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FRACKING WITH "FOREVER CHEMICALS" IN NEW MEXICO

Evidence Shows Oil and Gas Companies Have Used PFAS in New Mexico Wells; Water Risks Especially High for Groundwater-Dependent State

By Dusty Horwitt, J.D.
and Barbara Gottlieb

Data Analysis by Gary Allison

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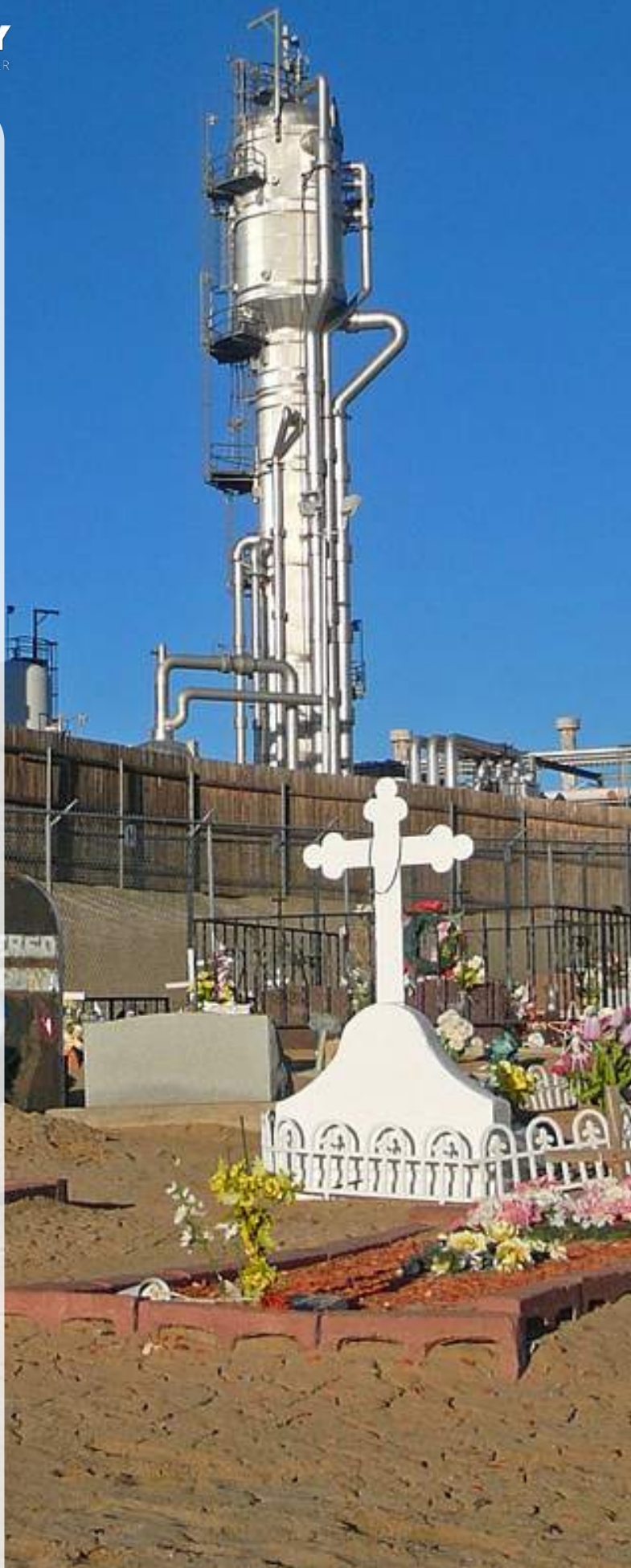

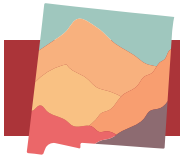

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Cover photo: Williams Field Services Natural Gas Processing Facility, Bloomfield, New Mexico, Oct. 2012. Photo credit: Jane Pargiter, EcoFlight.

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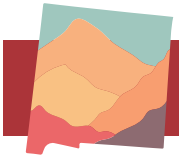


EXECUTIVE SUMMARY

Previously unpublicized information unearthed by Physicians for Social Responsibility (PSR) shows that since at least 2013, oil and gas companies used in New Mexico's oil and gas wells a class of extremely toxic and persistent chemicals known as PFAS. However, gaps in New Mexico's disclosure rules prevent the public from knowing how widely PFAS – or other toxic chemicals – have been used. These findings raise concerns that New Mexicans may unknowingly be exposed to highly hazardous substances that are toxic in minuscule amounts.

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 in a state where 80 percent of the population depends on groundwater for drinking water. Oil and gas production and waste disposal operations can contaminate groundwater with toxic chemicals including PFAS – and, once contaminated, groundwater is particularly difficult to clean up.

The present report is based on data publicly disclosed by the oil and gas industry regarding the use of chemicals in the stage of oil and gas operations known as hydraulic fracturing, or fracking. We found that between 2013 and 2022, oil and gas companies injected more than 200 oil and gas wells in six counties, in both the Permian and San Juan Basins, with the PFAS known as PTFE (marketed as Teflon). Oil and gas companies also injected wells in Lea County in the Permian Basin with the PFAS called fluoroalkyl alcohol substituted polyethylene glycol.

However, the number of cases of PFAS use we have been able to definitively identify in New Mexico oil and gas extraction may significantly underrepresent the reality. That is in large part because New Mexico law allows oil and gas companies to withhold fracking chemical identities from the public and regulators by claiming them as "trade secrets."

Between 2013 and 2022, oil and gas companies disclosed their use of fracking chemicals in 9,066 oil and gas wells. Of those wells, the companies injected more than 8,200 (over 90 percent) with at least one trade secret chemical per well. Trade secret chemicals used over this period totaled more than 240 million pounds. Information about these chemicals was limited, but scientific experts told PSR that chemicals injected into two dozen wells in the Permian Basin were PFAS, may be PFAS, or are precursor chemicals that could degrade into PFAS. Oil and gas companies injected more than 3,600 of the 8,200 wells with surfactants that could be fluorosurfactants, a class of chemical that include multiple PFAS. Should only a fraction of the unidentified chemicals used in New Mexico's oil and gas wells be PFAS, they could pose a significant threat. (An interactive map showing the locations of wells injected with PFAS and trade secret chemicals is https://psr.org/new-mexico-pfas-map/ Users can zoom in to identify wells near them.)

By shielding from public view the chemicals injected into oil and gas wells, weak disclosure rules raise the potential that New Mexicans may be directly exposed, or their groundwater and well water may be exposed, to PFAS (and other toxic chemicals) from hundreds or even thousands of oil and gas wells and waste disposal sites.

In light of these findings, PSR recommends the following:

- **Halt PFAS use in oil and gas extraction.** New Mexico should follow 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. Furthermore, New Mexico 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.

- **Expand public disclosure.** New Mexico should greatly expand its requirements for public disclosure of oil and gas chemicals. TThe 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, while still protecting chemical product formulas. New Mexico 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.** New Mexico 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. Testing equipment should be used that is 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 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 water cleanup is impossible, companies responsible for the use of PFAS should pay for alternative sources of water for household and agricultural uses, as needed.

Ruins at Chaco Culture National Historic Park, near Nageezi, New Mexico, Sept. 2009. Photo Credit: SkybirdForever, https://commons.wikimedia.org/wiki/File:Chaco_Canyon_-_Pueblo_Bonito_kiva_and_ruins.JPG.

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

- **Reform New Mexico'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, New Mexico should transition away from oil and gas production and move toward renewable energy and 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 New Mexicans 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 NEW MEXICO'S OIL AND GAS WELLS

a. PFAS Used in New Mexico 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 in New Mexico's oil and gas* wells for hydraulic fracturing ("fracking"). 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 been used in additional stages and methods of oil and gas production in New Mexico.

The likely use of PFAS in oil and gas production in New Mexico was first exposed in 2021, initially in a report by PSR[5] and subsequently by Public Employees for Environmental Responsibility.[6] Based on fracking chemical disclosures made to the state and to the nongovernmental organization FracFocus, PSR is now able to identify New Mexico oil and gas wells definitively known to have been injected with PFAS between 2013 and 2022. They include 227 wells in six counties that were injected with PTFE, also known as Teflon and identified by the U.S. Environmental Protection Agency (EPA) as a PFAS.[7] Another 34 wells in Lea county were injected with fluoroalkyl alcohol substituted polyethylene glycol, also identified as a PFAS by EPA.[8] (See chapter 2 for details on these chemicals.) In reaching definitive conclusions about these chemicals, PSR relied on Chemical Abstracts Service (CAS) numbers that are unique numeric identifiers assigned to chemicals by the American Chemical Society.[9] Scientists consider

* 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.

Table 1. Disclosed Use in Fracking of PFAS and Possible PFAS in New Mexico Oil and Gas Wells, 2013-2022

Chemical Name	Chemical Abstracts Service (CAS) Number	PFAS or PFAS Precursor?	Source of Determination as PFAS or PFAS Precursor
PTFE/Teflon	9002-84-0	PFAS	Identified as PFAS on EPA's Master List of PFAS
Fluoroalkyl alcohol substituted polyethylene glycol	65545-80-4	PFAS	Identified as PFAS on EPA's Master List of PFAS
Nonionic fluorosurfactant	Unknown (identity withheld as a trade secret)	Could be PFAS or PFAS precursor.	Some chemical experts identify nonionic fluorosurfactants as PFAS or PFAS precursors, others as likely to be PFAS or possibly PFAS.
Trade secret surfactants	Unknown (identity withheld as a trade secret)	Could include fluorosurfactants that are PFAS or PFAS precursors.	No determination possible where chemical identity is withheld.
Trade secret chemicals	Unknown (identity withheld as a trade secret)	Could include PFAS or PFAS precursors.	No determination possible where chemical identity is withheld.

