

# Dangerous and Close

**Fracking Puts the Nation's  
Most Vulnerable People at Risk**



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## Fracking Puts the Nation's Most Vulnerable People at Risk



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Cover photo: Natural gas flaring near Pennsylvania school playground: Kelly Finan

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# Executive Summary

Oil and gas companies are fracking near our communities, polluting our air and water, and risking the health of our children and other vulnerable populations. Fracking operations are intensive industrial activities involving diesel-powered machinery, the use of large volumes of chemicals, and the storage of vast amounts of hazardous wastewater. Fracking often is done very close to vulnerable people – infants, school children, the elderly and those with weakened immune systems – even though communities typically seek to keep industrial activities far away from facilities serving these populations, such as schools, hospitals, nursing homes and day care centers.

In nine of the most heavily drilled states – Arkansas, California, Colorado, New Mexico, North Dakota, Ohio, Pennsylvania, Texas and West Virginia – oil and gas companies have drilled at least 160,000 fracked wells since 2005. Many of those wells have been drilled close to hospitals, nursing homes, schools

and day cares. Thousands more wells have been drilled and fracked in other states.

## **Drilling companies are fracking for oil and gas in close proximity to many vulnerable Americans.**

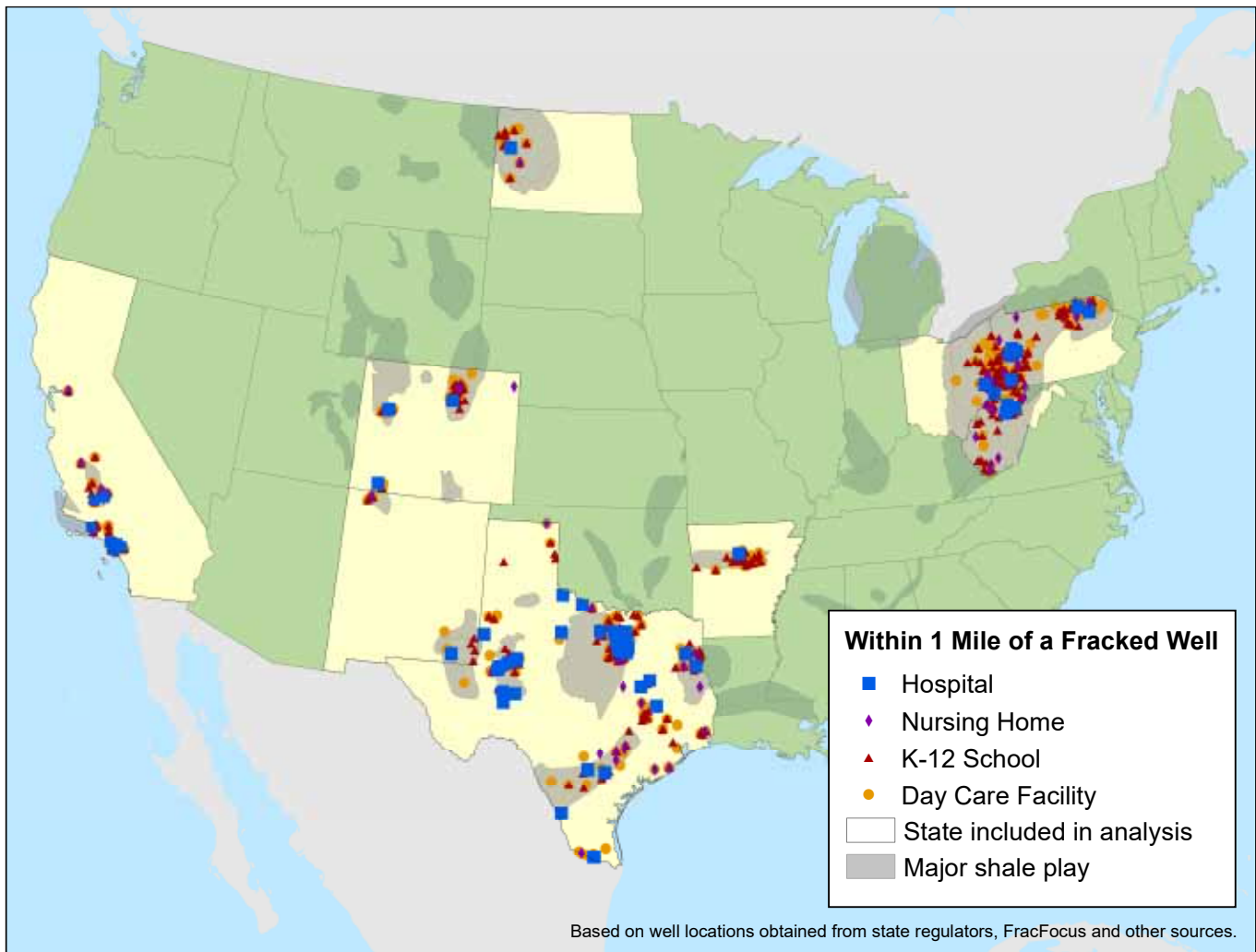
- There are 1,947 child care facilities, 1,376 schools, 236 nursing care providers and 103 hospitals within a one-mile radius of fracked wells in the nine states examined. (See Figure ES-1.) Often, these facilities are located close to more than one well and are also near compressor stations, pipelines and other fossil fuel infrastructure with impacts on public health.
- More than 650,000 kindergarten through twelfth grade children attend school within one mile of a fracked well.
- The highest percentage of children attending school close to fracked wells is in West Virginia, where 8 percent of children spend their school days within one mile of a fracked well.

## 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. This includes drilling the well, operating that well, processing the gas or oil produced from that well, and delivering the gas or oil 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 ES-1. Hospitals, Nursing Homes, Schools and Day Care Facilities within One Mile of a Fracked Well, 2005 through early 2016, Arkansas, California, Colorado, New Mexico, North Dakota, Ohio, Pennsylvania, Texas and West Virginia**



- In Texas, 9 percent of day care centers are within one mile of a fracked well.

**Fracking creates a range of threats to public health and safety.**

- Explosions, fires and other incidents at well sites can present an immediate safety threat to nearby residents, occasionally resulting in evacuations of homes and businesses.
- Fracking brings with it the potential for spills, blowouts and well failures that can contaminate drinking water.
- Fracking creates health-threatening air pollution. Volatile compounds including carcinogens in oil and 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.

**Table ES-1: Proximity of Facilities Serving Vulnerable Populations to Fracked Wells**

	Day Care Centers	Schools	Nursing Care Facilities	Hospitals
One-half Mile	723	484	81	37
One Mile	1,947	1,376	236	103
Two Miles	3,728	2,906	596	202

**People who live near fracking sites are at an increased risk of health problems.**

- Researchers at Johns Hopkins University have found that Pennsylvanians with asthma who live near fracked oil and gas wells had more asthma flare-ups that required medical care than did patients who lived farther away.
- In Colorado, residents living within one-half mile of natural gas wells were exposed to air pollutants that increased their risk of illness.

**Children, the elderly and the sick are particularly vulnerable to the health risks created by fracking.**

- Children’s developing respiratory, immune and nervous systems are more susceptible to damage from toxic chemicals. In addition, children tend to breathe more rapidly than adults and are also more likely to play outdoors, increasing their exposure to air pollution from fracking.

**Table ES-2: Number of K-12 Students Enrolled at Schools Close to Fracked Wells**

	Students Enrolled
One-half Mile	229,904
One Mile	674,044
Two Miles	1,417,369

- Older adults and the sick have weaker immune systems and more difficulty breaking down toxins in the body. In addition, 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 diesel trucks or a drilling rig.

**Given the scale and severity of fracking’s impacts, banning fracking is the prudent and necessary course to protect public health and the environment.**

- Until fracking ends, state and federal officials must take action to protect public health and the environment from the impacts of oil and gas production.
- Existing fracked oil and gas wells should be closed, beginning with those that are closest to vulnerable populations. As documented in this report, tens of thousands of our most vulnerable residents live, play, receive health services or study very close to fracked wells. Closing those wells would help protect public health.
- The federal government should close loopholes that exempt the fracking industry from 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.
- At the same time, all levels of government should act to accelerate our transition to 100 percent renewable energy, including investments in energy efficiency and increasing development of clean, renewable energy sources.

The legacy of hydrocarbon extraction and the rapid spread of fracking across the U.S. over the last decade has caused widespread harm to our environment and our health. By limiting fracking and ensuring that all oil and gas production is tightly regulated, the nation can take the first steps toward healing the damage.

# Introduction

In 2015, at Sequoia Elementary School, in California's Kern County, bad odor assumed to come from nearby wells led teachers to sometimes keep children inside instead of sending them out for recess.<sup>1</sup>

Odor from wastewater pits containing fracking fluids caused the temporary closure of a day care center in Lochgelly, West Virginia, in 2004.<sup>2</sup> Nearby homes were evacuated and other businesses closed. Though the wastewater pits have since been covered, reducing the smell from the pits, the site operator continues to accept fracking waste for disposal into underground wells. Tests in 2014 suggest that this fracking waste may be polluting a nearby stream that contributes to the local drinking water supply.

On the Navajo Nation, in New Mexico, pollution from nearby oil wells can be smelled in the air outside Lybrook Elementary School, which is located in the oil-rich San Juan Basin.<sup>3</sup> Heavy trucks serving five oil wells within one-half mile of the school add additional air pollution.

Children, the sick and the elderly spending time in the shadow of fracking sites run the daily risk of exposure to the dangers of oil and gas extraction. Those dangers are not always as obvious as an explosion or blowout – even wells that operate as intended can create air pollution from leaks in infrastructure and emissions from the tailpipes of thousands of trucks, and use toxic chemicals for fracking that can contaminate drinking water.

Yet, fracking near vulnerable populations – infants, school children, the elderly and the sick – is all too common. Hundreds of schools, child care centers, hospitals and nursing homes are alarmingly close to fracking operations. This report catalogs the number of schools, child care centers, hospitals and nursing homes that now exist within a short distance of fracked oil and gas wells in states across the country in order to better illustrate the threats that fracking poses to public health.

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, 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 drilling companies to exploit oil and natural gas deposits locked in rock formations deep underground. In little more than a decade, companies have drilled and fracked at least 160,000 oil and gas wells in Arkansas, California, Colorado, New Mexico, North Dakota, Ohio, Pennsylvania, Texas and West Virginia, as well as others in states that have experienced less-intensive fracking activity.<sup>4</sup>

To produce oil or natural gas from a fracking well, a drilling company must first drill a vertical well into

