ATTACHMENT 10

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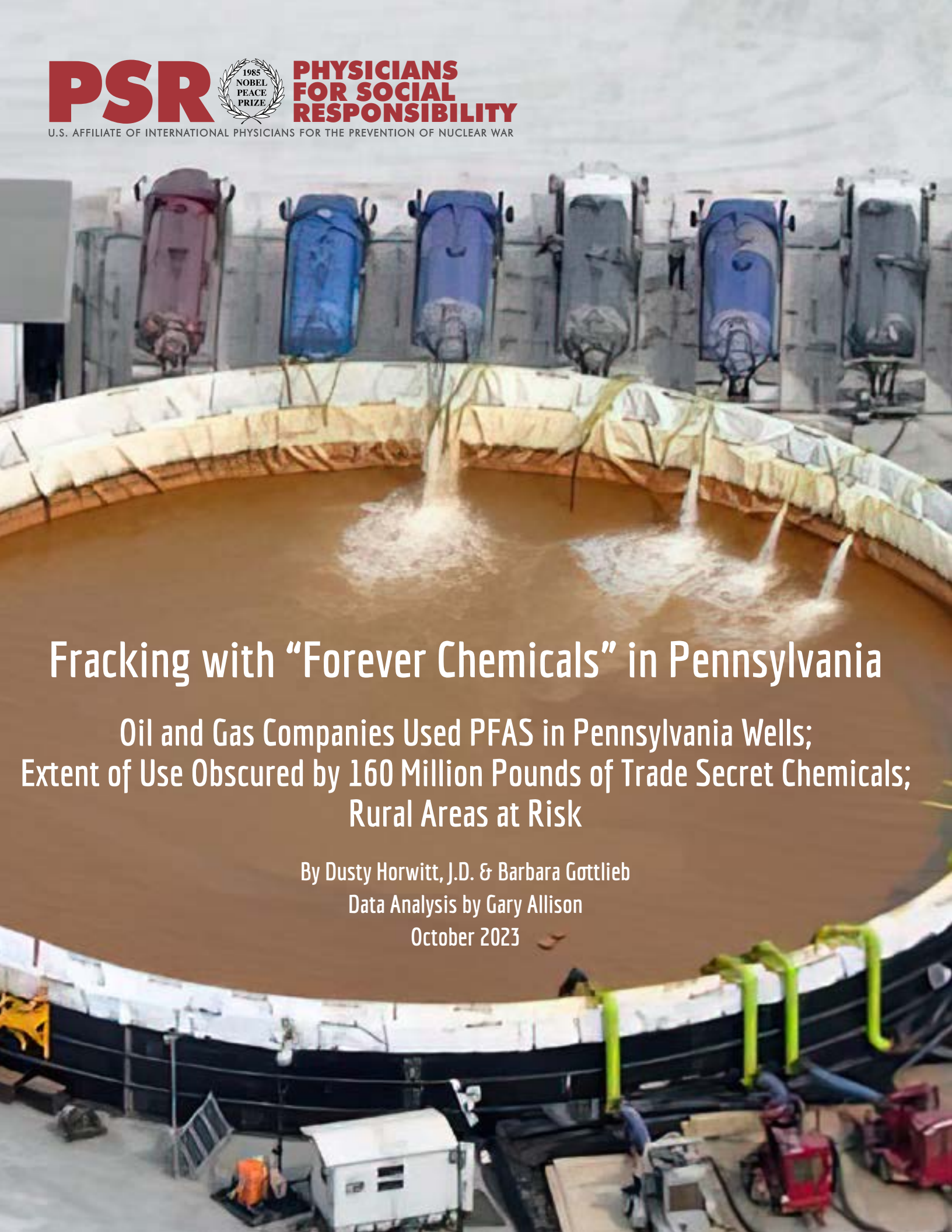

Fracking with "Forever Chemicals" in Pennsylvania

Oil and Gas Companies Used PFAS in Pennsylvania Wells; Extent of Use Obscured by 160 Million Pounds of Trade Secret Chemicals; Rural Areas at Risk

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Cover photo: Fluids impoundment at Wherry unconventional gas well pad, West Bethlehem Township, Washington County, Pa., April 5, 2021. Photo credit: Courtesy of Marcellus Air.

Maps by Matt Kelso, FracTracker Alliance

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EXECUTIVE SUMMARY

Information unearthed and analyzed by Physicians for Social Responsibility (PSR) shows that since 2012, oil and gas companies* used in Pennsylvania's unconventional or "fracking" gas wells a class of extremely toxic and persistent chemicals known as PFAS. During that same period, the companies used 160 million pounds of unidentified chemicals that could themselves be PFAS. The companies withheld these chemical identities from the public as "trade secrets," a practice allowed by state law.

PFAS are a class of chemicals known for their toxicity at extraordinarily low levels, their multiple negative health effects including cancer, and their persistence in the environment, leading to their nickname, "forever chemicals." Using these chemicals may be particularly risky because PFAS could not only cause contamination near well sites; they could also pollute places where solid waste and enormous volumes of toxic wastewater from oil and gas wells are disposed of, miles from well sites.

Data publicly disclosed by the oil and gas industry indicates that between 2012 and 2022, two oil and gas companies injected the PFAS known as PTFE or Teflon into a total of eight unconventional gas wells in Western Pennsylvania. **However, this number of industry-reported instances may significantly underrepresent the reality of PFAS use in the Keystone State, due to weaknesses in state reporting rules**.

One major hindrance to quantifying the use of PFAS chemicals is the extensive use of trade secret or Confidential Business Information designations. Between 2012 and 2022, oil and gas companies injected more than 5,000 unconventional gas wells with at least one trade secret chemical per well, totaling 160 million pounds. Oil and gas companies injected more than 1,200 wells with incompletely identified chemicals that could be fluorosurfactants, a class of chemical that includes multiple PFAS.

During the same decade-long period, 15 oil and gas companies operating in Pennsylvania injected oil and gas wells in other states with fracking chemicals that are PFAS or potential PFAS, while not reporting that they used these substances in their Pennsylvania wells. These substances include PTFE/Teflon and fluoroalkyl alcohol substituted polyethylene glycol, both of which have been identified as PFAS by EPA. In addition, five companies operating in Pennsylvania disclosed that they injected wells in five other states with nonionic fluorosurfactants, a class of chemicals identified as PFAS, potential PFAS, or precursors that could degrade into PFAS. Yet in Pennsylvania, only two companies reported the use of a single PFAS, PTFE, in eight wells. This raises questions about whether some companies are using PFAS in Pennsylvania on an undisclosed basis.

Should only a fraction of the unidentified chemicals used in Pennsylvania's unconventional gas wells be PFAS, they could pose a significant threat to human health.

It is difficult to access fracking chemical data in Pennsylvania for conventional wells that can be developed without fracking – far more difficult than it is for unconventional gas wells that must typically be hydraulically fractured or "fracked." This difficulty explains why this report focuses on unconventional gas wells. This and other regulatory hurdles prevent the public from knowing how widely PFAS – or other toxic chemicals – have been used in unconventional gas wells or in other types of oil and gas wells. Another potential route of contamination from PFAS is the use in fracking of water already tainted with PFAS. State regulations do not require testing for contaminants in water used for fracking. Our findings, including the gaps in our findings, raise concerns that Pennsylvanians may unknowingly be exposed to highly hazardous PFAS chemicals, particularly in rural areas where most unconventional gas wells are drilled and fracked.

* This report refers to "oil and gas companies" or the "oil and gas industry" even when discussing only unconventional gas wells, as some of the companies that operate unconventional gas wells also operate oil wells, whether in Pennsylvania or other states.

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An interactive map showing the locations of wells injected with PFAS and trade secret chemicals is available here. Users can zoom in to identify wells near them.

In light of our findings, PSR recommends the following:

• **Halt PFAS use in oil and gas extraction.** Pennsylvania and the U.S. Environmental Protection Agency (EPA) should prohibit PFAS from being used, manufactured, or imported for oil and gas extraction. Many PFAS are replaceable with less-persistent and less-toxic alternatives. In taking this step, Pennsylvania would be following the lead of Colorado, a major oil- and gas-producing state that in June 2022 passed legislation banning the use of PFAS in oil and gas wells.

• **Expand public disclosure.** Pennsylvania should greatly expand its requirements for public disclosure of oil and gas chemicals. The state could again follow the example offered by Colorado by requiring disclosure of all individual chemicals used in oil and gas wells, without exceptions for trade secrets. This action can be done while still protecting product formulas as trade secrets. Pennsylvania should also require disclosure on the part of chemical manufacturers and require chemical disclosure prior to permitting, as have California, West Virginia, and Wyoming.

• **Increase testing and tracking.** Pennsylvania and/or the U.S. EPA should determine where PFAS have been used in oil and gas operations in the state and where related wastes have been deposited. They should test nearby residents, water, soil, flora, and fauna for PFAS, both for the particular type(s) of PFAS used and for organic fluorine to detect the presence of other PFAS and/or their breakdown products. They should use testing equipment sensitive enough to detect PFAS at a level of single-digit parts per trillion or lower.

• **Require funding and cleanup.** Oil and gas and chemical manufacturing firms should be required to fund environmental testing for PFAS in their areas of operation, and should PFAS be found, be required to fund cleanup. If cleanup of water sources is impossible, companies responsible for the use of PFAS should pay for alternative sources of water for homes, schools, hospitals, agriculture and other uses for as long as needed.

• **Remove Pennsylvania's oil and gas hazardous waste exemption.** Pennsylvania exempts oil and gas industry wastes from state hazardous waste rules. Pennsylvania should follow New York's lead and remove its state-level hazardous waste exemption for the oil and gas industry.

• **Reform Pennsylvania's regulations for oil and gas production wells and underground injection disposal wells**. The state should prohibit production wells and underground wastewater disposal wells close to underground sources of drinking water, homes, health care facilities and schools; require groundwater monitoring for contaminants near the wells, and for disposal wells, require full public disclosure of chemicals in the wastewater.

• **Transition to renewable energy and better regulation.** Given the use of highly toxic chemicals in oil and gas extraction, including but not limited to PFAS, as well as climate impacts of oil and gas extraction and use, Pennsylvania should transition away from fracking and move toward renewable energy and energy efficiency while providing economic support for displaced oil and gas workers. As long as drilling and fracking continue, the state should better regulate these practices so that Pennsylvanians are not exposed to toxic substances and should empower local governments also to regulate the industry. When doubt exists as to the existence or danger of contamination, the rule of thumb should be, "First, do no harm."

CH. 1 PFAS: A MANMADE THREAT TO HEALTH AND THE ENVIRONMENT, USED IN PENNSYLVANIA'S OIL AND GAS WELLS

a. PFAS Used in Pennsylvania Wells

Physicians for Social Responsibility (PSR) has identified evidence from publicly reported oil and gas industry* records that a highly dangerous class of chemicals, known as per- and polyfluoroalkyl substances (PFAS), has been used for hydraulic fracturing ("fracking") in Pennsylvania's unconventional gas** wells and that such use could be much more extensive than reported. PFAS are known for their toxicity at extremely low levels,[1] their multiple negative health effects including cancer,[2] and their persistence in the environment, which has endowed them with their nickname, "forever chemicals."[3] Fracking is the stage of oil and gas operations that typically involves high-pressure injections into oil and gas wells of up to tens of millions of gallons of water, sand, and chemicals to fracture rock formations and free up trapped oil and gas.[4]*** It is possible that PFAS have also been used in additional stages and methods of oil and gas production in Pennsylvania.

The use of PFAS in oil and gas production in Pennsylvania was first exposed in 2021 in an editorial by the Philadelphia Inquirer[5] that was prompted by a report from Physicians for Social Responsibility about the use of PFAS in oil and gas operations in other states.[6] Later in 2021, the nonprofit Public Employees for Environmental Responsibility published a report based on U.S. Environmental Protection Agency data indicating that PFAS had been used in oil and gas operations in Pennsylvania.[7] PSR's findings in this report, however, go even further. Based on fracking chemical disclosures made by oil and gas well operators to the nongovernmental organization FracFocus, PSR is able to identify not only the unconventional gas wells definitively known to have been injected with PFAS between 2012 and 2022, but also the wells injected with trade secret chemicals and, for the first time, the staggering quantities of these unidentified substances.

The wells known to be injected with PFAS consist of eight wells injected with PTFE, also known as Teflon and identified by the U.S. Environmental Protection Agency (EPA) as a PFAS.[8] One of these wells, fracked by Chesapeake Operating Inc. with 18 pounds of PTFE, was located in Beaver County;[9] three wells fracked by Hilcorp Energy Company with 12 pounds of PTFE were located in Lawrence County,[10] and four wells fracked by Chesapeake Operating Inc. with an unknown amount of PTFE were located in Washington County.[11] See Appendix C for more detail about PTFE. PSR was able to identify wells injected with PTFE through disclosure of Chemical Abstract Service (CAS) numbers, unique numeric identifiers assigned to each chemical by the American Chemical Society.[12] Scientists consider CAS numbers the best way to identify chemicals because chemicals can have multiple names or trade names but only one CAS number.[13]

The larger story, however, is the staggering number of wells injected with trade secret chemicals that could be PFAS. PSR found that between 2012 and 2022, oil and gas companies disclosed the use of fracking chemicals in more than 7,200 unconventional gas wells and injected more than 5,000 (70 percent) with at least one trade secret fracking chemical. These chemicals totaled 160 million pounds. In these cases, oil and gas companies did not disclose a CAS number for the chemical, preventing the public from knowing what these chemicals are. Oil and gas companies injected more than 1,000 of the wells with trade secret surfactants, a category of chemical that may be more likely to be PFAS because they include a subcategory known as fluorosurfactants that are often PFAS. According to EPA, surfactants are commonly used in fracking.[14] These substances lower the surface tension of a liquid, the interaction at the surface between two liquids (called interfacial tension), or the interaction between

* This report refers to "oil and gas companies," the "oil and gas industry," etc. even when discussing only unconventional gas wells because at least some of the companies that operate unconventional gas wells also operate oil wells, whether in Pennsylvania or other states.

** Gas, the principal component of which is methane, is also known as "natural" gas, "fossil" gas and "fracked" gas.

*** In this report, the term "fracking" is used to discuss a particular stage in oil and/or gas production as distinct from other stages or methods of production such as drilling that precedes fracking. The terms "oil and gas production," "oil and gas extraction," and "oil and gas operations" cover the entire process of producing oil and/or gas.

