults and fractures in the Marcellus Shale region could accelerate the movement of fracking chemicals – possibly bringing these contaminants into contact with groundwater in a matter of years.⁴⁹ In addition, a study by researchers at Duke University found evidence for the existence of underground pathways between the Marcellus Shale and groundwater supplies closer to the surface.⁵⁰

Potential Contaminants

Gas extraction from shale deposits can contaminate water supplies with pollutants including methane gas, drilling fluid, hydraulic fracturing fluid, and naturally occurring contaminants forced up through the well. Many of these substances have been linked to acute and long-term health impacts.

Chemicals in Hydraulic Fracturing Fluid

Studies have identified more than 600 different chemicals that have been used by oil and gas companies in fracturing fluid.⁵¹

In general, fracturing fluid used in the Marcellus contains about 84 to 90 percent water, 8 to 15 percent sand, and typically less than 1 percent chemical additives, by weight.⁵² Although the chemical additives are a relatively small fraction of the fracturing fluid by volume, this still represents a large amount of chemicals due to the significant volumes of water needed for fracturing. A well that requires 3 million gallons of fluid would require on the order of 250,000 pounds of chemicals.⁵³ Drilling as many as 60,000 Marcellus wells in Pennsylvania could require the use of more than 10 billion pounds of chemicals.

In Pennsylvania, PA DEP has documented the use of 85 chemicals in fracking activities, including mineral spirits, toluene and xylene.⁵⁴ New York state regulators conducted a similar accounting and identified a list of 235 different chemicals that can be used in fracturing additives.⁵⁵ A searchable database of the chemicals used in each fracking well is available at www.fracfocus.org.

Little information is available on the toxicity of many fracking chemicals, particularly at prolonged exposure to combinations of relatively small amounts of chemicals, as would be caused by contamination of an aquifer used for drinking water.

Doctors and health scientists, however, have associated many of these pollutants with a wide variety of acute illnesses and long-term diseases, including

cancer, asthma and problems with the liver, kidneys and central nervous system.⁵⁶ Evolving understanding of long-term exposure to small amounts of these types of contaminants suggests that contaminants from gas extraction could have serious impacts on public health, especially near well sites.⁵⁷

Naturally Occurring Contaminants

After hydraulic fracturing of a well is completed, approximately 9 to 35 percent of the fracturing fluid flows back up to the surface, totaling between 216,000 and 2.7 million gallons per well.⁵⁸ In Pennsylvania in 2014, fracking produced 1.81 billion gallons of waste fluid, a 51 percent increase from 2012.⁵⁹ In addition to fracturing chemicals, this fluid can contain salt and other substances from the rock formation that have been released by the drilling and fracturing process, plus the products of any chemical reactions happening in the well. These contaminants can include:

- **Heavy metals.** An analysis of flowback water from wells in Pennsylvania and West Virginia found a variety of hazardous metals, including arsenic, antimony, barium, cadmium, chromium, cobalt, copper, iron, lead, molybdenum, nickel, silver, strontium, thallium and titanium.⁶⁰ Arsenic causes cancer.⁶¹ Very low levels of lead exposure have been linked to learning difficulties, mental and physical developmental problems and behavioral changes.⁶²
- **Hydrocarbons.** Shale deposits can sometimes contain hydrocarbons heavier than methane, including benzene, toluene, ethylbenzene and xylene. These are chemicals associated with cancer and other serious health problems.⁶³
- **Radioactive elements.** Flowback water samples from several wells in Pennsylvania and West Virginia all contained radioactive components, including radium, a radioactive metal.⁶⁴ A 2013 study of a fracking waste treatment facility in western Pennsylvania found radium levels 200

times greater in downstream sediment samples versus upstream samples, at levels that exceed radioactive waste disposal thresholds. The study authors warned of potential slow bioaccumulation of radium that could eventually threaten fish.⁶⁵ A recently commissioned study for PA DEP of radiation exposure related to oil and gas development concluded that wastewater spills could pose a risk to the environment due to the presence of radium.⁶⁶

How Contaminants Reach Water Supplies

Contaminants can reach water supplies through faulty well construction, through surface spills, through improper wastewater disposal, or potentially through migration from the shale layer itself.