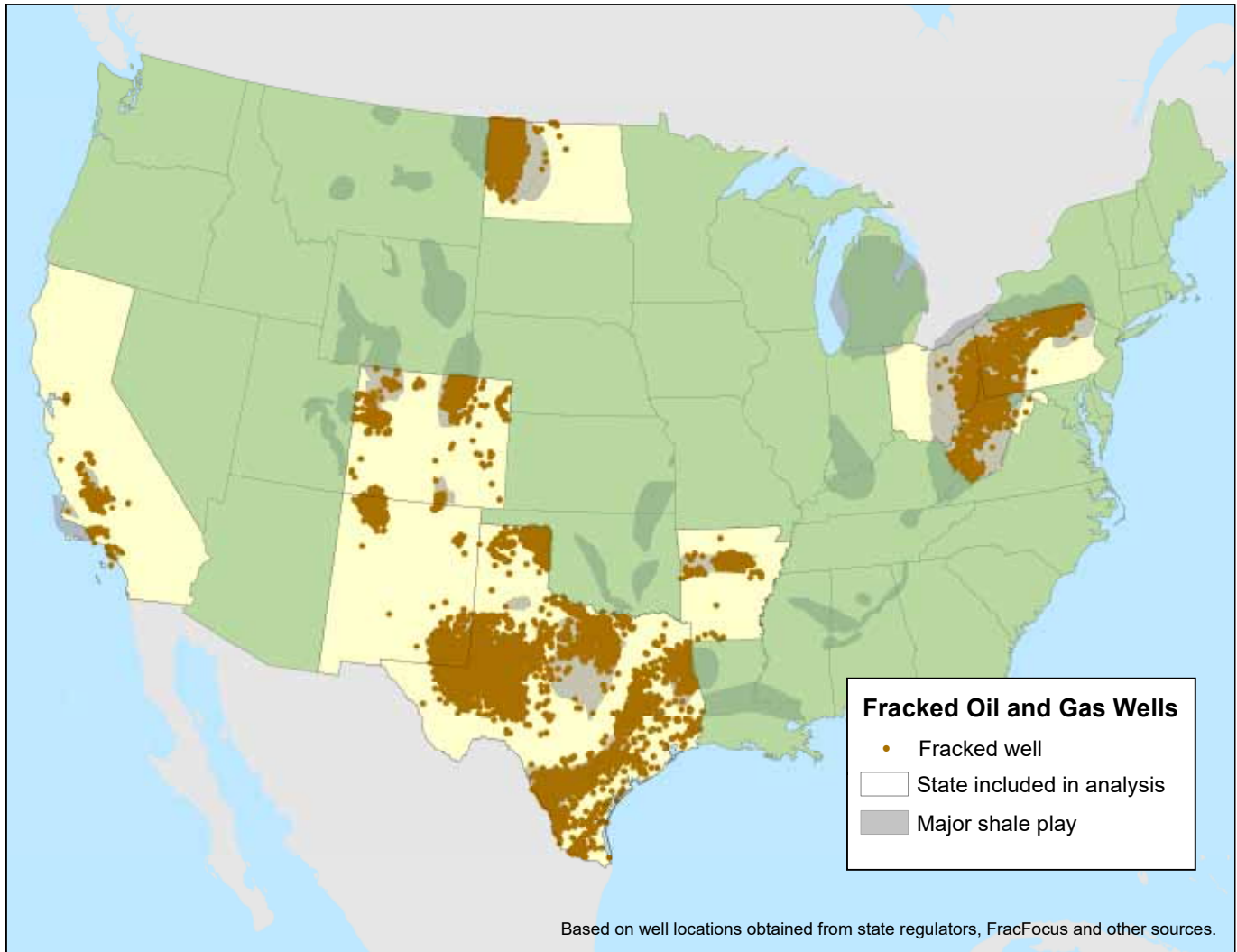
the shale formation. Then, operators' drill rigs cut horizontal branches into the shale, radiating outward thousands of feet to reach sections of rock away from the central wellbore. Once a well is drilled, operators pump water containing a proppant (typically sand) and a mixture of chemicals into the ground at high pressure. The water forces its way into cracks in the rock, widening them, and the proppant holds those cracks open wide enough for gas or oil to escape. After drilling a well, operators can repeat the process of hydraulic fracturing to boost oil and gas production anywhere from one to 10 years after the well began operation.<sup>5</sup>

Photo: Bill Cunningham, USGS

Fracking is an industrial activity that doesn't belong in neighborhoods, close to day care facilities, schools, nursing homes and hospitals.



Figure 1. Location of Oil and Gas Shale Plays and Fracked Wells, 2005 through Early 2016, Selected States



## Where Fracking Happens

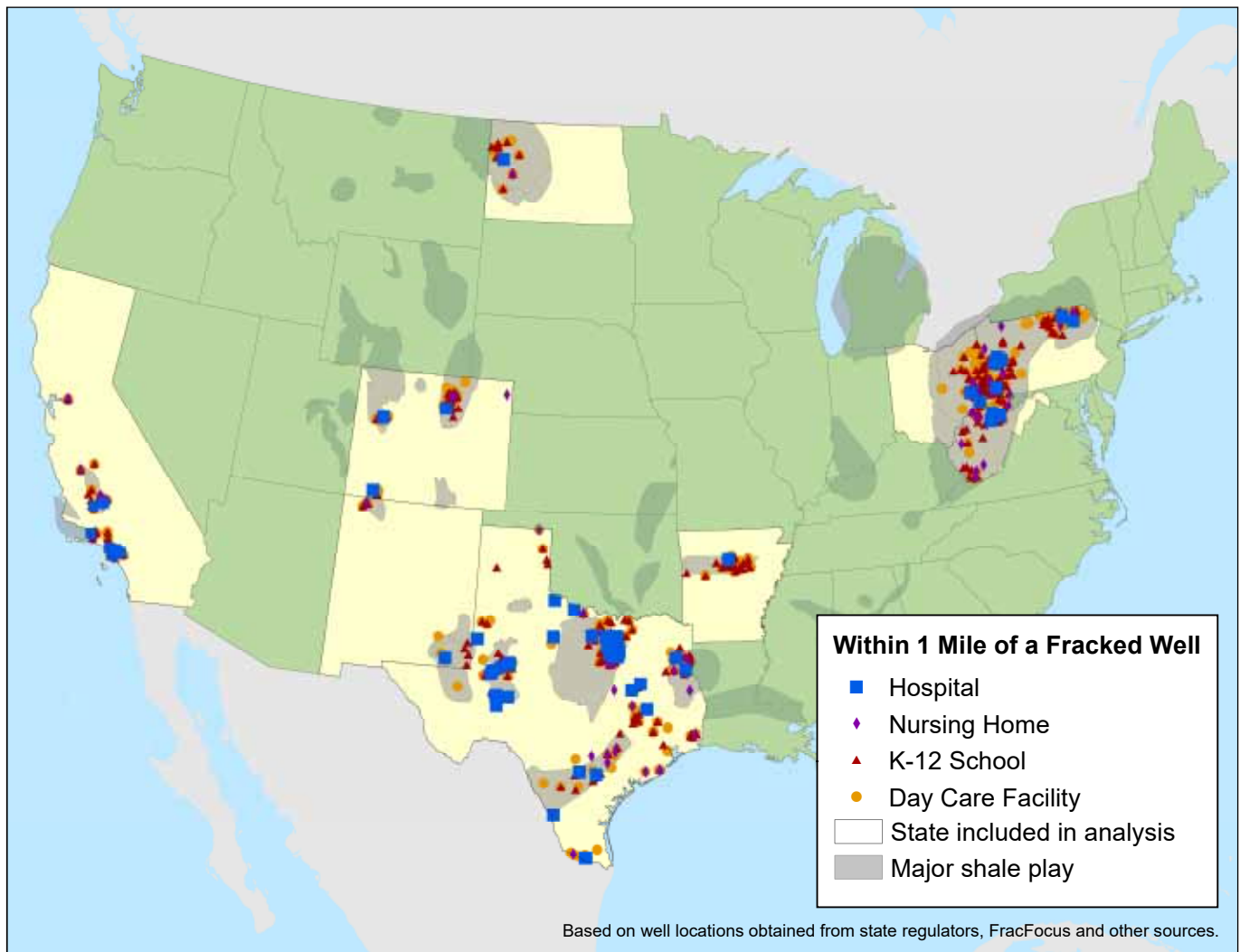
Fracking targets the oil and gas trapped in shale formations. Major shale formations include the Barnett (Texas), Marcellus (Pennsylvania, West Virginia and Ohio), Bakken (North Dakota), Monterey (California) and Niobrara (Colorado). Fracking operations target other, smaller formations, too. Figure 1 shows the location of oil and gas shale plays in the U.S., along with fracked wells in nine states.<sup>6</sup>

Often, the location of these wells is selected to provide the best access to oil and gas deposits. Sometimes that means wells are drilled in rural areas, such as portions of Colorado or North Dakota, and

sometimes that wells are in densely populated areas, such as Los Angeles or Dallas-Forth Worth. Wells are accompanied by additional equipment, such as processing facilities, compressor stations and pipelines, that must be located nearby.

Fracking operations are intensive industrial activities involving diesel-powered machinery, the use of large volumes of chemicals, and the storage and sometimes re-injection of vast amounts of wastewater. In most circumstances, communities seek to keep industrial activities far away from day care facilities, schools, nursing homes and hospitals due to the disruption they create and the environmental and safety dangers they pose.

**Figure 2. Hospitals, Nursing Homes, Schools and Day Care Facilities within One Mile of a Fracked Well, 2005 through Early 2016, Arkansas, California, Colorado, New Mexico, North Dakota, Ohio, Pennsylvania, Texas and West Virginia**



Nonetheless, drilling for oil and gas has occurred in close proximity to many vulnerable residents of the nine states examined in this analysis. 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 and compressor stations, must also be considered to provide a comprehensive view.

## 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 abil-

ity to detoxify dangerous chemicals compared to adults.<sup>7</sup>

Short-term exposure to hazardous pollutants can cause acute distress, with symptoms including difficulty breathing, wheezing, watery or itchy eyes, rashes or headaches. Very high exposures can cause nausea, vomiting, lack of coordination or more serious impacts.<sup>8</sup>

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 but may contribute to long-term health problems. Exposure to low levels of many of the chemicals used in or generated by oil and gas extraction activities can contribute to a variety of health effects, including asthma, cancer, birth defects, damage to the reproductive system and impaired brain development.<sup>9</sup> For example, children's long-term

exposure to low levels of benzene, generally classified as a carcinogen, also harms respiratory health.<sup>10</sup>

## Child Care Providers

In the nine states examined in this report, there are more than 50,000 child care providers, including both day care centers and family-run day care providers in private homes.

Of these, 3,728 day care facilities – one out of every 14 in the states examined – are located within two miles of fracked wells, and 1,947 are within one mile. Within one-half mile, there are 723 day care facilities. Often, these facilities are close to more than one well. In several states, we were unable to obtain the addresses of home-based day care facilities, meaning that this estimate likely undercounts the number of day care facilities close to fracked wells.

**Table 1. Count of Day Care Centers Close to Fracked Wells**

State	Day care facilities within one-half mile of a fracked well	Day care facilities within 1 mile of a fracked well	Day care facilities within 2 miles of a fracked well	Total day care facilities analyzed
Arkansas	16	24	51	2,089
California	29	118	385	12,050
Colorado	157	302	466	5,480
New Mexico	5	22	61	1,031
North Dakota	5	38	86	2,080
Ohio	7	30	81	8,168
Pennsylvania	41	135	360	7,736
Texas	444	1,240	2,145	14,026
West Virginia	19	38	93	492
<b>Total</b>	<b>723</b>	<b>1,947</b>	<b>3,728</b>	<b>53,152</b>

**Table 2. Count of Public and Private K-12 Schools Close to Fracked Wells**

State	Schools within a half-mile of a fracked well	Schools within 1 mile of a fracked well	Schools within 2 miles of a fracked well	Total K-12 schools analyzed
Arkansas	18	30	60	1,031
California	38	117	332	9,989
Colorado	55	110	182	1,920
New Mexico	6	21	41	960
North Dakota	7	19	49	326
Ohio	2	28	95	4,246
Pennsylvania	27	125	326	4,387
Texas	303	850	1,644	9,274
West Virginia	28	76	177	783
<b>TOTAL</b>	<b>484</b>	<b>1,376</b>	<b>2,906</b>	<b>32,916</b>

## Schools

More than 2,900 schools in the nine states are located within two miles of a fracked well. Total enrollment at those schools is more than 1.4 million students. Nearly 1,400 schools are located within one mile of a fracked well, and 484 schools are within one-half mile. That means that more than 200,000 kindergarten through twelfth grade children spend their school hours within one-half mile of a fracked well.

Texas has the most children, 430,000, attending school within one mile of a fracked well. Eighteen percent of the state's schools are located within two miles of a fracked well.

West Virginia has the highest percentage of children who attend school within one mile of a fracked well, at 8 percent, and also the highest percentage of schools close to fracked wells. Twenty-three percent

**Table 3. Number of Public and Private K-12 Students Close to Fracked Wells**

State	Students within a half-mile of a fracked well	Students within one mile of a fracked well	Students within 2 miles of a fracked well	Number of students enrolled at analyzed schools
Arkansas	5,574	8,708	22,916	503,216
California	23,135	74,566	231,690	6,223,630
Colorado	28,624	54,567	86,301	895,480
New Mexico	2,431	6,423	16,070	107,042
North Dakota	1,102	4,070	9,115	353,263
Ohio	206	7,181	29,660	1,868,879
Pennsylvania	8,613	57,667	131,817	1,894,626
Texas	151,876	436,690	827,396	5,288,709
West Virginia	8,343	24,172	62,404	291,870
<b>TOTAL</b>	<b>229,904</b>	<b>674,044</b>	<b>1,417,369</b>	<b>17,426,715</b>



## In West Virginia, 23 percent of K-12 schools are within two miles of a fracked well.

of West Virginia's K-12 schools are within two miles of a fracked well. (See Appendix A for details on each state.)

