FRACKING IN MONTANA: ASKING QUESTIONS, FINDING ANSWERS

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Introduction

High Volume Hydraulic Fracturing, commonly known as fracking,[1] is a complex, expensive mining process, relatively mysterious to all but a few who are closely involved with it. The risks and benefits of fracking are potentially significant -- to the oil and gas industry, to Montana consumers, and to Montana landowners.

When 16 national stakeholders from energy companies, academia, state and federal agencies, and environmental organizations were surveyed about fracking in 2012, their top concerns were:

1) Water quantity or availability;
2) Truck traffic;
3) Surface spills and leaks; and
4) Air pollution.[2]

Research on the environmental and health impacts of fracking substantiates these concerns.[3] Potential risks of fracking and the disposal of fracking byproducts include earthquakes and adverse impacts on water, air, agriculture, public health and safety, property values, climate stability, and economic vitality.[4] Potential benefits include economic development, reduction in the use of "dirtier" fuels such as coal, and progress toward independence from foreign fuels.[5] The state of New York, with a wealth of gas that could be developed through fracking, has refused to give industry the go-ahead.[6]

Nineteen peer-reviewed studies on fracking's impacts were published in 2014. In the first six months of 2015 alone, 103 studies were published, the "vast majority of [which] reveal problems."[7] Several governmental reports on the impacts of fracking were issued in 2014-

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[1] You sometimes see this spelled "fracing" or "fraccing." We use "fracking" because it has become the most commonly used spelling over the past few years.
[2] Heather Cooley and Kristina Donnelly, "Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction," Pacific Institute (June 2012), http://pacinst.org/pacinst/wp-content/uploads/sites/21/2013/02/full_report5.pdf.
[3] Concerned Health Professionals of New York & Physicians for Social Responsibility, *Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction)* (3rd ed.) (Oct. 14, 2015), http://concernedhealthny.org/wp-content/uploads/2012/11/PSR-CHPNY-Compendium-3.0.pdf.
[4] *Id.* at 4.
[5] USA Today Editorial Board, *Fracking, with care, brings big benefits*, (July 5, 2015), http://www.usatoday.com/story/opinion/2015/07/05/fracking-oil-gas-hydraulic-fracturing-epa-editorials-debates/29120887/.
[6] Timothy Cama, *New York makes fracking ban official*, The Hill (June 29, 2015), http://thehill.com/policy/energy-environment/246479-new-york-makes-fracking-ban-official.
[7] Concerned Health Professionals of New York & Physicians for Social Responsibility, *Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction)* 3 (3rd ed.) (Oct. 14, 2015) ("as demonstrated by PSE's statistical analysis, 69 percent of original research studies on water quality found potential for, or actual evidence of, water contamination; 88 percent of original research studies on air quality found elevated air pollutant emissions; and 84 percent of original research studies on human health risks found signs of harm or indication of potential harm"), http://concernedhealthny.org/wp-content/uploads/2012/11/PSR-CHPNY-Compendium-3.0.pdf.

2015, including one from the U.S. Environmental Protection Agency (EPA) on water,[8] two from California examining a wide array of impacts,[9] and one from New York.[10] EPA's report found no "widespread, systemic impacts on drinking water resources in the United States" from fracking.[11]

Movies such as "Gasland" and "Split Estates" illustrate the negative impacts. Images such as the rancher setting methane-tainted water from his kitchen faucet on fire have become part of the collective conversation. Charges that the U.S. Environmental Protection Agency (EPA) scuttled studies of contamination in Wyoming by passing responsibility to an industry-dominated state agency have fueled the controversy.

For years, virtually every public figure who has addressed impacts on water quality and the disposal of fracking fluids has made an identical statement: "There has never been a single example of a water well that was contaminated by fracking." A growing number of sources are challenging that statement, leading people to wonder:

- How much water is used in the fracking process? Where is the water coming from? Can the water be reused after it has been used for fracking?
- Does the disposal of fracking fluids in deep disposal wells lubricate faults and cause or contribute to earthquakes in certain areas of the country?
- What substances are in the complex chemical cocktail being mixed on-site as fracking fluid, and why are drilling companies insisting that some of the ingredients be labeled a "trade secret"?
- Is chemically tainted fracking fluid returning to groundwater?
- Can regulation of this industry keep up with its growth?
- What are the impacts of fracking in times of increasing drought?

The goal of this paper is to discuss potential impacts of fracking – impacts that may affect all Montanans, not just those who live in Sidney and Glendive. We hope to encourage clear, evidence-based thinking about fracking's potential impacts on water quantity, water quality, economic development, and more.

We don't know all of the answers at this point, but we believe now – rather than later – is the time to ask hard questions. Now is the time to figure out what we do and don't know. Now is

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[8] U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources,* ES-5, ES-23 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

[9] A. Brandt, et al., *Air quality impacts from well stimulation*, California Council on Science and Technology, An Independent Scientific Assessment of Well Stimulation in California (July 9, 2015), http://ccst.us/publications/2015/vol-II-chapter-3.pdf; California Dept. of Conservation, Div. of Oil, Gas, and Geothermal Resources, *Analysis of Oil and Gas Well Stimulation Treatments in California* (vol. II) (July 1, 2015), http://www.conservation.ca.gov/dog/SB4DEIR/Pages/SB4_DEIR_TOC.aspx.

[10] New York State Dept. of Health, *A Public Health Review of High Volume Fracturing for Shale Gas Development* (Dec. 2014), http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf.

[11] U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources,* ES-23 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

the time to begin to make informed decisions that take into account the risks of fracking as well as its benefits, and take whatever steps are necessary to protect Montana water, and thereby protect Montana landowners, farmers, and ranchers.

The Authors

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Hertha is a Montana native, having grown up on ranches around Browning and Lewistown. Hertha attended Montana State University before transferring to Temple University, where she graduated with a degree in journalism. She covered policy issues in Washington, D.C. for the American Farm Bureau Federation before returning to Montana for law school, where she graduated in 1995.

Hertha has been defending landowners' property rights in the West for over 20 years, specializing in property rights litigation, eminent domain, water rights, and other general litigation. She is the founding partner of Lund Law, PLLC, in Bozeman.