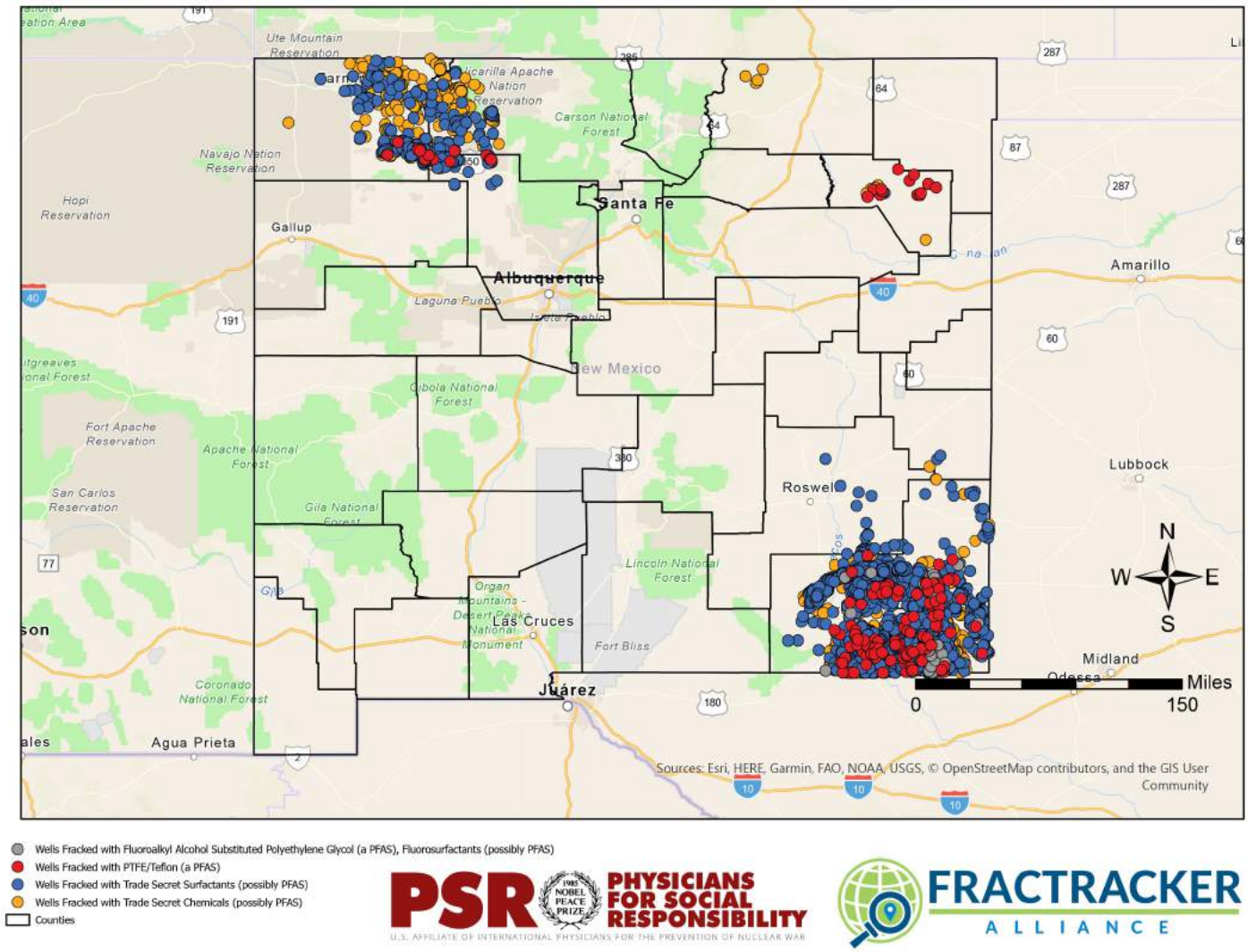
This table shows the types of chemicals that are PFAS or could be PFAS that oil and gas companies injected for fracking into oil and gas wells in New Mexico between January 1, 2013 and September 29, 2022. PFAS precursors are chemicals that can break down into PFAS. Some scientists believe that if a chemical can break down into a PFAS, it could or should be considered a PFAS.[12]

CAS numbers the best way to identify chemicals because chemicals can have multiple names or trade names but only one CAS number.[10]

In addition, PSR found that oil and gas companies injected 24 wells in Eddy and Lea Counties with unspecified nonionic fluorosurfactants that could be PFAS or precursors (chemicals that could degrade into PFAS), according to three chemists and a board-certified toxicologist who reviewed the fluorosurfactants' names.[11]

The wells injected with PFAS or possible PFAS may significantly underrepresent the extent of PFAS use in the state's oil and gas wells, due to gaps in chemical disclosure

New Mexico Oil & Gas Wells Fracked with PFAS and Possible PFAS, Including Trade Secret Chemicals, 2013-2022



Wells Fracked with Fluoroalkyl Alcohol Substituted Polyethylene Glycol (a PFAS), Fluorosurfactants (possibly PFAS)
Wells Fracked with PTFE/Teflon (a PFAS)
Wells Fracked with Trade Secret Surfactants (possibly PFAS)
Wells Fracked with Trade Secret Chemicals (possibly PFAS)
Counties

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FRACTRACKER ALLIANCE

This map shows the location of oil and gas wells in New Mexico known to have been fracked between January 1, 2013 and September 29, 2022 using PTFE/Teflon (a known PFAS), fluoroalkyl alcohol substituted polyethylene glycol (a known PFAS), fluorosurfactants that may be PFAS or PFAS precursors, trade secret chemicals, and/or trade secret surfactants. An interactive version of the map is available at https://psr.org/new-mexico-pfas-map/. Users can zoom in to identify wells near them. For a more detailed explanation of data sources, see the Appendix.

rules, including those that allow oil and gas companies to conceal from the public as trade secrets the specific identities of chemicals they use in fracking. **PSR's review of fracking chemical disclosure in New Mexico found that oil and gas companies disclosed that they used fracking chemicals between 2013 and 2022 in 9,066 oil and gas wells. Of those wells, the companies injected more than 90 percent with at least one trade secret chemical and more than 40 percent with at least one trade secret surfactant. Some of these trade secret chemicals could be PFAS.**

The use of these chemicals is particularly alarming as New Mexico's oil production has increased seven-fold in roughly a decade, from about 65.5 million barrels in 2010 to more than 457 million barrels in 2021,[13] and gas production has roughly doubled from about a trillion cubic feet in 2013 to more than two trillion cubic feet in 2021.[14] While these increases, driven largely by production in the Permian Basin,[15] mean more revenue for the state,[16] they also mean more wells being drilled and fractured, more greenhouse gas emissions,[17] and more opportunities for drilling companies to use PFAS or other toxic chemicals.

b. 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, including being slippery, oil- and water-repellant, and able to serve as dispersants or foaming agents.[18] PFAS have been called "perfluorinated chemicals" and "polyfluorinated compounds," or PFCs, though the term currently preferred by EPA is PFAS.[19]

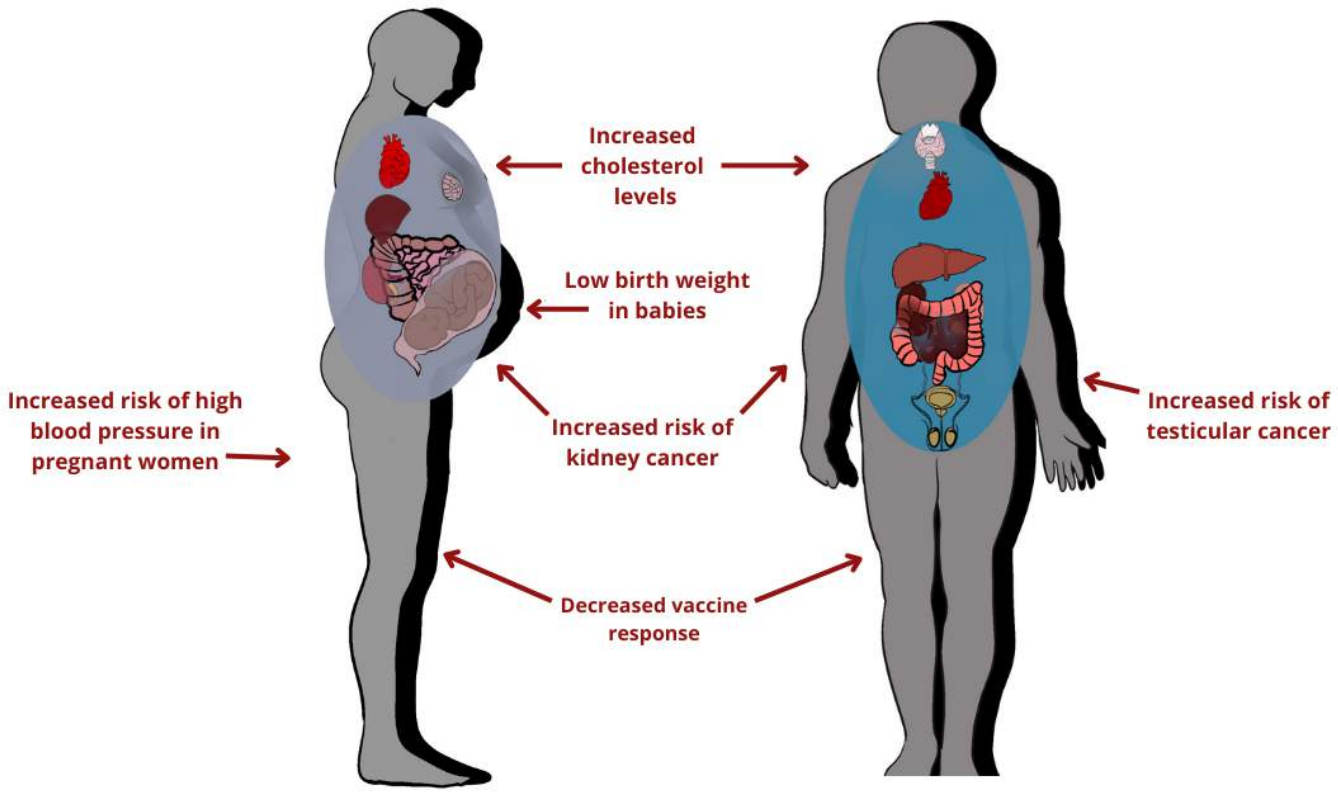
The first PFAS to be sold commercially was created by a chemist at Dupont and was patented as Teflon. Since 1949, it has been used in thousands of products, from nonstick cookware to waterproof clothing to plastics to dental floss.[20] Other PFAS chemicals, the most prominent of which are known as PFOA and PFOS, were used in food packaging, fire-fighting foam, and in 3M's widely used fabric protector, Scotchgard.[21] EPA reported in 2021 that about 650 types of PFAS remained in commerce.[22] 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.[23]

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).[24] 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).[25]

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, or different exposed populations. However, some findings are more widely endorsed; for example, the U.S. Environmental Protection Agency (EPA)[26] and the Center for Disease Control and Prevention's Agency for Toxic Substances and Disease Registry (ATSDR)[27] 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;

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

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. **See graphic above.**

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.[28] PFAS are also extremely mobile in water,[29] making them able to spread through the environment via groundwater or surface water. Another risk, discussed in Chapter 5, is that PFAS could compound the health effects from other dangerous chemicals associated with oil and gas production.

c. EPA Recognizes 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 chemicals at 70 parts per trillion.[30] **"The new published peer-reviewed data and draft EPA analyses…" EPA wrote in June 2022, "indicate that the levels at which negative health outcomes could occur are much lower than previously understood."**[31] EPA set 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.[32] 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.[33] EPA said that its interim health advisory levels were intended to provide guidance until enforceable drinking water regulations for PFAS take effect.[34]

EPA then in March 2023 released proposed standards for levels of six PFAS in drinking water. These included a level of four parts per trillion for both PFOA and PFOS. EPA explained in an email, sent in response to a question from PSR, the difference between the health advisory levels and the proposed drinking water standards:

> Health advisories reflect EPA's assessment of health risks of a contaminant based on the best available science and provide advice and information on actions that water systems may take to address contamination for these and other PFAS.[35]

Besides focusing on possible health effects, health advisories differ from rules in that they do not take into account whether a particular level of protection can be achieved or at what cost.[36] In this respect they resemble EPA's proposed Maximum Contaminant Level Goal, which for PFOA and PFOS is zero in drinking water.