Faulty Well Construction or Abandoned Well Shafts

Shale deposits lie thousands of feet beneath the surface. Wells drilled to reach shale formations pass through a layer of earth that contains aquifers – underground reservoirs of water – in the first thousand feet. Many people rely upon these underground supplies for drinking water, especially in rural areas, where municipal water supplies may not be available.

Drilling a well creates a conduit that could carry contaminants into groundwater. Gas drilling companies use metal casing pipes and cement to line wells. The casing pipes are intended to isolate the well from non-gas bearing rock layers and allow gas and fluids to pass into or out of the well without contaminating drinking water supplies.

If the well casings do not function properly, fracturing fluid and water in the shale formation could contaminate groundwater supplies. During fracturing, operators increase the pressure inside the well to as high as 10,000 pounds per square inch – this high pressure could force contaminants through any improperly sealed gaps in the casing.⁶⁷

According to analysis by the group Physicians, Scientists and Engineers for Healthy Energy, about 6 to 7 percent of new wells drilled in Pennsylvania from 2010 through 2012 were structurally unsound.⁶⁸

Surface Contamination at the Well Site

Spills caused by tank ruptures, wastewater impoundment failures, overfills or accidents – or by sloppy handling of dangerous substances – can contaminate nearby soils, groundwater, streams or wetlands. States have documented many of instances of water contamination resulting from surface spills at gas well sites. For example:

- In October 2014, PA DEP announced it was seeking a record-setting \$4.5 million fine from EQT Corp. in response to the damage caused by a leaking wastewater impoundment. More than 200 holes were found in the impoundment's lining, allowing wastewater to leak out and harm streams and vegetation in the Duncan Township area.⁶⁹
- Workers emptying wastewater from a holding pond in Butler County in 2013 spilled approximately 840 gallons on the ground, triggering a notice of violation from PA DEP.⁷⁰
- In May 2010, a fracturing wastewater pit owned by East Resources leaked into a farm field. The state Department of Agriculture quarantined 28 cattle exposed to the fluid to prevent any contaminated meat from reaching the market.⁷¹

Air Pollution

Fracking and related activities also create air pollution. Air pollutants are released during at least 15 different steps in the oil and gas development process.⁷² From the diesel exhaust produced by trucks and equipment to gases vented from wells, compressor stations and waste ponds, this air pollution poses risks to the health of nearby residents.

Smog-Forming Emissions

Gas production creates large amounts of pollutants such as volatile organic compounds and nitrogen oxides that contribute to the formation of ozone smog. According to estimates by the New York Department of Environmental Conservation, constructing and operating a single well generates nearly 70,000 pounds of smog-forming emissions in the first year of operation.⁷³ Studies in Wyoming and Utah have shown that ozone levels in drilling regions can spike well above federal standards.⁷⁴

Air pollution related to fracking can travel long distances, affecting people who live far from fracking areas, in addition to those who live near where fracking occurs.⁷⁵ Several counties in and around Lancaster, Philadelphia and Pittsburgh earned failing grades in a recent American Lung Association report assessing smog and soot pollution across the country. A failing grade indicates air pollution levels in excess of federal standards.⁷⁶ Increased emissions from shale gas extraction could worsen air quality. A 2014 study predicted that by 2020, Marcellus drilling alone could contribute 6 to 18 percent of the region's nitrogen oxide emissions and 7 to 28 percent of the region's anthropogenic volatile organic compounds – the two components of smog.⁷⁷ When inhaled, smog can cause problems for human health by irritating the respiratory system causing coughing, reducing lung function, aggravating asthma, and damaging the lining of the lungs.⁷⁸

Hazardous Air Pollutants from Trucks, Equipment and Gas Flaring

Closer to well sites, hazardous air pollutants pose a direct threat to public health. Gas extraction operations produce a variety of hazardous air pollutants, including diesel soot from trucks and pump engines, contaminants from processing the substances that come up out of the well, and fumes evaporating from fracturing water waste ponds.