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Willis earned a bachelor's degree in engineering geology from Brigham Young University, and a Ph.D. in mathematical geology from the University of Wyoming. He is a professor of engineering at Carroll College in Helena, Montana, where he has taught for eight years. Before that, he was a professor of geological engineering at Montana Tech in Butte for 20 years. He worked in industry for five years prior to his graduate studies. He has written two books on field hydrogeology and authored many peer-reviewed articles.

Willis has been the president of his own consulting company since 1989, solving hydrogeology, groundwater modeling, and engineering problems for his clients. He loves Montana and enjoys fly-fishing, hiking, snowboarding, photography, hunting, and camping.

Dennis Lopach, J.D.

Dennis was born in Great Falls and attended the University of Montana, where he earned degrees in history and law. Dennis has spent most of his career in Montana, after working for about 10 years in Denver and Atlanta. Most of Dennis' career has been spent working for regulatory agencies or with regulated industries, including electricity, natural gas, telecommunications, water and motor carriers. He was chief legal counsel for the Montana Public Service Commission for two years. Dennis is currently in private practice in Helena, and has lobbied extensively for clients and citizen groups on various issues related to energy development.

What Can You Learn From Reading This Paper?

If you live in Montana but far away from the Bakken, you can:

- Learn how fracking may affect water availability in Montana.
- Learn how fracking may affect air and water quality in Montana.
- Understand the short- and long-term economic impacts of fracking throughout Montana.
- Better understand how Montana regulates fracking.
- Learn how and why other states have attempted to control fracking.

If you live near fracking wells but do not have drilling taking place on your land, you can:

- Learn how fracking may impact water availability in your watershed.
- Learn how fracking may affect air and water quality in your community.
- Understand the short- and long-term economic impacts of fracking on your community.

If you are a landowner in eastern Montana and your land may (or does) have oil and gas underneath, you can:

- Learn about "split estates," where one person owns the surface of the land and another owns the rights to the minerals underneath.
  - Many landowners in eastern Montana do not own the mineral rights underneath their land.
- Prepare to negotiate a lease or royalty agreement.
  - Understand the scope of surface rights that accompany mineral rights.
  - Obtain baseline information about your property to document any damage done by drilling, producing, and/or waste disposal.
- Understand how fracking may affect your water rights.
- Understand how much land reclamation you can expect and/or demand from the developer.
- Determine what governmental bodies regulate fracking.

If you are a public official or policy maker in Montana, you can:

- Learn about the positive and negative impacts fracking may have on:
  - Water quantity and availability
  - Water quality
  - Air quality
  - State and local economies
    - Infrastructure
    - Schools
    - Crime
    - Local services
- Decide whether additional legislation or regulations might help protect Montana landowners and Montana resources.

Fracking: What Is It?

High Volume Hydraulic Fracturing (HVHF), or *fracking*, is a process designed to release oil and gas that is trapped inside bedrock. Fracking involves excavating the surface, drilling vertically and then horizontally deep underground, and injecting high-pressure fluid into rock.[12] The injected fluid fractures the rock, which releases water, oil, and gas that were contained in the rock. The oil, gas, and water come to the surface, where the oil is separated, the natural gas is captured or flared off, and the water -- "produced water" that is very salty from minerals in the rock, oil, and gas, plus some of the water that was injected as fracking fluid -- must be stored and then disposed.

A hydraulic fracturing operation drill pad in the Marcellus Shale gas play of southwestern Pennsylvania. Pumps, diesel engines, water trucks, sand mixers and plumbing fixtures are all in place. Image by Doug Duncan, USGS.

Oil and gas development occurs in "plays," which are defined as oil and/or gas accumulations that share similar geologic, geographic, and temporal properties, such as source rock, migration pathways, timing, trapping mechanism, and hydrocarbon type.[13]
Once a surface location has been identified, a drill pad is cleared and leveled. Roads may be constructed to reach the site. The leveled area must accommodate a large number of water trucks, tankers and other vehicles, in addition to the drill rig. It's a busy place.

A drill rig is set up, and a large pit is excavated for drilling fluids and drill cuttings.

[12] *See generally* U.S. EPA, *The Process of Hydraulic Fracturing*, http://www2.epa.gov/hydraulicfracturing/process-hydraulic-fracturing.
[13] D. L. Gautier et al., *1995 National Assessment of Oil and Gas Resources*, U.S. Geological Survey Digital Data Series DDS-30, Release 2, one CD-ROM, http://greenwood.cr.usgs.gov/energy/PubsPgs/DDS-30.html.

Approximately 60,000-650,000 gallons of water are used to control drill cuttings and lubricate the bit.[14]

A large-diameter preliminary surface casing is used to case-off the upper shallow groundwater section. For example, a 20- to 24-inch diameter casing may extend from the surface down to a depth of several hundred feet, and is then cemented into place. Casings are added in a "telescoped" manner, with successively smaller casing diameters (e.g., 9 5/8" down to 5 ½" diameter are used). The smaller casings are designed to seal off other shallow oil, gas or brine zones. They too are cemented into place.[15]

Fracking in Montana: The Bakken Formation

Drill bits used in the oil and gas industry. Exhibit at the Kern County Museum, Bakersfield Calif. A 5-year-old girl stands next to a 24-inch bit for scale.

The vast majority of fracking wells are in eastern Montana, in the area known as the Bakken Oil Field. The Bakken Formation is late Devonian to Mississippian in age. It lies over the Devonian Three Forks Formation, and under the Lodgepole Formation, which is the lower member of the Madison Formation. The Madison aquifer is an important source of potable water for many parts of Montana.

The Bakken Formation consists of an upper shale member (5-15 feet thick), a middle sandstone member (a well-known source rock for oil, about 50 feet thick in Montana), and a lower shaley-siltstone member (about 15 feet thick).[16]

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[14] David R. Stewart, *Analytical Testing for Hydraulic Fracturing Fluids—Water Recovery and Reuse*, EPA Workshop for Analytical Chemistry (Feb. 2013).
[15] *Process of Fracking*, Shalestuff.com, http://shalestuff.com/education/fracking/fracking.
[16] Julie A. LeFever, U.S. Geological Survey, *Montana-North Dakota? Middle Member Bakken Play* (undated), www.dmr.nd.gov/ndgs/bakken/Papers/HW%20Bakken%20Paper.pdf.