EPA's interim health advisory levels mean that the toxicity of PFOA is almost beyond comprehension. According to EPA's advisory levels, one tablespoon of PFOA would be enough to contaminate 1.75 trillion gallons of water,[37] which is more than twice the total storage capacity of Elephant Butte Reservoir (720 billion gallons),[38] which forms New Mexico's largest lake on the Rio Grande River in the southwestern part of the state.[39] (Current levels in the lake are far below total storage capacity due to drought.[40]) EPA's new health advisory levels further show that PFOS is similarly extraordinarily toxic. In March 2023, EPA proposed drinking water regulations that would limit the amount of PFOA and PFOS in drinking water to four parts per trillion. The agency also proposed that drinking water providers limit the combined levels of four other types of PFAS: PFNA, PFHxS, PFBS, and/or GenX Chemicals. The agency said that it expects to finalize the rule by the end of 2023.[41]

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;[42] Zacariah Hildenbrand Ph.D., research professor in Chemistry and Biochemistry at the University of Texas at El Paso;[43] Kevin Schug Ph.D., Shimadzu Distinguished Professor of Analytical Chemistry at the University of Texas at Arlington,[44] 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.[45] 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 only might fail to detect other forms of PFAS present in the sample.

d. PFAS Already Present in New Mexico's Environment

Evidence has mounted over the years of cases of PFAS pollution from a variety of sources, including in New Mexico.

In 2018, the U.S. Air Force reported that PFAS had been detected in groundwater below Cannon Air Force base in Clovis and beneath Holloman Air Force base outside Alamogordo.[46]

At Cannon Air Force base, the levels were as high as 26,200 parts per trillion in groundwater for combined PFOA and PFOS.[47] At Holloman Air Force base, the levels reached as high as 1,294,000 parts per trillion for combined PFOA and PFOS.[48] (As noted above, EPA's health advisory levels for PFOA and PFOS in drinking water are 0.004 parts per trillion and 0.02 parts per trillion, respectively.) In both cases, the pollution was linked to the use of firefighting foam that contained PFAS.[49] It is unclear whether both PFOA and PFOS were in the foam. The Interstate Technology Regulatory Council reports that firefighting foam used between the 1960s and 2002 can contain both types of PFAS as well as precursors that may degrade into PFOA.[50] The pollution near Cannon Air Force Base devastated a local dairy farm. Because of the pollution, farmer Art Schaap told the Albuquerque

Journal in 2022 that since he learned of the PFAS contamination in his water in 2018, he had been unable to sell his cow's milk or meat. He was forced to euthanize thousands of cows, and he and the state must determine how to safely dispose of the PFAS-tainted carcasses so that the persistent pollutants do not cause further contamination. "I've lost so much money, I don't know if I can restart," Schaap told the Journal.[51]

The state Environment Department began a water sampling effort in mid-2020 with support from the U.S. Geological Survey to determine levels of PFAS around the state, and the concentrations discovered showed some cause for concern.[52] The sampling, which ran from August 2020 to November 2021, focused on ground and surface water supplies in 19 New Mexico counties.[53] In a news release published in January 2021, the Department reported that "To date, the data from this effort does not indicate any imminent public health threats....None of the results received so far show levels of PFOS or PFOA at or above the [EPA's] Lifetime Health Advisory." However, that health advisory of 70 parts per trillion of combined PFOA and PFOS is now outdated. Under EPA's June 2022 interim health advisory levels for PFOA and PFOS, multiple samples of water in New Mexico's sampling for PFAS have levels that are now judged unsafe. They range from 145 times to 9,000 times EPA's interim health advisory levels for PFOA and PFOS, including:

- 2.9 parts per trillion of PFOS in the Melrose water system in Curry County (145 times EPA's interim health advisory level);
- 8 parts per trillion of PFOA in the Alamogordo Domestic Water System/Golf Course Well in Otero County (2,000 times EPA's interim health advisory level), and
- 36 parts per trillion of PFOA in spring 10 of the Cloudcroft Water System in Otero County (9,000 times EPA's interim health advisory level).

"If, during the study, levels of PFOS and PFOA are detected in drinking water resources above the Lifetime Health Advisory," the department wrote, "NMED will work with public water systems to identify the best mitigation options, if requested." It is unclear if the department will take the same steps if the levels detected are above EPA's much more protective interim health advisory levels. The department has said on a separate website that "PFAS contamination in New Mexico is one of the New Mexico Environment Department's top priorities, as is the protection of human health and the environment."[54] The Department added that in the absence of federal drinking water standards for PFAS, it was considering developing standards of its own.[55]

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

Oil and gas operations in New Mexico deserve scrutiny as a possible additional source of PFAS contamination due to the now-documented use of PFAS in the state's oil and gas wells and the potential that people could be exposed to PFAS via multiple pathways.

An oil and/or gas site in Aztec, New Mexico, Sept. 2008. Photo credit: Jane Pargiter, EcoFlight.

EPA in its 2016 national report on fracking and drinking water found that fracking-related pollution could follow a number of pathways that could impact surface- 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;
- 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.[56]

PFAS used in oil and gas extraction could pollute water

through any of these pathways, plus other routes discussed in more detail in Chapter 5 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.[57]

PFAS contamination could further reduce available water supplies. EPA reported in 2013 that "about 87 percent of New Mexico's public water supply comes from groundwater. No other southwestern state gets such a large percentage of its domestic water from groundwater sources."[58] A representative of the federal Bureau of Reclamation told the Carlsbad Current-Argus in 2021 that in the Pecos River Basin in southeastern New Mexico, 80 percent of water was consumed by agricultural interests for irrigation, and 64 percent of that water came from groundwater. Much of the Pecos Basin overlaps with the heavily drilled Permian Basin.[59] The EPA stated in 2015 that "because groundwater usually moves slowly, contaminants generally undergo less dilution than when in surface water."[60] The agency added that

> [b]ecause ground water generally moves slowly, contamination often remains undetected for long periods of time. This makes cleanup of a contaminated water supply difficult, if not impossible. If a cleanup is undertaken, it can cost thousands to millions of dollars.[61]

Furthermore, water supplies are expected to shrink in future years as the climate heats up, making clean water supplies even more important. The Bureau of Reclamation forecast that in coming years, farmers in the basin will encounter higher temperatures and scarcer water.[62] PFAS contaminate could further reduce available water supplies.

f. PFAS: Among Many Dangerous Chemicals Used in Fracking

When used in oil and gas operations, PFAS may add to the cumulative human exposure to a host of toxic substances. In the fracturing stage of oil and gas production, 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.[63] 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.[64]

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.[65] 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),[66] shows that Statoil, Norway's state oil company (since renamed Equinor), has used the neurotoxic chemical xylene in drilling.[67] 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.[68]

CH. 2 PFAS USED IN NEW MEXICO'S OIL AND GAS WELLS: A DEEPER LOOK

a. PTFE (Teflon), a PFAS Fluoropolymer

One of the types of PFAS used for fracking in New Mexico's oil and gas wells between 2013 and 2022 was PTFE, commonly known as Teflon.

PTFE is a fluoropolymer, a type of plastic.[69] Scientists'[70] and environmentalists'[71] 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.[72] PTFE and other fluoropolymers may contain these more toxic PFAS fragments, and those fragments may leach out of the PTFE during use.[73] 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.[74]

In addition, PTFE may generate other PFAS if the PTFE breaks down under heat.[75]

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.[76] 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,"[77] 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."[78] A representative from New Mexico's Oil Conservation Division said that wells with the characteristics described by Schlumberger "would be atypical for any oil or gas producing wells in New Mexico." He added that the Oil Conservation Division does not track pressures or temperatures inside oil and gas wells, though operators sometimes report downhole pressures during initial production testing or "may report the temperatures in the well logs."[79] These data are publicly accessible online.[80]

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

Table 2. Disclosed Use in Fracking of PTFE in New Mexico Oil and Gas Wells, 2013-2022

County Name	Number of wells injected with PTFE	Mass of PTFE (lbs.)[84]
Eddy	113	2028
Harding	14	2
Lea	74	557
Rio Arriba	2	2
San Juan	18)	10
Sandoval	6	6
Total	**227**	**2605**

This table shows by county the number of New Mexico wells in which oil and gas companies injected PTFE for fracking between 2013 and 2022. For a more detailed explanation of data sources, see the Appendix.

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.[81]

Public records make it difficult to know for what purpose PTFE was used. In most cases, either no purpose or various purposes were listed for chemical products, but the individual chemical components of these products were listed in a separate portion of the disclosure form, making it impossible to know which components are part of which product.[82] 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.[83]

Oil and gas companies that have disclosed using PTFE for fracking in New Mexico (Table 3) include ExxonMobil Corp., the nation's largest publicly traded oil and gas company;[85] and Devon Energy Corp.[86] and Occidental Petroleum Corp.,[87] both major producers in the Permian Basin.

Disclosure gaps in New Mexico law, discussed below, may prevent scientists and the public from knowing the extent of the use of PTFE and other PFAS in the state's oil and gas operations.

b. Fluoroalkyl Alcohol Substituted Polyethylene Glycol

The other type of PFAS disclosed as being used for fracking in New Mexico's oil and gas wells between 2013 and 2022 was fluoroalkyl alcohol substituted polyethylene glycol. EOG Resources, a major oil producer in the Permian and San Juan Basins,[88] injected 34 wells, all in Lea County, with a total of 6,400 pounds of this chemical. Fluoroalkyl alcohol

Table 3. Oil and Gas Companies that Fracked Wells in New Mexico Using PTFE, 2013-2022

Well Operator	Number of wells injected with PTFE	Total mass of PTFE (lbs.)
Devon Energy Production Company L. P.	60	456
Occidental Oil and Gas	45	354
Matador Production Company	23	204
Yates Petroleum Co.	22	No data available
Cimarex Energy Co.	13	134
Encana Oil & Gas Inc.	12	20
Whiting Petroleum	10	1
WPX Energy	9	No data available
XTO Energy/ExxonMobil	7	1286
BreitBurn Operating LP	6	2
ConocoPhillips Company/Burlington Resources	4	30
Energen Resources Corp.	3	No data available
COG Operating LLC	2	10
Dugan Production Corp.	2	No data available
Kaiser-Francis Oil Company	2	No data available
BOPCO, L.P.	1	No data available
DGP Energy	1	14
Mewbourne Oil Co.	1	No data available
Murchison Oil and Gas Co.	1	7
Oxy USA Inc.	1	No data available
Tap Rock Resources	1	90
V-F Petroleum Inc.	1	No data available

This table shows the oil and gas companies that fracked oil and gas wells in New Mexico with PTFE between 2013 and 2022. For a more detailed explanation of data sources, see the Appendix.

substituted polyethylene glycol is listed on EPA's Master List of PFAS Substances under a different name.[89] PSR was able to identify it there using its CAS number of 65545-80-4, which appears in the FracFocus records.[90] Its purpose as declared in FracFocus is "oil field surfactant," suggesting that it could be a fluorosurfactant,[91] a type of chemical discussed in more detail in Chapter 3.

Limited toxicological data is available about chemical 65545-80-4, but according to data on the website of the National Library of Medicine's ChemIDplus, at high doses, the chemical is associated with convulsions or effects on the threshold for seizures; dyspnea, or shortness of breath; and muscle weakness.[92] A safety data sheet for the chemical published by its manufacturer says little about human health effects. "To the best of our knowledge," the safety data sheet says, referencing the substance using a trade name Zonyl® FSO-100, "the chemical, physical, and toxicological properties have not been thoroughly investigated."