In Texas, monitoring by the Texas Department of Environmental Quality detected levels of benzene – a known cancer-causing chemical – in the air that were high enough to cause immediate human health concern at two sites in the Barnett Shale region, and at levels that pose long-term health concern at an additional 19 sites. Several chemicals were also found at levels that can cause foul odors.⁷⁹ Less extensive testing conducted by the PA DEP detected components of natural gas, particularly methane, in the air near Marcellus Shale drilling operations.⁸⁰ A series of 2012 measurements by officials of the Texas Department of Environmental Quality found volatile organic compound (VOC) levels so high at one fracking location that the officials themselves were forced to stop taking measurements and leave the site because it was too dangerous for them to remain.⁸¹

Diesel Soot

Diesel engines operate throughout the drilling and fracturing process producing sooty exhaust that is hazardous to health. While a well is being drilled, diesel engines on the drilling rig operate 24 hours a day. After drilling, operators fracture the shale with millions of gallons of pressurized water, sand and chemicals. Transporting all of the equipment and material to the well pad, and then trucking away the waste, requires hundreds to thousands of trips by diesel-powered trucks per well.⁸² This increased truck traffic contributes to air pollution.⁸³ Additionally, injecting the fracturing fluid into the well and pressurizing the system requires the operation of pumps, typically also powered by diesel engines.⁸⁴

Diesel particulate exhaust can remain suspended in the air for weeks. The particles can get inside buildings and conventional heating and air conditioning filters. When inhaled, they can penetrate deep into the lungs. The chemicals delivered into the body by inhaled particulates are very dangerous. Some of them cause cancer, some cause irritation to lung tissues, and some cause changes in the function of the heart.⁸⁵ As a result, particulates cause and aggravate

a host of health problems, including lung cancer and cardiovascular disease.

Particulate pollution can cause irreversible damage to children, interfering with the growth and development of the lungs. For example, researchers at the University of Southern California followed the health of more than 1,000 ten-year-olds until they reached 18 years of age. Children who lived in areas with higher levels of particulate pollution were less able to breathe with normal capacity.⁸⁶

Particulate pollution is also deadly, killing upwards of 50,000 Americans every year. In fact, according to the largest study on the effects of particulates on mortality, breathing sooty air at the levels found in major U.S. cities is about as dangerous as living or working with a smoker.⁸⁷

Gas Flares, Venting and Blowouts

The drilling process can accidentally puncture underground pockets of gas, which returns to the surface in drilling fluid, and is often vented into the atmosphere, creating air pollution. A well blowout produces the same impacts but at a higher volume.

Once a well is fractured, wastewater, often containing gas, returns to the surface. Gas drilling companies can dispose of the extra gases by flaring them.⁸⁸ When flaring takes place, incomplete combustion of the waste gas results in air pollution.

After the wastewater has stopped flowing out of the well, drilling companies connect the gas flow to a pipeline. Before the gas can be shipped to market, it must be cleaned of impurities, including water and larger hydrocarbon molecules. Gas processing units typically vent impurities to the atmosphere as air pollution.

To transport the gas from the well to market, gas companies operate compressor stations, typically within four to six miles of a group of wells.⁸⁹ These compressor stations are typically powered by combustion engines fueled by raw or processed natural

gas, which generates pollution-laden exhaust.⁹⁰ Compressor stations operate continuously as long-term sources of air pollution, as opposed to the wells themselves, which produce the greatest amount of pollution during a relatively short period of time.

