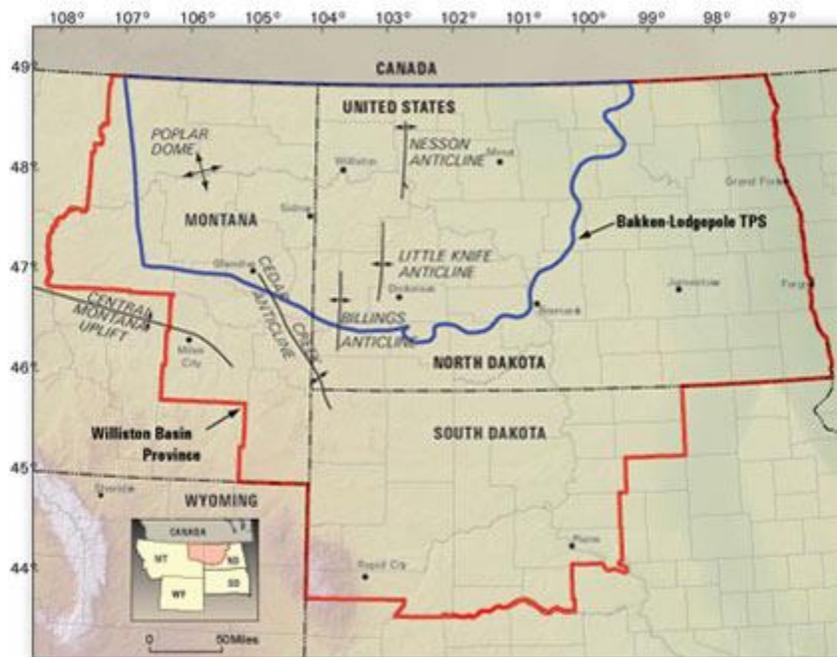


Potential Health and Environmental Effects of Hydrofracking in the Williston Basin, Montana

Author: Joe Hoffman

[How to Teach Controversial Topics »](#)

This case study is part of a collection of pages developed by students in the 2012 introductory-level Geology and Human Health course in the Department of Earth Sciences, Montana State University. [Learn more about this project.](#)



×

▶ [Show Caption](#)

▼ [Hide](#)

Map of the Williston Basin. USGS map, retrieved from <http://geology.com/usgs/bakken-formation-oil.shtml>

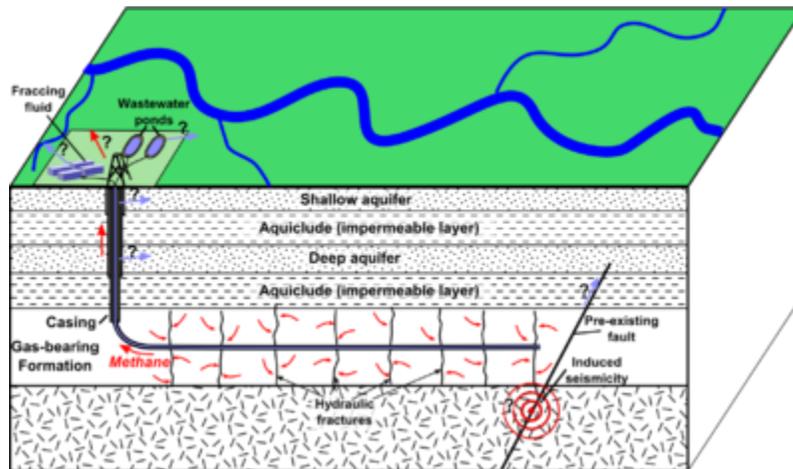
Hydrofracking is a controversial oil and gas extraction technique developed in the late 1940s to gain access to fossil energy deposits previously inaccessible to drilling operations. The process, "hydraulic fracturing", literally involves the smashing of rock with millions of gallons of water—along with sand and a undisclosed assortment of chemicals in order to bring gas to the surface.