In addition to being near wells, these schools may also be located near other infrastructure for processing and transporting oil and gas.

### 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.<sup>11</sup> For example, people over 60 years old who regularly breathe air polluted with benzene are more likely to become insulin resistant because their bodies cannot process toxins as easily.<sup>12</sup>

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 particulate matter or soot pollution, such as that from diesel trucks or a drilling rig.<sup>13</sup> 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.<sup>14</sup>

### Nursing Care Facilities

In the nine states examined in this analysis, there were 596 nursing homes located within two miles of a fracked well. Within one mile of a fracked well, there were 236 nursing homes and there were 81 within one-half mile.

**Table 4. Count of Nursing Care Facilities Close to Fracked Wells**

State	Nursing homes within one-half mile of a fracked well	Nursing homes within 1 mile of a fracked well	Nursing homes within 2 miles of a fracked well	Total nursing homes analyzed
Arkansas	1	1	5	231
California	25	87	277	8,356
Colorado	1	4	13	211
New Mexico	0	1	2	70
North Dakota	0	2	5	85
Ohio	0	3	19	958
Pennsylvania	3	15	51	712
Texas	45	110	191	1,156
West Virginia	6	13	33	125
<b>Total</b>	<b>81</b>	<b>236</b>	<b>596</b>	11,904

**Table 5. Count of Hospitals Close to Fracked Wells**

<b>State</b>	<b>Hospitals within one-half mile of a fracked well</b>	<b>Hospitals within 1 mile of a fracked well</b>	<b>Hospitals within 2 miles of fracked well</b>	<b>Total hospitals analyzed</b>
Arkansas	1	1	2	171
California	3	10	16	598
Colorado	1	3	11	163
New Mexico	0	1	2	116
North Dakota	0	1	4	61
Ohio	0	3	4	412
Pennsylvania	2	6	20	389
Texas	26	72	126	843
West Virginia	4	6	17	84
<b>Total</b>	<b>37</b>	<b>103</b>	<b>202</b>	<b>2,837</b>

One hundred ninety-one nursing homes in Texas are within two miles of a fracked well, or 17 percent of all Texas nursing homes included in this analysis.

## Hospitals

More than 200 hospitals in nine states are located within two miles of a fracked well, and

more than 100 hospitals are within one mile of a well. Thirty-seven hospitals are within one-half mile of a fracked well.

Texas has the largest number of hospitals close to fracked wells. Twenty-six of the 37 hospitals within one-half mile of a fracked well are in Texas. West Virginia is second, with four hospitals within one-half mile of a fracked well.

# Fracking Jeopardizes the Health and Safety of Nearby Residents

Fracking endangers the health of all residents, but the most vulnerable among us are at an elevated 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 brought up from deep underground. They

create air pollution through emissions from diesel trucks and engines, evaporation of pollutants 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.

## Environmental and Safety Violations at Fracking Well Sites Near Vulnerable Populations

Fracking in close proximity to schools, day care centers, nursing homes and hospitals risks exposing vulnerable people to air and water pollution and other impacts even when well operators obey oil and gas regulations to the letter. Unfortunately, as data from Pennsylvania show, often drillers don't follow the rules and many of those violations have occurred close to vulnerable populations.

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.<sup>15</sup> A violation implies that a drilling company was caught breaking a rule intended to protect 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:<sup>16</sup>

- 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.

# 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 surface and groundwater contamination and air pollution present both a localized and more widespread regional danger.

## 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. Listed below are several recent high-profile blowouts and fires that illustrate the risk.

- Methane leaking from a ruptured gas well in Bloomingdale, Ohio, in October 2014 forced the evacuation of 400 families by authorities worried about health impacts and the potential for an explosion.<sup>17</sup>
- More than 100 residents were evacuated in Arlington, Texas, in 2015 after crews struggled to plug a gas well that was leaking fracking fluid. Officials feared that natural gas could leak from the well, creating a fire hazard.<sup>18</sup>
- A March 2013 blowout in Washington Township, Pennsylvania, 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.<sup>19</sup>

Explosions also can happen at other steps in the oil and gas extraction process. For example, a compressor station that moves natural gas in pipelines in

Table 6. Summary of Fracking’s Health and Safety Impacts

Safety
Well blowouts create explosion risk. Heavy truck traffic raises car crash risk. 24-hour noise and light raise health risks.
Air pollution
Diesel soot from trucks and equipment can impair lung development and worsen heart disease. Exhaust from venting or flaring natural gas increases air pollution. Hazardous air pollutants from trucks, equipment and wastewater raise cancer risk. Elevated levels of cancer-causing radon may be found in buildings. Smog can harm developing lungs. Airborne silica sand can scar the lungs.
Water pollution
Spills and leaks can dump toxic and radioactive wastewater.

western Colorado exploded in June 2012. The explosion killed one worker and injured two others, and forced a temporary highway closure.<sup>20</sup> In April 2016, a natural gas pipeline in Pennsylvania exploded, badly burning a man when his home caught fire and forcing the evacuation of nearby homes and businesses.<sup>21</sup> More recently, 36 storage tanks at a fracking site in a New Mexico oil field caught fire, forcing the evacuation of 55 homes.<sup>22</sup>

### *Truck Traffic*

Fracking requires the transportation of massive amounts of water, sand and chemicals to and from well sites. Each fracked well requires as many as 1,650 truck trips for sand and water delivery, well pad development, well drilling, and extraction.<sup>23</sup>

Increased traffic volume leads to more crashes and thus to more injuries and deaths.<sup>24</sup> States at the heart of the fracking boom have seen an increase in deadly traffic collisions. A May 2014 Associated Press analysis found that traffic fatalities in six drilling states had quadrupled since 2004 at a time when crashes nationwide were trending down.<sup>25</sup> In northern Pennsylvania, vehicle crash rates were significantly higher in counties where fracking took place.<sup>26</sup> Around the Eagle Ford Shale play in southern Texas, traffic fatalities increased by 48 percent from 2008 to 2013, compared with a statewide decrease of 3 percent.<sup>27</sup>

### *Noise and Light*

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 those who spend long periods of time nearby. 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.<sup>28</sup> Drilling operations persist 24 hours per day and seven days per week, causing



**Flaring of natural gas at a well in North Dakota lights up the surrounding area.**

unnatural levels of light that can disrupt peoples' natural biological rhythms. Such disruptions are linked to sleep disturbances and depression.<sup>29</sup>

### **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.<sup>30</sup> 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.

#### *Hazardous Air Pollutants from Trucks, Equipment and Gas Flaring*

Hazardous air pollutants (HAPs) pose a direct threat to public health. Oil and 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 wastewater ponds.



Pollution levels near wells are often high. Air quality tests at playgrounds close to fracked wells in north Texas found elevated levels of benzene at all but one location. A number of other toxic or cancer-causing compounds were also detected.<sup>31</sup> In Utah, researchers from the University of Colorado, Boulder, sampled the air near oil and gas wells and found elevated levels of volatile organic compounds (VOCs). Pollution levels were consistently above background levels, with occasional short-term, localized spikes in pollution concentrations.<sup>32</sup> Weekly tests of air quality 0.7 miles from a well pad in Colorado's Front Range detected VOCs throughout the year-long study, which spanned multiple stages of well drilling and production.<sup>33</sup> Another Colorado-based study found that concentrations of benzene, toluene and other pollutants were three to nine times higher within one-half mile of a gas well site than farther away.<sup>34</sup>

A series of 2012 measurements by officials of the Texas Department of Environmental Quality found VOCs 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.<sup>35</sup> Earlier monitoring in Texas detected benzene – a known cancer-causing chemical – at levels that were high enough to cause immediate human health concern at two sites in the Barnett Shale region, and at levels that posed long-term health concern at an additional 19 sites.<sup>36</sup>

### **Diesel Soot**

Diesel engines that operate throughout the drilling and fracturing process produce 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 per well by diesel-powered trucks.<sup>37</sup> This increased truck traffic contributes to air pollution.<sup>38</sup> Additionally, injecting the fracturing fluid into the well and pressurizing the system requires the operation of pumps, typically also powered by diesel engines.<sup>39</sup>

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.<sup>40</sup> 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.<sup>41</sup>

Particulate pollution is also deadly, killing upwards of 50,000 Americans every year.<sup>42</sup>

**Air quality tests at playgrounds close to fracked wells in north Texas found elevated levels of benzene.**



**Generators and other heavy equipment produce diesel soot and other hazardous air pollutants.**

### **Gas Flares, Venting and Blowouts**

The drilling process can 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. Oil and gas drilling companies can dispose of the extra gases by flaring them.<sup>43</sup> 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, drilling companies operate compressor stations, typically within four to six miles of a group of wells.<sup>44</sup> These compressor stations are typically powered by combustion engines fueled by raw or processed natural gas, which generates pollution-laden exhaust.<sup>45</sup>

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.

### ***Hazardous Air Pollutants from Wastewater Ponds***

Impoundment ponds where fracking wastewater sometimes is stored are also sources of air pollution, as chemicals – some linked to human health problems – evaporate from the open-air pits.<sup>46</sup> In an assessment of the impacts of fracking, the New York Department of Environmental Conservation found that compounds of concern that could evaporate from a flowback pit in harmful amounts include formaldehyde, acrylamide, naphthalene, glutaraldehyde and methanol.<sup>47</sup>

Wastewater pits may also contribute to elevated levels of radon in nearby homes. Radon, which can cause lung cancer, has been measured at high concentrations in fracking wastewater. Because of the health hazard created by radon, Pennsylvania has a long record of radon measurements in homes. An analysis of those radon measurements by researchers at Johns Hopkins School of Public Health found

## Indoor radon levels have increased in counties with extensive fracking.

that radon levels have increased in counties with extensive fracking since 2004, and also found elevated radon levels on the first floor of houses located within 12.5 miles of a fracked well.<sup>48</sup> For each additional nearby well, radon measurements increased. One possible explanation is that radon released from wastewater in holding ponds increases ambient radon, which then gets trapped indoors.

### *Smog-Forming Emissions*

Oil and gas production at fracked wells releases volatile organic compounds and nitrogen oxides that contribute to the formation of smog. 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.<sup>49</sup>

Photo: Ken Skipper, USGS



Clouds of silica hang in the air over a frack site in Pennsylvania.

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.<sup>50</sup> Studies in Wyoming and Utah have shown that ozone levels in drilling regions can spike well above federal standards.<sup>51</sup>

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.<sup>52</sup> Measurements of ethane, a telltale pollutant from fracking, show increased levels near Baltimore, MD, and Washington, D.C., though the closest fracking activity is in Pennsylvania and West Virginia.<sup>53</sup> The researchers suggest that other pollutants are similarly likely to travel from fracking in the Marcellus region to major population centers. A 2014 study predicted that by 2020, drilling in the Marcellus Shale beneath Pennsylvania, Ohio and West Virginia 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.<sup>54</sup>

### *Airborne Silica*

One of the key components of the fracking fluid pumped into wells is a proppant, typically silica sand. When the sand is transferred from trucks and mixed with other elements of fracking fluid, the sand can become airborne, creating a respiratory threat to workers but also potentially to others nearby.

Workers who are regularly exposed to high levels of airborne silica can develop silicosis, permanent scarring of the lungs that impairs the ability to breathe and eventually can be fatal. A 2012 study of airborne

silica at 11 fracking sites in five states found that workers at every site were exposed to unacceptably high levels of silica. At one-third of the sites, airborne silica was 10 times higher than safe levels for workers.<sup>55</sup>

Airborne sand may present a risk to people close to well sites as the fine particles are carried on the wind.