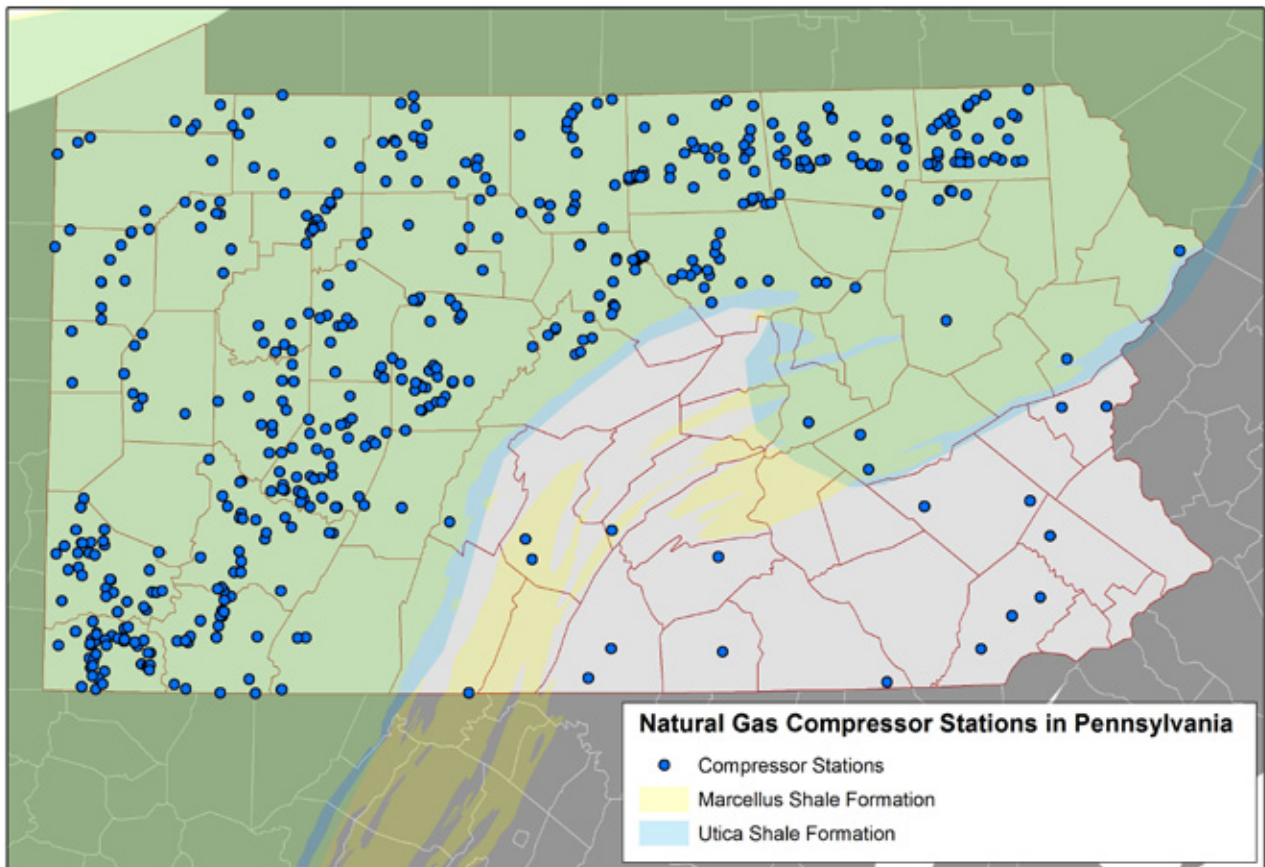
According to estimates by the New York Department of Environmental Conservation, the process of drilling, well completion and finally producing gas for one year produces the following emissions at a Marcellus Shale well site:⁹¹

- 90,400 pounds of carbon monoxide;
- 4,800 pounds of sulfur dioxide and combustion soot; and
- 440 pounds of toxic air pollutants, such as benzene.

Hazardous Air Pollutants from Wastewater Ponds

Impoundment ponds where fracking wastewater is stored are also sources of air pollution, as chemicals – some linked to human health problems – evaporate from the open-air pits.⁹² In a 2009 assessment of the impacts of fracking, the New York Department of Environmental Conservation estimated that the flowback water from a single well could emit 6,500 pounds of methanol into to the air from a storage pit.⁹³ The department noted that other compounds of concern that could evaporate from a flowback pit in harmful amounts include formaldehyde, acrylamide, naphthalene, glutaraldehyde and other chemicals that evaporate easily.⁹⁴ Overall, the agency determined that a flowback water storage pond could be defined as a “major source” of hazardous air pollution.⁹⁵