The 2005 Energy Policy Act exempted fracking from the Safe Drinking Water Act—this regulatory exclusion is often referred to as the "[Halliburton Loophole.](#)"

Montana fracking is still in the early stages of development compared to other states and has been described by a Texas oil company as "[the best kept secret in oil and gas.](#)"

How Fracking Works

×



► [Show caption](#)

▼ [Hide](#)

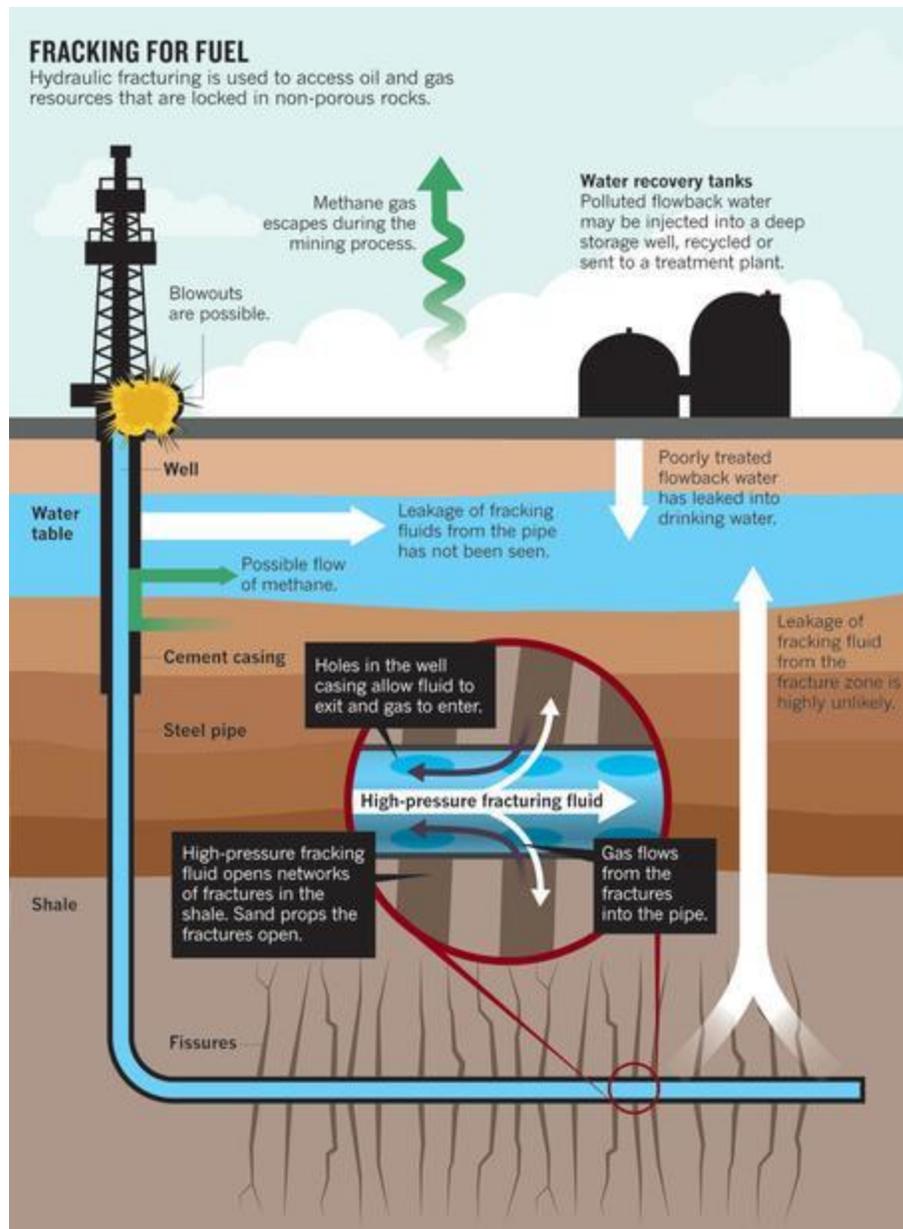
The Fracking Process. Illustration: Courtesy of Wikipedia / July 31, 2012.

http://en.wikipedia.org/wiki/Hydraulic_fracturing

Vertical well bores are drilled thousands of feet into the earth, through sediment layers, the water table, and shale rock formations in order to reach the oil and gas. The drilling is then angled horizontally, where a cement casing is installed and will serve as a conduit for the massive volume of water, fracking fluid, chemicals and sand needed to fracture the rock and shale. In some cases, prior to the injection of fluids, small explosives are used to open up the bedrock. The fractures allow the gas and oil to be removed from the formerly impervious rock formations.