In eastern Montana, vertical wells are drilled to depths of 10,000 - 11,000 feet below the surface to reach the target layer known as the Bakken Formation.[17] Once vertical drilling reaches within a few hundred feet of the target zone there is a "kick-off" point where the drilling becomes curved and finally horizontal. A specialized motor is added to the drilling assembly, which turns the drilling process through the curve to horizontal for a distance up to about 10,000 feet. Additional steel casing is inserted into the length of the horizontal hole and cemented into place. A perforating assembly is inserted at the end of the drill hole, and the first of several intervals are perforated by explosive charges to create openings in the casing that extend into the formation.[18]

Fracking fluid – a combination of water and proppants (98.5%-99.5%) and chemicals (.5%-1.5%) -- is then injected into the rock at a pressure that exceeds the tensile strength of the rock formation. Best management practices require that the fracking zone be secluded by using a packer, so that the intense fluid pressures are isolated within the targeted fracturing area. When packer isolation is not used, the entire length of the borehole is exposed to these pressures, causing the pipe to expand. The cement surrounding the casing cannot expand and breaks up, after which it cannot provide a protective seal.[19] This provides a pathway for fugitive gas to migrate up the borehole and potentially cause water or air quality problems. Packer isolation is therefore an essential component of protecting air quality.

When the fluid injected rock begins to fracture at depths of 10,000-11,000 feet the fractures form vertically, or perpendicular to the casing.[20]

About 98.5%- 99.5% of fracking fluid is water and proppant, which is a combination of silica sand and/or ceramic beads that hold open the newly created fractures so that oil and gas can flow into the well. Fluid additives such as guar gum are used to mobilize the proppant to the end of the fracture zone.[21] Fracking proponents describe the amount of chemicals used in fracking fluid as a tiny percentage of the total fluid rather than the total amount used. They point out that many of the chemicals used in fracking fluid are also used in cosmetics, housecleaning products, and even food. Some of the chemicals are known carcinogens, such as benzene, and housecleaning products are not generally safe to drink.

A plug is normally placed to seal off the first prepared interval at the end of the horizontal portion of the well. After the fracking fluids have been injected, the perforate-inject-plug cycle is repeated successively for the entire horizontal section of the well. Once this is complete, the plugs are drilled out and removed so that the oil, gas, and water mixtures can flow into the well and up to the surface. The initial drilling and fracking process is usually accomplished in two to three months.

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[17] Leigh C. Price & Julie A. LeFever, *Does Bakken Horizontal Drilling Imply a Huge Oil-Resource Base in Fractured Shales?,* Geological Studies Relevant to Horizontal Drilling in Western North America 199 (1992), http://www.undeerc.org/News-Publications/Leigh-Price-Paper/pdf/Price-LefeverPaper.pdf.

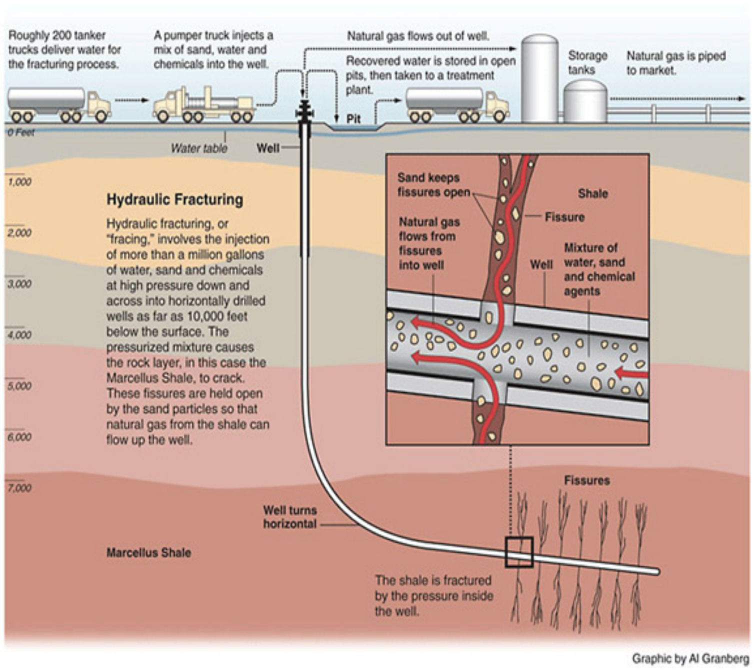
[18] *Process of Fracking*, Shalestuff.com, http://shalestuff.com/education/fracking/fracking.

[19] Erik B. Nelson & Dominique Guillot (eds.), *Well Cementing* (Schlumberger 2006), http://www.slb.com/resources/publications/books/well_cementing.aspx.

[20] *Hydraulic Fracturing: The Process*, FracFocus.org (undated), https://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process.

[21] David R. Stewart, *Analytical Testing for Hydraulic Fracturing Fluids—Water Recovery and Reuse*, EPA Workshop for Analytical Chemistry (Feb. 2013).

Diagram of a Fracking Operation[22]



Produced Water: Not the Same as Fracking Fluid

Two to eight million gallons of water may be injected into bedrock as fracking fluid.[23] It is important to distinguish between "produced water," which is existing water released from the rock formation after it has been fractured, and "fracking fluids," which are injected into the ground at very high pressures to fracture the rock and release the oil and natural gas trapped inside. Both produced water and fracking fluid eventually return to the surface. Produced water is highly mineralized from having been part of deep rock formations for thousands of years, while fracking fluids are mostly water with varying degrees of chemical additives.

- **Produced water** was trapped within bedrock and is released with the oil and/or gas during the fracking process.
- Hydraulic fracturing **flowback water** is the **fracking fluid** originally injected into bedrock after it returns to the surface with the oil and gas. It may contain radioactive material.[24]
  - Flowback water normally will return 50%-80% of the water originally used in the hydraulic fracturing process over a 60-90 day period.
  - Produced water will follow flowback water after the initial 60-90 day period.
- Thus, if 5 million gallons of water are used in fracking, 2.5-4 million gallons will return to the surface as flowback water over 2-3 months.[25]

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[22] *Process of Fracking*, Shalestuff.com, http://shalestuff.com/education/fracking/fracking.
[23] Matthew E. Mantell, *Produced Water Reuse and Recycling Challenges and Opportunities Across Major Shale Plays*, Chesapeake Energy Corporation (Mar. 29, 2011).
[24] Marc Lallanilla, *Facts About Fracking*, LiveScience (Jan. 23, 2015), http://www.livescience.com/34464-what-is-fracking.html.
[25] This explanation of the two types of water was offered at a National EPA Workshop for Analytic Chemistry. David R. Stewart, *Analytical Testing for Hydraulic Fracturing Fluids—Water Recovery and Reuse*, EPA Workshop for Analytical Chemistry (Feb. 2013).