Regarding impacts to the environment, the safety data sheet says, "Toxic to aquatic life with long lasting effects… Avoid release to the environment…Collect spillage…Dispose of contents/ container to an approved waste disposal plant."[93] A message on the website of ChemPoint, a chemical distributor, suggests that this chemical was phased out due to concerns that it could break down into PFOA or PFOS. A message apparently from Chemours, a company spun off from Dupont, says

> Zonyl® fluorosurfactant and repellent grades were discontinued between 2009 and 2014. Capstone® fluorosurfactants [a new type of fluorosurfactant] and repellents were introduced as sustainable replacements that meet the goals of the U.S. EPA 2010/15 PFOA Stewardship Program. They are based on short-chain molecules that cannot break down to PFOA or PFOS in the environment."[94]

However, as is discussed below, scientists have raised concerns about the health and environmental effects of these replacement chemicals.

Table 4. Disclosed Use of Fluoroalkyl Alcohol Substituted Polyethylene Glycol in New Mexico Oil and Gas Wells, 2013-2022

Well Operator	Number of wells injected with fluoroalkyl alcohol substituted polyethylene glycol – all in Lea County	Total weight of fluoroalkyl alcohol substituted polyethylene glycol (lbs.)
EOG Resources, Inc.	34	6,400

This table shows that EOG Resources, Inc., fracked oil and gas wells in New Mexico with fluoroalkyl alcohol substituted polyethylene glycol between 2013 and 2022. For a more detailed explanation of data sources, see the Appendix.

NEW MEXICO'S CHEMICAL DISCLOSURE LAWS SHIELD CHEMICAL IDENTITIES

a. New Mexico's "Trade Secret" Law Shields Potentially Dangerous Substances, Including PFAS

The danger of exposure to unknown chemicals – PFAS and others – from oil and gas operations persists in New Mexico, despite state rules that generally require public disclosure of fracking and drilling chemicals.[95] On the face of it, these disclosure requirements seem effective. However, an important exception allows companies to avoid full and meaningful disclosure: The law allows chemical manufacturers, well operators and other companies in the chemical supply chain to withhold exact fracking and drilling fluid ingredient information if they deem it a trade secret.** [96] In some cases in New Mexico fracking chemical disclosure records, oil and gas operators disclose generic names of chemicals while withholding as trade secrets their specific identities. These generic identifiers include "nonionic fluorosurfactant,"[97] a chemical identified as PFAS or possible PFAS by several scientists as discussed below, and "proprietary Acid Inhibitor/Surfactant."[98] Regrettably, the use of such vague descriptors can hide from public view the true identities of dangerous chemicals, including PFAS. The use of trade secrets to conceal chemicals' specific identities effectively undermines the public health benefits of disclosure by preventing health professionals, first responders, state regulators and the public from knowing where PFAS – or other toxic chemicals – have been used in oil and gas wells.

In addition to allowing trade secret exemptions, New Mexico does not require public disclosure of chemicals used in drilling, enhanced oil recovery, or in other extraction techniques that are distinct from fracking per se. Chemicals used during the first stage of the drilling process would be highly likely to leach into groundwater since during this stage, according to EPA, drilling passes directly through groundwater zones[99] before any casing or cement is placed in the well to seal it off. The resulting potential for groundwater contamination makes public disclosure of chemicals used in drilling especially important, as these regulatory gaps increase the potential that New Mexicans could unknowingly be exposed to PFAS and other chemicals used during oil and gas extraction.[100]

In at least some cases, the New Mexico Oil Conservation Division has prohibited oil and gas companies from using "oil base muds" for drilling "until fresh water zones are cased and cemented providing isolation from the oil or diesel. This includes synthetic oils."[101] Such "muds," according to oilfield services company Schlumberger, are "generally synonymous with drilling fluid."[102] According to the Oklahoma State University Extension Service, oil-based muds can include diesel fuel and the highly dangerous chemicals benzene, toluene, ethylbenzene, and xylene.[103]

It is unclear whether New Mexico's prohibition would prohibit the use of PFAS during drilling that passes through fresh water zones.

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

PSR found extensive application of the trade secret provisions under New Mexico's fracking chemical disclosure rules – so extensive that it could serve to mask widespread use of PFAS in the state's oil and gas wells. Our data analysis revealed that, between 2013 and 2022, New Mexico's well operators claimed at least one fracking chemical as a trade secret in 8,293 oil and gas wells located across 11 counties. The trade secret chemicals used in New Mexico over this roughly 10-year period totaled 243 million pounds (see Table 5).[104] If even a small fraction of this weight were PFAS, that fraction could pose significant risks to health and the environment. In an effort to identify PFAS among these trade secret chemicals, PSR examined whether any were listed as a surfactant or a fluorosurfactant. According to EPA, surfactants are commonly used in fracking[105] and lower the surface tension of a liquid, the interaction at the surface between two liquids (called interfacial tension), or

** Trade secret information is also called "proprietary" or "confidential business information" (CBI).

the interaction between a liquid and a solid.[106] 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."[107] At least some fluorosurfactants are PFAS, including the dangerous chemicals PFOA and PFOS[108] and 8:2 fluorotelomer alcohol,[109] a nonionic fluorosurfactant[110] that can break down into PFOA.[111] Two scientists told PSR that all or most fluorosurfactants could be classified as a PFAS[112] while two other scientists were uncertain.[113]

Like the broader class of surfactants, fluorosurfactants are also used in fracking, and perhaps other stages and methods of oil and gas extraction, according to scientific and industry sources. 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.[114] 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.[115]

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."[116] This evidence suggests that any time an unidentified surfactant or fluorosurfactant is used in oil and gas production, there is a potential that it is a 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 3,680 wells, spread across 10 counties (see Table 5).[117] Operators' names for these chemicals were vague, including "surfactant" and "surfactant blend." These trade secret surfactants totaled 19.3 million pounds. (See examples from individual wells in Table 8 below.) While we cannot know what these trade secret chemicals are, should even a small percentage of them be fluorosurfactants that are PFAS, they could pose significant threats to human health and the environment.

In 24 wells (16 in Eddy County and 8 in Lea County), oil and gas companies disclosed the use of trade secret chemicals listed with the nonspecific name "nonionic fluorosurfactant" that are apparently fluorosurfactants and may be PFAS. The weight of these chemicals totaled 970 pounds.[118] Even if some of that volume were PFAS, it could pose significant health and environmental risks, depending on the chemicals' toxicity. According to two Texas university-based chemists, Hildenbrand and Schug, both of whom are authors of multiple peer-reviewed articles about chemicals related to oil and gas production,[119] nonionic fluorosurfactants are PFAS or could degrade into PFAS. In addition, Subra, the chemist and MacArthur Foundation "Genius" grant winner, identified the chemicals as potential PFAS.[120] Still another expert, toxicologist Birnbaum, informed PSR that the chemicals are likely to be PFAS.[121] Birnbaum added that PFAS, perhaps including the nonionic fluorosurfactants used in New Mexico's oil and gas wells, could degrade into one or more smaller PFAS[122] (Hildenbrand agreed). Birnbaum,[123] Hildenbrand,[124] Subra,[125] and Schug[126] generally agree that if a chemical can break down into a PFAS, it could or should be considered a PFAS.

PSR has had to rely on scientists to identify these chemicals as PFAS, potential PFAS, or PFAS precursors because the oil and gas companies that made the public disclosures to FracFocus withheld as trade secrets the chemicals' CAS numbers, data that would have enabled a precise identification of the chemicals. The identification in the FracFocus records included only the generic name "nonionic fluorosurfactant" and the trade name "S-222" for the product containing the nonionic fluorosurfactants,[127] information insufficient to identify the chemicals with specificity. The fact that only one trade name was listed each time the chemical was reported suggests that the fluorosurfactant might be the same chemical in each use, but it is impossible to know without a CAS number. The sole purpose for which these chemicals were listed: "Surfactants."[128] The locations of the wells where nonionic fluorosurfactants were used are displayed in the map on page two.

Table 5. Disclosed Use of Trade Secret Chemicals in New Mexico Oil and Gas Wells, 2013-2022

County Name	No. of wells injected with at least one trade secret chemical	Mass of all trade secret chemicals (lbs.)	No. of wells injected with trade secret surfactants	Mass of trade secret surfactants (lbs.)	No. of wells injected with nonionic fluoro-surfactants	Mass of nonionic fluoro-surfactants (lbs.)
Chaves	62	2,590,000	41	174,000	0	0
Colfax	4	615	0	0	0	0
De Baca	1	1,490	1	273	0	0
Eddy	3,787	110,000,000	1,895	9,120,000	8	106
Harding	15	2,820	3	33	0	0
Lea	3,606	120,000,000	1,435	8,270,000	16	860
McKinley	2	397	2	11	0	0
Rio Arriba	271	1,980,000	68	138,000	0	0
Roosevelt	5	15,000	2	12,300	0	0
San Juan	415	5,200,000	179	1,140,000	0	0
Sandoval	125	2,590,000	55	415,000	0	0
Total	**8,293**	**243,000,000**	**3,681**	**19,300,000**	**24**	**966**

This table shows by county the number of New Mexico wells in which oil and gas companies injected at least one trade secret fracking chemical, at least one trade secret surfactant, and/or at least one unspecified nonionic fluorosurfactant. 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. The wells injected with unspecified nonionic fluorosurfactants are a subset of the wells injected with trade secret chemicals and trade secret surfactants. For a more detailed explanation of data sources, see the Appendix.

Data show that multiple oil and gas companies have injected oil and gas wells in New Mexico with trade secret chemicals that could be or could break down into PFAS. The excerpted table below shows the 15 companies that fracked the most wells in New Mexico between 2013 and 2022 with at least one trade secret chemical.

Table 6. Excerpt (full table in Appendix). Oil and Gas Companies that Fracked the Most Wells in New Mexico Using Trade Secret Chemicals and Trade Secret Surfactants, 2013-2022

Operator	Number of wells injected with trade secret chemicals	Number of wells injected with trade secret surfactants
EOG Resources, Inc.	1177	214
COG Operating LLC	844	438
Devon Energy Production Company L. P.	586	358
Mewbourne Oil Company	575	116
Occidental Oil and Gas	498	141
XTO Energy/ExxonMobil	442	203
Apache Corporation	439	386
Cimarex Energy Co.	336	186
Matador Production Company	288	63
Chevron USA Inc.	264	189
Hilcorp Energy Company	203	0
ConocoPhillips Company/Burlington Resources	161	112
WPX Energy	148	21
Kaiser-Francis Oil Company	131	67
Lime Rock Resources Ii-A, L.P.	129	91

This excerpted table shows the oil and gas companies that fracked the greatest number of oil and gas wells in New Mexico with trade secret chemicals and trade secret surfactants between January 1, 2013 and September 29, 2022. The full table showing all of the companies that fracked at least one well with trade secret chemicals and trade secret surfactants between January 1, 2013, and September 29, 2022, is located in the appendix. 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 the Appendix.