Although fracking has technically been in existence for decades, the scale and type of drilling now taking place, deep fracking, is a new form of drilling and was first used in the Barnett shale of Texas in 1999.

Risks and Concerns of Fracking



×

► [Show Caption](#)

▼ [Hide](#)

Fracking infrastructure. Illustration from article in *Nature*, Sept. 15, 2011, Natural Gas: Should fracking stop?, by Robert W. Howarth, Anthony Ingraffea, & Terry Engelder.

http://www.nature.com/nature/journal/v477/n7364/fig_tab/477271a_F1.html

- Contamination of groundwater
- Methane pollution and its impact on climate change
- Air pollution impacts
- Exposure to toxic chemicals
- Blowouts due to gas explosion

- Waste disposal
- Large volume water use in water-deficient regions
- Fracking-induced earthquakes
- Workplace safety
- Infrastructure degradation

Source of Fracking Contamination

Due to the multitude of potential health and environmental impacts of hydrofracking source contamination can be complicated. The well location where drilling takes place is only one piece of the frack puzzle. Since each well can require up to 8 million gallons of water, and up to 40,000 gallons of chemicals, a well site may need up [to 2000 tanker truck trips](#), per frack. A well can be fracked up to 20 times.

Storage for the waste water can take place either on site, in an injection well, or in open air ponds in the surrounding areas. Transport of the waste poses a contamination risk outside the actual well location. Air pollution also extends beyond the immediate drilling site and transportation route, since a by-product of natural gas drilling is methane gas, one of the worst greenhouse gas pollutants contributing to climate change.

Impacts of Fracking

Air Pollution

×



Natural gas flares from a flare-head at the Orvis State well on the Evanson family farm in McKenzie County, North Dakota, east of Arnegard and west of Watford City. ©

Methane is a main component of natural gas and is 25 times more potent in trapping heat in the atmosphere than carbon dioxide. A recent study by the National Oceanic and Atmospheric Administration (NOAA) monitoring gas wells in Weld County, Colorado, estimated that 4 percent of the methane produced by these wells is escaping into the atmosphere. NOAA scientists found the Weld County gas wells to be equal to the carbon emissions of 1-3 million cars.

A number of other air contaminants are released through the various drilling procedures, including construction and operation of the well site, transport of the materials and equipment, and disposal of the waste. Some of the pollutants released by drilling include: benzene, toluene, xylene and ethyl benzene (BTEX), particulate matter and dust, ground level ozone, or smog, nitrogen oxides, carbon monoxide, formaldehyde and metals contained in diesel fuel combustion—with exposure to these pollutants known to cause short-term illness, cancer, organ damage, nervous system disorders and birth defects or even death .

The Associated press recently reported that [Wyoming's air quality near rural drilling sites is worse than Los Angeles'](#)—with Wyoming ozone levels recorded at 124 parts per billion compared to the worst air day of the year for Los Angeles, at 114 parts per billion. The Environmental Protection Agency's maximum healthy limit is 75 parts per billion.



×

Oblique low-altitude aerial photo of wellpads, access roads, pipeline corridors and other natural-gas infrastructure in the Jonah Field of western Wyoming's upper Green River valley 

A 2007 report prepared for the Western Governor's Association, that inventoried present and future nitrogen oxide and sulfur dioxide emissions from oil and gas drilling in the west, projects Montana to experience a [310% increase in nitrogen oxide pollution](#) (smog).