## Drinking Water Pollution

### *Potential Contaminants*

Oil and 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**

A variety of toxic substances – such as hydrochloric acid, ethylene glycol (antifreeze), and benzene – are added to fracking fluid injected into wells. Researchers at the Yale School of Public Health analyzed more than 1,000 chemicals found in fracking fluid and wastewater. Toxicity data were not available for three-quarters of the chemicals. Of the chemicals for which toxicity data were available, 65 percent are potential developmental or reproductive toxins.<sup>56</sup>

Doctors and health scientists have associated many of these pollutants with a wide variety of acute and chronic diseases, including cancer, asthma and problems with the liver, kidneys and central nervous system.<sup>57</sup> Evolving understanding of long-term exposure to small amounts of these types of contaminants suggests that contaminants from oil and gas extraction could have serious impacts on public health, especially near well sites.<sup>58</sup>

### **Naturally Occurring Contaminants**

After hydraulic fracturing of a well is completed, water flows back to the surface. That water includes

many of the chemicals that were used to frack the well. In addition, this water 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 metals, including arsenic, antimony, barium, cadmium, chromium, cobalt, copper, iron, lead, molybdenum, nickel, silver, strontium, thallium and titanium.<sup>59</sup> Arsenic causes cancer.<sup>60</sup> Very low levels of lead exposure have been linked to learning difficulties, mental and physical developmental problems and behavioral changes.<sup>61</sup>
- **Hydrocarbons.** Oil and gas deposits can sometimes contain benzene, toluene, ethylbenzene and xylene. These are chemicals associated with cancer and other serious health problems.<sup>62</sup>
- **Radioactive elements.** Flowback water samples from several wells in Pennsylvania and West Virginia all contained radioactive components, including radium, a radioactive metal.<sup>63</sup> A study 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.<sup>64</sup> North Dakota has encountered instances in which radioactive waste from drilling operations has been illegally dumped.<sup>65</sup>

### *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 hundreds or thousands of feet beneath the surface. Wells drilled to reach shale formations often 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. Oil and gas drilling companies use metal casing pipes and cement to line wells. The casing pipes are intended to isolate the well from other rock layers and allow oil, 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 can 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.<sup>66</sup>

## 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 instances of water contamination resulting from surface spills at oil and gas well sites. For example:

- The Associated Press examined records in 11 states and counted more than 21,000 wastewater spills from 2009 to 2014.<sup>67</sup> Accidental and deliberate spills dumped more than 180 million gallons of salty, polluted water.
- In Pennsylvania, more than 200 holes were found in the lining of an impoundment for fracking wastewater, allowing pollution to leak out and harm streams and vegetation.<sup>68</sup>
- Test of private wells in Pennsylvania have found diesel-like contaminants, and further analysis led researchers to conclude the pollution likely came from spills that percolated down into the water table.<sup>69</sup>

Photo: Hanna Hamilton USGS

Fracking wastewater often is stored in open pits. Leaks can contaminate groundwater, while toxic chemicals can evaporate and create air pollution.





## Examples of Water Pollution

Pennsylvania has documented many incidents of water pollution from fracking. Oil and gas development damaged the water supplies for at least 161 homes, farms, churches and businesses between 2008 and the fall of 2012. A more comprehensive analysis found 243 documented cases of contaminated drinking water supplies between December 2007 and August 2014 due to fracking activities.<sup>70</sup>

In one case, the well of a Pennsylvania home 600 feet from a fracked well was contaminated with barium at levels 20 times higher than the maximum level considered safe.<sup>71</sup> 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.<sup>72</sup>

A leak from a gas processing plant in western Colorado in 2013 contaminated a creek and groundwater with benzene, a cancer-causing chemical.<sup>73</sup> The creek and groundwater are used for irrigation.

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 underlying Pennsylvania, Ohio and West Virginia could accelerate the movement of fracking chemicals – possibly bringing these contaminants into contact with groundwater in a matter of years.<sup>74</sup> 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.<sup>75</sup>

## Health Problems Due to Fracking

The pollution produced by fracking affects the health of workers, nearby residents and even people living far away. Residents living near fracking sites have long complained about a range of health problems, including headaches, eye irritation, respiratory problems and nausea.<sup>76</sup> Multiple peer-reviewed studies have documented increased health problems in people living near fracking sites.

- Pennsylvanians with asthma who live near fracked oil and gas well sites experience more problems with their asthma than people who live farther from fracking sites. Researchers examined health records of more than 35,000 patients for hospitalizations, doctor visits and other treatments for asthma.<sup>77</sup> Patients near fracking operations had more frequent problems than patients living farther away, and those problems occurred during all stages of production, including when the well site was being prepared, and when the well was drilled, fracked and in production.
- A study by researchers at the Colorado School of Public Health found that residents living within one-half mile of natural gas wells in one area of Colorado were exposed to air pollutants that increased their risk of illness.<sup>78</sup> 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.”<sup>79</sup>
- 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.<sup>80</sup>

Oil and 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. A growing body of health research suggests proximity to fracking sites leads to a range of health problems.

This report has documented the proximity of fracking well sites to 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 residents – from the health hazards posed by fracking.

# Policy Recommendations

**F**racking is so dangerous to public health that we should phase out the practice altogether. In the meantime, we should not allow fracking to begin in additional regions and should enact baseline protections for communities where it is already occurring.

**Given the scale and severity of fracking's impacts, banning fracking is the prudent and necessary course to protect public health and the environment.** At a minimum, state officials should allow cities, towns and counties to protect their own citizens through local bans and restrictions on fracking.

**In addition, existing fracked oil and gas wells should be closed, beginning with those that are closest to vulnerable populations.** As documented in this report, tens of thousands of our most vulnerable residents live or study very close to fracked wells. Closing those wells would help protect public health.

**Until fracking ends, state and federal officials must take action to hold the oil and gas industry to the highest standards of public health and environmental protection.**

- Congress should close the loopholes that exempt fracking from key provisions of federal environmental laws. These include the Safe Drinking Water Act, the Clean Water Act and the Clean Air Act, the Resource Conservation and Recovery Act, and the National Environmental Policy Act.
- Policymakers should end the most dangerous drilling practices. Fracking operators should no longer be allowed to use open waste pits, even if they are

lined, for holding wastewater. The use of toxic chemicals should not be allowed in fracking fluids.

- Federal and state governments should protect drinking water supplies from the risks of fracking. Fracking should not be allowed in watersheds that supply drinking water.
- The public has a right to know how fracking operations are affecting the environment and public health. The data currently available on fracking are inconsistent, incomplete and difficult to analyze. To remedy this, oil and gas companies should be required to report all fracking wells drilled, all chemicals used, amount and source of water used, and volume of wastewater produced and toxic substances therein. Reporting should occur into an accessible, national database, with chemical use data provided 90 days before drilling begins.

At the same time, all levels of government should act to accelerate our transition to 100 percent renewable energy. That will require prioritizing energy savings. Conserving energy and using it more efficiently can ease the transition from dirty fuels to clean, renewable energy. In addition, the nation must promote steady and swift deployment of clean renewable energy sources. Solar and wind energy are poised to play a major role in every vision of a 100 percent renewable energy system.

The rapid spread of fracking across America in the last decade has caused widespread harm to our environment and our health. By limiting fracking and ensuring that all oil and gas production is tightly regulated, the nation can take the first steps toward healing the damage.

# Methodology and Data Sources

We used ESRI ArcGIS geographic information system software to plot the locations of fracked wells, child care facilities, schools, nursing care facilities and hospitals in nine states. We chose Arkansas, California, Colorado, New Mexico, North Dakota, Ohio, Pennsylvania, Texas and West Virginia because those states have experienced the most fracking activity. We then used the software to estimate the number of these facilities located within given radii of fracked well drilling sites. The methodology below explains the source of all data and provides details on the analysis.

## Wells

Well location information was obtained from state agencies or from the FracFocus database managed by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission. We downloaded FracFocus data on 18 May 2016; those data were last updated by FracFocus on 26 April 2016. Whenever possible, we selected for wells drilled since 2005. Because of data entry errors in the information from FracFocus and regulators, some wells appear in the incorrect location, which may result in incorrect identification of selected day care center, schools, nursing homes and hospitals as being close to a fracked well. If these wells were plotted correctly, a different set of facilities might be affected.

## Arkansas

A list of permitted wells with permit status dates since January 2005 was obtained from Arkansas Oil and Gas Commission, 3 May 2016. Horizontally drilled wells are designated by an “H” in the state-issued well number. We used permitted wells as a proxy for drilled wells, because about 99 percent of all permitted wells are drilled, per James Vinson, Webmaster, Arkansas Oil and Gas Commission, personal communication, 8 September 2015.

## California

California did not track all fracked wells prior to 2015. This report counts wells as fracked if 1) they are currently producing from an oil or gas pool that requires stimulation to any extent, and 2) actively produced hydrocarbons over the period of 2013-2016.

Identification of reservoirs that typically require stimulation comes from data collected for the California Council on Science and Technology’s Senate Bill 4 study, in which researchers calculated the probability that each oil and gas pool had been fracked (in CCST, *Well Stimulation in California, Volume 2, Appendix 5E: Estimate of the Number Hydraulic Fracturing Operations by Pool in California, 2015*, available at [http://ccst.us/projects/hydraulic\\_fracturing\\_public/SB4.php](http://ccst.us/projects/hydraulic_fracturing_public/SB4.php)). A list of all oil and gas wells in California came from the

California Department of Conservation, Division of Oil, Gas and Geothermal Resources (DOGGR), *All Wells*, accessed at [www.conservation.ca.gov/dog/maps/Pages/GISMapping2.aspx](http://www.conservation.ca.gov/dog/maps/Pages/GISMapping2.aspx), December 2015). That list of oil and gas wells was matched with production data (from DOGGR, [ftp://ftp.consrv.ca.gov/pub/oil/new\\_database\\_format](ftp://ftp.consrv.ca.gov/pub/oil/new_database_format)), allowing identification of wells with production numbers from 2013 to 2016.

Active wells identified as hydraulically fractured in other datasets were also included. Those datasets include FracFocus, South Coast Air Quality Management District, and Central Valley Regional Water Quality Control Board, through December 2015.

This method may overestimate the number of fracked wells by including all wells that tap pools that are typically fractured, though not all wells in those pools may have been fracked. However, this method may undercount fracked wells because it does not include any wells active before 2013, or wells that may have accessed multiple pools including a fracked pool before 2013.

## Colorado

Data on fracked wells in Colorado come from two sources. Since April 2012, Colorado has required that well operators report fracking activity to FracFocus. Before April 2012, there is no firm data on the number of fracked wells in Colorado. Based on conversations with staff at the Colorado Oil and Gas Commission (including Diana Burn, Eastern Colorado Engineering Supervisor, Colorado Oil and Gas Commission, personal communication, 4 September 2013), we assumed wells in Weld, Boulder, Garfield and Mesa counties are fracked. A list of all wells in Colorado was obtained from Colorado Oil & Gas Conservation Commission, Colorado Oil and Gas Information System (COGIS), *2015 Production Report*, downloaded 17 October 2015, from [cogcc.state.co.us/data.html#/cogis](http://cogcc.state.co.us/data.html#/cogis).

## North Dakota

We obtained data on fracked wells in North Dakota from FracFocus.

## New Mexico

New Mexico does not track which wells are fracked, nor does it require reporting to FracFocus. We identified fracked wells by using two sources: the state's list of horizontally drilled wells, and wells voluntarily reported to FracFocus.

Data on the number of horizontally drilled wells were used as a proxy for fracked wells. Data were obtained from the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division, *OCD Data and Statistics*, accessed at [www.emnrd.state.nm.us/OCD/statistics.html](http://www.emnrd.state.nm.us/OCD/statistics.html), 4 May 2016. Horizontally-drilled wells are designated by an "H" at the end of the well name. One well with status "never drilled" was excluded from our count. From FracFocus, we identified fracked wells in New Mexico. We combined the state list of wells with the FracFocus list of wells and excluded any duplicate records.