Erratum: The heading for the middle column in Table 6 on page 15 was corrected to show that the numbers in that column reflect the number of wells injected with trade secret chemicals, 2013-2022.

Table 7. Oil and Gas Companies that Fracked Wells in New Mexico Using Nonionic Fluorosurfactants, 2013-2022

Well Operator	Number of wells injected with nonionic fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Chevron USA Inc.	11	46
Apache Corporation	5	90
XTO Energy/ExxonMobil	4	814
COG Operating LLC	2	16
Nadel and Gussman Permian, LLC	1	<1
Seely Oil Co.	1	ND

This table shows the oil and gas companies that fracked oil and gas wells in New Mexico with unspecified nonionic fluorosurfactants between January 1, 2013 and September 29, 2022. The wells injected with the unspecified nonionic fluorosurfactants are a subset of the wells injected with trade secret chemicals and the wells injected with trade secret surfactants. For a more detailed explanation of data sources, see the Appendix.

ND=No Data Available

c. Examples of Individual Wells Injected with PFAS, Trade Secret Chemicals

Industry-disclosed data have allowed PSR to identify multiple types of fracking chemicals, including trade secret substances, that are injected into individual wells, as well as the quantities used. In some cases, oil and gas companies injected hundreds or even thousands of pounds of PFAS or trade secret chemicals into oil and 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 8 provides examples of the chemicals reported in several New Mexico wells.

Table 8. Examples of Chemical Reporting on Individual Oil and Gas Wells in New Mexico

Well Operator	Well Number	County	Year Fracking Completed	Chemical as Identified	CAS Number	Trade Name	Mass (lbs.)
EOG Resources, Inc.	3002542386	Lea	2015	fluoroalkyl alcohol substituted polyethylene glycol	65545-80-4	Plexflow RTS	120
XTO Energy/ ExxonMobil	3002542709	Lea	2015	nonionic fluorosurfactant	trade secret	S-222	226
XTO Energy/ ExxonMobil	3001542928	Eddy	2018	PTFE	9002-84-0	not reported	394
DJR Operating, LLC	3004321335	Sandoval	2020	surfactant 1	trade secret	FN2-02	29,400
Apache Corporation	3001545800	Eddy	2021	Surfactant Blend	trade secret	FRAQ SLIQ PFR-5560	4,559

This table shows illustrative samples of specific oil and/or gas wells injected with the types of fracking chemicals referenced in the larger tables above, including the identified PFAS fluoroalkyl alcohol substituted polyethylene glycol, fluorosurfactants, the identified PFAS PTFE, and trade secret surfactants such as "surfactant 1." The examples cover a range of years and represent wells fracked in several New Mexico counties. For a detailed explanation of data sources, see the Appendix

EXPOSURE PATHWAYS TO PFAS ASSOCIATED WITH OIL AND GAS OPERATIONS IN NEW MEXICO

a. Evidence of Oil and Gas Drilling-Related Spills

The potential in New Mexico for water contamination from PFAS or other chemicals used in oil and gas operations is not just hypothetical. In 2017, the news outlet EnergyWire reported on spills at oil and gas sites in New Mexico and other states that had occurred over a five-year period. EnergyWire found 847 reported spills in New Mexico in 2012, 777 in 2013, 1,303 in 2014, 1,471 in 2015, and 1,311 in 2016.[129] According to the Center for Western Priorities, oil and gas companies operating in New Mexico reported 1,368 liquid spills in the state in 2021. The total volume spilled in 2021 was more than 4.7 million gallons, of which more than four million gallons was "produced water."[130] The remaining roughly 660,000 gallons was oil. New Mexico considers produced water to be a mixture that flows out of oil and gas wells, made up of the naturally occurring water from underground and "flowback" or wastewater from drilling and/or fracturing injected into the well that returns to the surface.[131] As such, produced water in New Mexico could contain PFAS or other man-made chemicals added to drilling and/or fracking fluid as well as naturally occurring contaminants found in the formation water such as radioactive substances.[132]

The EPA has indicated that oil can also contain residues of chemicals used in oil wells.[133] Therefore, it is possible that spills of produced water or oil could contain PFAS, even small amounts of which could cause significant and dangerous contamination. A review of New Mexico Oil Conservation Division records by the Center for Biological Diversity and WildEarth Guardians found that the number of spills reported in 2022 increased to more than 1,450.[134]

In 2019, a well operated by Enduring Resources, located in the exterior boundaries of the Counselors Chapter of the Navajo Nation Government,[135] spilled almost 60,000 gallons of oil and oil and gas wastewater.[136] A report prepared by a consultant for Enduring Resources found that the spill entered two tributaries of Escavada Wash and that groundwater in the area is less than 50 feet below the ground surface.[137] The New Mexico Bureau of Geology & Mineral Resources suggests that a wash is a wide, shallow streambed that is dry most of the time and that washes are similar to arroyos.[138] A state report found that the spill impacted groundwater or surface water – the report did not specify which type.[139] A 2018 report from the New Mexico Bureau of Geology and Mineral Resources suggests that the spill would have been likely to contaminate groundwater in part because "it is considered that a depth-to-water of less than 50 ft has high susceptibility" to contamination from oil and gas-related spills and because "[a]rroyo and valley bottoms are uniformly considered to be high susceptibility" for groundwater contamination following such spills.[140]

One particularly high-profile spill occurred in January 2020 when a pipeline carrying produced water burst at night, awakening Penny Aucoin and her husband Carl George and showering their home in Otis, New Mexico with wastewater for an hour. Aucoin told the NM Political Report that she was forced to euthanize 18 chickens and a dog and give up her remaining goat. She added that a county official informed her that she could not eat her chicken eggs or the chickens' meat and that she probably should avoid eating anything grown on her property. She and her husband reached a settlement[141] with the company that owned the pipeline, WPX Energy,[142] but Aucoin said that she remained concerned. She said during a news conference in January 2021,

> The dispute has been resolved amicably, but what scares me now is that people are blissfully unaware of the dangers that come with fracking, including the enormous amount of flow back waste [produced water] produced during the fracking process.

Aucoin said that she would be moving out of the area.[143]

b. Disposal of Wastewater Raises Pollution Concerns

The risk that PFAS and other chemicals could pollute the

environment through the disposal of produced water is especially high because of the huge volumes involved. State data show that in 2022, the volume of produced water from New Mexico's oil and gas wells was almost 85 billion gallons, up from 67 billion gallons in 2021, and 57 billion gallons in 2020.[144]

According to a presentation by the state Environment Department, as of 2019, the most common method of produced water disposal was underground injection into wells that carry the wastewater into "deep, isolated geologic formations."[145] About 10 percent of the produced water was reused in oil and gas fields, where wastewater from oil and gas wells can be injected into oil wells to facilitate oil production in a process known as enhanced oil recovery or EOR. The surge of drilling in the Permian Basin has increased the generation of produced water and the need for more underground injection wells. Earthworks reported that

> [a]s of December, 2019, New Mexico had 983 active Class II disposal wells and 3,249 Class II EOR wells, for a total of 4,232. With the rapid expansion of Permian Basin development, the number of injection well permit applications has dramatically risen over time, with 538 new applications in 2019.[146]

If even a small percentage of the staggering amount of wastewater injected underground were tainted with PFAS, it could create significant pollution should it enter groundwater or surface water.

That fear is not unfounded; researchers have known for decades that produced water from injection wells can contaminate groundwater. In some cases, the produced water 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.[147] This migrating wastewater can break out of abandoned wells and contaminate groundwater near the earth's surface.[148] In 1985, the Texas Department of Agriculture reported that it had a name for this phenomenon: "saltwater breakout," a reference to the high salt content of produced water.[149] The department quoted the Congressional Office of Technology Assessment regarding the "insidious" problem of underground injection of oil and gas wastewater. The Congressional office noted that such wastewater is typically injected in exactly the places where prior drilling has created opportunities for the wastewater to migrate into groundwater.[150] The department further reported that produced water could contaminate groundwater through leaks in an injection well's steel or cement casing, designed to seal the well off from groundwater supplies.[151] The consequences of such events are particularly acute in New Mexico with its heavy reliance on groundwater.

In 1989, Congress' investigative arm, the General Accounting Office (now the Government Accountability Office) found multiple cases of water contamination linked to underground injection wells, including in New Mexico. The agency cited a case in Lea County where leaks in the casing of an injection well operated by Texaco caused contamination of a farm.

> During the 1970s, 20 million gallons of salt water leaked from a Texaco disposal well in Lea County, New Mexico, into portions of a drinking water source, the Ogallala aquifer. Some of the brine made its way into a rancher's irrigation well, damaging his crop and, according to the rancher, ultimately causing the foreclosure of his farm property. On the basis of the results of a pressure test, the rancher successfully sued Texaco in 1977 for damages. Texaco subsequently made repairs to the well, and it is now operating in compliance with UIC [underground injection control] regulations. Texaco was not required to clean the aquifer, however, because, according to the Chief of New Mexico's Environment Bureau, the cost could not be economically justified.[152]

New Mexico's Governor's Office reported in 2022 that there were 1,700 abandoned oil and gas wells on private and state land.[153] (It is unclear how many are on federal land in New Mexico.) The potential for contamination through these wells is cause for concern. The state plugs about 50

Oil and gas wastewater is dumped from a truck into one of a series of unlined pits at the R360 waste disposal facility outside Hobbs, New Mexico, 2019. Photo credit: Melissa A. Troutman.

wells per year, but the governor said that the rate would significantly increase as the result of a $43.7 million infusion from the federal Interior Department provided by the federal Infrastructure Investment and Jobs Act, passed in mid-2022.

Several other types of oil and gas waste disposal could pose serious risks to New Mexicans if the waste were contaminated with PFAS. One is the disposal of oil and gas waste in earthen pits known as impoundments. New Mexico has a well-documented history of groundwater contamination due to disposal of oil and gas waste in earthen pits. From the mid-1980s to 2003, the state's Oil Conservation Division found almost 7,000 cases of soil and water contamination from oil and gas waste pits and 400 cases of groundwater contamination.[154] This evidence prompted the state to enact the "pit rule" in 2008 that prohibited those unlined pits that were most likely to cause contamination, strengthened the standards for pit liners, mandated that all pits have a permit, and banned new pits within certain distances of water resources and homes.[155] New, permanent and temporary pits, for example, were prohibited within 1,000 feet of homes, schools, or drinking water wells used by five or more families.[156] According to Earthworks, the pit rule was effective in reducing contamination: In its first two years of operation, there were no groundwater violations at pits covered by the rule. Meanwhile, oil and gas drilling expanded in the state, indicating that the rule did not hinder oil and gas extraction.[157]

However, in 2013, after opposition to the pit rule from the oil and gas industry, lawmakers passed new legislation relaxing protections. As a result, companies can now locate temporary pits containing "low chloride" fluid within 100 feet

of perennial water courses, 200 feet from springs, wells or lakes, and 300 feet from homes or schools.[158] Such fluid with low chloride levels could pose risks if it were tainted with other toxics such as PFAS. Whereas the pit rule prohibited burying of waste at well sites unless the waste met more stringent health and environment

al standards (e.g. benzene levels in temporary pits 50-100 feet above groundwater could not exceed 0.2 parts per million),[159] the new rule allows burying at well sites of waste under much more permissive standards (benzene levels in temporary pits 51-100 feet above groundwater cannot exceed 10 parts per million).[160] As indicated by these standards, this waste often contains dangerous contaminants including carcinogenic hydrocarbons such as benzene.[161] This report suggests that the waste could contain PFAS, too. Neither the pit rule nor the new rule mention PFAS, but by allowing for the more permissive treatment of oil and gas waste, the new rule increases the risk of contamination from waste that could contain these highly toxic and persistent pollutants.