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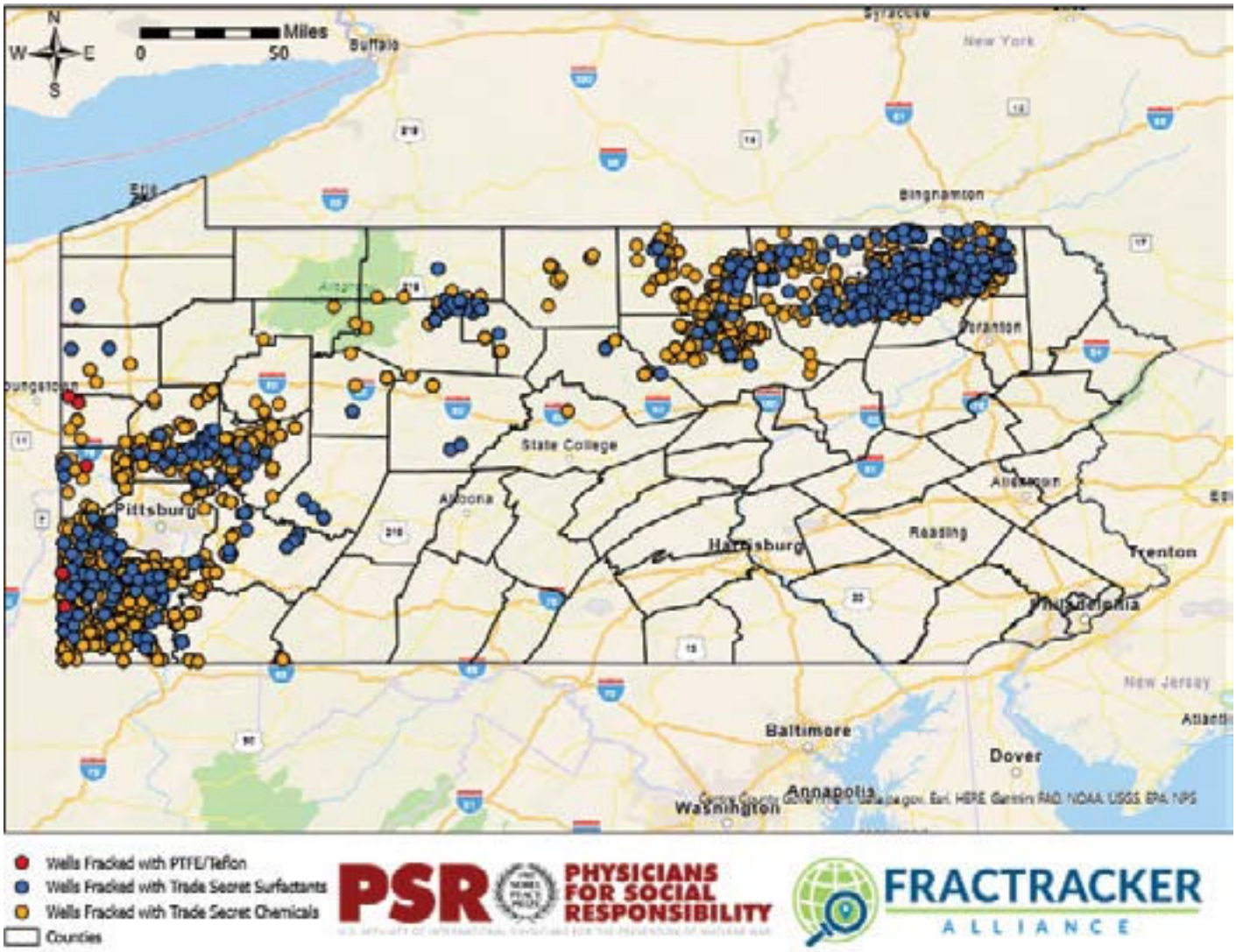
a liquid and a solid.[15] Compared to other surfactants, fluorosurfactants are said to be "superior in their aqueous surface tension reduction at very low concentrations and are useful as wetting and leveling agents, emulsifiers, foaming agents, or dispersants."[16] At least some fluorosurfactants are PFAS, including the dangerous chemicals PFOA and PFOS[17] and 8:2 fluorotelomer alcohol,[18] a nonionic fluorosurfactant[19] that can break down into PFOA.[20]

The use of PFAS and trade secret chemicals that may be PFAS is particularly alarming as Pennsylvania's gas production has increased by almost 45 times between 2005 and 2021, from 168 billion cubic feet to 7.5 trillion cubic feet.[21] These increases have led to modest gains in jobs in the major gas-producing counties[22] and somewhat more revenue for the state.[23] But they also mean more greenhouse gas emissions[24] and greater risk of pollution from PFAS and other toxic substances associated

Figure 1. Pennsylvania Oil & Gas Wells Fracked with PFAS and Possible PFAS, Including Trade Secret Chemicals, 2012-2022



This map shows the location of oil and gas wells in Pennsylvania known to have been fracked between January 1, 2012 and September 29, 2022 using PTFE/Teflon (a known PFAS), trade secret chemicals, and/or trade secret surfactants. An interactive version of the map is available at https://ft.maps.arcgis.com/apps/webappviewer/index.html?appid=dc81f7ec3af64541a1875e8e6e5add60 where users can zoom in to identify wells near them. For a detailed explanation of data sources, see Appendix A.

with gas extraction, including an increased risk of exposure to naturally occurring carcinogenic radium that emerges from Marcellus Shale wells in millions of gallons of wastewater.[25]

b. Oil and Gas Operations Provide Many Potential Routes of Exposure to PFAS

Oil and gas operations in Pennsylvania deserve scrutiny as a possible source of PFAS contamination, given the documented use of PFAS in the state's oil and gas wells and the potential that people could be exposed to such PFAS via multiple pathways.

EPA in a 2016 national report on fracking and drinking water found that fracking-related pollution could follow a number of pathways that could impact surface water and groundwater. The agency cited the following possible pathways to exposure:

- spills of fracking fluid that seep into groundwater;
- injection of fracking fluid into wells with cracks in the casing or cement, allowing the fluid to migrate into aquifers (see opposite diagram)
- injection of fracking fluids directly into groundwater;
- underground migration of fracking fluids through fracking-related or natural fractures;
- intersection of fracking fluid with nearby oil and gas wells,
- spills of wastewater after the fracking process is completed, and
- inadequate treatment and discharge of fracking wastewater to surface water supplies.[26]

PFAS used in oil and gas extraction could pollute water through any of these pathways, plus other routes discussed in more detail in Chapter 4, including through airborne releases and disposal of oil and gas wastewater in underground injection wells, a pathway that EPA did not examine in its 2016 report.[27]

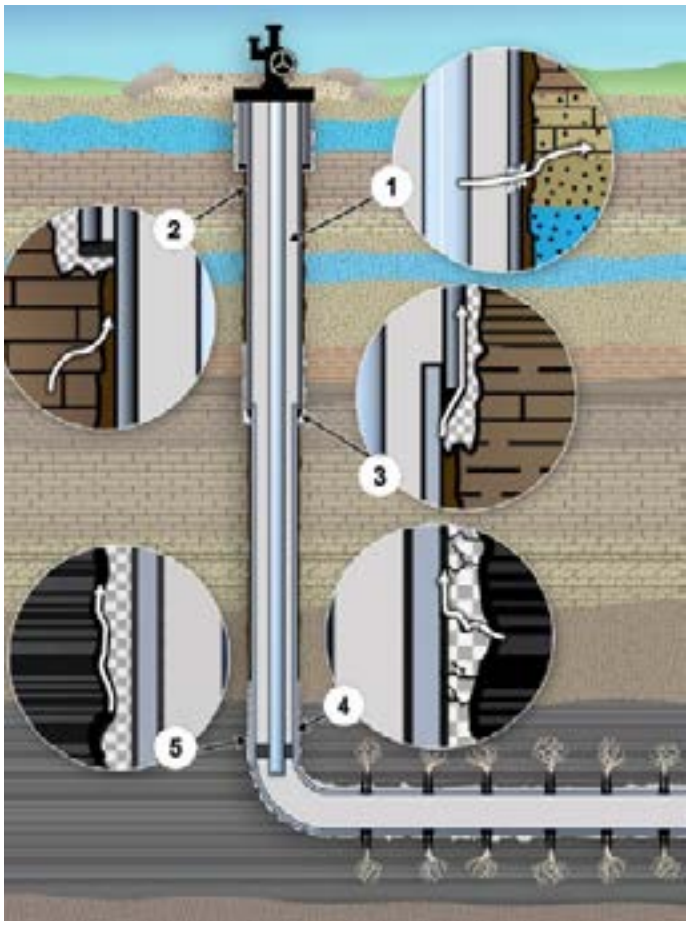


Diagram from U.S. Environmental Protection Agency's 2016 report on fracking and drinking water (p. ES-29) shows the various pathways through which fluid can migrate up an oil or natural gas well and potentially pollute groundwater including through leaks in the steel casing or cement designed to seal off the casing from the groundwater. EPA wrote that "These pathways (represented by the white arrows) include: (1) a casing and tubing leak into the surrounding rock, (2) an uncemented annulus (i.e., the space behind the casing), (3) microannuli between the casing and the cement, (4) gaps in cement due to poor cement quality, and (5) microannuli between the cement and the surrounding rock." EPA noted that the diagram is not to scale.

c. Manmade and Dangerous: PFAS's History and Health Effects

PFAS are a class of thousands of synthetic chemicals manufactured to have properties that are valuable in multiple industrial contexts, such as being slippery, oil- and water-repellant, and able to serve as dispersants or foaming agents.[28] PFAS have been called "perfluorinated chemicals"

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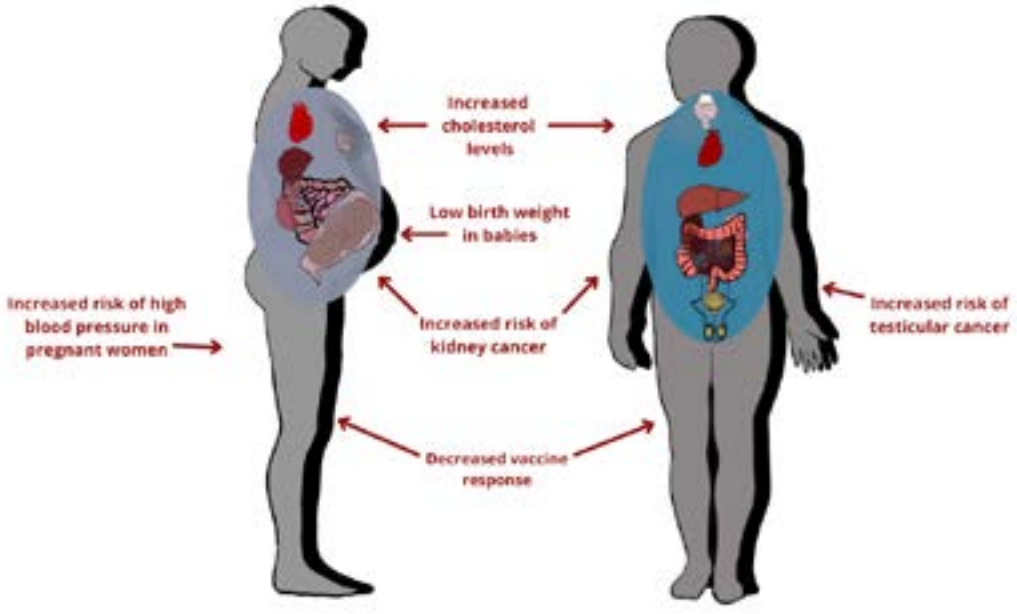
and "polyfluorinated compounds," or PFCs, though the term currently preferred by EPA is PFAS.[29]

The first PFAS to be sold commercially was created by a chemist at Dupont and was patented as Teflon. Since 1949, it has been used in thousands of products, from nonstick cookware to waterproof clothing to plastics to dental floss.[30] Other PFAS chemicals, the most prominent of which are known as PFOA and PFOS, were used in food packaging, fire-fighting foam, and in 3M's widely used fabric protector, Scotchgard.[31] EPA reported in 2021 that about 650 types of PFAS remained in commerce.[32] Weak chemical disclosure laws make it difficult for the Agency to identify which PFAS chemicals are used, and where.

Between the 1960s and 1990s, researchers inside Dupont and 3M became aware that at least some of the PFAS they were manufacturing or using, particularly PFOA and PFOS, were associated with health problems including cancers and birth defects, had accumulated in people worldwide, and persisted in the environment.[33] Many of these facts, kept internal by the companies, came to light after attorney Rob Bilott filed lawsuits in 1999 and 2001 accusing Dupont of causing pollution in and around Parkersburg, West Virginia with PFOA, a type of PFAS then used in making PTFE (Teflon).[34] In December 2011, as part of Dupont's settlement of the 2001 lawsuit, a team of epidemiologists completed a study of the blood of 70,000 West Virginians and found a probable link between PFOA and kidney cancer, testicular cancer, thyroid disease (over or under-production of hormones by the thyroid gland), high cholesterol, pre-eclampsia (a potentially dangerous complication during pregnancy characterized by high blood pressure and signs of damage to other organ systems, most often the liver and kidneys), and ulcerative colitis (a disease causing inflammation and ulcers in the large intestine or colon).[35]

Current peer-reviewed scientific research on PFAS suggests that exposure to certain levels of some PFAS may lead to adverse health outcomes. Research findings differ, as different studies have examined different PFAS chemicals, different types or levels of exposure, and different exposed populations. However, some findings are more widely endorsed; for example, the U.S. Environmental Protection Agency (EPA)[36] and the Center for Disease Control and Prevention's Agency for Toxic Substances and Disease

POTENTIAL HEALTH EFFECTS OF PFAS EXPOSURE



Exposure to PFAS chemicals can result in a variety of serious health effects including those indicated above. Source: U.S. Environmental Protection Agency, Agency for Toxic Substances and Disease Registry. Graphic by Astra Robles.

Registry (ATSDR)[37] agree that exposure to high levels of certain PFAS may lead to increased risk of high blood pressure in pregnant women; low birth weight in babies; increased risk of kidney or testicular cancer; decreased vaccine response, and increased cholesterol levels. Research is ongoing to determine the health effects of different levels of exposure to different PFAS, including the health effects of long-term, low-level PFAS exposure, especially in children.

PFAS are not only highly toxic; they also demonstrate extreme persistence in the environment. PFAS' nickname "forever chemicals" reflects their chemistry – created by chemical manufacturers – that features a bond between fluorine and carbon atoms that is among the strongest in chemistry and rarely if ever exists in nature. The result: chemicals that are extremely resistant to breaking down.[38] PFAS are also extremely mobile in water,[39] making them able to spread through the environment via groundwater or surface water. Another risk, discussed in Chapter 3, is that PFAS could compound the health effects from other dangerous chemicals associated with oil and gas production.

d. EPA – and Pennsylvania – Recognize Risks of PFAS

EPA has been slow to regulate PFAS, but the agency has taken actions, particularly in recent years, that recognize PFAS's extraordinary risks. In June 2022, reflecting growing public concern about PFAS, EPA significantly lowered its non-binding health advisory level for PFOA and PFOS in drinking water. Previously, EPA had set the combined health advisory level for these two chemicals at 70 parts per trillion.[40]

"**The new published peer-reviewed data and draft EPA analyses [citation omitted] indicate that the levels at which negative health outcomes could occur are much lower than previously understood,**" EPA wrote in June 2022.[41] EPA lowered its new interim health advisory level for PFOA in drinking water to 0.004 parts per trillion and its interim health advisory level for PFOS to 0.02 parts per trillion.[42] EPA also set new final health advisory levels for two other PFAS, known as GenX and PFBS, at 10 parts per trillion and 2,000 parts per trillion, respectively.[43] EPA said that its interim health advisory levels were intended to provide guidance until enforceable drinking water regulations for PFAS take effect.[44] EPA explained that its health advisory level "is designed to be protective of noncancer effects over a lifetime of exposure, including sensitive populations and life stages, and is typically based on data from experimental animal toxicity and/or human studies." The agency wrote that exposure to PFOA, PFOS, and Gen X is associated with cancer. But the agency had not yet developed cancer risk concentrations in water for these substances. EPA added that, at least for PFOA and PFOS, the interim health advisory levels could change following review by its Science Advisory Board.[45]