Figure 10: Locations of Natural Gas Compressor Stations in Pennsylvania



Health Problems Due to Fracking

Fracking produces pollution that affects the health of workers, nearby residents and even people living far away. Toxic substances in fracking chemicals and produced water, as well as pollution from trucks and compressor stations, have been linked to a variety of negative health effects. Residents living near fracking sites in Pennsylvania and elsewhere have long complained about a range of health problems, including headaches, eye irritation, respiratory problems and nausea.⁹⁶

Researchers at the University of Pittsburgh Graduate School of Public Health interviewed Pennsylvania residents concerned about the impacts of nearby drilling operations on multiple occasions over the course of two years, identifying 59 different health impacts and 13 different sources of stress. From the initial interview to the final interview, most participants reported that their perceived health troubles had increased.⁹⁷ Health workers at the Southwest Pennsylvania Environmental Health Project have documented similar symptoms in people concerned that their health may have been harmed by nearby gas drilling activities.⁹⁸

A study by researchers at the Colorado School of Public Health found that residents living within a half-mile of natural gas wells in one area of Colorado were exposed to air pollutants that increased their risk of illness.⁹⁹ The report noted that “health effects, such as headaches and throat and eye irritation reported by residents during well completion activities occurring in Garfield County, are consistent with known health effects of many of the hydrocarbons evaluated in this analysis.”¹⁰⁰

Residents in six states living near oil and gas drilling operations, most involving fracking, interviewed as part of another study, indicated that fracking-related pollution had killed cows, sterilized farm animals, and resulted in stillborn offspring or offspring with birth defects.¹⁰¹ Some owners even noted that dogs and cats that had walked on roads where fracking wastewater had been spread tended to lick their paws and get sick, some dying within a few days.¹⁰²

More recent studies have found associations between proximity to fracking sites and health impacts:

- A survey of Washington County, Pennsylvania, residents relying on well water found increased rates of adverse health symptoms – including skin conditions and upper respiratory ailments – reported by those living within 1 kilometer (0.6 miles) of a gas well site, compared with those living more than 2 kilometers (1.2 miles) away.¹⁰³
- A study of more than 15,000 live births in Butler, Washington and Westmoreland counties between 2007 and 2010 found an association between low birth weight and maternal proximity to unconventional gas wells.¹⁰⁴ A similar study examining births taking place throughout Pennsylvania between 2003 and 2010 found an association between a mother’s residence within 2.5 kilometers (1.6 miles) of a shale gas well and higher likelihood of low birth weight and reduced newborn health (as measured by the APGAR score).¹⁰⁵
- A Colorado study found an association between residence within a 10-mile radius of natural gas development and elevated rates of certain birth defects, including congenital heart defects.¹⁰⁶

Gas production using fracking is an intensive industrial activity that includes the use of toxic chemicals and produces large volumes of pollution with known links to health problems. Even though fracking in Pennsylvania is only a decade old, a growing body of health research points to links between proximity to fracking sites and a range of health problems.

This report has documented the proximity of fracking well sites to tens of thousands of children and elderly residents of Pennsylvania, as well as the child care centers, schools, hospitals and nursing facilities that care for them. State and federal officials should take immediate action to protect these vulnerable residents – and all Pennsylvanians – from the health hazards posed by fracking.

Policy Recommendations

The gas industry has projected drilling on the order of 60,000 new fracking wells in Pennsylvania by 2030. Should this occur, gas extraction activity could move into even greater proximity to infants, school children, the elderly and the sick. To protect their health, and the health of all Pennsylvania residents, public officials should take the following action.

Ban Additional Fracking Operations in Pennsylvania

As there is currently no proof that drilling companies will operate without contaminating our drinking water, threatening our safety, damaging our forests and parks, and polluting our air, Pennsylvania should issue a moratorium on additional fracking operations. Until such time, Pennsylvania should at least take the following actions:

- **Require a minimum setback of one mile for all fracking operations and associated infrastructure** relative to schools, child care providers, hospitals and nursing care facilities.
- **Ban the use of fracking waste pits and toxic chemicals in fracking fluid.**
- **Increase sanctions on oil and gas companies for violations committed near schools, child care providers, hospitals and nursing**

care facilities to better safeguard vulnerable populations. Fines or other sanctions should increase in proportion to the number of violations committed by a company, and in inverse proportion to the distance between the violation and a community of vulnerable Pennsylvanians. The more violations a driller is responsible for, or the closer those violations are to children, the elderly or the sick, the greater the consequence should be.