Who Regulates Fracking?

The oil and gas industry has long been part of Montana's economy. The Montana Legislature created the Board of Oil and Gas Conservation (BOGC) in 1953 with the mission of regulating oil and gas exploration and development in Montana.[26] The term "conservation" in the board's title refers to conservation of oil and gas—i.e., bringing as much product as possible to the surface so that it can be used, not wasted.

The board regulates the industry through:

1. Issuing drilling permits – in 2010, 330 permits were issued
2. Classifying wells
3. Establishing well spacing units and reservoir pooling orders
4. Inspecting oil and gas operations – in 2010, 4,430 inspections were conducted
5. Investigating complaints
6. Performing engineering studies
7. Implementing the tax incentive program for specific projects
8. Operating the underground injection control program
9. Overseeing orphan well plugging
10. Collecting and maintaining well data and production information

The board and staff oversee more than 43,000 wells, of which 17,600 are active.[27] BOGC is administratively attached to the Department of Natural Resources and Conservation (DNRC). The seven board members are appointed by the governor, and must consist of three industry representatives, one landowner from an oil-and-gas-producing county who owns the mineral rights, and one landowner who does not, and two members of the public, one of whom must be an attorney. Board members are appointed to four-year terms, and meet six times a year, usually in Billings. BOGC has a field office in Shelby, administrative headquarters in Helena, and additional field staff in Plentywood, Sidney, Glendive and Roundup.[28]

The board is authorized to employ 21.5 full-time employees (FTEs).[29] In 2011, at the time of the legislative audit, the board employed 16 FTEs, including a petroleum engineer, an underground injection well coordinator, field inspectors, administrative assistants, and board support staff.[30] The board also adopts administrative rules.

In 2011, the Montana Legislative Audit Division audited BOGC to determine:

1. Whether BOGC has effective controls in place to enforce oil and gas conservation laws and rules; and
2. Whether controls are designed to promote integrity of data maintained on the Oil and Gas Information System.[31]

The audit revealed that BOGC had no standardized inspection protocol when inspectors visit a well.[32] More importantly, it found that many wells are never inspected.[33] Follow-up reports by

[26] Mont. Code Ann. § 2-15-3303; Title 82, Chapter 11, Part 1, MCA.
[27] *Performance Audit: Board of Oil and Gas Conservation Regulatory Program*, Legis. Audit Division (Sept. 2011), http://leg.mt.gov/content/Publications/Audit/Report/11P-04.pdf.
[28] *See general*, DNRC Montana Board of Oil and Gas, http://bogc.dnrc.mt.gov/.
[29] *Id.* at 7.
[30] *Id.*
[31] *Id.*
[32] *Performance Audit: Board of Oil and Gas Conservation Regulatory Program*, Legis. Audit Division (Sept. 2011), http://leg.mt.gov/content/Publications/Audit/Report/11P-04.pdf.

the Legislative Auditor have shown the BOGC is working to improve its performance by standardizing procedures and improving reporting.[34]

BOGC is funded by a tax of up to .3% of the value of oil and gas produced, plus an incidental fee on injection wells, for a total operating budget in fiscal year 2011 of $2.3 million. Montana's oil and gas production totaled $2.6 billion in 2013.[35] At 0.3% that would be $7.8 million and $2.3 million is 29.5% of its authorized rate. The BOGC operates at about 1/3 of its authorized spending rate.[36] Unlike most state agencies, BOGC has sufficient available funding to do a more thorough job.

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33 *Id.*
34 *Id.*
35 Dr. Scott Rickard, *The Economic & Fiscal Impacts of the Oil and Gas Industry in Montana*, MSU Billings Center for Applied Economic Research (June 2012), http://www.westernenergyalliance.org/wp-content/uploads/2013/08/The-Economic-and-Fiscal-Impacts-of-Montanas-Oil-and-Gas-Industry-2011-Published-6-2012.pdf.
36 *Performance Audit*, at 8.

Water Quantity: Getting Down to Numbers

Montana is a headwaters state; mountain streams feed major rivers on both sides of the continental divide. There are four major river basins in Montana: the Clark Fork/Kootenai River basin, the Lower Missouri River basin, the Upper Missouri River basin, and the Yellowstone River basin.[37]

> **WATER QUANTITY QUESTIONS**
>
> - If more water is required for fracking, where is it going to come from?
> - Should water used for fracking be considered a "beneficial use"?

For purposes of water rights, the Montana Department of Natural Resources & Conservation (DNRC) has further divided Montana into 85 drainage basins.[38] The year-round contribution of groundwater to stream flow is referred to as "base flow," which can keep streams flowing during dry months.[39] According to the DNRC, groundwater provides more than half of the base flow for over 60% of Montana streams. Depleting groundwater will therefore – in some areas – deplete surface water.

Montana's 85 drainage basins are either "open" or "closed" to additional water development.[40] For example, the Milk River is closed because it is within the Fort Belknap Compact Closure Area. Closed basins account for about 40% of Montana's 147,000 square miles of surface area. Basins that are not closed are open to additional water projects as long as the project is for a "beneficial use." Using water for oil and gas production is considered a beneficial use in Montana.[41]

Fracking requires two to eight million gallons of water per well, depending on the conditions of a given oil field. Approximately 25,000-30,000 new wells were drilled in the U.S. each year between 2011 and 2014, although EPA acknowledges that the exact number and location are unknown.[42] According to EPA, the national median of water used per hydraulically fractured well is 1.5 million gallons, but this number is typically closer to four million gallons per well for horizontal wells.[43] For example, 1.4-7.5 million gallons of water is required to drill and hydraulically fracture horizontal wells in the Colorado Wattenberg Field before energy is extracted.[44]

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37 http://dnrc.mt.gov/divisions/water/management/regional-river-basin-information.