## Ohio

For Ohio, we included data for wells drilled in both the Marcellus and Utica/Point Pleasant shales from Ohio Department of Natural Resources, Division of Oil & Gas Resources, *Cumulative Permitting Activity*, accessed at [oilandgas.ohiodnr.gov/shale#SHALE](http://oilandgas.ohiodnr.gov/shale#SHALE), 3 May 2016. We included Utica/Point Pleasant wells and Marcellus wells with a status of "drilled," "drilling," or "producing."

## Pennsylvania

We obtained information about the locations of unconventionally drilled wells from the Pennsylvania Department of Environmental Protection (PA DEP) from an online public database entitled "Spud Data Report," available at [www.dep.pa.gov/DataandTools/Reports/](http://www.dep.pa.gov/DataandTools/Reports/).<sup>81</sup> These sites correspond to oil and gas wells 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.<sup>82</sup> The list includes only wells for which drilling dates have been reported to the PA DEP. The date range for our analysis of spud sites was 1 January 2005 through 3 May 2016.

The universe of wells considered in this report differs from that analyzed in a similar report (Elizabeth Ridlington, Tony Dutzik and Tom Van Heeke, Frontier Group; Adam Garber and David Masur, PennEnvironment Research & Policy Center, *Dangerous and Close: Fracking Near Pennsylvania's Most Vulnerable Residents*, October 2015), which measured the proximity of facilities to *permitted* unconventional well sites. In this report, to ensure consistency across multiple states, the universe of wells is limited to those that have actually been drilled. Because the list of drilled unconventional wells is significantly smaller than list of permitted unconventional wells, our count of nearby facilities in this analysis is lower than in the previous report.

## Texas

Data on fracked wells in Texas were obtained from FracFocus. Texas began requiring reporting to FracFocus in 2012, though there are a few wells before that date, too. Wells with no date or with a date before 2005 were excluded.

## West Virginia

Oil and gas well permitting data were downloaded in shapefile format from the West Virginia Department of Environmental Protection's Technical Applications and GIS (TAGIS) Unit.<sup>83</sup> We filtered the dataset to include only wells with a completion date after 1 January 2005 and to include permit types that explicitly involved fracking: Fracture (FRACT), Fracture/Drill Deeper (FRADD), Fracture/New Well (FRANW), Fracture/Horizontal Well (FRAHW), Frac-

ture/Gas Injection Well (FRAGI), Partial Plug Frac (FRAPP), Horizontal Deep Well (HDEEP), Rework/Horizontal 6A Well (RWH6A) and Horizontal 6A Well (HRW6A).

## Locations of Facilities Serving Vulnerable Populations

We obtained the addresses of day care facilities, schools, nursing homes and hospitals from state and federal sources as described below. From these datasets, we removed locations without physical address information, including most facilities where only a post office box was listed. A subset of these facilities was manually matched to physical locations and thus included.

Most of our school and day care facility data 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.<sup>84</sup> Typographical mistakes in the addresses in the original sources could introduce error into the geolocation process which in turn could introduce error into our distance calculations.

From the geocoded results, we retained only those locations that were geocoded based on precise street addresses, parcel centroid points or zip code centroids. Though zip code centroids are less precise than street addresses, we included them because they do not introduce any systemic bias. We excluded locations that were geocoded to state or city centroids or other imprecise measures.

## Schools

Data on public and private schools, except in California, serving kindergarten through twelfth graders were obtained from U.S. Department of Education, National Center for Education Statistics, *Search for Public Schools*, available at [nces.ed.gov/ipeds/data/ipedssearch/](https://nces.ed.gov/ipeds/data/ipedssearch/) and U.S. Department of Educa-

tion, National Center for Education Statistics, *Search for Private Schools*, available at [nces.ed.gov/surveys/pss/privateschoolsearch/](http://nces.ed.gov/surveys/pss/privateschoolsearch/). Data were downloaded on 4 May 2016 and 5 May 2016. We excluded preschools from the search because they are captured in the day care facility data.

For public schools, including charter and magnet schools, data were from the 2014-15 academic year.<sup>85</sup> For private schools, data were from the 2013-14 academic year.<sup>86</sup> We then combined and deduplicated the datasets, and removed any schools that did not appear to serve K-12 children (e.g., pre-kindergarten, post-high school vocational training centers and community colleges).

A subset of K-12 schools with only a post office box instead of a street address were manually matched to physical locations, enabling their inclusion in the dataset for analysis. We obtained street addresses through web searches and by using data from older versions of National Center for Education Statistics that have been geocoded.<sup>87</sup> We were able to match school names between the two versions of the NCES data and obtain physical addresses for a subset of schools that otherwise listed only post office boxes. Table 7 shows the share of schools in each state that had sufficiently detailed geographic information to be included in our analysis.

Most schools listed included enrollment numbers, which we used to estimate how many students attended school near fracked wells. As some schools did not list enrollment numbers, our estimate of total K-12 students near fracking sites is likely an undercount.

Data for California elementary, secondary and unified school districts were downloaded from the State of California, *Geoportal*, which draws on information from the California Department of Education, *Public Schools Database* and *Private School Directory*. School locations were verified using satellite imagery and geolocation tools, including GIS data from U.S. Cen-

**Table 7. Success Rate of Geocoding School Locations by State**

State	Percentage of total K-12 schools included in analysis
Arkansas	85%
Colorado	90%
New Mexico	94%
North Dakota	58%
Ohio	96%
Pennsylvania	98%
Texas	93%
West Virginia	91%

sus Bureau, accessed from <ftp://ftp2.census.gov/geo/tiger/TIGER2014/> on 1 October 2014.

That list of schools was compared to enrollment data from California Department of Education, *DataQuest*, [data1.cde.ca.gov/dataquest/](http://data1.cde.ca.gov/dataquest/), accessed 10/1/14. Schools in the GIS files that did not match the schools listed in the *DataQuest* files were eliminated from the analysis.

## Day Care Centers

### Arkansas

We obtained a list of licensed Arkansas child care centers in shapefile format using ESRI Homeland Infrastructure Foundation-Level Data (HIFLD), available at [www.arcgis.com/home/item.html?id=c87c1c687e274285aeefdf88d53c8703](http://www.arcgis.com/home/item.html?id=c87c1c687e274285aeefdf88d53c8703).<sup>88</sup> This data set does not include home- or family-based day care centers, and thus potentially underestimates the number of child care facilities near fracked wells.

### California

A list of licensed child care centers, preschools and daycares was extracted from a larger dataset of all child care facilities, from California Department of Social Services, [cld.ca.gov/PG3581.htm](http://cld.ca.gov/PG3581.htm).

## Colorado

A list of licensed child care facilities in Colorado was obtained from Office of Early Childhood, Colorado Department of Human Services, *Colorado Licensed Child Care Facilities Monthly Report*, updated 4 May 2016, downloaded 13 May 2016 from [www.coloradoofficeofearlychildhood.com/#!/child-care-licensing--administration/c5cf](http://www.coloradoofficeofearlychildhood.com/#!/child-care-licensing--administration/c5cf). The list already included geographical coordinates, which we used to map facility locations.

## New Mexico

The locations of New Mexico child care centers were obtained from ESRI, Homeland Infrastructure Foundation-Level Data, *Day Care Centers*, downloaded 17 June 2016 from [www.arcgis.com/home/item.html?id=c87c1c687e274285aeefdf88d53c8703](http://www.arcgis.com/home/item.html?id=c87c1c687e274285aeefdf88d53c8703).HIFLD. This data set does not include home- or family-based day care centers. The locations of residential day care centers in New Mexico were obtained from a spreadsheet, *Registered Child Care Providers*, provided by Kathleen Hardy, Public Records Custodian, New Mexico Children, Youth and Families Department, personal communication, 24 May 2016.

## North Dakota

A list of day care providers in North Dakota was obtained from Becky Eberhardt, Early Childhood Services Administrator, Division of Children and Family Services, Department of Human Services in January 2016.

## Ohio

The addresses of day care facilities were obtained from the Ohio Department of Job and Family Services, Office of Family Assistance after submitting a public records request. We analyzed active full-time day care centers and family day care homes.<sup>89</sup>

## Pennsylvania

The addresses of day care facilities were obtained from the State of Pennsylvania's Office of Child Devel-

opment and Early Learning.<sup>90</sup> The list of providers, current as of March 31, 2016, includes child care centers, family child care homes and group child care homes.

## Texas

We downloaded and combined lists of Texas-based facilities from the Texas Department of Family and Protective Services.<sup>91</sup> Our list included all Licensed Child Care Centers, Licensed Child Care Homes and Registered Child Care Homes that serve infants, toddlers and preschool aged children.

## West Virginia

We obtained a listing of addresses of child care centers from the State of West Virginia, Department of Health and Human Resources, Division of Early Care and Education.<sup>92</sup> The list of providers includes only child care centers, not family or group child care homes.

## Hospitals

Hospital location data, except for California, came from ESRI and United States Geological Survey, *U.S.A. Hospitals*, updated 1 March 2015, downloaded 17 June 2016 from [www.arcgis.com/home/item.html?id=f114757725a24d8d9ce203f61eaf8f75](http://www.arcgis.com/home/item.html?id=f114757725a24d8d9ce203f61eaf8f75). The data set includes names and locations of U.S. hospitals, generated using data from the Geographic Names Information System (GNIS), part of the U.S. Geological Survey. We excluded closed facilities but included medical centers and psychiatric inpatient facilities.

A list of California health care facilities was obtained from the California Health Care Facility Dataset (HLTHFAC), through State of California, *Geoportal*, [portal.gis.ca.gov/geoportal/catalog/search/resource/details.page?uuid={2BA6C6BD-2803-4CA3-BB10-EF914B96B4A2}](http://portal.gis.ca.gov/geoportal/catalog/search/resource/details.page?uuid={2BA6C6BD-2803-4CA3-BB10-EF914B96B4A2}), accessed 1 December 2014.

## Nursing Homes

Nursing home location data, except for California, were obtained from U.S. Department of Health and Human Services, *U.S. Department of Health & Human Services: Healthcare Facilities*, 2012, downloaded 17 June 2016 from [www.arcgis.com/home/item.html?id=b3813b2d3a054c378247bf32bcd8d203](http://www.arcgis.com/home/item.html?id=b3813b2d3a054c378247bf32bcd8d203). Nursing homes are defined as residential facilities “for people who require constant nursing care and have significant deficiencies with activities of daily living.”<sup>93</sup> The map package was created using U.S. Department of Health & Human Services (HHS) data current through 2012. To focus on nursing homes that are currently operating, we counted only those facilities that were also listed in the updated database administered by the Centers for Medicare & Medicaid Services.<sup>94</sup>

A list of California health care facilities was obtained from the California Health Care Facility Dataset (HLTHFAC), through State of California, *Geoportal*, [portal.gis.ca.gov/geoportal/catalog/search/resource/details.page?uuid={2BA6C6BD-2803-4CA3-BB10-EF914B96B4A2}](http://portal.gis.ca.gov/geoportal/catalog/search/resource/details.page?uuid={2BA6C6BD-2803-4CA3-BB10-EF914B96B4A2}), accessed 1 December 2014. The dataset was limited to residential elderly care facilities.

## Calculating Distances

We used ESRI ArcGIS geographic information system software to plot the locations of fracked well sites, child care providers, schools, hospitals and nursing care facilities on a single map. All locations were converted and projected in the North America Equal Albers Conic coordinate system. We used the “Select

by Location” function to select facilities that fell within one-half mile, one-mile and two-miles of each well. Counting the relevant facilities at each distance yielded the number of facilities within the specified distance of a fracked well.