Earthworks identified other methods of oil and gas waste disposal in New Mexico that could pose risks for PFAS contamination including taking the waste to treatment plants, recycling facilities, landfills, and "landfarms," where contaminated soils, drill cuttings, and tank bottoms are allowed to be spread over land.[162]

c. 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

A poorly lit flare at Rustler Breaks SWD #6/ API #30-015-45034, a San Mateo Midstream facility in Eddy County, New Mexico, Sept. 2022. Photo credit Charlie Barrett, Earthworks.

Department of Health who has investigated health effects associated with unconventional gas drilling with the Southwest Pennsylvania Environmental Health Project. He warned that if PFAS were to enter drinking water, it could subsequently volatilize or become airborne inside homes. Brown also added another potential pathway for airborne exposure: PFAS could become airborne when gas is burned off during flaring at the wellhead or vented unburned at the wellhead.[163]

Flaring and venting are used extensively in New Mexico, suggesting that airborne PFAS through these pathways could be a risk in the state. The Howard Center for Investigative Journalism analyzed satellite data and found that between 2012 and 2020, oil and gas operators on federal land in New Mexico flared more than 138 billion cubic feet of gas,[164] enough to power more than 1.1 million homes for a year, according to a home energy consumption estimate by Popular Science magazine.[165] Gas is flared or vented unburned in emergencies and when there is insufficient pipeline capacity to bring the gas to market.[166] Insufficient pipeline capacity has been an issue in the Permian Basin in recent years when oil prices were much higher than gas prices, leaving oil and gas companies with little incentive to build pipelines to transport and sell the gas that was extracted along with the oil.[167] Soaring gas prices due to the war in Ukraine may change that equation, but it takes time to construct pipelines, and gas may not be captured if it cannot be transported to market.

In 2021, New Mexico enacted rules designed to reduce flaring and venting of gas.[168] However, some New Mexicans are skeptical that the rules can be enforced, considering that New Mexico had only 11 well inspectors as of end-2022 but 51,000 operating oil and gas wells.[169] Continued flaring and venting may provide another pathway for PFAS contamination from oil and gas wells.

Louisiana-based chemist Subra told PSR that the risk of airborne PFAS exposure might even be an issue for people living hundreds of miles from oil and gas fields.[170] Noting that gas from across the nation is delivered via pipeline to liquefied natural gas (LNG) facilities in Louisiana and Texas on the coast of the Gulf of Mexico, she proposed that residents of these communities ought to know if they are being exposed to PFAS in the gas from air emissions related to transforming the gas into a liquid for export. Bolstering Subra's concern, Reuters reported that in 2020, an LNG export facility in Corpus Christi, Texas operated by Cheniere Energy, Inc., exceeded permitted limits for air emissions in 293 instances. At least some of the emissions were volatile organic compounds from chemicals removed from the natural gas during the liquefaction process.[171] Reuters did not report that PFAS was released, but it is unclear whether anyone monitored for it. Some of the gas to be exported as LNG that could contain PFAS may arrive at the Gulf Coast from New Mexico. The Energy Information Administration reported in 2022 that three new pipelines will allow gas producers in the Permian basin to reach LNG export facilities on Texas's Gulf Coast.[172]

CH. 5 HEALTH STUDIES LINK OIL AND GAS OPERATIONS TO ILLNESS

a. Oil, Gas Well Proximity Associated with Disease

Peer-reviewed studies of people living near oil and gas operations have found that proximity to active well sites correlates with a variety of diseases and other health effects. While studies are lacking on health effects in New Mexico, a 2021 study of more than three million pregnant women in Texas showed that living within one kilometer of an active oil or gas well increased the odds of gestational hypertension (high blood pressure) and eclampsia[173] (a pregnancy-related high blood pressure disorder that can induce seizures or coma).[174] A 2020 study of pregnant women living in the Eagle Ford Shale area of South Texas found that exposure to a high number of nightly flaring events was associated with a 50 percent increase in the risk of preterm birth.[175] A 2020 study in Texas documented a link between natural gas drilling and production from both conventional and unconventional wells and frequency of hospitalization for childhood asthma.[176] Several studies conducted in Colorado, another major producer of oil and gas, also found associations between proximity to oil and gas operations and health effects, including congenital heart defects in newborns[177] and cancer diagnoses among Coloradans from birth to 24 years old.[178]

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. 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."[179]

Low birthweight is a leading contributor to infant death in the United States.[180]

Many residents living near oil and gas operations have reported serious health concerns while expressing frustration over the secrecy surrounding chemicals used by the oil and gas industry.[181] In 2020, Pennsylvania's Attorney General issued a report based on a criminal grand jury investigation of oil and gas drilling pollution in the Keystone State. Drilling for gas in shale formations has surged in that state over the past 15 years,[182] vaulting it into the number two spot among gas-producing states (Texas is number one)[183] and bringing many more Pennsylvanians into contact with gas drilling and its impacts. Based on testimony from over 70 households, the attorney general compiled evidence of serious health impacts, 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.[184]

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. This lack of testing is not surprising; there were few if any grounds to

Angel Peak Scenic Area, Farmington, New Mexico, May 2012. New Mexico's natural beauty is well worth protecting. Photo credit: Judy Gallagher, https://creativecommons.org/licenses/by/4.0/.

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 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.

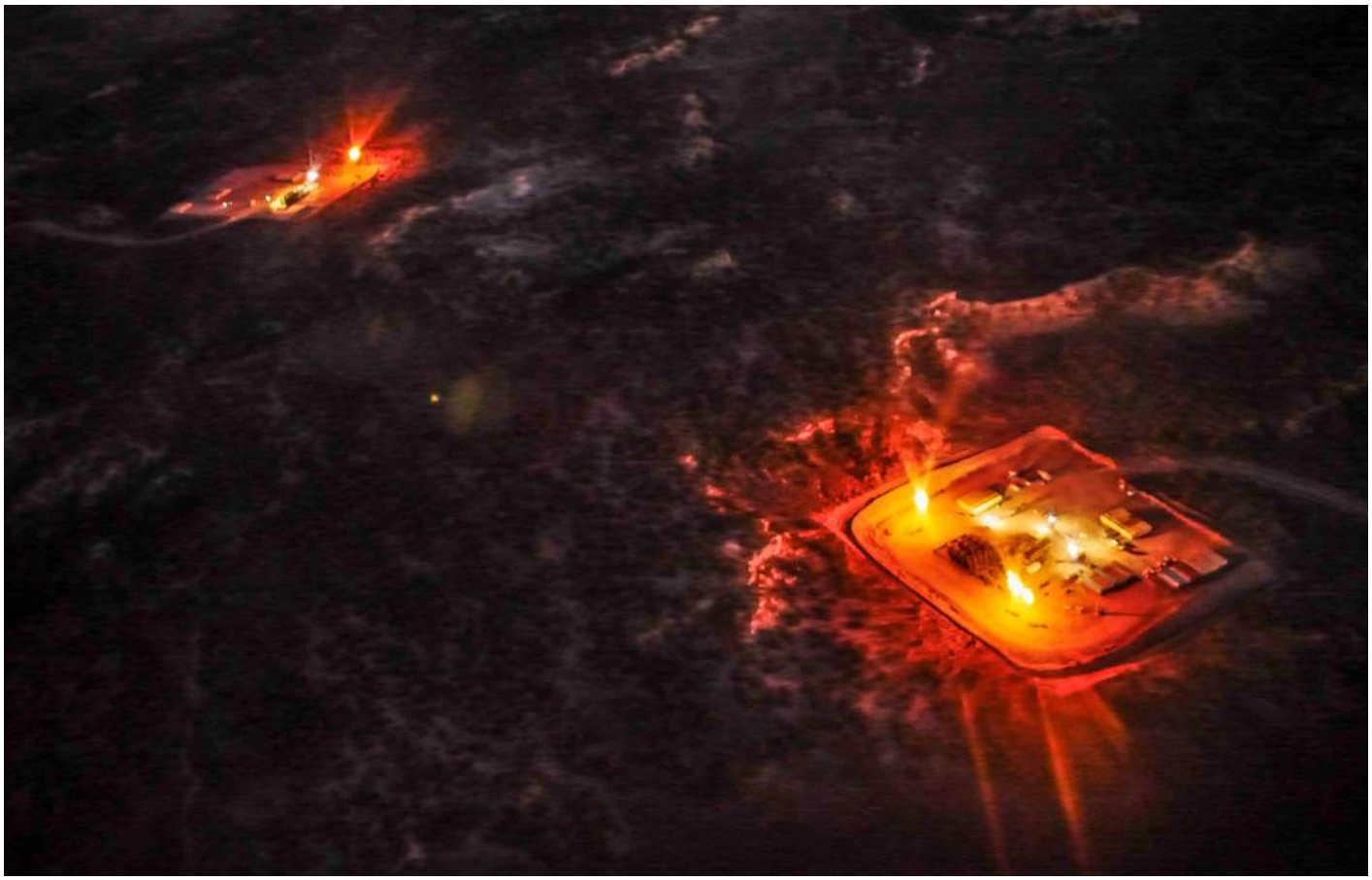
CH. 6 OIL & GAS-RELATED CHEMICAL EXPOSURE AS AN ENVIRONMENTAL JUSTICE ISSUE

a. Disproportionate Impacts on Environmental Justice Communities

"Fenceline" communities – people living close to oil and gas operations – often bear a disproportionate risk of exposure to toxic chemicals and thus may be particularly at risk from PFAS used in oil and gas extraction. Although drilling and fracking take place in the majority of U.S. states, 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.