EPA then in March 2023 released proposed legally enforceable "Maximum Contaminant Levels" for six PFAS in drinking water. These regulations, unlike health advisories, must take into account whether a particular level of protection can be achieved and at what cost.[46] For this reason, they may be much less stringent than the health advisories. The MCLs proposed by EPA included a level of four parts per trillion for both PFOA and PFOS. EPA also proposed an MCL Goal or non-enforceable target of zero for both of these PFAS. The agency proposed that drinking water providers limit the combined levels of four other types of PFAS: PFNA, PFHxS, PFBS, and/or GenX Chemicals.[47] The MCLs would require public water systems to monitor for the six PFAS, notify the public about the levels of these PFAS, and reduce levels of the six PFAS in drinking water if levels exceed the MCLs.[48] The agency said that it expects to finalize the regulations by the end of 2023,[49] though the Pennsylvania Environmental Quality Board has stated that the rules are not expected to take effect until several years after that date.[50]

Even the higher MCL figures demonstrate the extraordinary toxicity of some types of PFAS. At a level of four parts per trillion, a measuring cup of PFOA could contaminate 28 billion gallons of water,[51] more than 90 times the 300 million gallons of drinking water treated each day by Philadelphia.[52]

Pennsylvania has also taken action to identify and regulate PFAS pollution. In March 2021, the Pennsylvania

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Department of Environmental Protection (DEP) completed sampling of concentrations for 18 types of PFAS at 372 public water systems and 40 baseline sites.[53] These baseline sites featured at least 75 percent forested land and were located at least five miles from potential sources of contamination such as airports, manufacturing facilities, and military bases.[54] The DEP found PFOA in 112 of the 412 samples at an average concentration of 7.5 parts per trillion and a median concentration of 5.3 parts per trillion.[55] The agency found PFOS in 103 of the 412 samples at an average concentration of 9.9 parts per trillion and a median concentration of 6.5 parts per trillion.[56] All of these average and median concentrations were much higher than EPA's health advisory levels and somewhat higher than EPA's proposed drinking water standard. Environmental Working Group, a nonprofit, has also found elevated levels of PFAS pollution – some staggering high – in public drinking water systems, and at military bases and industrial sites.[57]

Following its sampling program, and before EPA announced its drinking water standards in March 2023, Pennsylvania in January issued drinking water standards for PFOA and PFOS that applied to 3,117 water systems in the state.[58] For PFOA, the state's Environmental Quality Board set an enforceable Maximum Contaminant Level of 14 parts per trillion and a non-enforceable maximum contaminant Goal of 8 parts per trillion.[59] For PFOS, the Board set an enforceable MCL of 18 parts per trillion[60] and a maximum contaminant Goal of 14 parts per trillion.[61] "Although the EPA has started the process of setting more stringent standards for PFOA and PFOS in drinking water," the Board wrote, "that process is expected to take years to complete. For that reason, these more protective standards for this Commonwealth will better protect the health of residents in this Commonwealth."[62]

Several experts told PSR that because of the extreme potency of certain types of PFAS and the fact that chemical makers have created thousands of these forever chemicals, they would recommend particular testing methods to detect PFAS in the environment. The scientists are Linda Birnbaum, Ph.D., D.A.B.T., A.T.S., a board-certified toxicologist and former director of the National Institute of Environmental Health Sciences;[63] Zacariah Hildenbrand Ph.D., research professor in Chemistry and Biochemistry at the University of Texas at El Paso;[64] Kevin Schug Ph.D., Shimadzu Distinguished Professor of Analytical Chemistry at the University of Texas at Arlington,[65] and Wilma Subra, holder of a master's degree in chemistry and recipient of a John D. and Catherine T. MacArthur Foundation "Genius" grant for her work helping to protect communities from toxic pollution.[66] All were in agreement in recommending the use of testing equipment that can detect PFAS in concentrations at least as low as single-digit parts per trillion. They further recommended testing for total organic fluorine in addition to testing for specific types of PFAS. Total organic fluorine is a marker that would indicate the presence of PFAS even if a specific PFAS were not tested for. Testing for specific PFAS might fail to detect other forms of PFAS present in the sample.

e. PFAS in Oil and Gas Operations May Threaten Rural Areas, Add to PFAS from Other Sources

The risk of PFAS pollution from oil and gas operations is likely to be particularly high in rural areas and may add to PFAS pollution from better-studied sources such as military bases. The risk to rural areas is based partly on the fact that most unconventional fracked gas wells, if not other types of wells, are developed in rural areas.[67] In addition, people in rural areas rely on private wells for drinking water that may not be tested for PFAS or other contaminants as frequently as public water supplies.[68] In total, about 2.5 million Pennsylvanians (about 20 percent of the state's population)[69] rely on private water wells.[70] Water wells near oil and gas operations may be at particular risk of contamination from PFAS as a result of leaks, spills, or underground migration of PFAS from the oil and gas wells. However, PSR is aware of only one test for PFAS in a private water well in Pennsylvania near an oil and gas extraction site (see Chapter 3). This lack of testing means that Pennsylvanians living near oil and gas operations may be unknowingly exposed to PFAS through their water wells and other pathways.

A fracking site in Westmoreland County, Pa., Oct. 2022. Photo credit: Ted Auch. Photo courtesy of FracTracker Alliance.

f. PFAS: Among Many Dangerous Chemicals Used in Oil and Gas Extraction

When used in oil and gas operations, PFAS may add to the cumulative human exposure to a host of toxic substances. In fracking, chemicals serve a variety of purposes, including killing bacteria inside the wellbore, reducing friction during high-pressure fracking, and thickening the fluid so that the sand, suspended in the gelled fluid, can travel farther into underground formations.[71]

In its 2016 study of fracking and drinking water, the EPA identified 1,606 chemicals used in fracking fluid and/or found in fracking wastewater. While the agency found high-quality information on health effects for only about 10 percent (173) of these chemicals, that information was troubling. EPA found that health effects associated with chronic oral exposure to these chemicals include carcinogenicity, neurotoxicity, immune system effects, changes in body weight, changes in blood chemistry, liver and kidney toxicity, and reproductive and developmental toxicity.[72]

Chemicals used in the drilling stage that precedes actual fracturing can also pose health risks, including developmental toxicity and the formation of tumors, according to EPA regulators.[73] A disclosure form filed with the state of Ohio, one of only two states to require public disclosure of drilling chemicals (Colorado is the other),[74] shows that Statoil, Norway's state oil company (since renamed Equinor), has used the neurotoxic chemical xylene in drilling.[75] In short, when chemicals used in drilling, fracking or other stages and methods of oil and gas operations come into contact with people or the environment, they can produce serious negative health effects.[76] The use of PFAS in fracking and/or drilling operations would only multiply these health risks.

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CH. 2 CHEMICAL DISCLOSURE LAWS SHIELD CHEMICAL IDENTITIES

Due to Pennsylvania's byzantine system of oil and gas chemical disclosure, it is impossible to know how widely PFAS or other toxic chemicals have been used in the state's oil and gas wells. This set of rules features, among other elements that frustrate the public's right to know, opportunities for oil and gas companies to hide fracking chemical identities behind trade secret claims, conceal the identities of chemicals used in other stages and methods of extraction such as the drilling that precedes fracking, and allow chemical manufacturers – the companies who know best what chemicals are being used – to avoid disclosure of chemical ingredients. Pennsylvania also has different standards for fracking chemical disclosure in conventional and unconventional wells, requiring the public to consult multiple repositories in order to secure full information.

Many residents living near oil and gas operations have reported serious health impacts while expressing frustration over the secrecy surrounding chemicals used by the oil and gas industry.[77] In 2020, the Attorney General's criminal grand jury documented these experiences, finding that

> Many of those living in close proximity to a well pad began to become chronically, and inexplicably, sick. Pets died; farm animals that lived outside started miscarrying, or giving birth to deformed offspring. But the worst was the children, who were most susceptible to the effects. Families went to their doctors for answers, but the doctors didn't know what to do. The unconventional oil and gas companies would not even identify the chemicals they were using, so that they could be studied; the companies said the compounds were "trade secrets" and "proprietary information." The absence of information created roadblocks to effective medical treatment. One family was told that doctors would discuss their hypotheses, but only if the information never left the room.[78]

Pennsylvania's rules and laws regarding oil and gas chemical disclosure mean that oil and gas companies could be using PFAS or other toxics much more widely than has been reported, leaving Pennsylvanians at risk of serious health problems.

a. Extensive Use of "Trade Secret" Claims Veils Actual Use

Perhaps the most prominent shortcoming in Pennsylvania law that could conceal wider use of PFAS in oil and gas wells is the ability for oil and gas companies to withhold from the public, though not from regulators, information on their use of fracking chemicals deemed trade secrets, for both unconventional gas wells[79] and conventional oil and gas wells.[80] This provision is an exception to the general requirement that oil and gas well operators are required to publicly disclose their fracking chemicals, whether to FracFocus[81] or to the DEP (see section e pg. 15).[82] According to the DEP, well operators, well service providers, chemical suppliers/vendors, and chemical manufacturers can all declare that a fracking chemical is a trade secret.[83] In these cases, the company declaring the trade secret must submit to the DEP a "Registration of Trade Secret-Confidential Proprietary Stimulation Fluid Chemical Information" form.[84] The submitter must include on the form the CAS Number and/or name of the chemical claimed as a trade secret. The submitter must also assign a code to the chemical in a format designated by the DEP and must include a justification for the trade secret claim.[85] The code is used in place of the chemical name and/or CAS Number in the publicly available Completion Report required to be submitted electronically to the DEP for each oil and gas well.[86] Through this system, the DEP learns the identities of trade secret chemicals, but the public does not. Trade secret claims can thus hide from public view the true identities of dangerous chemicals, including PFAS.

In 2021, the Philadelphia Inquirer reported in an editorial that the state's list of trade secret chemicals contained about 430 substances and that the newspaper had asked the DEP if the agency "would audit the list for 'forever chemicals' — not disclosing the name of the substance or other details." The Inquirer wrote that "a spokesperson wrote that such review is 'possible' but time-consuming as 'staff will need to review approximately 90 individual paper submissions' to identify the chemicals."[87]

Table 1. Disclosed Use of Trade Secret Chemicals in Pennsylvania Oil and Gas Wells, 2012-2022

County Name	Number of wells injected with at least one trade secret chemical	Mass of all trade secret chemicals (lbs.)	Number of wells injected with trade secret surfactants	Mass of trade secret surfactants (lbs.)
Allegheny	107	3,980,000	19	1,860
Armstrong	150	1,160,000	17	1,720
Beaver	79	3,660,000	3	4,280
Bradford	458	14,100,000	168	1,790,000
Butler	219	4,550,000	65	118,000
Cameron	92	937,000	40	77,400
Centre	2	11,300	0	0
Clarion	6	117,000	0	0
Clearfield	7	136,000	2	5,600
Clinton	18	105,000	2	3,260
Crawford	1	60,700	1	918
Elk	154	1,260,000	43	4,360
Fayette	89	2,060,000	3	777
Forest	4	33,000	0	0
Greene	654	22,200,000	40	28,900
Indiana	4	10,400	4	2,350
Jefferson	10	821,000	1	18,900
Lawrence	8	65,300	0	0
Lycoming	290	5,500,000	24	41,900
McKean	80	660,000	15	59,200
Mercer	7	432,000	2	4,850
Potter	16	256,000	0	0
Somerset	5	88,300	0	0
Sullivan	51	1,640,000	10	153,000
Susquehanna	949	21,600,000	443	1,000,000
Tioga	264	5,010,000	55	167,000
Washington	1,082	60,800,000	179	798,000
Westmoreland	63	1,400,000	16	46,100
Wyoming	193	7,660,000	82	463,000
Total	**5,062**	**160,000,000**	**1,234**	**4,790,000**

This table shows by county the number of Pennsylvania wells in which oil and gas companies injected at least one trade secret fracking chemical and/or at least one trade secret surfactant. It also shows the total combined weight of these chemicals by county and statewide. The total weight figures reflect the sum of all records for which we have enough information to calculate a chemical's weight. However, the total weight figures represent an undercount because many fracking chemical disclosures lack sufficient data to perform this calculation. The wells injected with trade secret surfactants are a subset of the wells injected with trade secret chemicals. For a more detailed explanation of data sources, see Appendix A.

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Table 2. Oil and Gas Companies that Fracked Unconventional Gas Wells in Pennsylvania Using Trade Secret Chemicals and Trade Secret Surfactants, 2012-2022

Operator	No. of wells injected with at least one trade secret chemical	Mass of all trade secret chemicals (lbs.)	No. of wells injected with at least one trade secret surfactant	Mass of all trade secret chemicals (lbs.)
Range Resources Corporation	816	49,100,000	147	487,000
EQT Production	780	33,700,000	15	25,300
Chesapeake Operating, Inc.	545	25,600,000	224	2,820,000
Cabot Oil & Gas Corp	509	7,220,000	327	356,000
Seneca Resources Corporation	447	3,610,000	128	229,000
Southwestern Energy	343	12,000,000	34	188,000
Chevron USA Inc.	151	2,920,000	3	778
Talisman Energy USA Inc.	140	1,860,000	47	No data available
XTO Energy/ExxonMobil	118	1,380,000	63	133,000
Repsol O&G, LLC.	114	999,000	3	128
Rice Drilling B, LLC	109	1,540,000	31	40
Anadarko Petroleum Corporation	109	86,100	0	0
Shell Oil Company affiliate	107	1,730,000	29	82,100
Snyder Brothers Inc.	99	942,000	9	1,350
PennEnergy Resources, LLC	71	1,470,000	0	0
CONSOL Energy Inc.	69	1,530,000	8	4,970
Carrizo Oil & Gas, Inc.	49	1,050,000	44	19,000
CNX Gas Company LLC	43	734,000	12	301,000
Rex Energy	42	338,000	4	265
Alta Resources	40	3,280,000	0	0
Noble Energy, Inc.	32	2,200,000	12	3,550
EdgeMarc Energy Holdings, LLC	27	1,320,000	0	0
COTERRA ENERGY INC.	27	308,000	14	842
Vantage Energy Appalachia II LLC	27	177,000	0	0
BKV Operating LLC	22	804,000	10	19,700
WPX Energy	20	628,000	14	1,400
Greylock Production LLC	20	518,000	13	3,910
MDS Energy Development LLC	20	54,100	4	364
EOG Resources, Inc.	20	37,200	5	247
Olympus Energy	19	82,600	5	455
Apex Energy LLC	17	560,000	4	41,100
JKLM ENERGY	15	220,000	0	0
MDS Energy, Ltd	12	31,500	1	No data available
Pennsylvania General Energy	11	195,000	0	0
Citrus Energy Corporation	8	43,500	7	41,700
EXCO Resources, Inc.	7	101,000	1	3,260
Rockdale Marcellus, LLC	6	936,000	0	0
Hilcorp Energy Company	6	77,700	0	0
Huntley & Huntley Energy Exploration	6	41,200	6	515
Inflection Energy (PA) LLC	5	69,300	3	11,800
Alpha Shale Resource, LP	5	849	0	0

Table 2. (CONTINUED) Oil and Gas Companies that Fracked Unconventional Gas Wells in Pennsylvania Using Trade Secret Chemicals and Trade Secret Surfactants, 2012-2022

Operator	No. of wells injected with at least one trade secret chemical	Mass of all trade secret chemicals (lbs.)	No. of wells injected with at least one trade secret surfactant	Mass of all trade secret surfactants (lbs.)
Northeast Natural Energy LLC	4	102,000	0	0
LOLA Energy PetroCo	4	56,000	0	0
Chief Oil & Gas	4	38,500	0	0
Halcon Resources Corporation	3	323,000	3	5,770
Campbell Oil & Gas. Inc	3	66,800	2	5,600
Energy Corporation of America	3	8,960	0	0
Warren E&P, Inc.	3	4,910	0	0
INR Operating, LLC	2	125,000	0	0
Clean Energy Exploration and Production	2	21,400	0	0
RMD	2	No data available	0	0
Travis Peak Resources, LLC	1	4,400	0	0
Arrington Oil & Gas Operating LLC	1	2,330	1	2,330
Endeavour Operating Corp	1	No data available	1	No data available
Total	**5,066***	**160,000,000**	**1,234**	**4,790,000**

This table shows the oil and gas companies that fracked unconventional gas wells in Pennsylvania with trade secret chemicals and trade secret surfactants between January 1, 2012 and September 29, 2022. The wells injected with trade secret surfactants are a subset of the wells injected with trade secret chemicals. For a more detailed explanation of data sources, see Appendix A. Please note: separate companies in this table could now be the same company as a result of subsequent mergers and/or name changes.