Crystalline silica, in the form of sand, can cause silicosis (an incurable but preventable lung disease) when inhaled by workers. Sand is a main ingredient used in the fracking process. The National Institute for Occupational Safety (NIOSH) [collected air samples from 11 fracking sites](#) around the country. All 11 sites exceeded relevant occupational health criteria for exposure to respirable crystalline silica. In 31% of the samples, silica concentrations exceeded the NIOSH exposure limit by a factor of 10, which means that even if workers were wearing proper respiratory equipment, they would not be adequately protected.

Water Pollution:



×

▶ [Show caption](#)

▼ [Hide](#)

Waste water storage pond. Photo Image: NETL.gov, from Oct. 21, 2011 article in Scientific American, EPA Plans to Issue Rules for Fracking Wastewater, by Nicholas Kusnetz and Pro Publica. <http://www.scientificamerican.com/article.cfm?id=epa-plans-issue-rules-fracking-wastewater>

Chemical additives are used in the drilling mud, slurries and fluids required for the fracking process. Each well produces millions of gallons of toxic fluid containing not only the added chemicals, but other naturally occurring radioactive material, liquid hydrocarbons, brine water and heavy metals. Fissures created by the fracking process can also create underground pathways for gases, chemicals and radioactive material.

The Environmental Protection Agency ([EPA](#)) and United States Geological Survey ([USGS](#)) have recently confirmed what residents of Pavillion, Wyoming had been claiming—that hydrofracking had contaminated their groundwater.

The Environmental Protection Agency (EPA) initially under an [emergency administrative order](#) forced three oil production companies operating on the Fort Peck Reservation, to reimburse the city of Poplar, MT for water infrastructure expenditures incurred as a result of drilling

contamination. The oil companies appealed the EPA order, but were forced to rectify their violations by a federal judge.

Another scenario for contamination to occur is by faulty design or construction of the cement well casings—something that happened in the BP Gulf blowout disaster. Storage of the waste water is currently under the regulatory jurisdiction of states, many of whom have weak to nonexistent policies protecting the environment.

Soil and Oil Spill Contamination:



×

Resident Canada geese inhabit impacted portion of Yellowstone River July 9, 2011. [i](#)

According to journalists at [Pro Publica](#), oil companies reported over 1,000 oil spills in North Dakota, 2011, with many more going unreported, state officials admit. The Associated Press also recently reported that the amount of chemically tainted soil from [drilling waste increased nearly 5,100 percent](#) over the past decade, to more than 512,000 tons last year. Steve Tillotson, assistant director of the North Dakota Health Department's waste management division, told reporters that trucks are hauling oilfield waste to facilities "24 hours a day, seven days a week."

An [ExxonMobil pipeline rupture spilled 42,000 gallons of oil into the Yellowstone River](#), near Billings, MT. In the aftermath of the spill, ExxonMobil has disclosed that the [pipeline has been transporting tar sands oil](#) from Alberta, Canada, which is a low grade, more toxic and corrosive type of oil. Regulators had not been informed that the pipeline was carrying tar sands oil and the disclosure was a result of the spill. Tar sands oil was not in the pipeline at the time of the spill, though regulators are investigating whether or not it played a role in causing the pipeline to corrode.

Earthquakes

Earthquakes constitute another problem associated with deep-well oil and gas drilling. Scientists refer to the earthquakes caused by the injection of fracking wastewater underground as "[induced seismic events](#)." Although most of the earthquakes are small in magnitude (the strongest measured 5.2), their relationship with the storage of millions of gallons of toxic wastewater does little to ease the fears over fossil energy's long list of externalities.

Health Effects of Fracking:

A 2011 article in the journal, *Human and Ecological Risk Assessment*, examined the [potential health impacts of oil and gas drilling](#) in relation to the chemicals used during drilling, fracking, processing, and delivery of natural gas. The paper compiled a list of 632 chemicals (an incomplete list due to trade secrecy exemptions) identified from drilling operations throughout the U.S. Their research found that 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40–50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations.

Health impacts from fracking are only now being examined by health experts, since such large-scale drilling is a recent phenomenon. Exposure to toxic chemicals even at low levels can cause tremendous harm to humans; the endocrine system is sensitive to chemical exposures measuring in parts-per-billion, or less. Nevertheless, many of the health risks from the toxins used during the fracking process do not express themselves immediately, and require studies looking into long-term health effects.