38 Montana DNRC, *Montana State Water Plan* 29 (Dec. 2014), http://dnrc.mt.gov/divisions/water/management/docs/state-water-plan/2015_mt_water_plan.pdf

39 *Id.*

40 http://www.dnrc.mt.gov/wrd/water_rts/appro_info/basinclose-cgw_map.pdf.

41 Mont. Code Ann. § 85-2-102(4)(a).

42 U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources* ES-5, ES-23 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

43 *Id.* at ES-9.

44 Stephen Goodwin et al., *Water Intensity Assessment of Shale Gas Resources in the Wattenberg Field in Northeastern Colorado*, Envtl. Science & Technology (April 21, 2014), http://pubs.acs.org/doi/abs/10.1021/es404675h.

A rough estimate of the total water used for fracking each year ranges from 70 to 140 billion gallons of water per year (an average of roughly three million gallons per well).[45] The exact amount is difficult to quantify, and EPA's estimate differs from the industry's.[46]

Closer to home, North Dakota uses approximately 2.93-3.26 million gallons of water per well during drilling and development.[47] Records from the North Dakota Water Commission indicate that 12,629 acre-feet of surface and groundwater (4.1 billion gallons) were used for fracking in 2012, which represents approximately 4% of North Dakota's total consumptive use.[48] This number is expected to grow significantly as the number of projected new fracking wells exceeds 40,000 over the next 30 years.[49]

The federal government does not know how much water is actually being used for fracking, but supports a website to gather the data. The website, www.FracFocus.org, was created by two organizations, the Ground Water Protection Council and Interstate Oil and Gas Compact Commission (IOGCC), which describe their missions as conservation and environmental protection.

Industry reports data one well at a time to FracFocus.org. There is no independent verification of the numbers, nor is there documentation of the source of water being used -- i.e., whether it is surface water or groundwater (fresh or saline/brackish), or whether it is reused after treatment or recycling. The timing of the water use would also be useful information, especially for places where traditional water uses (irrigation, pumping for water supply) may occur simultaneously, and multiple simultaneous uses may pose an acute threat to a water source.[50] This is especially critical during a time of drought.

The data reported to FracFocus.org include the percentage of additives and chemicals used in the fracking process. The specific types and amount of chemicals and additives are not reported, and industry often refuses to disclose them on the grounds that they are "trade secrets."[51] According to FracFocus.org, chemicals and additives comprise .5% - 1.5% of fracking fluids. While the percentages are very low, the actual amounts are nonetheless significant. The amount of chemicals used in a well requiring 2-4 million gallons of water will

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45 Western Org. of Resource Councils, *Fracking and Water Loss in the West* (2013), http://www.worc.org/userfiles/file/Oil%20Gas%20Coalbed%20Methane/Hydraulic%20Fracturing/Gone_for_Good.pdf.

46 *Id.*

47 K. Blasch (USGS), *Water-Use Requirements Associated with Hydraulic Fracturing Within the Williston Basin*, American Water Resources Association Meeting Presentation (Kalispell, Montana) (Oct. 9, 2014); J. Stimson (Mont. DEQ), *Assessing Risk to Public Water Supplies from Oil And Gas Activities and Prioritizing DEQ's Surface and Ground Water Monitoring Efforts*, American Water Resources Association Meeting Presentation (Kalispell, Montana) (Oct. 9, 2014). An acre-foot is the amount of water needed to cover an acre of land with one foot of water.

48 Jason Spiess, *Advancing technology – Has the shale revolution gotten us into deep water?*, Bakken Breakout (Feb. 9, 2015), http://bismarcktribune.com/bakken/breakout/advancing-technology---has-the-shale-revolution-gotten-us/article_ee9b5cf2-b076-11e4-9398-e7097fa2a4c9.html.

49 McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

50 http://www.colorado.edu/geography/class_homepages/geog_4501_s14/ceres_frackwaterbynumbers_021014.pdf.

51 Mark Jaffe, *Drillers claim "trade secrets" when they don't reveal chemicals in fracking fluid*, Denver Post (Dec. 4, 2011), http://www.denverpost.com/ci_19461782.

range from 10,000-60,000 gallons. When multiplied for each well, the amount of chemicals being injected into the ground quickly grows.

While much of the water injected during the fracking process remains in the ground, significant percentages return as flowback water.[52] Enough of the chemicals used in the fracking process are carcinogenic to render flowback water unusable if it is not treated. These waters can be treated to drinking water standards, but at significant expense. As a result, industry more commonly stores flowback water in surface pits, hauls it away for disposal, or injects it back into the ground.

Produced water is highly mineralized, or salty. It generally contains total dissolved solids at levels 5-10 times higher than seawater.[53] Concerns about disposing these fluids are discussed in more detail in the water quality section.

Montana is one of several member states in the Interstate Oil and Gas Compact Commission (IOGCC), formed in 1935 and comprised of the governors of oil and gas producing states, as well as appointed representatives.[54] Montana joined the Compact in 1945.[55] As a member of the IOGCC, Montana has adopted a policy requiring drillers to report their fracking data to fracfocus.org. Industry is not required to report fracking data to any Montana governmental agency.

Using water for fracking requires a water right, which may be obtained from the Water Resources Division of the DNRC, leased or purchased from the owner of a water right, or bought from sources such as municipal water depots. Permits for drilling and injection are issued by the Montana Board of Oil and Gas Conservation, a quasi-judicial body attached to the DNRC.

Before considering the question, "Where is all that water going to come from?," it is instructive to take a look at a current inventory of water use in Montana.

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[52] *Shale Gas Fracking*, WaterWorld (undated), http://www.waterworld.com/articles/wwi/print/volume-27/issue-2/regional-spotlight-europe/shale-gas-fracking.html.
[53] Kelvin B. Gregory et al., *Water Management Challenges Associated with the Production of Shale Gas by Hydraulic* Fracturing, Elements (Jun. 1, 2011), http://elements.geoscienceworld.org/content/7/3/181.
[54] IOGCC website, http://iogcc.publishpath.com/about-us.
[55] *See* Mont. Code. Ann. §§ 82-11-301 to -306.