*In this table, the total number of unconventional gas wells that companies operating in Pennsylvania injected with at least one trade secret chemical (5,066) differs slightly from the total number reported in table 1 (5,062) because a handful of the 5,062 wells were fracked more than once, but by different operators, and those handful of wells are counted more than once in this table.

"Compared with Pennsylvania's important efforts to test water for those substances," the Inquirer commented, "reviewing 90 paper submissions for critical information about potential risk seems a minor cost."[88]

The lack of evidence of additional PFAS use in Pennsylvania's oil and gas wells may reflect extensive use of the trade secret provisions in Pennsylvania's chemical disclosure rules. PSR's data analysis revealed that, between 2012 and 2022, Pennsylvania well operators listed at least one fracking chemical as a trade secret in 5,062 unconventional gas wells located across 29 counties (Table 1). The weight of the trade secret chemicals used in these wells over this roughly 10-year period totaled 160 million pounds.[89] If even a small fraction of this weight were PFAS, that fraction could pose significant health and environmental risks.

In an effort to determine if any of these trade secret chemicals were PFAS, PSR examined whether any were listed as a surfactant. (Surfactants, as noted in chapter 1, encompass dangerous fluorosurfactants, some of which are PFAS.) We found thousands of cases of oil and gas companies using at least one trade secret chemical that they described as a surfactant. These occurred in 1,234 wells, spread across 23 counties.[90] Operators' names for these chemicals were vague, including "proprietary surfactant 00015"[91] and "proprietary surfactant blend."[92] The weight of these trade secret surfactants totaled almost five million pounds. Should even a small percentage of them be fluorosurfactants, they could include PFAS, and pose significant and long-lasting threats to human health and the environment. Yet the public cannot know what these chemicals are, due to the extensive use of trade secret protections.

These data show that multiple oil and gas companies have injected oil and gas wells in Pennsylvania with trade secret

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TABLE 3. Examples of Individual Unconventional Gas Wells

Well Operator	Well Number	County	Year Fracking Completed	Chemical used in Well	CAS Number	Trade Name	Mass (lbs.)
Chesapeake Operating, Inc.	3712527156	Washington	2014	PTFE	9002-84-0	ambiguous	non calculable
Chesapeake Operating, Inc.	3700720415	Beaver	2014	PTFE	9002-84-0	ambiguous	19
Cabot Oil & Gas Corp	3711522540	Susquehanna	2020	nonionic surfactants	proprietary	not reported	3,102
Range Resources Corporation	3712527583	Washington	2015	surfactants	proprietary	StimOil ENX	35,179
Seneca Resources Corporation	3711722086	Tioga	2021	proprietary surfactant blend	proprietary	NFR-64	23,892

This table shows a sample of wells injected with the types of fracking chemicals referenced in the larger table above, including trade secret surfactants such as the "nonionic surfactants" and "proprietary surfactant blend" as well as PTFE. The examples cover a range of years and represent wells fracked in several Pennsylvania counties. Even the smallest mass shown for a proprietary chemical (3,102 pounds for nonionic surfactants) could be a highly dangerous amount if this proprietary chemical were PFAS.

chemicals that could be PFAS or other toxic substances. Table 2 identifies the companies responsible for this activity, as well as the quantities of trade secret chemicals and trade secret surfactants they injected.

b. Examples of Individual Wells Injected with PFAS and/or Trade Secret Chemicals

FracFocus data show that in some cases, oil and gas companies have injected hundreds or even thousands of pounds of trade secret chemicals into unconventional gas wells for fracking. If the toxicities of some of these chemicals were similar to those of PFOA or PFOS, these quantities would be enough to contaminate vast amounts of water. Table 3 provides selected examples of the chemicals reported to have been used in several Pennsylvania wells.

c. Lack of Disclosure of Drilling Chemicals Could Also Conceal PFAS Use

Another exemption in Pennsylvania's disclosure rules that prevents the public from knowing the extent of PFAS use in oil and gas wells is that well operators are not required to disclose the chemicals used in the drilling process that precedes fracking. During drilling, companies bore deep holes in the earth. Working in successive stages, companies bore deeper and deeper until the production zone is reached where the oil and/or gas are located.[93] During the first stage of drilling, these holes typically pass directly through groundwater.[94] Chemicals can be injected in this stage of the process to help keep the drill bit cool and to help lift rock cuttings out of the well.[95] EPA has indicated that any chemicals used during this first stage of the drilling process would be highly likely to leach into groundwater, because only after drilling through the groundwater zone is complete do oil and gas companies seal off the well from the groundwater by inserting into the well steel pipe known as casing as well as cement that fills the space between the outside of the pipe and the groundwater and rock formation.[96] Chemicals could infiltrate the groundwater before the casing and cement are in place.

Chemicals used in the drilling stage could include PFAS as well as other substances that can pose health risks. A peer-reviewed scientific paper published in 2020 reported that the PFAS known as fluorosurfactants have at least

been proposed for use in drilling.[97] EPA regulators have found that chemicals proposed for use in drilling could lead to developmental harms and the formation of tumors.[98] A disclosure form filed with the state of Ohio shows that Statoil, Norway's state oil company (since renamed Equinor), has used a neurotoxic chemical, xylene, in drilling.[99] If chemicals used in drilling were to come into contact with people or the environment, negative health effects could result. This potential makes it critically important for these chemicals to be disclosed publicly. However, there is no such requirement in Pennsylvania, creating the potential that people could be unknowingly exposed to PFAS and other dangerous chemicals used during the drilling process that precedes fracking.

d. Chemical Manufacturers' Exemption May Also Obscure PFAS Use in Oil & Gas Wells

Pennsylvania rules may obscure the extent of PFAS use in oil and gas wells in an additional respect: The rules for both unconventional gas wells and conventional oil and gas wells clearly exempt chemical manufacturers from having to disclose the ingredients in their fracking chemical products to the well operators who must ultimately disclose the fracking chemicals to the public.[100] As a result, it is likely that well operators are using at least some fracking chemicals unknowingly. Some of these chemicals could be PFAS.

Chemical manufacturers are in the best position to know the identities of individual fracking chemicals, whether these chemicals are used individually or as ingredients in fracking chemical products comprised of more than one chemical. Yet evidence shows manufacturers often withhold chemical identities from other companies in the supply chain. In 2014, four attorneys with years of experience litigating oil and gas-related cases in Pennsylvania filed a petition with the state Commonwealth Court suggesting manufacturers often withhold chemical identities from other companies in the supply chain. The attorneys discussed the use of Material Safety Data Sheets (MSDS) that manufacturers use to communicate the contents of fracking chemical products. The federal Occupational Safety and Health Administration (OSHA) requires chemical manufacturers to prepare MSDS (now called safety data sheets) to order to protect workers using the chemicals from on-the-job hazards.[101] The attorneys wrote that these sheets often omit chemical ingredients.

> Many times, a vendor of a hydraulic fracturing fluid product merely re-labels product manufactured by another company without ever knowing anything about the chemical make-up of the product it has relabeled other than what may be contained in the manufacturer's MSDS. If that MSDS does not list the full chemical content of the product the vendor obtained, the vendor has no way of discerning the full chemical make-up of the hydraulic fracturing fluid. Thus, if a service provider or vendor never had possession of the entire chemical content of hydraulic fracturing fluid, then it is impossible for the vendor or service provider to pass that information along to the operator who then cannot possibly disclose to the Department [of Environmental Protection].[102]

The attorneys provided as support a record filed in a separate case by well operator Range Resources in which Range suggested that it was relying on MSDS from manufacturers to reply to a request for the chemicals used to fracture or stimulate its wells. Range said that the chemical information in these sheets could be incomplete. "The MSDS are often useful for developing some understanding of what is in a particular chemical or product," Range wrote, continuing,

> However, they vary widely in terms of usefulness. Some manufacturers include very little information about the actual components of a particular product. As a result, Range is currently in the process of seeking additional information from manufacturers that have failed to provide enough information about their products in the MSDS.[103]

In one case, Range said that a fracking or stimulation product called "MC SS-5075" was "an Ammonium Bisulfite Solution manufactured by Multi-Chem. The MSDS describes the formula as 45-70% ammonium bisulfite by weight. Range is currently seeking information on the 30-55% missing from

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the formula."[104] In another case, Range mentioned that a chemical known as "MC S-2510T," also made by Multi-Chem, contained "Ethylene Glycol (30%-60% by weight)" and "Sodium Hydroxide (5% by weight)." Range acknowledged that "we recognize that this formula fails to account for at least 35% of the weight, so we have contacted Multi-Chem for an explanation."[105]

In 2011, the U.S. House of Representatives' Committee on Energy and Commerce minority staff issued a report on hydraulic fracturing chemicals in which they asked the 14 leading oil and gas service companies to "disclose the types and volumes of the hydraulic fracturing products they used in their fluids between 2005 and 2009 and the chemical contents of those products."[106] While the committee staff found, among other things, that the companies used products containing 29 chemicals that are known or possible human carcinogens, they also found that the companies could not completely respond to the committee staff's request because of chemical information withheld by chemical manufacturers.

> In many instances, the oil and gas service companies were unable to provide the Committee with a complete chemical makeup of the hydraulic fracturing fluids they used. Between 2005 and 2009, the companies used 94 million gallons of 279 products that contained at least one chemical or component that the manufacturers deemed proprietary or a trade secret. Committee staff requested that these [service] companies disclose this proprietary information. Although some companies did provide information about these proprietary fluids, in most cases the companies stated that they did not have access to proprietary information about products they purchased "off the shelf" from chemical suppliers. In these cases, the companies are injecting fluids containing chemicals that they themselves cannot identify.[107]

Researchers at Harvard University wrote in 2013 that rules for creating safety data sheets are unlikely to result in complete disclosure of fracking chemicals by chemical manufacturers. The researchers observed that the rules limit disclosure of chemicals to those that are hazardous and have been studied for workplace exposure. Many chemicals used in fracking might not have been studied for workplace exposure, they wrote, and therefore might not be disclosed in safety data sheets. The researchers also wrote that manufacturers might not list at least some substances in safety data sheets because federal regulations provide that substances are deemed hazardous or not due to existing test data; therefore, if no test data shows that a substance is hazardous, it would not have to be listed on a safety data sheet, even if the chemical were, in fact, hazardous. No new testing is required.[108] These chemicals, in turn, would not be disclosed to companies in the fracking chemical supply chain, leaving the companies unable to disclose these chemicals to the public.

A final example of how chemical manufacturers do not or may not disclose all of the chemicals used in fracking or other oil and gas extraction techniques is found in the book *Amity and Prosperity*. In this book, which won the 2019 Pulitzer Prize for general nonfiction, author Eliza Griswold focused on a woman named Stacey Haney, who lived in western Pennsylvania near three hydraulically fractured unconventional gas wells, a drilling waste pit, and a fracking wastewater storage pond. In 2009, after drilling activity began, Haney and her neighbors suffered unexplained illnesses and the deaths of animals. They suspected the illnesses and deaths were caused by air and water contamination from the gas activity.[109] In a lawsuit filed against Range Resources, the well operator that ran the drilling site, Haney sought a full list of chemicals used at the site. This list would have been important to prove that exposure to the chemicals contributed to her family's health problems. The court ordered Range to disclose the substances, but the company said it could not comply because it did not know all of them. "Range wasn't simply being obstructionist," Griswold writes, "it was likely the company didn't know, since some of the products its subcontractors used were proprietary, and their contents were secret."[110] At least some of the secret chemical identities were held by a chemical manufacturer.[111] After years of

litigation, Haney and another plaintiff accepted a confidential settlement that "left them feeling angry and defeated."[112] "The company never provided the plaintiffs with a definitive list of all the chemicals used at the site," Griswold wrote, and the court "refused to sanction Range for not complying" with the court order to disclose its chemicals.[113]

Considering these examples, it is important for states to require disclosure of fracking chemicals directly from the chemical manufacturers so that the public can know if dangerous chemicals such as PFAS are being used in oil and gas wells. Yet Pennsylvania's rules not only fail to require such disclosure; they also eliminate incentives for well operators or other companies in the oil and gas chemical supply chain to seek accurate chemical information from the manufacturers so that the information can be publicly disclosed. Pennsylvania's rules for unconventional gas wells provide that "a vendor, service provider or operator shall not be required to do any of the following… Disclose chemicals that are not disclosed to it by the manufacturer, vendor or service provider."[114] A second section of Pennsylvania's rules for unconventional gas wells similarly removes the incentive for other companies in the fracking chemical supply chain to hold accountable the chemical manufacturers for public disclosure of fracking chemicals.[115]

The rules for conventional oil and gas wells also shield chemical manufacturers from fracking chemical disclosure requirements by providing that a well operator must disclose "a list of the chemicals in the Material Safety Data Sheets, by name and chemical abstract service number, corresponding to the appropriate chemical additive."[116] This provision means that disclosure is limited to what is required on the safety data sheets, and therefore well operators are not responsible for compiling chemical information from manufacturers that is not on the sheets. As stated above, manufacturers do not have to include on the sheets chemicals that have not been studied for workplace exposure or those for which there is no data identifying the substances as hazardous. Therefore, the manufacturers do not have to disclose the identities of at least some chemicals, and operators would not have to disclose these chemicals publicly, including, perhaps, PFAS.

e. Pennsylvania's Rules Direct Fracking Chemical Data to Multiple Repositories

Another challenge the public faces in determining what chemicals oil and gas companies have used in Pennsylvania is that the state has two different systems of fracking chemical disclosure, resulting in disclosure of these chemicals to multiple repositories. For so-called "unconventional" wells, the state provides that gas well operators publicly disclose their fracking chemicals to the FracFocus database, an online repository that can be searched and sorted by multiple terms including type of chemical used.[117] The state defines unconventional wells as gas wells in "a geological shale formation existing below the base of the Elk Sandstone or its geologic equivalent stratigraphic interval" from which gas cannot be economically produced unless particular extraction techniques are used including fracking.[118] In the case of conventional wells, which the state defines as oil wells and all other gas wells, Pennsylvania requires oil and gas companies to disclose fracking chemicals to the Pennsylvania Department of Environmental Protection.[119] As of 2018, the records for conventional wells were stored as paper records in offices in Meadville and Pittsburgh[120] and were not accessible remotely.[121] In 2022, the Department of Environmental Protection reported that well operators can disclose fracking chemicals for conventional wells electronically or on paper to the appropriate office (Meadville, Pittsburgh, or Williamsport). The electronic disclosures are available online but are stored in pdf files that must be reviewed individually and cannot be searched and sorted as a group.[122]

Due to the time it would require to access the records for conventional wells from four different sources (online, Meadville, Pittsburgh, and Williamsport), none of which is easily searchable, PSR has limited this report to an analysis of fracking chemicals disclosed as used in unconventional gas wells. On the one hand, this analysis is robust because it covers more than 7,000 wells, and unconventional gas wells have largely accounted for Pennsylvania's boom in gas production over the past two decades.[123] However, this