Despite the complexities of the on-site mixtures of chemicals and their specific contributions to health and environmental problems involved in fracking—conventional drilling practices are more old school and do have known health consequences. Researchers at the [Colorado School of Public Health, University of Colorado](#), analyzed existing research of exposure to conventional petroleum hydrocarbons in occupational settings, and residences near refineries, in conjunction with known pollutants associated with fracking (nonconventional), in order to assess health risks to those residents living near fracking operations. Their basic conclusions were: the closer you live to drilling operations, the greater your health risk. Sounds obvious, but if you were to sue an oil company for the suspected killing a loved one via cancer, you would need a little more legal ammunition than "it just makes common sense" against an army of corporate lawyers.

Although the Centers for Disease Control and Prevention (CDC) has yet to investigate the potential impacts of fracking, the director of CDC's National Center for Environmental Health and the agency for Toxic Substances and Disease Registry, Christopher J. Portier, PhD, has [called for health studies to be published](#).

A 2012 paper was published in the journal, *Environmental Health Perspectives*, examining the composition of state and federal advisory committees tasked to consider the potential environmental and health effects of fracking in the Marcellus shale region. The researchers found that there was [not one health expert](#) among the 52 people comprising the various state and federal commissions and boards, even though public health was specified in the executive orders creating the committees.

Prevention or Mitigation

While many state agencies function more as facilitators of fossil energy development than regulators, federal guardians of public health are also vulnerable to 'getting into bed' with big business, literally. One need only recall the former federal agency in charge of collecting oil and gas royalties on public lands, the Minerals Management Service. Employees from the Bush administration working for that regulatory agency were [caught using cocaine and marijuana, and had sexual relations with oil and gas company representatives.](#)

Many people concerned by nonconventional oil and gas drilling would prefer the US adopt the so-called precautionary principle, which places the burden of proof on industries implementing new technologies and introducing new chemicals into our neighborhoods and environment. If your actions do not poison the water, accelerate climate change, cause cancer to those living near drilling and refineries, etc.—prove it. Current policy inverts such logic, instead forcing the victim (or their surviving relatives) to get into a legal fight with some of the richest and most politically powerful companies.

At a minimum, more stringent regulations should be passed at the national level, including repeal of oil and gas exemptions from the Safe Drinking Water Act. Violators of clean water and air laws should be prohibited from obtaining federal and state land drilling leases. Flaring of natural gas should be more strictly regulated. If a carbon tax were to be passed, energy companies would no longer get away with passing their so-called externalities (pollution) on to the community, tax payer, or environment.

Another approach would be the adoption of a legitimate national energy policy that is comprehensive in scope and science-based, as opposed to the current singular focus on short-term profits. Something more in line with what is occurring in Germany—where they have increased clean energy use from 6% in 2002, to 26% in 2012. A clean energy policy propelled by sophisticated technologies that require skilled workers could replace the third world fossil energy model en vogue these days. The specter of climate change makes the accelerated pursuit of carbon based fuel an irrational policy predicted to be far more expensive than the initial costs required to switch to clean energy technologies.

Recommended Readings

Bamberger, M., Oswald, R. (2012). [Impacts of Gas Drilling on Animal and Human Health.](#) *New Solutions: A Journal of Environmental and Occupational Health*, 22(1): 51-77.

The researchers conducted interviews with animal owners in six states—Colorado, Louisiana, New York, Ohio, Pennsylvania, and Texas—affected by gas drilling. They also interviewed the owners' veterinarians, and examined the results of water, soil, and air testing as well as the results of laboratory tests on affected animals and their owners. The study highlights the possible links between gas drilling and negative health effects, along with the difficulties associated with conducting careful studies of such a link.

Colborn T, Kwiatkowski C, Schultz K, Bachran M. 2012. [Natural Gas Operations from a Public Health Perspective](#), *Human and Ecological Risk Assessment: an International Journal* 17(5):1039-1056.