Montana Water Use by Source

Montanans used 160 million gallons of water per day for domestic uses in 2010 – 138 million gallons through public supplies, and 24.2 million gallons through self-supply. [56]

In 2010, 54% of all domestic water in Montana came from groundwater. In other words, Montanans consumed 86.8 million gallons of groundwater per day for domestic use in 2010, or about 31.7 billion gallons for the year.

Table 1

Montana 2010 Residential Water Use[57]
(Millions of gallons per day (Mgal)/day))

	No. of People	**Comments**	**Mgal/day**	
Public supply – Groundwater		Public supply sourced from groundwater	65.6	40.9%
Public supply – Surface water		Public supply sourced from surface water	72.4	45.2%
Total served by public supply	**704,000**	**Total public supply**	**138 Mgal/day**	**86.1%**
Self-supplied – Groundwater		Individual supply sourced from groundwater	21.2	13.2%
Self-supplied – Surface water		Individual supply sourced from surface water	1.04	0.65%
Total served by self-supply	**285,000**	**Total self-supply**	**22.24 Mgal/day**	**13.85%**
Total Supply – All sources	**989,000**		**160.24 Mgal/day**	**99.95%**
Total served by groundwater (public and self-supplied)			86.8 Mgal/day	54.1%

Researchers estimate that in 2013, about 5 billion gallons of water were used in Montana for fracking.[58] This is equivalent to approximately 15%-16% of Montana's daily residential use from groundwater. Importantly, while many water uses return the water to its source so that it

[56] U.S. Geological Survey, *Estimated Use of Water in the U.S.in 2010*, http://pubs.usgs.gov/circ/1405/pdf/circ1405.pdf.
[57] *Id.*
[58] A.M. Olschlager and U.J. Price, Course notes for *Natural Resources and the Law: Oil and Gas Development*, The Seminar Group Continuing Legal Education (Missoula, Mont.) (Nov. 6, 2014).

can be used again in the future, this is not always the case for water used in fracking – at least not without treating the water first.

The USGS also identified the following sources of water for industrial use in Montana, again in 2010.

Table 2

Montana Industrial Water use (Mgal/day)[59]

Water Use & Source	**Mgal/Day**	
Industrial supply from groundwater	37.42	
Industrial supply from surface water	29.63	
Total Industrial Supply		**67.05 Mgal/day**
Mining supply from groundwater (fresh and saline)	6.32	
Mining supply from surface water (fresh only)	34.2	
Total Mining water supply		**40.52 Mgal/day**
Thermo-electric supply from groundwater	.25	
Thermo-electric supply from surface water	89.62	
Total Thermo-electric supply		**89.87 Mgal/day**

Although most industrial uses in Montana rely on surface water, Montana industry uses 39.48 million gallons of groundwater per day, or 14.4 billion gallons per year.

Comparing these numbers to the 13.7 Mgal/day[60] used for fracking provides more context.

Fracking uses:

- 36.6% of the daily groundwater usage for self-supplied industrial water (36.9 Mgal/day), and
- 29.4% of the daily fresh and saline groundwater used for Montana's mining water supply.

[59] U.S. Geological Survey, *Estimated Use of Water in the U.S. in 2010,* http://pubs.usgs.gov/circ/1405/pdf/circ1405.pdf.

[60] A.M. Olschlager and U.J. Price, Course notes for *Natural Resources and the Law: Oil and Gas Development*, The Seminar Group Continuing Legal Education (Missoula, Mont.) (Nov. 6, 2014).

Additionally, fracking uses 54.8 times more than all daily groundwater used for thermo-electric applications.

While domestic and industrial uses are essential uses to Montanans, it is no surprise that agriculture uses the most water of any individual category in Montana.

Table 3

Montana Agricultural Water Use (2010)

Use	Groundwater (Mgal/day)	Surface Water (Mgal/day)
Livestock	4.96	27.39
Aquaculture (e.g., raising fish for consumption)	2.38	39.60
Irrigation	140.39	9,531.46
Total	**147.73**	**9,598.45**

In other words, Montana agriculture used 147.73 million gallons of groundwater per day in 2010, or about 54 billion gallons of groundwater per year. Of that, irrigation accounts for 95%, or about 51.2 billion gallons of groundwater per year.

Earlier, we mentioned researchers' estimate that fracking uses 5 billion gallons of water a year.[61] This 13.7 Mgal/day of water for fracking is equivalent to:

- 276% of all daily groundwater used for Montana livestock;
- 576% of daily groundwater used for Montana aquaculture; and
- 9.8% of the daily groundwater used for irrigation.

Summaries of the various sources used for groundwater are in Figure 3 and Table 4.

[61] *Id.*

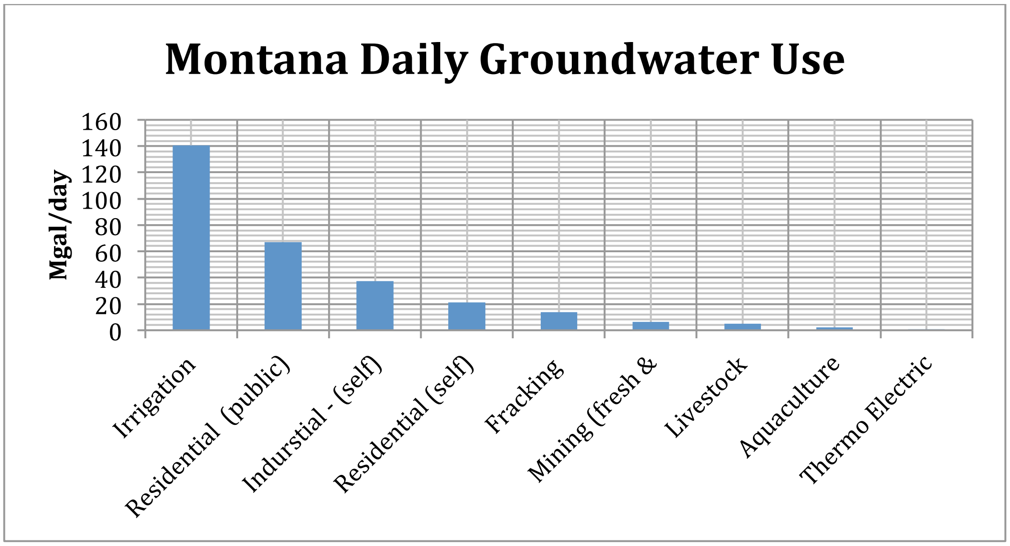

Figure 3. Groundwater by source (summarized from Tables 1, 2, and 3)