In 2021, researchers used satellite observations and census data to show that 83 percent of the flaring from unconventional oil and gas wells in the contiguous United States between March 2012 and February 2020 took place in three basins: the Permian Basin in New Mexico and Texas, the Williston Basin in North Dakota, and the Western Gulf Basin in southern Texas and Louisiana. They estimated that over half a million people in these basins lived within three miles of a flare, with 39 percent of them living near more than 100 flares each night. The researchers also reported that in these regions, Black, Indigenous, and people of color were disproportionately exposed to flaring.[185]

Other studies have also found disproportionate impacts on people of color. A 2020 study found that compared to white residents, Hispanic residents living in the Eagle Ford shale region of Texas were disproportionately exposed to



Nighttime flaring, just north of Chaco Culture National Historical Park near Nageezi, New Mexico, Oct. 2014. Photo credit: Dom Smith, EcoFlight.

flaring from unconventional oil and gas wells, even though they were less likely than white residents to live near unconventional oil and gas wells.[186] In 2016, a public health research team showed that in the Eagle Ford shale region, disposal wells for fracking wastewater were more than twice as common in areas where residents were more than 80 percent people of color than in majority-white communities. They also found that disposal wells were disproportionately located in areas with high rates of poverty, but even in these areas, the association with race was predominant. "Adjusting for both poverty and rurality," the researchers wrote, "we still found that as the proportion of people of color in the census block group increased, so did the presence of disposal wells." Since 2007, they reported, Texas had permitted more than 1,000 waste disposal wells in the Eagle Ford Shale region, where groundwater is the primary source of drinking water.[187]

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. "The question, who bears the costs of unconventional natural gas drilling, is of great relevance not only for the U.S., but worldwide," the researchers wrote.

b. Navajo Survey Shows Health Impacts

All chapters of the Navajo Nation in New Mexico were identified in 2020 as "environmental justice" communities by the United States Bureau of Land Management.[188] In 2021, the Counselor Chapter of the Navajo Nation in New Mexico conducted a health and cultural survey regarding oil drilling operations in the Counselor, Torreon, and Ojo Encino chapters that identified health risks and distrust of regulators and oil companies. The chapter conducted its health survey under the guidance of the Southwest Pennsylvania Environmental Health project, which had conducted similar surveys in other communities with oil and gas drilling. Among other things, the chapter measured the levels of fine particulate matter ($PM_{2.5}$) through air monitors near people's

Table 9. Wells on NM Federal, State, and Tribal Land Fracked with PFAS and Possible PFAS, 2013-2022

Type of fracking chemical injected	No. Wells in state	Total Mass in state (lbs.)	No. Wells on Federal Land	Total Mass Federal Land (lbs.)	No. Wells on State Land	Total Mass State Land (lbs.)	No. Wells on Tribal Land	Total Mass Tribal Land (lbs.)
	9066	--	4468	--	2350	--	192	--
Trade Secret chemicals	8293	243,000,000	4072	115,000,000	2153	54,600,000	186	2,040,000
Trade Secret surfactants	3681	19,300,000	1813	10,900,000	954	4,740,000	86	230,000
Fluoro-surfactants	24	965	12	790	10	164	0	0.0
65545-80-4	34	6,400	8	1,370	17	3,060	0	0.0
PTFE	227	2,610	113	1,650	53	552	3	data not available

This table shows the number of oil and gas wells in New Mexico -- statewide, on federal land, on state-owned land, and on tribal land – that oil and gas companies fracked between 2013 and 2022 with at least one trade secret chemical, at least one trade secret surfactant, at least one fluorosurfactant, fluoroalkyl alcohol substituted polyethylene glycol (CAS Number 65545-80-4, a known PFAS), or PTFE (a known PFAS). The total weight figures reflect the sum of all records for which PSR has enough information to calculate a chemical's weight. For a detailed explanation of data sources, see the Appendix.

homes on the side of the home nearest to the closest oil wells. The readings showed the $PM_{2.5}$ levels, generally recorded between peak releases, were significantly higher at six of eight measuring sites compared to median levels in other non-Navajo communities with oil and gas operations. Residents living near a source of such air pollution are at greater risk for contracting or intensifying respiratory or cardiovascular diseases.[189] In a survey of health symptoms of 80 residents of the Counselor Chapter, more than 60 percent reported 11 symptoms during the year after drilling began near their homes, including sore throat, cough, and sinus problems. This number of reported health symptoms was greater than the number reported by respondents living near oil and gas wells in other communities in the U.S.[190] Separately, the Chapter conducted a cultural survey regarding the effects of oil drilling, collecting data from 136 randomly selected adults in the three chapters. Among other findings, 104 respondents strongly agreed with the statement, "Our local leaders have spoken out against drilling and no one at the tribal, state or federal level, including BLM and BIA, has listened." One hundred and seventeen strongly agreed with the statement, "The oil companies have no respect for land, people & life."[191]

PSR found that about 97 percent of the wells in New Mexico drilled on tribal land for which oil and gas companies disclosed the use of fracking chemicals were injected with at least one trade secret fracking chemical. This percentage was a bit higher than for wells drilled statewide (about 91 percent). But the total number of wells drilled on tribal land was much smaller, so it is unclear whether this difference was statistically significant.

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.

POLICY CAN HELP PROTECT NEW MEXICANS FROM PFAS IN OIL & GAS OPERATIONS

a. Modest Federal Protections from PFAS Pollution

Governments at all levels will have to do more to protect the public from PFAS, in large part because 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 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. These exemptions increase the burden on state governments to address any PFAS pollution associated with oil and gas extraction.[192]

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.[193] 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.[194] 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.[195] 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 noted that existing stocks of PFOA might still be used, and imported products may contain some PFOA.[196] A 2020 scientific article reported that PFOA was still used in Asia.[197] EPA stated that limited ongoing uses of PFOS remain.[198] 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.[199]

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.[200]

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."[201] 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.[202] The month before, PSR asked EPA to collect data on PFAS use in oil and gas extraction, utilizing its authority under TSCA.[203] As previously stated, in June 2022, EPA announced new health advisory levels for several types of PFAS; unfortunately, these standards are advisory and not legally enforceable.[204] In August 2022, EPA proposed designating PFOA and PFOS as hazardous under Superfund.[205] 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 because 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."[206] Finally as previously stated, in March 2023, EPA announced a plan to regulate six types of PFAS in drinking water.

In acting belatedly to regulate at least some types of PFAS in drinking water, EPA is following the lead of several states. 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.[207] One of those to act is Michigan, which set standards in 2020 for limiting PFAS in drinking water and

for removing PFAS from groundwater. The standards apply to PFOA and six other forms of PFAS. Michigan's maximum allowable level is no more than eight parts per trillion for PFOA,[208] a standard that is one of the lowest among states but is now much more permissive than EPA's interim health advisory level. Even Michigan's standard, however, shows how toxic PFAS can be. By extrapolation, Michigan's standard suggests that one measuring cup of PFOA could contaminate almost eight billion gallons of water – the amount of water needed to fill almost 12,000 Olympic-sized swimming pools at about 660,000 gallons per pool.[209]

b. New Mexico Disclosure Rules: In Need of Sweeping Reform

In New Mexico, 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 should be 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 information on chemical identities from scientists, regulators, and the public. In 2015, California, a major oil-producing state,[210] began requiring full disclosure of chemicals used for well stimulation, including fracking. The policy did away with trade secret exemptions for the individual chemicals used in fracking products.[211] In June 2022, Colorado, a major producer of oil and gas,[212] 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.[213]

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.[214] 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.[215] 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. In addition, California has a process under which state regulators review secrecy requests from chemical companies to determine whether the information must be kept proprietary.[216] Health and safety data related to fracking fluids are not allowed to be hidden from public view under California law.[217] California also requires disclosure of fracking chemicals before fracking begins,[218] as do West Virginia[219] and Wyoming.[220]

New Mexico should also ensure that full chemical disclosure is required from all the companies in the chemical supply chain. Currently, New Mexico rules require chemical disclosure from the well operator.[221] Chemical manufacturers, however, are exempted from this reporting, despite being the only entity that always knows the precise contents of the chemicals they produce. Not only does New Mexico omit chemical manufacturers from disclosure requirements and allow them to claim trade secrets; it also limits their responsibility by providing that the Division of Oil and Gas "does not require the reporting of information beyond the material safety data sheet data as described in 29 C.F.R. 1910.1200." This provision means that disclosure is limited to what is required on material safety data sheets (now called safety data sheets) on which chemical manufacturers list information about their chemicals to protect workers. Well operators are not responsible for compiling chemical information from manufacturers that is not disclosed on the sheets.[222] As several Harvard researchers reported in 2013, manufacturers can legally omit chemical information from the sheets. For example, if a chemical has not been tested and found to be hazardous, it does not need to be disclosed, even if tests would show that it is hazardous.[223] Therefore, the manufacturers could effectively withhold this information from public disclosure with or without trade secret protection.

Flaring near Chaco Culture National Historic Park, Dec. 2014. Photo credit: Jane Pargiter, EcoFlight.

Evidence suggests that chemical manufacturers do not always tell companies farther down the supply chain the full contents of the chemical products they are using; rather, they provide these companies with vague descriptions, generic chemical family names or, as the Harvard researchers suggested, Material Safety Data Sheets with an incomplete list of chemicals.[224] In such cases, the end users may legitimately be unable to disclose all the identities of chemicals – including PFAS – used at a particular well, whether under trade secret protection or not. They simply would not have the information. Requiring disclosure of oil and gas chemicals by chemical manufacturers would avoid this problem. Colorado took this step in its June 2022 legislation.[225]

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 following section, including a ban on the use of PFAS in oil and gas operations, an action that Colorado took in 2022.[226] 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.[227]

c. New Mexico Hazardous Waste Rules Also in Need of Reform

New Mexico'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. In 2021, Governor Michelle Lujan Grisham petitioned EPA to list the class of chemicals known as PFAS as hazardous under Subtitle C of the federal Resource Conservation and Recovery Act (RCRA) or, alternatively, "list individual PFAS chemicals under RCRA known to have harmful effects to humans and the environment."[228] Subtitle C of RCRA is our nation's law that requires safe management of hazardous waste from "cradle-to-grave."[229] Gov. Luhan Grisham emphasized how important this policy change would be for New Mexico, writing

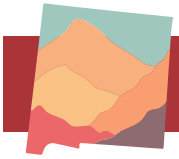
> I implore EPA to do what is immediately necessary to protect the people and environment of the United States from the real and potentially devastating effects of exposure to PFAS....Without a uniform regulatory process addressing PFAS from manufacture to disposal, states like New Mexico will be left attempting to use a patchwork of statutory and regulatory authorities that may or may not provide enough oversight...[230]

EPA administrator Michael Regan replied later in 2021 that the agency would initiate a rulemaking process to declare four types of PFAS to be hazardous under RCRA: PFOA, PFOS, PFBS, and GenX. He also said that EPA would initiate a rulemaking to "clarify that emerging contaminants such as PFAS can be addressed through RCRA corrective action."[231]

Yet under both the federal RCRA[232] and the state's implementation of the federal law,[233] oil and gas wastes are exempt from hazardous waste requirements. This exemption likely means that even if EPA acted on the governor's petition and declared PFAS hazardous, oil and gas wastes containing PFAS would not be subject to hazardous waste protections. New Mexico could act to avoid this problem and regulate oil and gas waste as hazardous by following the example of New York State. In 2020, New York enacted legislation to designate oil and gas waste as hazardous.[234] 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.[235]

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, these chemicals could be present in oil and gas wastes whether in New York, New Mexico, or other states. Continuing to exempt oil and gas wastes from hazardous waste treatment means that PFAS in these wastes would likely be exempt, too, with potentially serious consequences for New Mexicans.



RECOMMENDATIONS

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

- **Halt PFAS use in oil and gas extraction.** New Mexico should follow 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. Furthermore, New Mexico 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.

- **Expand public disclosure.** New Mexico should greatly expand its requirements for public disclosure of oil and gas chemicals. TThe 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, while still protecting chemical product formulas. New Mexico should also require disclosure on the part of chemical manufacturers and require chemical disclosure prior to permitting, as have California, West Virginia, and Wyoming.