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An oil and gas well site in Westmoreland County, Pa., Sept. 2021. Photo credit: Ted Auch. Photo courtesy of FracTracker Alliance.

analysis is incomplete, because it leaves Pennsylvanians uninformed about the chemicals they might be exposed to through conventional oil and gas wells. As of 2021, there were close to 40,000 conventional oil and gas wells operating in Pennsylvania.[124]

The difficulty of analyzing chemicals used in conventional wells is particularly troubling because in 2022, the DEP published a report surveying operators with 11 or more conventional wells which showed significant problems with regulatory compliance. Among the shortcomings that the DEP highlighted was improper abandonment of wells and a lack of reporting about waste production and the structural integrity of wells:

> Over the past five years, DEP's OOGM [Office of Oil and Gas Management] has identified significant non-compliance with laws and regulations in the conventional oil and gas industry, particularly regarding improper abandonment of oil and gas wells, as well as reporting requirements for hydrocarbon and waste production and mechanical integrity assessments [related to structural soundness of oil and gas wells]... The reporting non-compliance denies DEP and the public critical information about the operating status of individual wells. Overall performance is so poor among operators with 11 or more conventional oil and gas wells that the failure to report seems to be an industry-wide rule rather than the exception.[125]

The lack of reporting suggests that many conventional wells may pose unknown environmental risks to the public – risks that could be intensified if toxic chemicals such as PFAS are being used. But the public will have a difficult time discovering

what chemicals may be present, due in part to the state's fracking chemical disclosure records for conventional wells that are difficult and time-consuming to search.

f. Fracking Data, Published Papers Suggest Underreporting of PFAS Use in Pennsylvania

An indication that oil and gas companies operating in Pennsylvania might not have fully disclosed their use of PFAS is evidence that more of them have disclosed use of PFAS in oil and gas wells when they operate in other states then they have in Pennsylvania. Only two oil and gas companies, Chesapeake Operating, Inc. and Hilcorp Energy, reported using PFAS (in this case, PTFE) in a total of eight of Pennsylvania's unconventional gas wells between 2012 and 2022. However, during the same period, fifteen other oil and gas companies that fracked oil and gas wells in Pennsylvania reported using PTFE for fracking in 346 wells across nine other states. Chesapeake Operating and Hilcorp Energy also reported using PTFE in oil and gas wells outside Pennsylvania. One of the 15 companies, EOG Resources, also disclosed using another PFAS, fluoroalkyl alcohol substituted polyethylene glycol, in 86 wells across New Mexico and Texas, and five of the companies disclosed using chemicals that may be PFAS, known as nonionic fluorosurfactants, in Oklahoma, New Mexico, and Texas. The specific identities of the nonionic fluorosurfactants were withheld from the public under trade secret claims, but three chemists and a board-certified toxicologist who examined this chemical name believe that nonionic fluorosurfactants could be PFAS.[126] The disclosed use of PFAS or potential PFAS in hundreds of oil and gas wells in other states by oil and gas companies operating in Pennsylvania raises questions about whether these companies are using these chemicals in Pennsylvania more widely than they have reported.

An additional indication that the use of PFAS in oil and gas wells in Pennsylvania could be more widely used than disclosed are two papers showing that the use of PFAS in oil and gas wells dates back decades and encompasses a variety of extraction techniques. In 2020, several scientists published an article in *Environmental Science: Processes and Impacts* showing that since 1956, PFAS including fluorosurfactants had been used or proposed to be used globally in oil and gas extraction techniques including chemical-driven gas production, chemical flooding, fracking, and the drilling that precedes fracking and other oil and gas production techniques.[127] In 2008, two authors, one of whom was identified as an employee at DuPont, wrote in the peer-reviewed *Open Petroleum Engineering Journal* that the use of fluorosurfactants was relatively common in the oil and gas industry and that their use was about to surge. They referred to fluorosurfactants as an "emerging technology" and stated,

> While fluorosurfactants have been used in gas and oil exploration for four decades, the increased demand for petroleum and the greater understanding of the benefits of fluorosurfactants have led to growing acceptance for fluorosurfactants throughout the petroleum industry.[128]

The authors did not explicitly say that fluorosurfactants used in oil and gas operations were PFAS, but they described the fluorosurfactants in ways that are commonly used to describe PFAS. They wrote that

> The use of fluorosurfactants is a recent but growing trend due to (i) the exceptional hydrophobic [water-repellent] and oleophobic [oil-repellent] nature of the perfluoroalkyl and perfluoroalkyl ether groups... The bond strength of the carbon-fluorine bond in perfluoroalkyl and perfluoroalkyl ether groups has been demonstrated as the key to remarkable overall stability for fluorochemicals and fluoropolymers.[129]

This evidence suggests that any time an unidentified fluorosurfactant or unidentified surfactant is used in oil and gas production, there is a potential that it is a PFAS. Companies operating oil and gas wells in Pennsylvania have used fluorosurfactants for fracking in other states. It is important to know if they have used these substances in Pennsylvania as well.

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Table 4. Use of PFAS and Potential PFAS in Other States by Pennsylvania Oil & Gas Companies

Operator Name	Number of Unconventional Wells in Pa. with Fracking Chem. Disclosure of Any Type of Chemical	Disclosure of PTFE/Teflon for Fracking in Other States (no. of wells)	Disclosure of Nonionic Fluorosurfactants for Fracking in Other States (no. of wells)	Disclosure of Fluoroalkyl Alcohol Substituted Polyethylene Glycol for Fracking in Other States (no. of wells)
Cabot Oil & Gas Corp	689	Texas (1)		
Chesapeake Operating, Inc.	583	Texas (86) Ohio (78) Wyoming (12) West Virginia (11) Oklahoma (6) Pennsylvania (5) Louisiana (1)		
Southwestern Energy	536	Colorado (2) West Virginia (1)		
Chevron USA Inc.	246		Texas (26) New Mexico (11)	
XTO Energy/ExxonMobil	186	Texas (32) New Mexico (7) Ohio (4) Oklahoma (4) West Virginia (4)	Texas (67) Oklahoma (6) New Mexico (4)	
Anadarko Petroleum Corporation	112	Colorado (95) Wyoming (38)	Texas (8)	
Hilcorp Energy Company	87	Pennsylvania (3)		
Carrizo Oil & Gas, Inc.	50	Texas (15)		
Noble Energy, Inc.	46	Colorado (30)		
EOG Resources, Inc.	22	Texas (4)	Texas (2)	Texas (65) New Mexico (31)
WPX Energy	20	New Mexico (9)		
EXCO Resources, Inc.	12	Texas (87) Louisiana (1)		
Northeast Natural Energy LLC	4	West Virginia (9)		
Halcon Resources Corporation	3	Texas (2) Mississippi (1)		
Arrington Oil & Gas Operating LLC	1		Texas (3)	

This table shows the companies that disclosed the use of any and all fracking chemicals in Pennsylvania's unconventional gas wells between 2012 and 2022 and also disclosed the use of PFAS or potential PFAS for fracking in other states during the same period. The types of PFAS or potential PFAS disclosed as being used for fracking in other states include PTFE/Teflon, fluoroalkyl alcohol substituted polyethylene glycol, and nonionic fluorosurfactants. The numbers in (parentheses) show how many wells in each state the companies disclosed as being injected with the particular type of chemical. For example, the cell in the top of the table's third column from the left shows that between 2012 and 2022, Cabot Oil & Gas Corp. fractured one well in Texas with PTFE/Teflon. For a more detailed explanation of data sources, see Appendix A.

CH. 3 HEALTH STUDIES LINK OIL AND GAS OPERATIONS TO ILLNESS

a. Oil, Gas Well Proximity Associated with Disease

A robust and reliable body of scientific studies of PFAS in oil and gas operations – both their presence and their health effects – does not yet exist. However, peer-reviewed scientific studies of people living near oil and gas operations have correlated proximity to active well sites with a variety of diseases and other health effects. It is not unreasonable to extrapolate that, should PFAS have been used in those operations, it could be associated with some of those health effects.

A 2021 study comparing health data in Pennsylvania and New York counties atop the Marcellus Shale found that years of exposure to unconventional natural gas operations in Pennsylvania were associated with higher hospitalization and death rates from acute myocardial infarction (heart attack) than what was found in New York, where no unconventional gas operations took place.[130] The study was made possible by the natural experiment created by New York's moratorium and later ban on fracking and Pennsylvania's decision to pursue shale gas extraction.[131] Similarly, researchers from Johns Hopkins University analyzed data on more than 12,000 heart failure patients in Pennsylvania and compared those with and those without hospitalizations. They found that heart failure patients living near unconventional gas extraction sites were significantly more likely to become hospitalized.[132] The authors of both the New York/Pennsylvania study[133] and the study focused solely on Pennsylvania[134] suggested that particulate matter emitted from fracking operations and the stress associated with living nearby might have played a role in the findings. Neither study examined PFAS exposure, but one of the health impacts associated with PFAS exposure is high cholesterol that is, in turn, associated with heart attacks.[135] These associations, and the known use of PFAS in oil and gas operations, point to the need for more study of the use of PFAS in oil and gas operations and associated health effects.

PSR has collaborated with Concerned Health Professionals of New York to compile and summarize the substantial and growing number of scientific studies that have found serious health effects associated with oil and gas operations. At least two of these health effects, low birth weight in babies and heart disease (that can be linked to high cholesterol) are generally associated with exposure to PFAS, though the research to date has not investigated whether these health effects are specifically linked to PFAS used in oil and gas operations. In the eighth edition (2022) of our report, we wrote,

> Public health problems associated with fracking include prenatal harm, respiratory impacts, cancer, heart disease, mental health problems, and premature death… Poor birth outcomes have been linked to fracking activities in multiple studies in multiple locations using a variety of methods. Studies of mothers living near oil and gas extraction operations consistently find impaired infant health, especially elevated risks for low birth weight and preterm birth. As we go to press, a new study in Pennsylvania finds "consistent and robust evidence that drilling shale gas wells negatively impacts both drinking water and quality of infant health."[136]

Low birthweight is a leading contributor to infant death in the United States.[137]

b. Studies Needed on PFAS

PSR is not aware of published studies that have analyzed well sites for PFAS or that have analyzed health effects related to potential use of PFAS at well sites. We are aware of only two studies of PFAS associated with oil and gas operations, both conducted by government agencies, and both focused on Pennsylvania. In 2023, the DEP tested a water well for PFAS at the Washington County home of Bryan Latkanich[138] in response to Latkanich's complaint that nearby oil and gas operations had contaminated his water with PFAS.[139] The DEP reported that it found some PFAS in Latkanich's water (PFOS at 2.3 parts per trillion, as well as PFHxS and PFOSA), but it found no evidence that PFAS was used in the nearby oil and gas operations, specifically a gas well pad operated by Chevron about 500 feet from the Latkanich home that was the site of two unconventional

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gas wells.[140] The DEP speculated that the source of the PFAS could be, among many potential sources, water that already contained PFAS being used for fracking in the unconventional gas wells. State regulations do not require testing for chemicals contained in water used in fracking.[141]

These testing results are not necessarily reassuring. The PFOS concentration was 115 times higher than EPA's health advisory level of 0.02 parts per trillion, though below the EPA's proposed drinking water standard of four parts per trillion. DEP tested for 36 types of PFAS and found only three types in the Latkanich well, but there are thousands of types of PFAS in use. A test for total organic fluorine, which the DEP did not conduct, might have indicated the presence of additional PFAS. The lack of evidence of PFAS use at nearby oil and gas operations could have been consistent with actual lack of use, or it could have reflected the use of PFAS chemicals for which the DEP did not test and which regulators or even the companies conducting the gas operations may not have known about. For the second study focusing on PFAS associated with oil and gas operations, see Appendix B.

In the bigger picture, the lack of testing for PFAS at oil and gas sites is not surprising; there were few if any grounds to test for PFAS in connection with oil and gas operations prior to July 2021, when PSR first publicized the probable use of these chemicals in oil and gas extraction. Now that we know PFAS have been used in oil and gas operations for years, scientists should determine where this use takes place and whether there are connections between this use and health effects, for PFAS chemicals individually and as a compounding factor in conjunction with exposure to other fracking chemicals.

An oil and gas fluids impoundment near Zelienople, Pennsylvania, 2015. Photo credit: Ted Auch. Photo courtesy of FracTracker Alliance.

CH. 4 EXPOSURE PATHWAYS TO PFAS ASSOCIATED WITH OIL AND GAS OPERATIONS IN PENNSYLVANIA

As indicated by EPA in the agency's 2016 report on fracking and drinking water, there are multiple pathways through which contaminants associated with oil and gas operations in Pennsylvania can jeopardize health and the environment. These include leaks and spills of chemicals at well sites, leaks and spills of wastewater at well sites or disposal sites, underground migration into groundwater from production wells or wastewater disposal wells used as underground repositories for wastewater, spreading of wastewater on roads for dust suppression and deicing, and dumping at landfills of solid waste that could be tainted with toxic substances. All of these concerns would apply to PFAS as well as to other contaminants.

a. Disposal of Waste Intensifies Pollution Concerns

The risk that PFAS and other chemicals associated with oil and gas drilling could pollute the Pennsylvania environment is especially high because of the staggering volumes of wastewater and solid waste generated by oil and gas extraction. The volumes are so high largely because of the scale of many of the unconventional gas wells being drilled in Pennsylvania compared to conventional wells drilled in past decades. Developing each well involves injecting millions of gallons of water, sand and fracking fluid. A portion this mixture returns to the surface in the form of wastewater known as "flowback." In 2016, the EPA reported that flowback *per well* in the Marcellus and Utica shale formations that are exploited for gas in Pennsylvania can total between 300,000 and one million gallons over the first 10 days after fracking.[142] In addition, following flowback, huge volumes of naturally occurring water from underground formations, known as "produced water," flow out of the wells, potentially for years.[143] In 2016, EPA reported that five years after a well was drilled in the Marcellus shale, it would still be producing wastewater at a rate of hundreds of gallons per day.[144]

The wastewater, whether flowback or produced water, can contain chemicals intentionally added to the fracking fluid such as PFAS; naturally occurring contaminants found in underground formations, including radium, which occurs in significant concentrations in wastewater from Pennsylvania;[145] and may contain chemicals that are products of reactions that occur in underground formations such as those between fracking chemicals and naturally occurring compounds in the formation such as methane.[146] Intentionally added drilling fluids, as well as naturally occurring water encountered during drilling, may be part of the wastewater mix.[147] In addition, drilling the wells involves boring into the earth 9,000 feet vertically and 10,000 additional feet or more horizontally.[148] This process produces tons of rock shards known as "drill cuttings" that could be contaminated with human-made or naturally occurring toxics.[149] FracTracker Alliance has found that wastewater and drill cuttings are the two largest waste streams produced by oil and gas operations in Pennsylvania. According to the organization's analysis of Pennsylvania Department of Environmental Protection oil and gas waste reports, in 2022, oil and gas wells in Pennsylvania generated more than 2.6 billion gallons of wastewater.[150] That liquid waste was transported to 598 facilities in Pennsylvania, New York, Ohio, and West Virginia, with almost 90 percent of the wastewater and 80 percent of the solid waste remaining in Pennsylvania. Most of the wastewater went to other well pads where wastewater can be reused to offset the need for fresh water;[151] to residual waste processing facilities that appear to include facilities for wastewater storage and treatment;[152] to injection disposal wells where wastewater is injected underground for supposedly permanent disposal, and to storage facilities pending disposal or reuse.