Table 4

Daily Montana Groundwater Use

Daily Montana Groundwater Use (Mgal/day)	
Irrigation	140.39
Residential (public supply)	67.05
Industrial (self-supplied)	37.4
Residential (self-supplied)	21.2
Fracking	**13.7**
Mining (fresh & saline)	6.32
Livestock	4.96
Aquaculture	2.38
Thermoelectric	.85
Total	**294.25**

Legal and Policy Implications

Using water for oil and gas exploration, including fracking, is considered a "beneficial use" in Montana.[62] While a significant percentage of water used for irrigation and domestic uses returns to groundwater and can be reused, water used for fracking must usually be treated

[62] Mont. Code Ann. § 85-2-102(4)(a) (defining beneficial use as "a use of water for the benefit of the appropriator, other persons, or the public, including but not limited to agricultural, stock water, domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, and recreational uses").

before it can be reused for most purposes.[63] Montana would benefit from more empirical information about the reusability of water used in fracking. To the extent water cannot be reused, legislators must determine whether a use that removes water from future use without treatment should be considered a "beneficial use."

In some areas in eastern Montana, where annual precipitation may be less than 10 inches per year, the percentage of water used for fracking in the future may put significant pressure on water available for agriculture and domestic uses. For example, in the Barnett play of Texas, cumulative water use for fracking totaled 38.3 billion gallons from 2000 to mid-2011. This represented 9% of water use in Dallas, a major city with a population of 1.3 million. Impacts vary greatly depending on water availability and competing demands.[64]

Montana is not monitoring water used in oil and gas applications as closely as nearby states are, nor is it requiring industry transparency regarding the chemicals used in fracking fluids. In North Dakota, for example, a growing database of records regarding drilling and water use in the oil and gas industry is available and accessible.[65] One can submit information online regarding injection and production. Monthly records are available under the general statistics tab. Montana could learn from North Dakota.

Surface water during spring runoff may represent water available for other purposes, but not in basins that are "closed" to additional water appropriations.[66] Montana does not track whether the water used in fracking comes from surface water or groundwater. The trends in annual surface water flow are generally flat. If surface waters become a target for fracking waters, will the monitoring and permitting process require industry to keep track of the water used? If fresh water used in fracking is not returned for future uses, what impact will that have on existing water rights? Downstream users in other states may also have a concern about waters that they expect to see flowing into their states.

[63] McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

[64] Jean-Philippe Nicot & Bridget Scanlon, *Water Use for Shale-Gas Production in Texas-US,* Envtl. Science & Technology (March 20, 2012), https://www.zotero.org/groups/pse_study_citation_database/items/collectionKey/Q7GFAPNU/itemKey/37PWS28E.

[65] North Dakota Indus. Comm., Oil & Gas Division, www.dmr.nd.gov/oilgas/.

[66] Montana DNRC, Water Res. Div., *Montana's Basin Closures and Controlled Groundwater Areas* (Dec. 2003), http://dnrc.mt.gov/divisions/water/water-rights/docs/new-appropriations/basinclose-cgw_areas.pdf.

Water Quality

Hydraulic fracturing vastly increases the potential reserves of oil and gas in our country, providing economic benefits and reducing our dependence on foreign oil. Those benefits come with some risks. In this chapter, we will discuss potential risks to water quality, and whether and how those risks may be minimized.

The primary risks to water quality from fracking come from:

- Surface spills, blowouts, and leaking of poorly maintained surface pits;
- Poorly cemented underground casings that crack, allowing fracking fluid, oil and gas to escape and migrate into shallower water tables, which are used for domestic, agricultural, and industrial water;
- Flowback water that is contaminated by unknown chemicals and stored in pits and/or injected into deep wells;
- Produced water that is highly mineralized, toxic to agricultural uses, and unsuitable for domestic or industrial uses.

Water Contamination Concerns

Flowback and produced waters are temporarily stored in pits at the surface. These pits do not always perform as intended, due to either human or natural causes.[67] This can be a source of significant adverse impacts, including environmental damage and threat to public health, particularly with respect to the migration of the drilling waste material into water sources. Recent studies have raised questions about possible connections between reproductive health effects, including decreased sperm counts and an increase in premature births, and proximity to fracking wells.[68]

The potential for chemicals to make their way into surface and groundwater is real and ongoing. In discussing research conducted in the Williston Basin,[69] Rod Caldwell of the USGS stated that North Dakota experiences five to six spills per day greater than five gallons each.[70] This is consistent with a report indicating a 17% increase in oil and gas spills in 2013 for

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67 http://www2.epa.gov/hydraulicfracturing.

68 The Endocrine Society, *Fracking chemicals tied to reduced sperm count in mice,* EurekAlert! (Oct. 14, 2015), http://www.eurekalert.org/pub_releases/2015-10/tes-fct100915.php; Joan A. Casey et al., *Unconventional Natural Gas Development and Birth Outcomes in Pennsylvania,* Epidemiology (Sept. 2015) (abstract), http://journals.lww.com/epidem/Abstract/publishahead/Unconventional_Natural_Gas_Development_and_Birth.99128.aspx; Madeleine Thomas, *Does Fracking Reduce Sperm Count?*, Pacific Standard (Oct. 15, 2015), http://www.psmag.com/nature-and-technology/does-fracking-reduce-sperm-count; Ellen Webb et al., *Developmental and reproductive effects of chemicals associated with unconventional oil and gas operations*, Reviews on Envtl. Health (Dec. 2014), http://www.degruyter.com/view/j/reveh.2014.29.issue-4/reveh-2014-0057/reveh-2014-0057.xml?format=INT; Paul Solotaroff, *What's Killing the Babies of Vernal, Utah?*, Rolling Stone Magazine (June 22, 2015), http://www.rollingstone.com/culture/features/fracking-whats-killing-the-babies-of-vernal-utah-20150622.