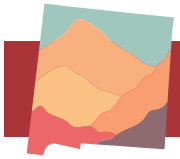
- **Increase testing and tracking.** New Mexico and/or the U.S. EPA should determine where PFAS have been used in oil and gas operations in the state and where related wastes have been deposited. They should test nearby residents, water, soil, flora, and fauna for PFAS, both for the particular type(s) of PFAS used and for organic fluorine to detect the presence of other PFAS. and/or their breakdown products. Testing equipment should be used that is 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 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 water cleanup is impossible, companies responsible for the use of PFAS should pay for alternative sources of water for household and agricultural uses, as needed.

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

- **Reform New Mexico'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, New Mexico should transition away from oil and gas production and move toward renewable energy and 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 New Mexicans 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

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

To identify where PFAS were used at oil and gas wells in New Mexico, PSR analyzed data from the state Oil Conservation Division that is part of the Energy, Minerals and Natural Resources Department. These data, based on reports from oil and gas well operators, show well-by-well which fracking chemicals were used.236 These data date from January 1, 2013 to early 2018, likely because a change in state rules in September 2017 required reporting to the FracFocus database rather than to the state.[237] PSR also relied on the well-by-well reports of fracking chemicals recorded in FracFocus, a database for the oil and gas industry[238] maintained by the Groundwater Protection Council,[239] a nonprofit comprised of regulators from state agencies. The dates of these records extend from January 1, 2013 to September 29, 2022. PSR consulted the open-source version of FracFocus, Open-FF,[240] which is more accurate and informative than the original version of FracFocus.[241]

Under current New Mexico law, operators must disclose the fracking chemicals used in each well to the FracFocus database using the "current edition of the hydraulic fluid product component information form published by FracFocus." Disclosure must occur within 45 days after hydraulic fracturing treatment.[242] 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.[243] New Mexico's prior fracking chemical disclosure rules required disclosure of similar information.[244] There are, however, significant exceptions to disclosure requirements under New Mexico's rules, including an exception for chemicals designated a trade secret[245] that are discussed in Chapter 3 and Chapter 7.

Table 6. Oil and Gas Companies that Fracked Wells in New Mexico Using Trade Secret Chemicals and Trade Secret Surfactants, 2013-2022.

Operator	Number of wells injected with trade secret chemicals	Number of wells injected with trade secret surfactants
EOG Resources, Inc.	1177	214
COG Operating LLC	844	438
Devon Energy Production Company L. P.	586	358
Mewbourne Oil Company	575	116
Occidental Oil and Gas	498	141
XTO Energy/ExxonMobil	442	203
Apache Corporation	439	386
Cimarex Energy Co.	336	186
Matador Production Company	288	63
Chevron USA Inc.	264	189
Hilcorp Energy Company	203	0
ConocoPhillips Company/Burlington Resources	161	112
WPX Energy	148	21
Kaiser-Francis Oil Company	131	67
Lime Rock Resources Ii-A, L.P.	129	91
BTA Oil Producers LLC	121	27
Marathon Oil	108	3
Mack Energy Corp	105	76
RKI Exploration & Production, LLC	100	55
Burnett Oil Co., Inc.	99	47
BOPCO, L.P.	86	64
Yates Petroleum Corporation	84	71
LRE Operating, LLC	82	64
Encana Oil & Gas (USA) Inc.	76	40
Tap Rock Resources	73	1
Centennial Resource Production, LLC	70	10
DJR Operating, LLC	70	63
Energen Resources Corporation	68	20
Advance Energy Partners Hat Mesa LLC	53	22
Murchison Oil & Gas Inc	47	44
Dugan Production Corp.	46	27
Novo Oil & Gas Texas, LLC	44	39
Logos Operating, LLC	42	21
Franklin Mountain Energy	39	0
Enduring Resources LLC	36	26
Vanguard Permian LLC	34	14
BP America Production Company	33	16
OXY USA WTP Limited Partnership	33	23

Table 6. Oil and Gas Companies that Fracked Wells in New Mexico Using Trade Secret Chemicals and Trade Secret Surfactants, 2013-2022.

Operator	Number of wells injected with trade secret chemicals	Number of wells injected with trade secret surfactants
Titus Oil & Gas Production, LLC	30	16
Caza Operating, LLC	23	13
Endurance Resources LLC	23	22
Chisholm Energy Operating, LLC	21	2
Legacy Reserves Operating LP	21	10
Ameredev Operations LLC	20	5
EnerVest, Ltd.	20	19
SM Energy	18	2
Colgate Operating, LLC	16	1
Gmt Exploration Company LLC	15	14
BreitBurn Operating LP	14	8
Burlington Resources Oil & Gas Company LP	14	14
Nearburg Producing Co	14	14
Longfellow Energy, LP	13	9
Redwood Operating LLC	13	4
Percussion Petroleum LLC	12	10
Steward Energy II, LLC	12	7
Fasken Oil & Ranch Ltd	11	10
Nadel and Gussman Permian, LLC	11	10
Read & Stevens, Inc.	10	10
Whiting Petroleum	10	3
Linn Operating, Inc.	9	2
Cross Timbers Energy, LLC	8	6
Pride Energy Company	8	8
Strata Production Co.	8	6
Chesapeake Operating, Inc.	7	7
Elm Ridge Exploration Company LLC	7	0
Forty Acres Energy LLC	7	6
Legend Natural Gas Iii Limited Partnership	7	1
McElvain Energy, Inc.	7	5
Regeneration Energy, Corp	7	6
Alamo Permian Resources, LLC	6	5
Manzano LLC	5	4
V-F Petroleum Inc	5	3
Atlas Energy, L.P.	4	0
Avant Operating, LLC	4	0
Capstone Natural Resources, LLC	4	4
Lynx Petroleum Consultants Inc	4	4

Table 6. Oil and Gas Companies that Fracked Wells in New Mexico Using Trade Secret Chemicals and Trade Secret Surfactants, 2013-2022.

Operator	Number of wells injected with trade secret chemicals	Number of wells injected with trade secret surfactants
Marshall & Winston Inc	4	4
Premier Oil & Gas Inc	4	4
Rockcliff Energy Operating	4	0
Special Energy Corporation	4	4
Hadaway Consulting and Engineering, LLC	3	3
Nemo Fund I, LLC	3	3
Stephens & Johnson Operating Co.	3	1
Sundown Energy LP	3	0
Catena Resources Operating, LLC	2	2
Foundation Energy Management, LLC	2	2
IACX Production	2	2
ICA Energy Operating LLC	2	0
Koch Exploration Company, LLC	2	2
Maverick Operating, LLC	2	2
Memorial Resource Development LLC	2	0
OneEnergy Partners Operating, LLC	2	0
Quantum Resources Management, LLC	2	2
Sg Interests I Ltd	2	2
SIMCOE LLC	2	0
Texland Petroleum, LP	2	2
Thompson Engr & Prod Corp	2	1
Amtex Energy Inc.	1	0
BAM Permian Operating, LLC	1	1
BC Operating, Inc.	1	1
Boaz Energy, LLC.	1	1
Chuza Oil Company	1	1
Clayton Williams Energy Inc.	1	0
CML Exploration, LLC	1	1
Cobra Oil & Gas Corporation	1	1
D J Simmons Inc	1	1
DGP Energy	1	0
Forge Energy, LLC	1	1
Harvey E Yates Co	1	1
HEXP Operating, LLC	1	1
Hunt Cimarron Limited Partnership	1	1
Huntington Energy, LLC	1	0
ImPetro Operating LLC	1	1
Mammoth Exploration, LLC	1	1

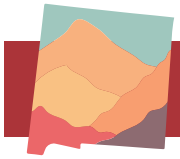
Table 6. Oil and Gas Companies that Fracked Wells in New Mexico Using Trade Secret Chemicals and Trade Secret Surfactants, 2013-2022.

Operator	Number of wells injected with trade secret chemicals	Number of wells injected with trade secret surfactants
Mar Oil & Gas Corp.	1	0
Merit Energy Company	1	1
Merrion Oil & Gas Corp	1	1
Ridgeway Arizona Oil Corp.	1	0
Robert L. Bayless, Producer LLC	1	1
Running Horse Production Company	1	0
San Juan Resources, Inc.	1	0
Seely Oil Co	1	1
Tacitus LLC	1	0
Western Refining Southwest, Inc.	1	0

This table shows the oil and gas companies that fracked oil and gas wells in New Mexico with trade secret chemicals and trade secret surfactants between January 1, 2013 and September 29, 2022. The wells injected with trade secret surfactants are a subset of the wells injected with trade secret chemicals.

*ND = No data available.

New Mexico must strengthen its protections from PFAS and other pollution related to oil and gas extraction to safeguard its land and people. View from Deep Access Cave, Carlsbad Caverns National Park, Sept. 2020. Photo credit: Dan Pawlak, National Park Service.



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methodology, we will use as an example the figures from XTO Energy/ExxonMobil's well number 35-019-26303 fractured in Carter County, Oklahoma in 2019. We estimated the total mass of the hydraulic fracking fluid used in each well in pounds by multiplying the gallons of water listed as being used as the base fluid for the fracking fluid (223,650 in this case) by 8.33, the number of pounds in a gallon of water as listed in a table of the weights of various solvents published by the U.S. Environmental Protection Agency. See U.S. Environmental Protection Agency. Conversion from Gallons to Pounds of Common Solvents. Accessed Jan. 12, 2022, at https://www.epa.gov/p2/pollution-prevention-tools-and-calculators. That quantity of water in the XTO Energy/ExxonMobil example weighs approximately 1,863,005 pounds. We then calculated the total mass of the fracking fluid by multiplying the mass of the water in pounds by 100 and dividing that product by the listed maximum percent concentration of water in the fracking fluid (78.31797). The estimated total maximum mass of the fracking fluid in the example is 2,378,770 pounds. Next, we multiplied the listed maximum concentration in percent by mass of the potential PFAS chemical in the fracking fluid (0.00074) by the total estimated mass of the fluid. The result was an estimated maximum of 17.6 pounds of potential PFAS used to fracture the well. PSR included in our analysis of trade secret chemicals those chemicals in Open-FF whose specific identities were explicitly labeled "proprietary," "trade secret," or "confidential business information" in place of a CAS number. PSR did not include as trade secrets additional unidentified chemicals for which the CAS number in Open-FF is blank.

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methodology, we will use as an example the figures from XTO Energy/ExxonMobil's well number 35-019-26303 fractured in Carter County, Oklahoma in 2019. We estimated the total mass of the fracking fluid used in each well in pounds by multiplying the gallons of water listed as being used as the base fluid for the fracking fluid (223,650 in this case) by 8.33, the number of pounds in a gallon of water as listed in a table of the weights of various solvents published by the U.S. Environmental Protection Agency. See U.S. Environmental Protection Agency. Conversion from Gallons to Pounds of Common Solvents. Accessed Sept. 9, 2022, at https://www.epa.gov/p2/pollution-prevention-tools-and-calculators. That quantity of water in the XTO Energy/ExxonMobil example weighs approximately 1,863,005 pounds. We then calculated the total mass of the fracking fluid by multiplying the mass of the water in pounds by 100 and dividing that product by the listed maximum percent concentration.

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