- **Ramp up enforcement – including regular inspections and mandatory penalties** – to ensure that drillers are following crucial laws and regulations intended to protect the public from the harms caused by fracking.

Pennsylvanians Should At Least Be Granted the Minimum Health Protections of Our Nation’s Core Environmental Laws

Federal law exempts shale oil and gas extraction from regulation under six key environmental policies that typically apply to industrial activities:¹⁰⁷

1. The **Resource Conservation and Recovery Act** (RCRA) is our nation’s primary hazardous waste law, giving the U.S. EPA authority to control hazardous waste. This should include the waste-

water produced by fracking. In the Marcellus Shale region alone, fracking has already generated billions of gallons of wastewater that is often laced with cancer-causing and even radioactive materials. Yet oil and gas operations are currently exempt from RCRA, and so this toxic wastewater from fracking is currently exempt from our nation's rules to protect public health from hazardous waste.

2. The **Safe Drinking Water Act** is meant to protect the quality of drinking water in the United States, whether in surface waterways or underground aquifers. In 2005, Congress amended the law to exempt gas extraction through hydraulic fracturing from all of the provisions of the law, except when diesel fuels are injected underground.
3. The **Clean Water Act** is the key law protecting America's rivers, streams and lakes from industrial discharges and runoff. For decades, all runoff from oil and gas extraction or production facilities has been exempt from regulation, except for sediment runoff caused by construction activity. In 2005, Congress passed the Energy Policy Act, which removed the Environmental Protection Agency's authority to regulate even sediment runoff from oil and gas-related construction sites.
4. The **Clean Air Act** is the cornerstone tool for ensuring that all Americans have healthy air to breathe. The law treats oil and gas wells – and often pipeline compressors and pump stations – as individual and separate sources of pollution. By failing to aggregate these sources of emissions by company and industry, the law fails to require operators to adequately control their polluting emissions – allowing the industry to pollute the air with few federal restrictions.
5. The **National Environmental Policy Act** ensures that all branches of government consider the impacts of any activity they undertake on the

health and well-being of people and their air, land and water. In 2005, the Energy Policy Act allowed the oil and gas industries to carry out a variety of activities without the thorough environmental review normally required by the National Environmental Policy Act, instead allowing a more limited review under a designation called a "categorical exclusion." For example, the categorical exclusion allows a company to drill new wells in an existing gas field, or add a new pipeline to an existing corridor, without new environmental review, even if the original review did not consider that level of development. This categorical exclusion puts the burden on the public to show that harm is occurring, rather than on the oil and gas drilling company to prove that their plans are safe.

6. The **Toxics Release Inventory** – which is authorized under the Emergency Planning and Community Right-to-Know Act – compiles information from a wide variety of industries about their discharges of hazardous chemicals to air, water and land. However, the Environmental Protection Agency, which implements the law, does not require the oil and gas extraction industry to report toxic releases. This leaves the public in the dark about the amounts of chemicals emitted into the air or water after hydraulic fracturing operations are complete.

At a minimum, the federal government should eliminate these exemptions and apply the nation's core public health and environmental laws to the oil and gas industry just as it would regulate any other potential threat to public health or the environment.

Methodology and Data Sources

We used ESRI ArcGIS geographic information system software to plot the locations of Pennsylvania's permitted well sites, compressor stations, regulatory violations, child care providers, schools, nursing care facilities and hospitals, and to determine the number of each facility within given radii of gas drilling infrastructure. Throughout, we maintained the software's data frame in the NAD 1983 State Plane Pennsylvania North projected coordinate system.