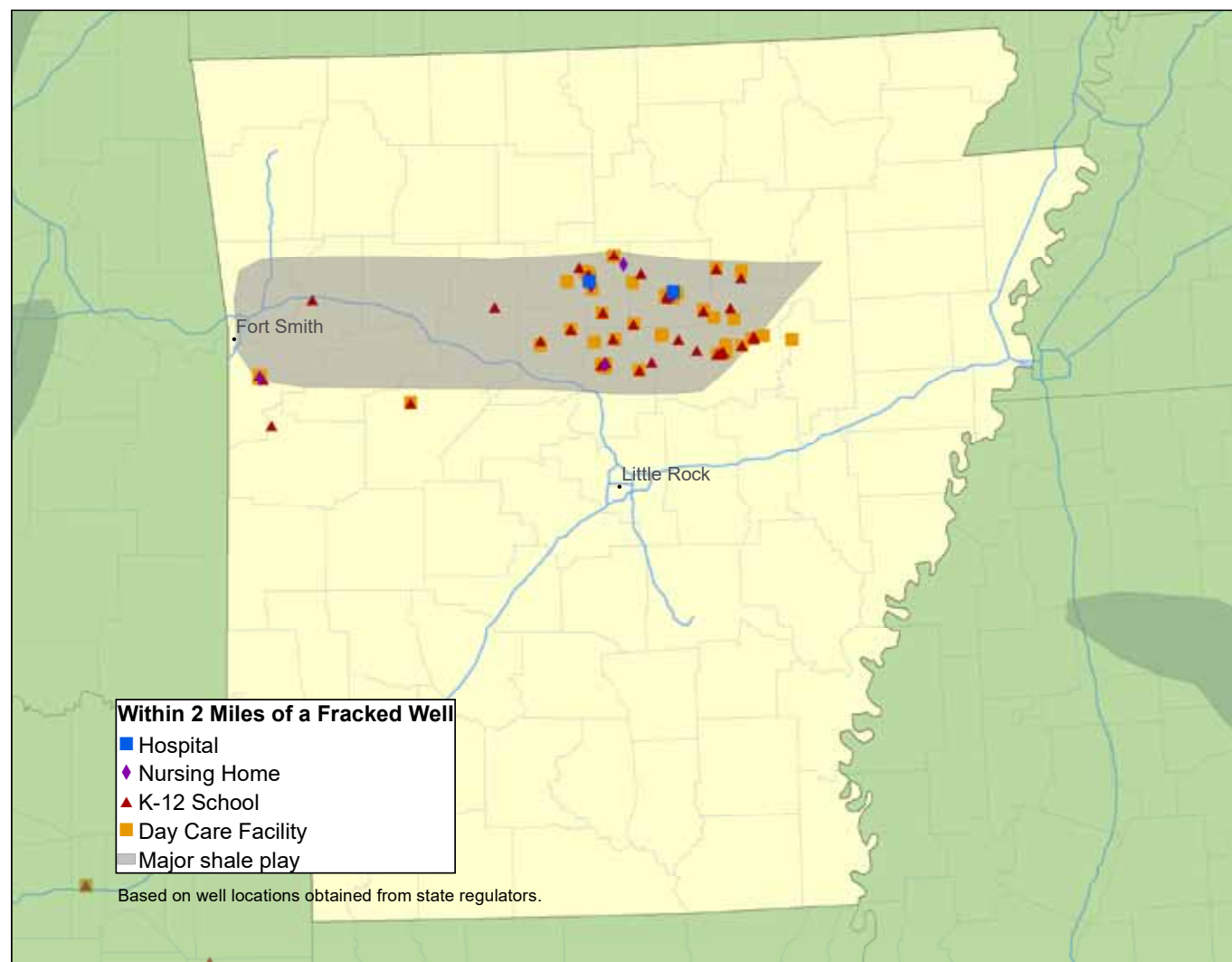
## Justification for Focusing on Facilities within One-Half Mile, One Mile and Two Miles of a Well Site

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 oil and gas extraction poses to vulnerable populations. 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 have found elevated levels of methane and ethane in drinking water wells within one kilometer (0.6 miles) of a well site.<sup>95</sup>
2. Researchers in Colorado have measured elevated levels of hazardous air pollutants at one-half mile distance from a well site or associated infrastructure.<sup>96</sup>
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.

# Appendix A. Count by State

## Arkansas

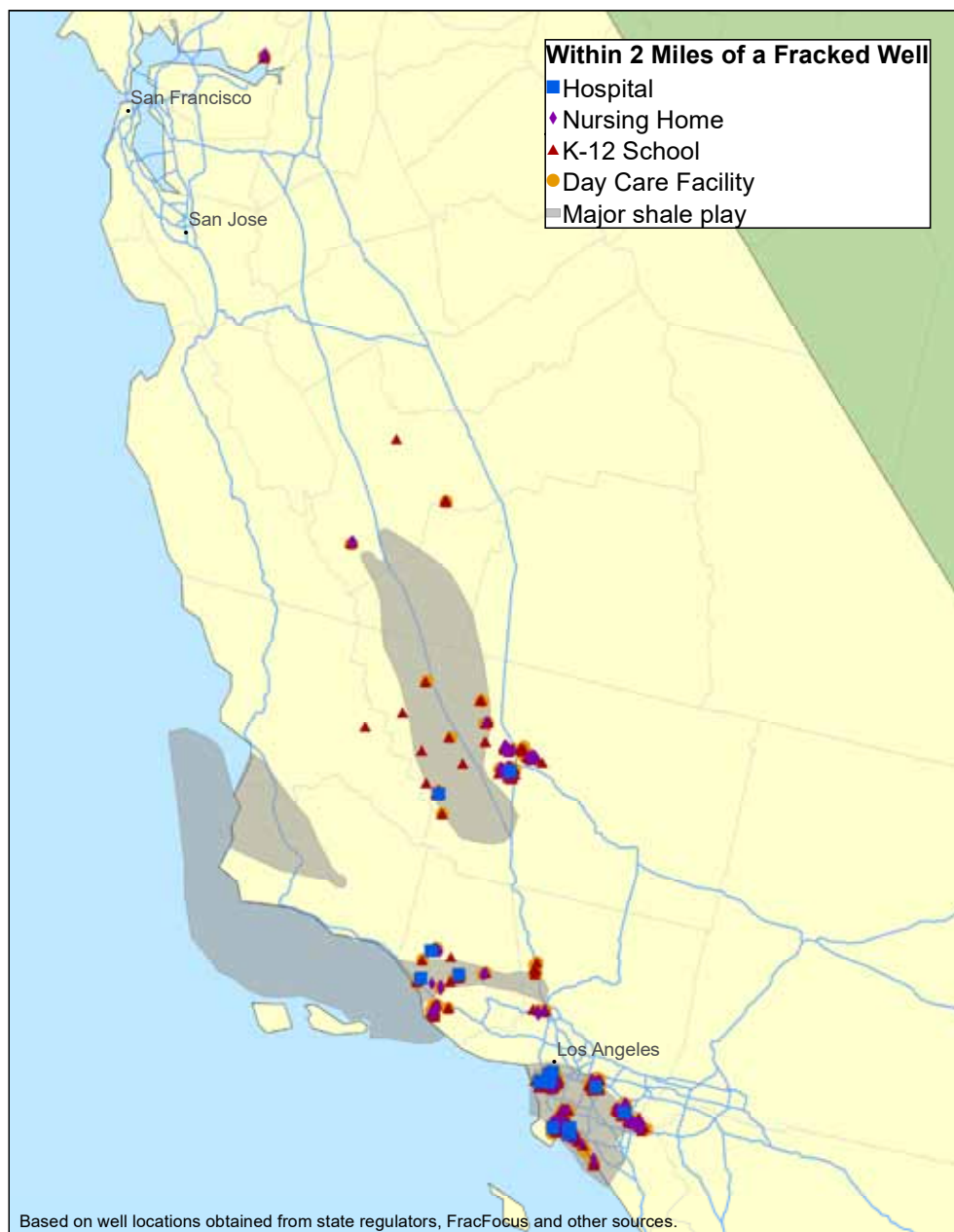


**Table A-1. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers*	16	24	51
K-12 schools	18	30	60
K-12 students	5,574	8,708	22,916
Nursing homes	1	1	5
Hospitals	1	1	2

\* Excludes home-based day care centers.

## California



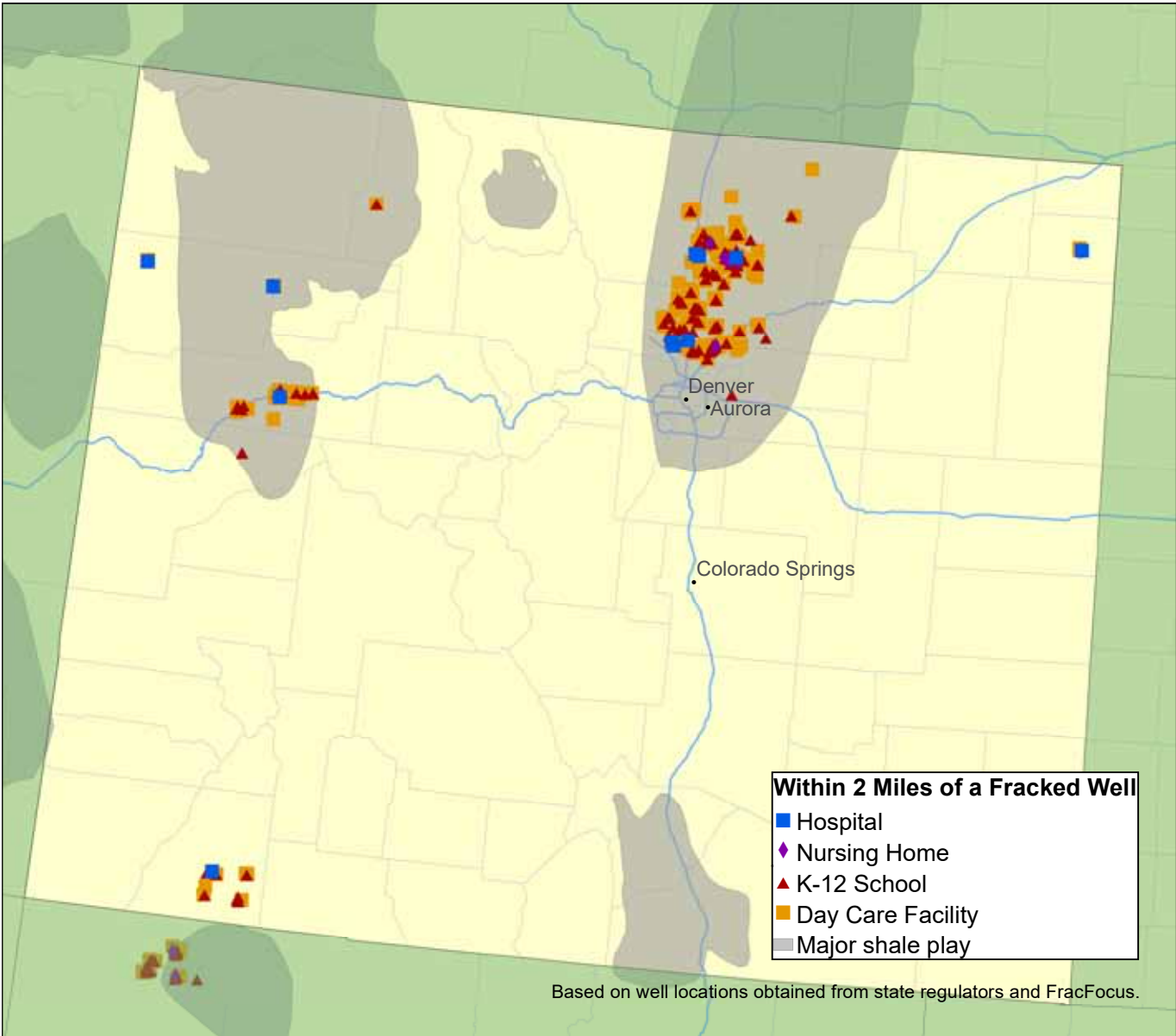
**Table A-2. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Daycares*	29	118	385
K-12 schools	38	117	332
K-12 students	23,135	74,566	231,690
Nursing homes	25	87	277
Hospitals	3	10	16

\* Excludes home-based day care centers.