The authors examined the chemicals known to be used in natural gas fracking procedures. Researchers were able to compile a list of 632 chemicals, though this list is incomplete due to trade secret exemptions given to the energy companies by Congressional allies. Many of the chemicals are toxic and represent the 'bad boys' of health concerns—causing everything from skin and eye irritation to cancer and mutations. They also highlight the "side effect" of air pollution and the resulting irreversible damage to lung tissue, along with damage to vegetation in the surrounding area.

Finewood, M. H. and Stroup, L. J. (2012), Fracking and the Neoliberalization of the Hydro-Social Cycle in Pennsylvania's Marcellus Shale. *Journal of Contemporary Water Research & Education*, 147: 72–79. doi: 10.1111/j.1936-704X.2012.03104.x

This article paper discusses how institutional forces from the energy industry, the media, and government obfuscate the impacts of fracking on communities and the environment. The narrative framing of natural gas as a 'green energy', or the fetishism of 'national energy independence' legitimizes and normalizes the harm to local water resources and local communities. Impacts to local health and ecology are pitted against the national agenda to retain dependence on fossil energy.

Horton, S. Disposal of hydrofracking waste fluid by injection into subsurface aquifers triggers earthquake swarm in central Arkansas with potential for damaging earthquake *Seismological Research Letters* (April 2012), 83(2):250-260 *Environ Health Perspect* 120(4). <http://dx.doi.org/10.1289/ehp.1104594>

This paper discusses waste fluid induced earthquakes related to fracking in Arkansas. The authors propose careful geologic study of those areas where wastewater injection occurs, since it is believed by geologists that the millions of gallons of fluids forced underground at high pressure can trigger earthquakes.

Howarth RW et al (2011). Methane and greenhouse-gas footprint of natural gas from shale formations. *Climatic Change Letters*. DOI 10.1007/s10584-011-0061-5

The greenhouse gas footprint is now known to have been significantly underestimated. This research assesses the role of methane being released by natural gas wells and its impact on climate change. Although natural gas was thought to be a cleaner form of energy than coal and oil, its relationship with methane actually makes it dirtier than the other two, in regards to their impact on climate change.

McKenzie L, Witter RZ, Newman LS, Adgate JL, 2012, [Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources](#), *Science of the Total Environment*, 424:79-87.

Researchers from the Colorado School of Public Health used EPA guidance to estimate chronic and subchronic non-cancer hazard indices and cancer risks from exposure to hydrocarbons for two populations: (1) residents living > ½ mile from wells and (2) residents living ≤ ½ mile from wells. Risks were higher for those living less than a 1/2 mile from wells than those living further from drilling sites.

Stephen G. Osborn, Avner Vengosh, Nathaniel R. Warner, and Robert B. Jackson
Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing PNAS 2011 108: 8172-8176.

Scientists found methane contamination of drinking water associated with shale-gas extraction. Average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well. Researchers also found a potential explosion hazard with the related concentrations of methane.

Related Links

To view [oil and natural gas air pollution standards](#) from the EPA.

Worker [Exposure to Silica during Hydraulic Fracturing](#), NIOSH, OSHA.

For a pro-fracking–*Fracking is crucial to global economic stability; the economic benefits outweigh the environmental risks, says Terry Engelder* vs. not-very-pro-fracking–*Natural gas extracted from shale comes at too great a cost to the environment, say Robert W. Howarth and Anthony Ingraffea*, [visit the site posted by Nature](#).

To view and in-depth analysis of the [concerns about fracking](#). This site is run by DeSmogBlog, whose work is covered by *The New York Times*, *The UK Guardian*, *BBC*, *The Globe and Mail*, *Associated Press* and *CBC*.

A website run by scientists concerned about the [health and environmental impacts of low-dose exposures to chemicals](#).

Environment Texas, a statewide, citizen-based environmental advocacy organization, released a September 20, 2012 report documenting [the cost of fracking](#) not figured into our utility bills. One example from the report states that the truck traffic to just one well site causes as much damage to roads as 3.5 million cars.