Sources of Data

Extent of the Marcellus and Utica Shale Formations

Mapping data describing the extent of U.S. shale gas deposits come from the Energy Information Administration of the U.S. Department of Energy, available at www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm#geodata. For this project, we used downloads entitled "Shapefiles for Marcellus shale play boundaries, elevations and isopachs," and "Shapefiles for shale plays and sedimentary basin boundaries." The latter was used as the source for data describing the extent of the Utica shale formation.

Locations and Identities of Well Sites and Compressor Stations

We obtained information about the locations of permitted well sites and details about the compa-

nies that applied for permits from the Pennsylvania Department of Environmental Protection (PA DEP). We focused on permits for "unconventional" wells – which, according to the Pennsylvania DEP, are "drilled into an Unconventional formation, which is defined as a geologic shale formation below the base of the Elk Sandstone or its geologic equivalent where natural gas generally cannot be produced except by horizontal or vertical well bores stimulated by hydraulic fracturing."¹⁰⁸

Information on permits issued from 1 January 2007 through 12 May 2015 was obtained from Pennsylvania Department of Environmental Protection, *Oil and Gas Reports*, available at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297. The specific report consulted was the "Permits Issued Detail Report." "Test wells" and "observation wells" were filtered out of the dataset and not included in our analysis. These data were used to map the locations of permitted well sites, as well as to calculate statistics on trends in permit numbers issued over time.

PA DEP also reported which well sites oil and gas drilling companies had actually developed as of 12 May 2015 (known as "spud sites"), in a database entitled "Spud Data Report," also available from Pennsylvania Department of Environmental Protection, *Oil and Gas Reports*, available at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297. As with permitted well sites, the

date range for our analysis of spud sites was 1 January 2007 through 12 May 2015. We used these data to report on the number of wells that have actually been drilled, as opposed to the number of well sites that have been permitted. Only “unconventional” wells were included in our analysis.

Information on the nature and location of violations of PA DEP regulations was gathered from Pennsylvania Department of Environmental Protection, *Oil and Gas Reports*, available at www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297. The specific report consulted was the “Oil and Gas Compliance Report,” filtered to account only for “unconventional” wells and “inspections with violations only.”¹⁰⁹ This report 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. This report did not identify the geographic location of violations, so we used Microsoft Access to query this database alongside the “Permits Issued Detail Report” to match well permit numbers and establish the location of each violation recorded.

We sourced our list of natural gas compressor stations from the Clean Air Council (CAC). CAC maintains an inventory of compressor stations using data collected from PA DEP regional offices and augmented with crowdsourced information. They do not believe their accounting to be comprehensive. Community testimony suggests that additional compressor stations exist across Pennsylvania and that the CAC inventory is particularly likely to be missing facilities in northeastern Pennsylvania and west of Pittsburgh. This is likely the result of the widely varying quality of data provided by regional offices of PA DEP. As such, the figures we present that are contingent upon these data are likely to be conservative.¹¹⁰

Population of Children and Elderly Living near Fracking Sites

The number of young and old Pennsylvanians living in proximity to fracking well sites was estimated using 2010 Census block group population counts and geographies embedded in ArcGIS. In the case of Census block groups that were partially within the one-mile radius from a fracking well site, we used ArcGIS’s “intersect” tool to isolate the portion of each block group located within the one-mile radius. We then divided the surface area located within the radius by the total surface area of the block group and multiplied the resulting percentage by the total population counts for each block group to estimate the number of people of each age group living within the one-mile radius. Note that this method assumes the even distribution of population across each block group and should be considered an estimate.

Locations of Day Care Facilities, Schools, Hospitals and Nursing Care Facilities

We obtained the addresses of desired service providers and community facilities from state regulatory agencies as described below. We removed any facilities without a physical address from consideration (for example, any facility with only post office box information). All datasets required geocoding to translate addresses into latitude/longitude coordinates for use in mapping software. We used a geocoding service provided by Texas A&M University Geoservices.¹¹¹ Any possible typographical mistakes in the address database provided by the states could introduce error into the geolocation process. Any discrepancies between the geocoded coordinates and the actual location of the facility building could introduce error into distance calculations.