Pennsylvania's oil and gas wells produced more than 2.1 billion pounds of solid waste, largely consisting of drill cuttings, but also including produced fluids reported in tons, soil contaminated from spills, and synthetic liner material. The solid waste was transported to 53 facilities in the same four states, with most of the waste going to Pennsylvania landfills. Other destinations for solid waste included reuse at other well pads, residual waste processing facilities, and disposal at injection wells. If some of the wastewater or solid waste were tainted with PFAS, it could pose risks to the environment or health, both at the well sites where the

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waste is generated, and also at waste disposal sites that can be miles away. See the map below and an interactive online version from FracTracker for destinations for this waste.

The reported volumes of waste from oil and gas wells could be even larger than reported. In 2014, the Pittsburgh Post-Gazette reported that nine landfills located in southwestern Pennsylvania reported accepting three to four times the amount of oil and gas waste that operators told the DEP that they sent to the landfills. The DEP told the Post-Gazette that it did not verify reports on the volume of oil and gas wastewater that oil and gas wells operators sent to centralized waste treatment facilities or underground injection wells, but the DEP had no reason to doubt the figures.[153]

The potential for oil and gas waste to contain PFAS is not just hypothetical, according to an analysis of Pennsylvania state records in 2022 by Environmental Health News.[154]

The publication found that the eight wells in Pennsylvania injected with PTFE/Teflon produced more than 23 million gallons of liquid waste and 30,390 tons of solid waste between 2012 and 2022.[155] A map developed for the publication by FracTracker Alliance showed that this waste was transported to at least 97 sites for reuse or disposal in Pennsylvania, Ohio, and West Virginia.[156]

Robert Delaney, a retired geologist and Superfund specialist with the Michigan Department of Environmental Quality (now called the Michigan Department of Environment, Great Lakes, and Energy), told Environmental Health News that "If there were PFAS in any of those waste products, it's likely that it would have gotten into the environment in some of those locations." Delaney spent 36 years working in natural resource protection for the state of Michigan and first warned state officials about the looming problem with PFAS in 2012, though unrelated to oil and gas extraction.[157] "The

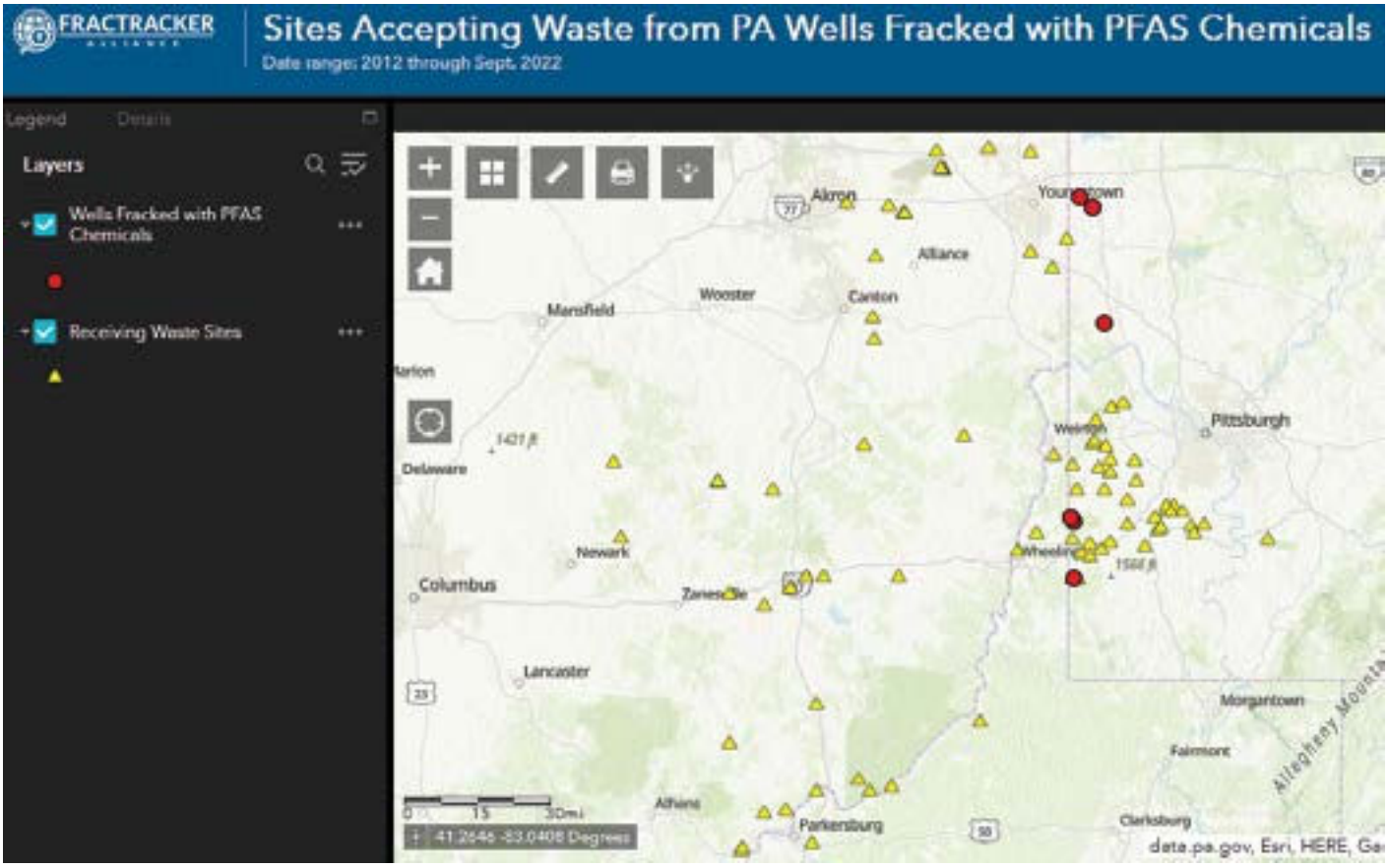
Figure 2. Facilities Accepting Pennsylvania Oil and Gas Waste in 2022

Map courtesy of FracTracker Alliance shows destinations in 2022 for liquid and solid waste generated by oil and gas wells in Pennsylvania. An interactive version of the map is available at https://ft.maps.arcgis.com/apps/webappviewer/index.html?appid=4c61de38fe714bf699349e0c7dbef779.

odds are that just as there were spills at the well pads, there have been spills and leaks at these disposal sites," Delaney told Environmental Health News. "All these places that accepted the waste didn't know that they were dealing with PFAS. And the things you do to treat other chemicals doesn't work on them…these chemicals never go away."[158]

When Environmental Health News first asked the Pennsylvania Department of Environmental Protection to comment on the use of PFAS in oil and gas operations in Pennsylvania, the Department responded that "absent a spill or release on the surface or below surface, there is no reason to conclude that wellsite fluids (whether including PFAS compounds or not) would have reached nearby soils or drinking water."[159] The publication then found evidence that there were two spills at one of the wells, known as Paul Schlinski 8H, in 2017 and 2020, and informed the DEP.[160] DEP spokesperson James Thrasher told the publication, "Given the time period between the use of the PFAS chemicals and the releases, the small amount of the spills, that the spills were contained to the gravel of the well pad, and that they were remediated quickly, DEP does not have current plans to sample for PFAS at this location." Thrasher explained that chemicals used in fracking are likely to be contained in so-called "flowback water" that typically emerges from wells within the first 30 days after fracking. In contrast, the spills occurred four years after fracking and were of produced water that primarily consists of naturally occurring brine from underground formations. His comments implied that the produced water was unlikely to contain chemicals that

Figure 3. Sites Accepting Waste from Pennsylvania Wells Fracked with PFAS Chemicals



Map developed by FracTracker Alliance for Environmental Health News showing destinations for liquid and solid waste from eight Pennsylvania oil and gas wells where oil and gas companies reported using PTFE/Teflon for fracking between 2012 and 2022. An interactive map of these sites is available here: https://www.ehn.org/fracking-pennsylvania-pfas-2658837888.html.

were used in fracking.[161] Delaney, the Superfund specialist, told Environmental Health News that Pennsylvania officials should at least test for PTFE near the well sites where the chemical was used and consider testing at the locations where waste from these wells was disposed of.[162] PTFE, a PFAS, persists, after all, in the environment.

b. Leaks, Spills Raise Pollution Concerns

As indicated by the cases of waste from wells injected with PTFE, one of the major pathways through which PFAS could contaminate water or soil is leaks and spills of drilling fluids, fracking fluids, or wastewater. These leaks and spills are common in oil and gas operations in Pennsylvania, as well as in other states, and they may be more common and serious than publicly reported. In 2017, a team of researchers published a paper in which they found that between 2005 and 2014, unconventional oil and gas well operators in Pennsylvania reported 1,293 spills from drilling through energy production.[163] The researchers calculated that the wells involved had an average spill rate of 4.3 percent during the period; this figure was defined as the total number of spills divided by the number of well-years during the period.[164] The researchers found that the total reported volume of spills in Pennsylvania during the period was 260,000 gallons. However, the authors cautioned that "Pennsylvania may have 'missing' volumes data because reporting of spills has only been required by telephone; agency guidance discouraged written notification." The researchers added that regulations set to take effect in 2016 would require written reports for spills greater than 42 gallons or when a spill may pollute Pennsylvania waters (These regulations for unconventional gas wells are in effect as of 2023).[165]

The freedom of the industry to self-report and the informal reporting of spills by telephone suggest that the number of spills and their volume could have been greater than was reported, increasing the potential for contamination by PFAS and other toxic substances.

Additional evidence from the criminal grand jury investigation conducted by Pennsylvania's Attorney General mentioned in Chapter 2 suggests that oil and gas-related spills and contamination may be more frequent and severe than reported. The grand jury heard testimony about the experience of more than 70 households, a sample size restricted by the Attorney General's limited jurisdiction over environmental crimes in Pennsylvania.[166] The grand jury also heard testimony from dozens of current and former employees of the DEP and Pennsylvania Department of Health.[167] The grand jury was dubious that spills were accurately and comprehensively reported, given that inspectors often relied on industry self-reporting of spills or denials that a spill had occurred and did not visit spill sites. "DEP employees would investigate citizen complaints simply by calling the [oil or gas well] operator and asking him what happened," the grand jury found. "If the operator sent in a photo purporting to show that no spill had occurred, the matter could be closed without ever leaving the office."[168]

The grand jury also found that the DEP used test methods known as a "suite code" to detect water contamination from oil and gas operations that often did not include testing for at least some of the contaminants likely to be associated with oil and gas extraction. The grand jury reported that

> An operator might be using a particular compound on a specific occasion that is not universally present at fracking sites. If DEP did not check the operator's records to see what he was using when a spill occurred (if the chemicals were fully disclosed), the Department would never know what to test for. Reliance on the standard suite code would actually be detrimental, because it would give a clean bill of health to water that might in fact be dangerously contaminated.[169]

PFAS was not one of the contaminants tested for by the DEP,[170] raising the potential that Pennsylvanians could have been unknowingly exposed to dangerous PFAS chemicals through oil and gas-related leaks and spills.

In some cases, authorities have documented water contamination from leaks and spills due to oil and gas operations. In 2018, Pennsylvania's DEP fined a West Virginia

company $1.7 million for a host of violations at more than a dozen well sites in Pennsylvania, including a leak of fluid from holes in the liner of a wellsite pit. The release killed nearby vegetation and impacted groundwater and a spring used for drinking water.[171] In a separate incident in 2014, the DEP fined Range Resources a record $4.15 million to settle violations that contaminated soil and groundwater near seven impoundments in Washington County; the impoundments held millions of gallons of fracking wastewater. The DEP reported that the violations included a release of 25 barrels of fracking fluid onto the ground; failure to prevent fracking fluid from flowing from a pipe onto soil and into a tributary of Brush Run, a state-designated High Quality stream, causing harm to aquatic life; and failure to contain about 400 barrels of used fracking fluids, which were released into soil and an adjacent stream.[172] Also in 2014, the Pittsburgh Post-Gazette analyzed DEP records showing that oil and gas operations had contaminated or reduced the flow of 243 private water supplies since the end of 2007. Some of the water supplies were contaminated through spills, the newspaper reported, though the records did not describe in much detail how the water supplies were impacted.[173]

c. Underground Injection Wells, Abandoned Wells Put Drinking Water at Risk

Another major pathway through which PFAS-tainted oil and gas wastewater could contaminate surface or groundwater is through underground injection into disposal wells. Wastewater from the eight unconventional gas wells in Pennsylvania that were injected with PTFE was injected into more than three dozen different underground injection wells in Ohio.[174]

The potential for pollution from oil and gas wastewater is not unfounded. Researchers have known for decades that wastewater from injection disposal wells can contaminate groundwater. In some cases, the wastewater, a mixture of naturally occurring brine and oil and gas waste, has migrated upward from deep underground, moving through nearby oil and gas wells, many of which have ceased operating but have not been properly sealed off from the surrounding underground rock formations.[175] This migrating wastewater can break out of abandoned wells and contaminate groundwater near the earth's surface.[176]

In 1985, the Texas Department of Agriculture quoted the then-existent Congressional Office of Technology Assessment regarding the "insidious" problem of underground injection of oil and gas wastewater. The congressional office had noted that such wastewater is typically injected in exactly the places where prior drilling has created opportunities for the wastewater to migrate through abandoned or closed wells into groundwater.[177] In 1989, Congress' investigative arm, the General Accounting Office (now the Government Accountability Office) reported on almost two dozen incidents of drinking water contamination associated with wastewater disposal wells.[178] Many of these cases involved wastewater migrating up abandoned oil and gas wells.[179]

Pennsylvania's own injection wells are not currently a major destination for wastewater from the state's oil and gas wells. Instead, Pennsylvania trucks far more of its oil and gas wastewater to neighboring Ohio. As of 2023, Pennsylvania had only 12 underground wastewater injection wells,[180] compared to 245 as of 2022 in Ohio, [181] where the geology is more favorable and permitting is easier. However, Inside Climate News reported in 2023 that minutes taken at a DEP Oil and Gas Technical Advisory Board meeting in 2021 alluded to a study from Tetra Tech, a consulting firm, saying that Pennsylvania would need between 17 and 34 extra disposal wells to handle the current amount of oil and gas wastewater produced in the state.