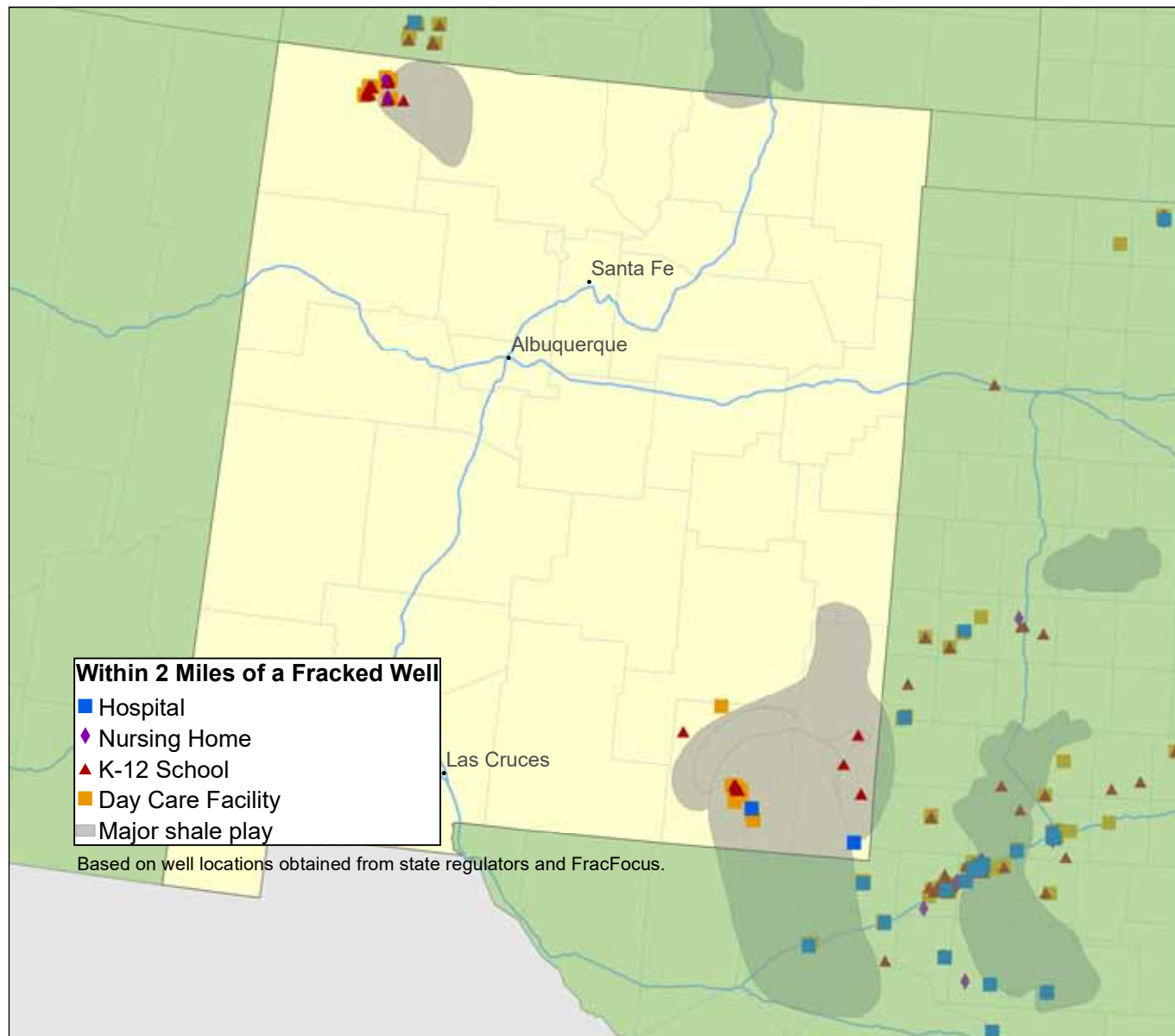
# Colorado



**Table A-3. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	157	302	466
K-12 schools	55	110	182
K-12 students	28,624	54,567	86,301
Nursing homes	1	4	13
Hospitals	1	3	11

## New Mexico



**Table A-4. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	5	22	61
K-12 schools	6	21	41
K-12 students	2,431	6,423	16,070
Nursing homes	0	1	2
Hospitals	0	1	2

# North Dakota

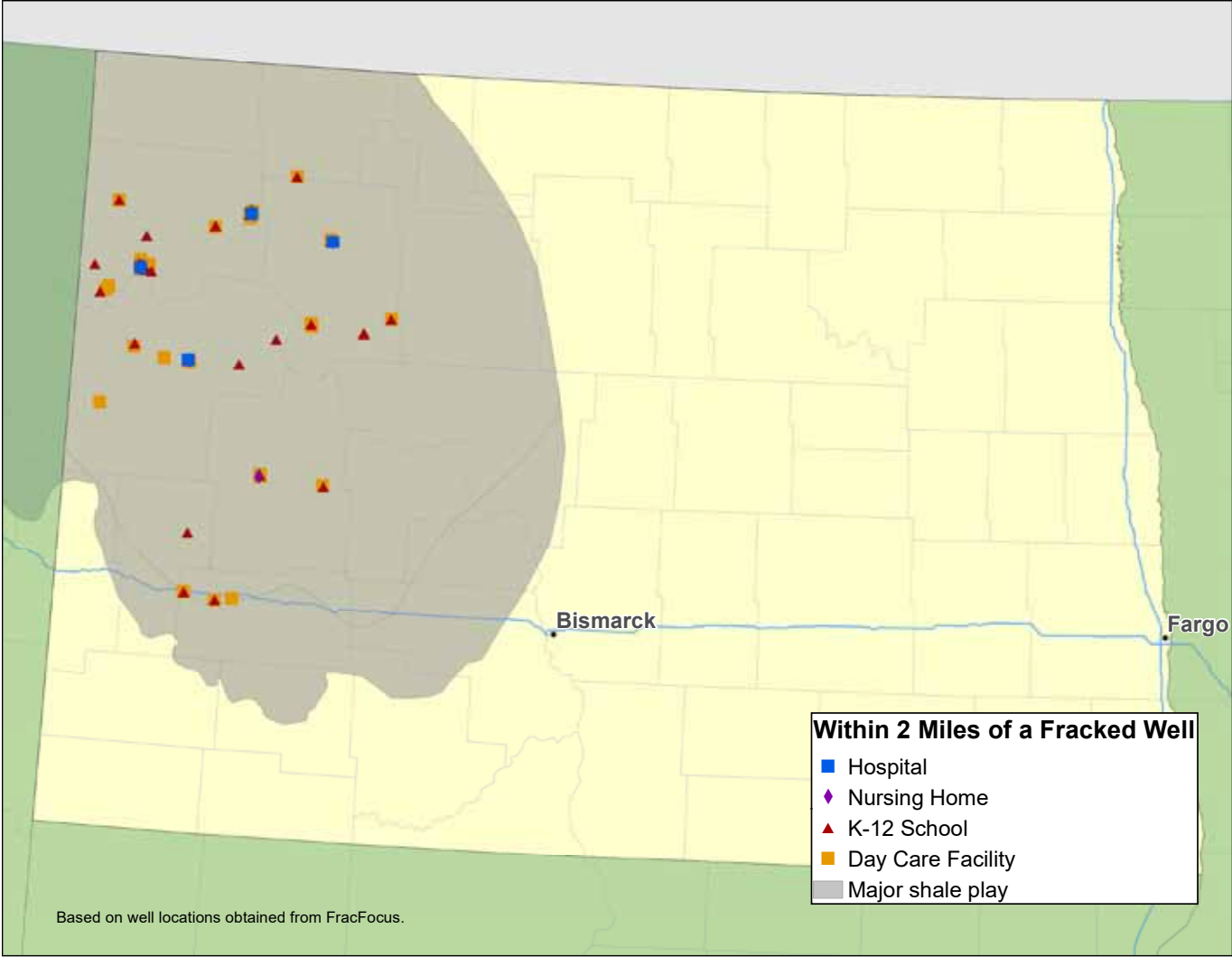
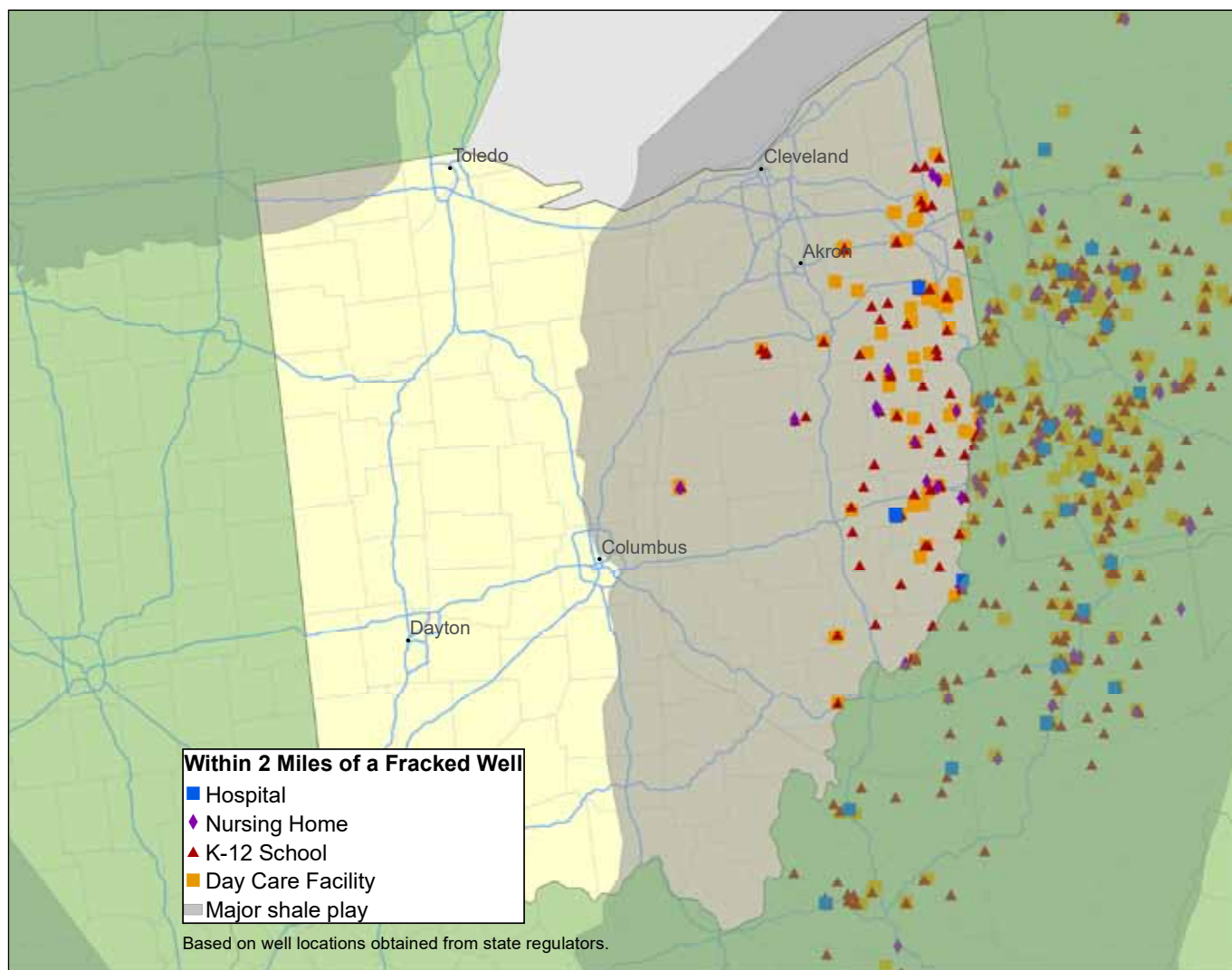


Table A-5. Number of Facilities and Students Close to a Fracked Well

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	5	38	86
K-12 schools	7	19	49
K-12 students	1,102	4,070	9,115
Nursing homes	0	2	5
Hospitals	0	1	4

# Ohio



**Table A-6. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	7	30	81
K-12 schools	2	28	95
K-12 students	206	7,181	29,660
Nursing homes	0	3	19
Hospitals	0	3	4