We obtained a list of all registered child care providers from Pennsylvania Office of Child Development and Early Learning Research, *Reports: OCDEL Public Data File*, accessed at www.ocdelresearch.org/Reports on

12 May 2015. The list of providers, “OCDEL Child Care Providers – March 2015,” includes child care centers, family child care homes, and group child care homes.

Our list of K-12 school addresses was sourced from Pennsylvania Department of Education, *EdNA: Education Names and Addresses*, available at www.edna.ed.state.pa.us/ReportSearch.asp. This web portal allowed us to export a list of desired facilities and their address to an Excel document. We exported the following categories of schools: school districts (this accounted for all regular, public elementary, middle and secondary schools); charter schools; private academic schools; charter schools; approved private schools; and non-public, non-licensed schools (this includes those affiliated with a church or other religious institution). This database was accessed on 19 June 2015.

Hospital addresses came from a database maintained by the Pennsylvania Department of Health and sourced via direct communication with department staff.¹¹² (Though facility information exists online it is not exportable in Excel format, which limits the information’s usefulness for analysis.) The database we received was current through 1 June 2015. We included only hospitals, excluding other types of health care facilities.

Nursing care facility addresses came from a database maintained by the Pennsylvania Department of Health and sourced via direct communication with department staff and a formal information request.¹¹³ (Though facility information exists online it is not exportable in Excel format, which limits the information’s usefulness for analysis.) The database we received was current through 1 June 2015.

Calculating Distances

We used ESRI ArcGIS geographic information system software to plot the locations of the permitted well sites, compressor stations, violations, wastewater ponds, child care providers, schools, hospitals and nursing care facilities on a single map.

We used the “buffer” proximity analysis tool to draw circles of half-mile, one-mile and two-mile radii around each well. We then used the “Select by Location” function to select facilities that fell within the boundary of the circles of each radius. Counting the relevant facilities at each distance yielded the number of facilities within the specified distance of fracking infrastructure.

Justification for Focusing on Facilities within One-Half Mile, One Mile and Two Miles of a Well Site

This analysis examines distance from child care providers, schools, hospitals and nursing homes as a first-order approach to better understand the risk that fracking and shale gas extraction poses to vulnerable populations in Pennsylvania, and to examine how drilling activity is moving closer to more people over time. We chose to examine the number of facilities within one-half, one and two miles from a well site for the following reasons:

1. Studies in Pennsylvania have found elevated levels of methane and ethane in drinking water wells within one kilometer (0.6 miles) of a well site.¹¹⁴
2. Air pollution goes where the wind blows. Researchers in Colorado have measured elevated levels of hazardous air pollutants at a half-mile distance from a well site or associated infrastructure.¹¹⁵
3. Some of the effects of fracking, such as increased truck traffic volumes, are experienced at a community scale as hundreds of trucks drive on a well site’s surrounding roadways. The air pollution caused and the potential for accidents will affect all who live along their routes.

The analysis does not attempt to estimate potential exposures to specific chemicals at specific distances from well sites.

Notes

1. The Allegheny Front, “As Fracking Nears Schools, Parents Push Back,” *TheAlleghenyFront.org*, 13 February 2015, archived at web.archive.org/web/20151005133832/http://www.pennlive.com/midstate/index.ssf/2015/09/dep_investigating_if_drilling.html.

2. Zoning boards: see note 1; forming community groups: Protect Our Children Coalition, *Parent Group Fights Wells 3,000 Feet from School District* (blog), 2 October 2014, accessed at www.protectourchildrencoalition.org on 7 August 2015.

3. By “fracking well,” we refer to wells targeting the Marcellus Shale. Pennsylvania describes these wells as “unconventional.” All data in this report, unless otherwise noted, were collected for a date range of 1/1/2007-5/12/2015 from an online database maintained by the Pennsylvania Department of Environmental Protection (www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Spud_External_Data). For further details on data collection, see the methodology.

4. Marcellus Center for Outreach and Research, Pennsylvania State University, *Resources: Maps and Graphics*, accessed at www.marcellus.psu.edu/resources/maps.php, 11 April 2013.

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