Inside Climate News also reported that a company called Penneco was planning a second injection well near Monroeville in western Pennsylvania. [183] Some local residents were opposing the well, as was the Plum Borough Council, which filed an appeal against its own appointed zoning board after the zoning board approved the well.[184]

Aside from underground injection wells, Pennsylvania is home to thousands of abandoned oil and gas wells, many of them unplugged and in unmarked locations. The world's

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first commercial oil well was drilled in Titusville, Pennsylvania in 1859,[185] but oil and gas companies were not required to plug non-producing wells until 1984 and were not required to register old wells until 1985. Largely as a result, the state is riddled with old, unplugged or improperly plugged wells. Estimates of the number of these "orphan" wells, as they are known, range in the hundreds of thousands, but the true number may never be known. As noted earlier, the DEP found in 2023 that the practice of abandoning oil and gas wells, at least for conventional wells, has continued into the present day.[186]

Recent history shows that wastewater from injection wells, potentially contaminated with PFAS or other dangerous chemicals, could reach these abandoned wells and migrate up the well shaft. This scenario could occur both in Pennsylvania and across the state line in Ohio where injection disposal wells are more common. Since 2020, two cases – one suspected to have involved an injection well, the other known to have done so – have been documented. In January 2021, more than 1.6 million gallons of what appeared to be fracking wastewater flowed for four days from an unplugged oil and gas well in Noble County, Ohio, idle since 2012.[187] A nearby tributary, Taylor Fork, was impacted by the spill, resulting in a fish kill. The cause of the spill was unclear, but there were six active fracking wastewater injection wells in Noble County, including three within four miles of the leaking oil and gas well. Another example occurred in September 2020 in Washington County, Ohio, when fracking wastewater from a disposal well migrated at least five miles to gas-producing wells, causing state officials to worry about possible groundwater contamination.[188]

Abandoned wells could also be conduits for fracking fluid injected into active oil and gas production wells as opposed to disposal wells – fracking fluid that may be tainted with PFAS or other toxics. In 2022, the Pittsburgh Post-Gazette reported that a man in New Freeport reported that he witnessed "a geyser" of water erupting from the location of an abandoned well on his property. He learned that a Pennsylvania-based oil and gas company, EQT Corp., was simultaneously fracking a horizontal well more than a mile away. The next day, EQT notified DEP about a "well communication" issue, a term that refers to a situation in which one well interacts with another. The company, however, told the Post-Gazette that it did not know if its fracking had caused the geyser. The company and the DEP were investigating. Several neighbors reported that they thought the apparent communication impacted their water.[189]In one case, a person who took a shower on the day of the incident later broke out in hives.[190]

The Post-Gazette's reporting indicated that communication with abandoned wells may be more common than reports reflect because it is likely that no one would be nearby to observe impacts in an abandoned well.[191] Over the previous six years, oil and gas companies had reported to DEP 45 suspected cases of well communication. Most of these suspected cases were discovered by operators of shale gas wells adjacent to the wells that were the apparent source of the communication. These adjacent operators noticed changes in pressure or other impacts in their own wells. But if no one were near an abandoned well with which an active well communicated, the result could be water or soil contamination unknown to the public, whether from PFAS or other toxics.

Compounding these problems is that oil and gas production wells in Pennsylvania can be located as close as 500 feet from a building or water well in the case of unconventional wells, and within 200 feet in the case of conventional wells.[192] This reality means that abandoned wells can be located near people's homes, and communication of toxic fluids from a production well or disposal well nearby could emerge from an abandoned well and pollute well water or soil at a residence. Fluids from the well could also migrate directly into groundwater that feeds a private water well. And airborne pollutants could easily travel such a short distance (see section f below). The Attorney General's grand jury recommended a setback or no-drilling zone of 2,500 feet from homes and 5,000 feet from schools and hospitals. These distances that would be more protective but perhaps not protective enough:[193] In 2012, a New York office of the U.S. Geological Survey warned that if the type of fracking

practiced in Pennsylvania were allowed in New York, fracking could jeopardize water supplies within a radius of up to five square miles.[194]

d. Road Spreading

Road spreading -- the practice of spraying oil and gas wastewater on roads for deicing or dust suppression – constitutes another pathway through which PFAS used in oil and gas wells could jeopardize Pennsylvanians' health. Researchers at Penn State University have found salts, metals, and radioactive elements in runoff from road spreading at levels higher than are considered healthy for people and the environment. There is no evidence that they tested for PFAS, but any chemical contained in the wastewater could run off of roads and contaminate water sources. The researchers also found that road spreading is no more effective at controlling dust than rainwater, a conclusion that the oil and gas industry disputes.[195] Two actions have created a partial ban on road spreading in Pennsylvania. In 2016, DEP banned the practice of road spreading with wastewater from unconventional gas wells.[196] In 2018, as a result of a settlement of an Environmental Hearing Board appeal, DEP's Oil and Gas Program halted the practice of approving road spreading of conventional wastewater.[197] However, road spreading with conventional wastewater has continued under a provision of the Solid Waste Management Act called "coproduct determination," in which a company can use industrial waste in place of a commercially available product if the industrial waste does "not present a greater threat of harm to human health and the environment than use of an intentionally manufactured product or produced raw material." The law requires various tests to demonstrate this relative level of safety. However, the tests do not require analysis for PFAS or radium.[198] As indicated earlier, PFAS could be used for drilling in conventional wells, even if the wells are not fracked.

The nonprofit Better Path Coalition found that conventional oil and gas drilling companies spread more than 2.2 million gallons of their wastewater on roads in Pennsylvania between 2018 and the end of 2020,[199] and more than 977,000 additional gallons in 2021,[200] bringing the four-year total to more than 3.1 million gallons. This wastewater could have contained PFAS or other toxics, but it is impossible to know without adequate testing.

e. Landfills

When solid waste from oil and gas operations is taken to landfills, Pennsylvanians could also be impacted by chemicals in that waste, including, potentially, PFAS. Landfills produce their own dangerous wastewater, known as "leachate," when rainwater percolates through the contents of the landfill, comes in contact with buried wastes, and leaches out their chemicals or constituents.[201] Should the rainwater contact oil and gas waste tainted with PFAS and leach out those chemicals, and if that leachate were to escape from the landfill, it could cause contamination.

One case in Fayette County, Pennsylvania demonstrates the potential of leachate from oil and gas waste to cause water pollution, although it is unknown whether PFAS were involved. In 2019, local prosecutors asked the Pennsylvania Attorney General's office to investigate after leachate from a landfill that had accepted drill cuttings was taken to a wastewater treatment plant that discharged into the Monongahela River, a major source of drinking water for Western Pennsylvania.[202] While accepting leachate from the landfill, the plant's discharge of treated water exceeded state and federal pollution standards for several pollutants including ammonia-nitrogen because its treatment system stopped functioning, allowing pollutants to pass through, according to the local prosecutors' complaint.[203] A test of the landfill's leachate in 2019 detected "volatile organic compounds (VOCs), including Xylene, Ethylbenzene, Naphthalene, 1,3, 5 Trimethylbenzene and 1, 2, 4 Trimethylbenzene… All of these contaminates (sic) are constituents of diesel fuel and are associated with waste streams from unconventional wells," an attorney for the wastewater treatment plant wrote in a letter accompanying a consent order prohibiting the landfill from sending its leachate to the treatment plant for 90 days.[204] Oilfield services company Schlumberger[205] and the Oklahoma State

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University Extension[206] have stated that diesel fuel has been, or may currently be used, in drilling of oil and gas wells. The treatment plant's superintendent wrote in an affidavit that the plant was able to effectively treat its wastewater during a two-week experiment when it temporarily stopped accepting waste from the landfill – an experiment which showed that the landfill's waste was causing the treatment plant to exceed pollution control standards.[207]

A more recent case involved allegations that leachate from a landfill in Pennsylvania contaminated a creek near York with PFAS, though the source of the PFAS in the landfill was unspecified. In 2023, Lower Susquehanna Riverkeeper Ted Evgeniadis sued Modern Landfill and its owner Republic Services, asking a federal judge to force the company to comply with the Clean Water Act and to impose penalties for alleged violations.[208] Evgeniadis asserted that the landfill was discharging extremely high levels of PFAS into the creek in violation of the law. In his written complaint, he stated that he tested discharges from the landfill into Kreutz Creek as well as areas of the creek downstream from the discharges and found levels of PFOS at 374.3 parts per trillion, levels of PFOA at 847 parts per trillion and added that "25 other PFAS compounds were also measured at very high levels."[209] DEP records show that in April 2019, Modern Landfill received three tons of produced fluid from unconventional gas wells,[210] but it is unclear that this volume of fluid was accurate because records of oil and gas waste shipments and deliveries in Pennsylvania are often inconsistent.[211] Nor is it clear or whether gas-related waste contributed to the high PFAS levels near the landfill.

f. Volatilizing, Flaring Could Pollute Air with PFAS

PFAS used in oil and gas wells could follow airborne exposure routes, according to toxicologist David Brown, former director of environmental epidemiology at the Connecticut Department of Health. Brown, who has investigated health effects associated with unconventional gas drilling for the Southwest Pennsylvania Environmental Health Project, warned that if PFAS were to enter drinking water, it could subsequently volatilize or become airborne inside homes.[212] Brown also added another potential pathway for airborne exposure: PFAS could become airborne when gas is either vented or burned off during flaring at the wellhead.[213]

Bolstering Brown's concern, both the EPA and the Interstate Technology Regulatory Council say that PFAS can be spread through air. Neither source mentions pathways from oil and gas operations, perhaps because such pathways have only recently come to the public's attention. On a webpage devoted to "PFAS Analytical Methods Development and Sampling Research," EPA includes a heading entitled "Source (Air) Emissions." It states under that heading that "There are diverse sources of [air] emissions, including chemical manufacturers, commercial applications, and thermal treatment incineration processes. EPA is developing test methods for measuring PFAS source emissions."[214] The Interstate Technology Regulatory Council (ITRC), a state-led environmental coalition that includes members from state, federal, tribal, and international agencies as well as academia, the private sector and the general public,[215] reported that "Under certain conditions, particularly within industrial stack emissions, or during fire suppression, incineration, or combustion, PFAS can be transported through the atmosphere."[216] The ITRC added that deposition of PFAS could result in pollution of soil, groundwater, or other media:

> Short-range atmospheric transport and deposition can result in PFAS contamination in terrestrial and aquatic systems near points of significant emissions, impacting soil, groundwater, and other media of concern (citation omitted). Evidence of releases has been observed in areas where hydrologic transport could not plausibly explain the presence of PFAS in groundwater, with the extent of contamination reaching several miles from sources and in distribution patterns independent of regional hydrology (citations omitted).[217]

If PFAS are used in oil and gas wells, this information indicates that nearby residents should be concerned about airborne emissions.

John Day unconventional gas well site and fluids impoundment in Amwell Township, Washington County, Pa., June 7, 2021. The Pennsylvania Department of Environmental Protection (DEP) cited discharges from this impoundment as some of the violations and releases that prompted the DEP's $4.15 million fine against Range mentioned on page 25 of this report. Photo credit: Courtesy of Marcellus Air.

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CH. 5 OIL & GAS-RELATED CHEMICAL EXPOSURE AS AN ENVIRONMENTAL JUSTICE ISSUE

"Fenceline" communities – people living close to oil and gas operations – often bear a disproportionate risk of exposure to toxic chemicals. Thus, they may be particularly at risk from PFAS used in oil and gas extraction. Although drilling and fracking take place across the U.S., not everyone shares in the risks equally. Rather, oil and gas infrastructure and associated chemicals are frequently located in or adjacent to lower-income, underserved, and marginalized communities, notably Black, Indigenous, and other communities of color, as has been documented in a variety of studies.

A 2019 analysis conducted in Colorado, Oklahoma, Pennsylvania, and Texas found strong evidence that African Americans disproportionately lived near fracking wells in Texas and Oklahoma, while Hispanics disproportionately lived near fracking wells in Texas and urban Colorado. "In Pennsylvania," the study reported, "where natural gas drilling generally takes place in counties with low shares of minorities, no environmental disparities by race/ethnicity are found, however we do find significantly lower incomes near fracking wells."[218] Similarly, in 2017, FracTracker Alliance published an analysis that found that out of almost 800 oil and gas wells drilled in Allegheny, Armstrong, and Butler counties between 2010 and 2014, only two were drilled in census tracts where the median home value was $200,000 or greater.[219] A separate study published in 2015 found that census tracts in Pennsylvania with potential exposure to unconventional wells have a higher percentage of lower-income people.[220]

Where a pattern of risks affects people of color and/or lower-income people disproportionately, oil and gas production methods should be viewed and addressed as an Environmental Justice issue. So too should any oil- and gas-related exposure to PFAS.

Unconventional gas well in Union Township, Washington County, Pa., May 19, 2014. Photo credit: Courtesy of Marcellus Air.

CH. 6 POLICY CAN HELP PROTECT PENNSYLVANIANS FROM PFAS IN FRACKING

a. Modest Federal Protections from PFAS Pollution

Governments at all levels will have to do more to protect the public from PFAS, as EPA has taken only modest steps to do so, while Congress and the executive branch have exempted the oil and gas industry from major provisions of multiple federal environmental laws. For example, oil and gas operations are exempt from important permitting and pollution control requirements of the Clean Water Act, including the stormwater runoff permit requirement. [221] Fracking is exempted from the Safe Drinking Water Act pollution control measures unless diesel is used in the fracking process.[222] Oil and gas waste is exempted from the hazardous waste rules that require cradle-to-grave tracking and safe handling of hazardous substances under the Resource Conservation and Recovery Act.[223] These exemptions increase the burden on state governments to address any PFAS pollution associated with oil and gas extraction. [224]

EPA has taken some steps to protect the public from dangerous PFAS. In 2005, EPA reached a then-record $16.5 million settlement with chemical manufacturer Dupont after accusing the company of violating the federal Toxic Substances Control Act (TSCA) by failing to disclose information about PFOA's toxicity and presence in the environment.[225] In 2006, EPA invited Dupont, 3M and six other companies to join a "stewardship" program in which the companies promised to achieve a 95 percent reduction of emissions of PFOA and related chemicals by 2010, compared to a year 2000 baseline. The agreement also required the companies to eliminate such emissions and use of these chemicals by 2015.[226] In 2022, EPA said on its website that the companies reported that they had accomplished those goals, either by exiting the PFAS industry or by transitioning to alternative chemicals.[227] EPA reported in 2022 that the manufacture and use of at least one PFAS, PFOA, had been phased out in the U.S., and that no chemical company had reported making PFOS in the U.S. since 2002. EPA did note that existing stocks of PFOA might still be used, and imported products may contain some PFOA,[228] and a 2020 scientific article reported that PFOA was still used in Asia. EPA stated that limited ongoing uses of PFOS remain. Since the announcement of its PFAS stewardship program in 2006, EPA has allowed nearly unlimited use of closely related "replacement" chemicals in dozens of industries.[231] In response, in 2015 a group of more than 200 scientists raised health and environmental concerns that the new PFAS designed to replace PFOA and PFOS may not be safer for health or the environment.[232]

In October 2021, EPA announced a "strategic roadmap" for regulating PFAS. This plan encompasses a goal of setting federal drinking water standards for several PFAS chemicals by 2023, as well as commitments to "use all available regulatory and permitting authorities to limit emissions and discharges from industrial facilities" and "hold polluters accountable."[233] The plan does not, however, include an examination of PFAS use in the oil and gas industry. (Later that month, 15 members of the U.S. House of Representatives asked EPA to examine this topic.[234] The month before, PSR had asked EPA to collect data on PFAS use in oil and gas extraction, utilizing its authority under TSCA.[235]) As previously stated, in June 2022, EPA announced new health advisory levels for several types of PFAS and in March 2023, announced a plan to regulate six types of PFAS in drinking water. In August 2022, EPA proposed designating PFOA and PFOS as hazardous under Superfund.[236] This designation would enable affected parties to more easily hold oil and gas companies accountable for cleanup costs if PFOA and PFOS were found at oil and gas sites. Under Superfund, liability does not require negligence, and any potentially responsible party (PRP) can be held liable for cleanup of an entire site when it is difficult to distinguish contributions to pollution among several parties. As EPA writes about Superfund, "[i]f a PRP sent some amount of the hazardous waste found at the site, that party is liable."[237]

In acting belatedly to regulate at least some types of PFAS in drinking water, EPA is following the lead of several states, including Pennsylvania. As of 2023 nine states, including at least several with contaminated military sites, had developed enforceable standards for concentrations of several types of PFAS in drinking water.[238]

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b. Pennsylvania's Disclosure Rules: In Need of Sweeping Reform

In Pennsylvania, multiple reforms are needed to protect the public from the use of PFAS in oil and gas operations, including changing the state's chemical disclosure rules to lift the veil of secrecy that oil and gas companies have used to conceal the use of potentially dangerous chemicals including, perhaps, PFAS. One such change is tighter limits on the use of trade secret provisions.