# Pennsylvania

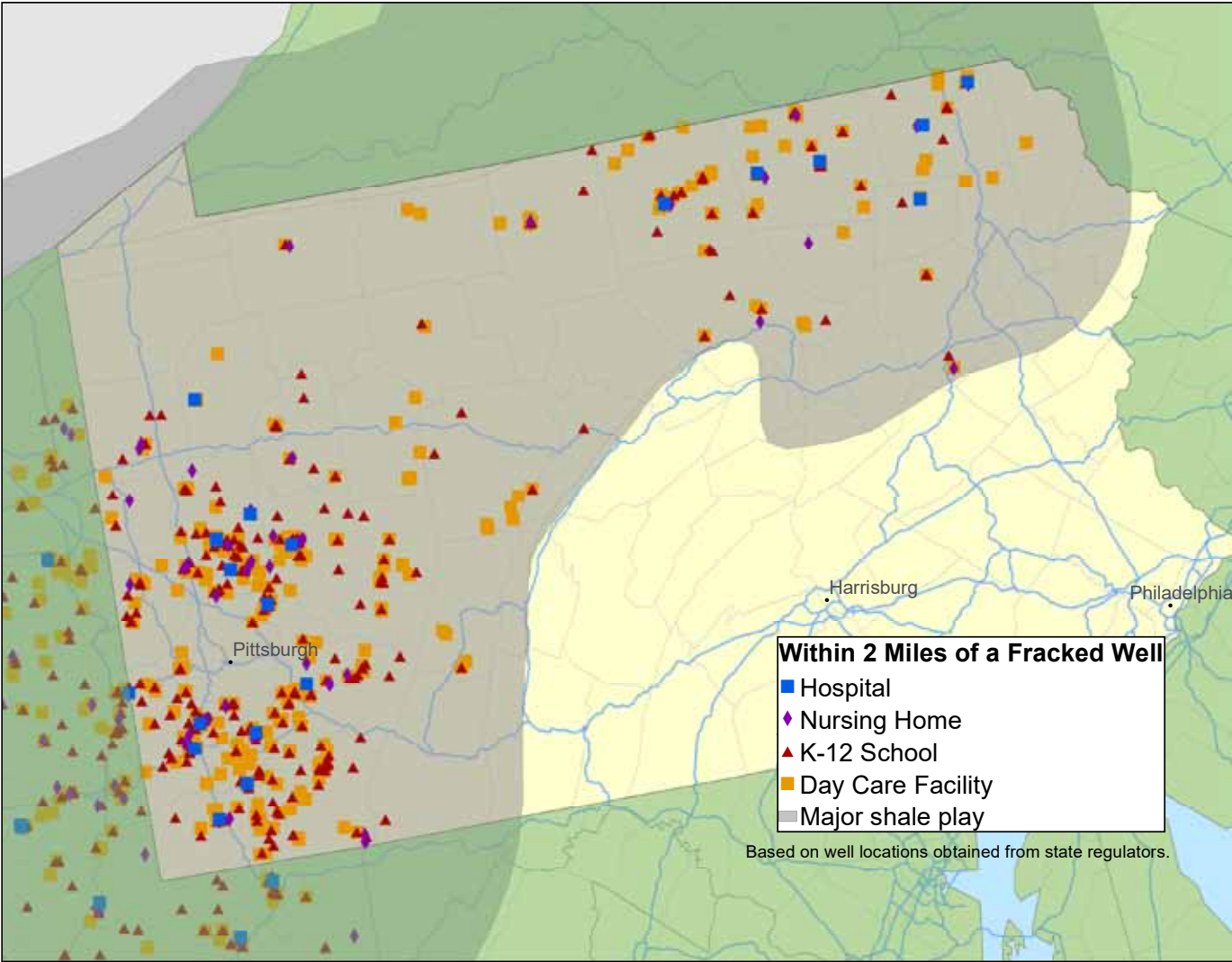
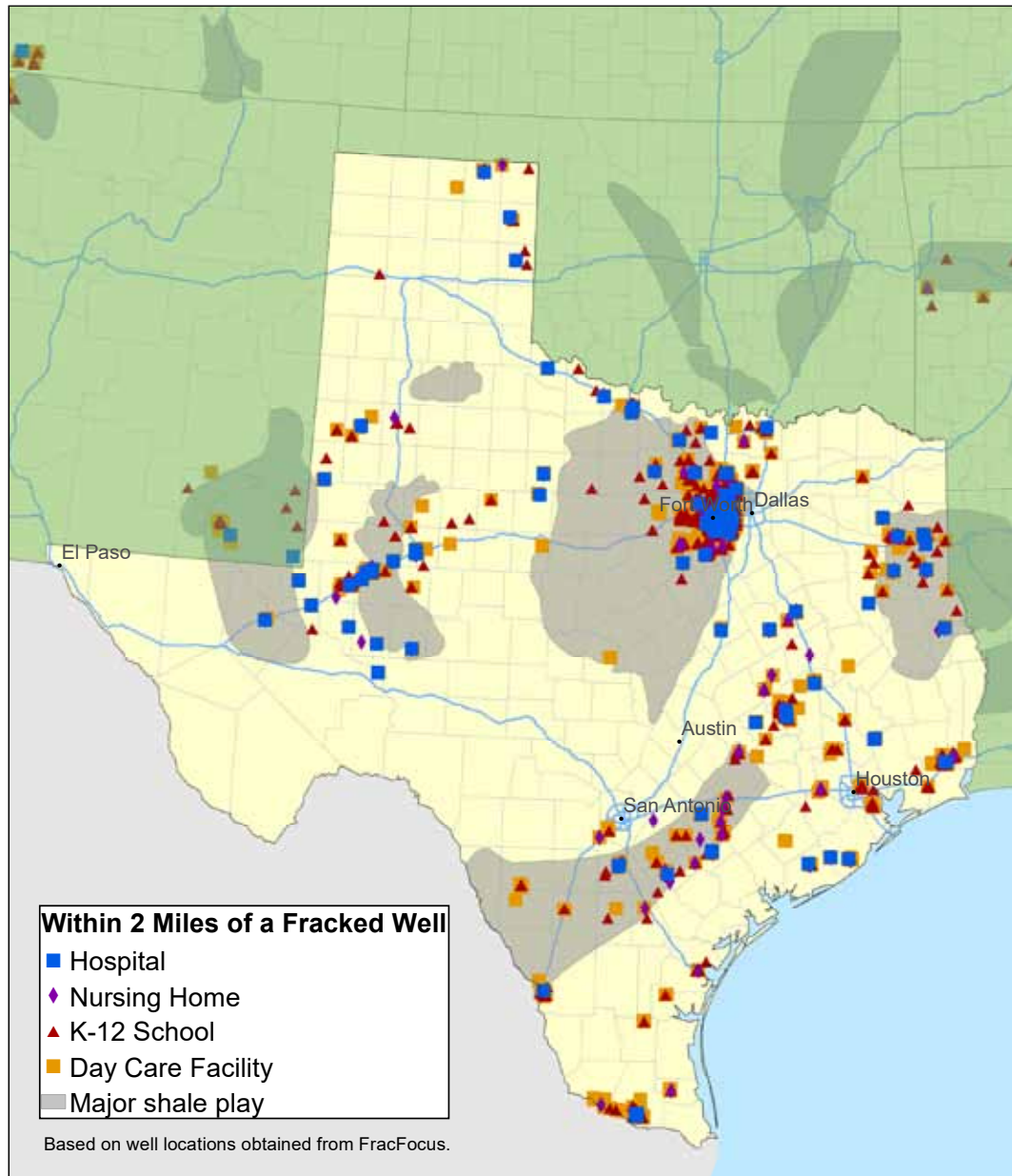


Table A-7. Number of Facilities and Students Close to a Fracked Well

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	41	135	360
K-12 schools	27	125	326
K-12 students	8,613	57,667	131,817
Nursing homes	3	15	51
Hospitals	2	6	20



## Texas

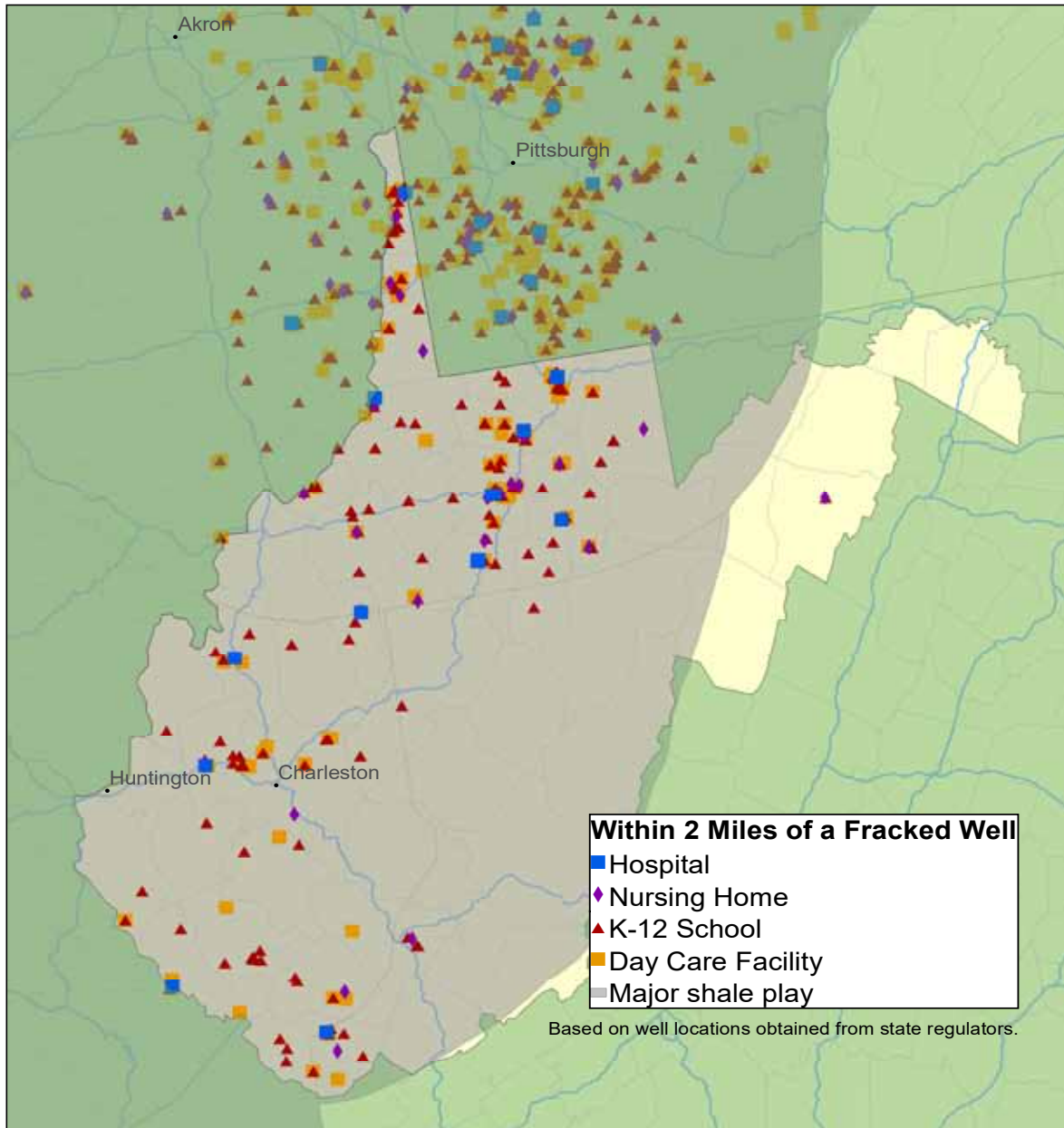


**Table A-8. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers	444	1,240	2,145
K-12 schools	303	850	1,644
K-12 students	151,876	436,690	827,396
Nursing homes	45	110	191
Hospitals	26	72	126



## West Virginia



**Table A-9. Number of Facilities and Students Close to a Fracked Well**

Facility	Within one-half mile of a fracked well	Within 1 mile of a fracked well	Within 2 miles of a fracked well
Day care centers*	19	38	93
K-12 schools	28	76	177
K-12 students	8,343	24,172	62,404
Nursing homes	6	13	33
Hospitals	4	6	17

\* Excludes home-based day care centers.

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