Oil and gas companies have argued that chemical trade secrets are necessary to protect their intellectual property from competitors. However, this interest does not have to mean a complete withholding of chemical identities from scientists, regulators, and the public. In 2015, California, a major oil-producing state,[239] began requiring full disclosure of the individual chemicals used for well stimulation, including fracking.[240] In June 2022, Colorado, a major producer of oil and gas,[241] followed in California's footsteps but extended the disclosure requirements to all chemicals used in oil and gas wells, not just fracking or stimulation chemicals.[242]

The methodology utilized in California and Colorado is consistent with a recommendation issued in 2014 by an advisory panel to the U.S. Department of Energy: that companies reveal the fracking chemicals injected into each well, providing that information in a list in which the chemicals are disassociated from the trade name of the commercial products they are part of.[243] This form of disclosure enables the public to know all the chemicals used in fracking without disclosing to rival chemical manufacturers the exact components of proprietary formulas.[244] In a similar way, food producers keep recipes secret while disclosing individual ingredients, enabling the public to know the contents of food products but making it difficult for rival producers to recreate valuable food brands. For unconventional wells, Pennsylvania requires that individual chemicals injected into each well be disclosed, disassociated from chemical products.[245] However, the state's simultaneous allowance of trade secret claims for individual chemicals, unlike California and Colorado, ensures that Pennsylvania's disclosure technique results in less than full disclosure.

California, Colorado and other states have additional provisions in their oil and gas chemical disclosure rules that could be models for Pennsylvania. California has a process under which state regulators review secrecy requests from chemical companies to determine whether the information must be kept proprietary,[246] and health and safety data related to fracking fluids are not allowed to be hidden from public view under California law.[247] California also requires disclosure of fracking chemicals before fracking begins,[248] as do West Virginia[249] and Wyoming.[250] Colorado, in its June 2022 legislation, required chemical disclosure from chemical manufacturers.[251] The Pennsylvania Attorney General's grand jury endorsed many of these measures, recommending full chemical disclosure of all chemicals used in oil and gas wells before they can be used.[252]

These reasonable and feasible reforms are valuable steps to protect the health of people who may be exposed to PFAS and other dangerous oil and gas chemicals, be they industry workers, residents living near well sites, or first responders called to the scene of an accident. They can improve health and potentially save lives. Additional steps to reduce the harms caused by oil and gas extraction are outlined in the recommendations section, including a ban on the use of PFAS in oil and gas operations, an action that Colorado took in 2022.[253] Among the evidence supporting the feasibility of this measure is a peer-reviewed analysis published in 2021 showing that many PFAS are immediately replaceable with less-persistent and less-toxic substances, including for use in the oil and gas industry.[254]

c. Pennsylvania's Hazardous Waste Rules Also in Need of Reform

Pennsylvania's state government has recognized the dangers of PFAS but, in doing so, has illuminated another gap in state rules that should be closed to protect the public from PFAS use in oil and gas operations. Subtitle C of RCRA is our

nation's law that requires safe management of hazardous waste from "cradle-to-grave."[255] In 2021, in response to a request from New Mexico's Governor Michelle Lujan Grisham to regulate PFAS under Subtitle C, EPA Administrator Michael Regan said that the agency would initiate a rulemaking process to declare four types of PFAS to be "Hazardous Constituents" under RCRA – PFOA, PFOS, PFBS, and GenX – as a step toward listing them under Subtitle C. He also said that EPA would initiate a rulemaking to "clarify that emerging contaminants such as PFAS can be addressed through RCRA corrective action."[256]

Yet under both the federal RCRA[257] and the state's implementation of the federal law in the Solid Waste Management Act,[258] oil and gas wastes are exempt from hazardous waste requirements. This exemption allows drilling companies to take solid oil and gas waste to municipal landfills that have inadequate testing for radioactivity and other toxics, according to Duquesne University microbiologist John Stolz.[259] Similarly, the exemption allows oil and gas companies to inject their liquid waste underground into so-called Class II wells designated for oil and gas waste; these wells have lower standards of environmental protection than Class I wells that are designated for hazardous waste. For example, operators of Class I hazardous waste injection wells must analyze an area of at least two miles' radius from the well to ensure that there are no adjacent wells that could be conduits allowing the oil and gas waste to migrate to the surface.[260] Class II wells can analyze an area as small as within a quarter-mile radius.[261]

Pennsylvania could act to regulate oil and gas waste as hazardous by following the example of New York State, which in 2020 enacted legislation to designate oil and gas waste as hazardous.[262] State Senator Rachel May, one of the bill's sponsors, said in a statement,

> Wastewater from fracking can contain carcinogenic compounds and naturally occurring radioactive materials. The regulatory loophole that allowed waste from fracking and crude oil processing to be treated as standard industrial waste means it enters local sewage treatment facilities, sometimes with radiation levels hundreds of times the safe limit, it then flows directly back into our waterways – the source of drinking water for thousands of New Yorkers.[263]

May issued her statement before it was widely known that PFAS was used in oil and gas operations, but considering the oil and gas industry's record of using PFAS, the statement could apply as well to these dangerous "forever" chemicals. Continuing to exempt oil and gas wastes from hazardous waste treatment means that PFAS in these wastes would be exempt, too, with potentially serious consequences for Pennsylvanians.

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RECOMMENDATIONS

In light of the findings shared in this report, PSR recommends the following:

• **Halt PFAS use in oil and gas extraction.** Pennsylvania and the U.S. Environmental Protection Agency (EPA) should prohibit PFAS from being used, manufactured, or imported for oil and gas extraction. Many PFAS are replaceable with less-persistent and less-toxic alternatives. In taking this step, Pennsylvania would be following the lead of Colorado, a major oil- and gas-producing state that in June 2022 passed legislation banning the use of PFAS in oil and gas wells.

• **Expand public disclosure.** Pennsylvania should greatly expand its requirements for public disclosure of oil and gas chemicals. The state could again follow the example offered by Colorado by requiring disclosure of all individual chemicals used in oil and gas wells, without exceptions for trade secrets. This action can be done while still protecting product formulas as trade secrets. Pennsylvania should also require disclosure on the part of chemical manufacturers and require chemical disclosure prior to permitting, as have California, West Virginia, and Wyoming.

• **Increase testing and tracking.** Pennsylvania and/or the U.S. EPA should determine where PFAS have been used in oil and gas operations in the state and where related wastes have been deposited. They should test nearby residents, water, soil, flora, and fauna for PFAS, both for the particular type(s) of PFAS used and for organic fluorine to detect the presence of other PFAS and/or their breakdown products. They should use testing equipment sensitive enough to detect PFAS at a level of single-digit parts per trillion or lower.

• **Require funding and cleanup.** Oil and gas and chemical manufacturing firms should be required to fund environmental testing for PFAS in their areas of operation, and should PFAS be found, be required to fund cleanup. If cleanup of water sources is impossible, companies responsible for the use of PFAS should pay for alternative sources of water for homes, schools, hospitals, agriculture and other uses for as long as needed.

• **Remove Pennsylvania's oil and gas hazardous waste exemption.** Pennsylvania exempts oil and gas industry wastes from state hazardous waste rules. Pennsylvania should follow New York's lead and remove its state-level hazardous waste exemption for the oil and gas industry.

• **Reform Pennsylvania's regulations for oil and gas production wells and underground injection disposal wells.** The state should prohibit production wells and underground wastewater disposal wells close to underground sources of drinking water, homes, health care facilities and schools; require groundwater monitoring for contaminants near the wells, and for disposal wells, require full public disclosure of chemicals in the wastewater.

• **Transition to renewable energy and better regulation.** Given the use of highly toxic chemicals in oil and gas extraction, including but not limited to PFAS, as well as climate impacts of oil and gas extraction and use, Pennsylvania should transition away from fracking and move toward renewable energy and energy efficiency while providing economic support for displaced oil and gas workers. As long as drilling and fracking continue, the state should better regulate these practices so that Pennsylvanians are not exposed to toxic substances and should empower local governments also to regulate the industry. When doubt exists as to the existence or danger of contamination, the rule of thumb should be, "First, do no harm."

APPENDIX A

Data Sources for PFAS Used in Pennsylvania's Oil and Gas Wells

To identify where, and to what extent, PFAS and trade secret chemicals were used at unconventional gas wells in Pennsylvania, PSR analyzed well-by-well reports of fracking chemicals recorded in FracFocus, a database for the oil and gas industry[264] maintained by the Groundwater Protection Council, a nonprofit comprised of regulators from state agencies.[265] The dates of these records extend from January 1, 2012 to September 29, 2022. PSR consulted the open-source version of FracFocus, Open-FF,[266] which is more accurate and informative than the original version of FracFocus. For example, Open-FF corrects for numerous spellings of the same term and consolidates the spellings into a single, corrected term. For more information about the differences between FracFocus and Open-FF, see the link above.

Under Pennsylvania law, well operators must disclose the fracking chemicals used in unconventional gas wells to the FracFocus database. Disclosure must occur within 60 days after hydraulic fracturing treatment.[267] Based on the disclosure forms available on FracFocus' website, operators must list, among other things, each individual chemical injected into the well and each chemical's CAS number, if available.[268] There are, however, significant exceptions to disclosure requirements under Pennsylvania's rules, including an exception for chemicals designated a trade secret[269] as discussed in Chapter 2 and Chapter 6.

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APPENDIX B

Government Scientists Investigate Link between Pennsylvania Oil and Gas Wells, PFAS Pollution

In August 2023, as we prepared to go to press, a study conducted by the U.S. Geological Survey (USGS) and the Pennsylvania Department of Environmental Protection (DEP) with implications for PFAS use in oil and gas operations in Pennsylvania was published in a peer-reviewed journal. The study may be the first, or one of the first, by government agencies to recognize oil and gas wells as "facilities that have been documented as potential sources of PFAS."[270] In making this determination, the authors relied on two sources, also cited by PSR in this report, providing evidence of PFAS use in oil and gas operations including a 2008 paper by Murphy and Hewat[271] and a 2020 paper by Glüge.[272] The authors also relied on a paper published in 2022 by Hussain et al.[273]

The study by USGS and DEP detailed testing by scientists of surface water in Pennsylvania from 161 streams for 33 different types of PFAS.[274] The goals of the study included measuring PFAS concentrations, determining the sources of PFAS, and comparing PFAS concentrations to health and environmental standards.[275] The scientists found that 123 of the streams, 76 percent, contained one or more of the 33 types of PFAS.[276] In addition, 16 of the streams contained levels of PFOA that exceeded EPA's proposed drinking water standard for PFOA, and 11 streams had concentrations of PFOS that exceeded EPA's proposed drinking water standard for PFOS.[277]

While the scientists did not report a direct link between oil and gas wells and the types of PFAS for which they tested, they did find concentrations of PFAS in streams located in areas that featured both high levels of oil and gas wells and combined sewer overflow outfalls[278] (pipes that discharge into streams the combination of wastewater from homes and businesses, and runoff from roads, typically during rain storms).[279] The scientists commented that "Research documenting the impacts of OG [oil and gas] development on PFAS contamination in surface waters is limited, but in this study the CSO [combined sewer overflow outfalls] surrounded by OG development in local catchments could be a potential source of PFAS to surrounding streams."[280]

While the study recognized a potential link between oil and gas wells and PFAS pollution in water, the extent of such pollution cannot yet be determined for several reasons. First, the researchers tested for only 33 PFAS out of thousands that have been manufactured. It is possible that oil and gas companies used types of PFAS for which the researchers did not sample. (The researchers stated that future investigation could involve testing for total organic fluorine that could indicate the presence of non-specific PFAS without having to test for individual types.)[281] Second, it is nearly impossible for researchers to test for all the types of PFAS potentially used in oil and gas wells because multiple regulatory gaps allow oil and gas companies and chemical manufacturers to withhold the identities of the chemicals used in oil and gas wells. Third, the researchers did not sample groundwater. PFAS used in oil and gas wells may be especially likely to impact groundwater because PFAS may be used in drilling that precedes fracking,[282] and has been used in fracking fluids.[283] These PFAS could infiltrate groundwater through multiple pathways including during the first stage of drilling when the drill bit passes directly through groundwater before steel casing or cement is placed in the well to separate the well from the groundwater,[284] through leaks and cracks in the casing and/or cement after these protective materials are installed,[285] migration up adjacent faults[286] or adjacent active and abandoned oil and gas wells,[287] and through surface spills.[288] More research and transparency is necessary to fully characterize the extent of PFAS pollution in water supplies located near oil and gas wells or near sites where oil and gas waste is disposed of.

APPENDIX C

Health and Environmental Risks of PTFE/Teflon

Polytetrafluoroethylene (PTFE) is the type of PFAS that oil and gas companies disclosed as being used for fracking in eight unconventional gas wells in Pennsylvania between 2012 and 2022. PTFE is a fluoropolymer, a type of plastic.[289] Scientists'[290] and environmentalists'[291] major concerns about PTFE and other fluoropolymers are related less to these substances themselves, but rather to the associated impacts of their production, use, and disposal. The production of PTFE and other fluoropolymers relies on the use of other, highly toxic PFAS that are used as production aids. As noted in a peer-reviewed study published in 2020, these other PFAS have included fluorosurfactants such as PFOA, whose risks are discussed in the previous chapter, and GenX, which is similarly harmful and has replaced PFOA in fluoropolymer production.[292] PTFE and other fluoropolymers may contain these more toxic PFAS fragments, and those fragments may leach out of the PTFE during use.[293] The authors of the 2020 paper noted that

> The levels of leachables…in individual fluoropolymer substances and products depend on the production process and subsequent treatment processes; a comprehensive global overview is currently lacking.[294] In addition, PTFE may generate other PFAS if the PTFE breaks down under heat.[295]

The 2020 paper authors noted that the persistence in the environment of PTFE and other fluoropolymers could pose problems during disposal, observing that "Landfilling of fluoropolymers leads to contamination of leachates with PFAS and can contribute to release of plastics and microplastics."[296] One of the authors added in an email to PSR that if PTFE were used in oil and gas wells that have especially high temperatures, defined in publications by oilfield services company, Schlumberger, as 300°-350° F or higher for so-called "high-pressure, high-temperature wells,"[297] the PTFE could undergo a process called "thermolysis" and generate toxic PFAS called perfluoroalkyl carboxylic acids (PFCAs). As a result, he wrote, "there could be some additional problems that need some investigation."[298] A spokesperson for the Pennsylvania Department of Environmental Protection told PSR in June 2023 that members of the department's sub-surface team "have found no producing formation in the 300F range or above."[299]

In 2021, a coalition of national environmental organizations including the Center for Environmental Health, Clean Water Action, Ecology Center, Environmental Working Group, Natural Resources Defense Council, Safer States, and the Sierra Club voiced several environmental and health concerns regarding the risks of fluoropolymers such as PTFE, based on their review of multiple scientific articles. The groups also noted that fluoropolymers are manufactured with chemicals that have an outsized negative effect on climate change.[300]

Public records make it difficult to know for what purpose PTFE was used in Pennsylvania's unconventional gas wells. For all eight wells in which the substance was injected, multiple purposes were listed for multiple chemical products, and it was unclear which purpose was connected to which product. In addition, the individual chemical components of the products were listed together in a separate portion of each disclosure form, making it impossible to know which components were part of which product or for what purpose the components were used.[301] However, PTFE, which is marketed as Teflon, is known for its slipperiness, suggesting it might have been used as a friction reducer, a common purpose for fracking chemicals.[302]

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McIntyre Wild Area, Lycoming County, Pa., April 2021. Photo credit: Rebecca Johnson. Photo courtesy of FracTracker Alliance.

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