69 McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

70 Rod Caldwell (USGS), Carroll College presentation (Helena, Mont.) (Dec. 1, 2014); *see also Environmental Incident Reports,* North Dakota Dept. of Health, http://www.ndhealth.gov/EHS/Spills/.

onshore oil and gas activities.[71]

The number of reported spills for 2013 was 7,662 in 15 states; however, there was a 43% increase in North Dakota even though the average number of rigs working in the state dropped 8 percent.[72] Spills may include blowouts, minor spills, leaks and other mishaps.[73] Surface spills and leaks are one of the primary concerns of the energy-related stakeholders mentioned earlier.[74] This concern recently became reality in April 2015 in Arlington, Texas, when more than 42,000 gallons of fracking fluids boiled up to the surface from a blowout, spilling into city streets and storm sewers.[75]

Another blowout recently occurred in the Bakken oil field in North Dakota on Oct 17, 2015, when a well began spewing oil and saltwater. It released over a half million gallons of oil and brine before being capped three days later.[76] A new well was being fracked and its fracture system apparently connected with the fracture system of a four-year old well nearby. When fractures intermingle and the system is under pressure, fluids in the system naturally seek release. The older well is about 850 feet from the White Earth River, on which an "oily sheen from the blowout mist" was visible a few days after the blowout.[77] Absorbent booms were placed across the river to prevent the oily material from migrating downstream to Lake Sakakawea and the Missouri River, the primary source of drinking water for southwest North Dakota.[78]

North Dakota prohibits vertical wells from being located within 1,300 feet of each other to prevent this type of problem.[79] Blowouts are not uncommon in the Bakken; a single operator experienced 11 blowouts between 2006 and 2013.[80] Setback rules, or minimum distances between wells and features such as homes and schools are under discussion in Montana and have been adopted in many states. According to the EPA, between 2000 and 2013, 9.4 million

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[71] Mike Soraghan, *Oil and gas: Spills up 17 percent in U.S. in 2013,* EnergyWire (May 12,2014), http://www.eenews.net/stories/1059999364.
[72] Mike Soraghan, *Oil and gas: Spills up 17 percent in U.S. in 2013,* EnergyWire (May 12,2014), http://www.eenews.net/stories/1059999364.
[73] Mike Soraghan, *Oil and gas: Spills up 17 percent in U.S. in 2013,* EnergyWire (May 12,2014), http://www.eenews.net/stories/1059999364.
[74] Heather Cooley and Kristina Donnelly, "Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction," Pacific Institute (June 2012), http://pacinst.org/pacinst/wp-content/uploads/sites/21/2013/02/full_report5.pdf.
[75] ABC News, *Report: Over 40,000 Gallons of Fracking Fluid Spilled in Texas Neighborhood Due to Drilling Co. Mishandling* (June 17, 2015), http://www.mintpressnews.com/report-over-40000-gallons-of-fracking-fluid-spilled-into-texas-neighborhood-due-to-drilling-co-mishandling/206653/.
[76] Lauren Donovan, *Oil well plugged after blowout*, Bismarck Tribune (Oct. 20, 2015), http://bismarcktribune.com/bakken/oil-well-plugged-after-blowout/article_e4205512-479e-5df1-bf5e-b97b99fcc35c.html.
[77] Lauren Donovan, *Well blowout spills contaminants in White Earth valley*, Bismarck Tribune (Oct. 9, 2015), http://bismarcktribune.com/bakken/well-blowout-spills-contaminants-in-white-earth-valley/article_d0ec80d1-a476-55d5-8d00-2af573afec5d.html.
[78] Dustin Monke, *'Significant' oil, brine spill affects White Earth River in northwest North Dakota*, Grand Forks Herald (Oct. 20, 2015), http://www.grandforksherald.com/news/region/3864510-significant-oil-brine-spill-affects-white-earth-river-northwest-north-dakota.
[79] *Well Blowout Capped in North Dakota*, OK Energy Today (Oct. 21, 2015), http://okenergytoday.com/2015/10/well-blowout-capped-in-north-dakota-2/.
[80] Deborah Sontag and Robert Gebeloff, *The Downside of the Boom*, N.Y. Times (Nov. 22, 2014), http://www.nytimes.com/interactive/2014/11/23/us/north-dakota-oil-boom-downside.html?_r=0.

people lived within one mile of a fracking well.[81]

A primary method of disposing of oil and gas waste is through injection wells.[82] Prior to being injected, the waste is often stored in surface ponds.[83] Injection wells that are improperly drilled, tested or used can cause irreparable damage to aquifers. Nearly three billion gallons of oil industry wastewater were illegally injected directly into central California's aquifers through 178 injection wells.[84]

A recent study sampled 69 permitted injection/disposal wells in six Montana counties.[85] Of the 69 wells, 45 are non-permitted or pending a permit because they failed mechanical integrity tests. These injection/disposal wells will not be permitted until they have been fixed. Some have failed multiple times.

There are more than 10,000 active wells in the Bakken Formation.[86] Each barrel (42 gallons) of oil results in about three barrels (126 gallons) of produced water. The math is easy: one million barrels of oil per day – which was the 2014 production -- creates about three million barrels of produced water, or 126 million gallons (388 acre-feet) of produced water per day. Produced water in the Bakken is usually disposed of by injecting it into the Dakota Formation, at a depth of about 4,500 feet below the surface.

Projections indicate there may be 40,000-60,000 producing wells in the next 30 years.[87] This will result in 0.63-0.95 billion gallons (1,940-2,910 acre-feet) of produced water *every day* for as long as these wells produce oil. Can all of this produced water be stored in deep injection wells? These questions are especially important in light of research linking deep injection wells to increased seismic activity.[88]

Storing this much water underground requires a massive amount of space. There is no infinite storage tank below the surface. The waters being injected must fit into the porosity or open spaces between sandstone grains. In the Dakota sandstone the porosity is approximately 20%,[89] which means that 80% of the rock is already occupied.

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[81] U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, ES-5 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

[82] U.S. EPA, *Basic Information about Injection Wells,* http://water.epa.gov/type/groundwater/uic/basicinformation.cfm.

[83] U.S. EPA, *The Hydraulic Fracturing Water Cycle*, http://www.epa.gov/hfstudy/hydraulic-fracturing-water-cycle.

[84] David R. Baker, *State shuts 33 wells injecting oil wastewater into aquifers,* SFGate (Oct. 16, 2015), http://m.sfgate.com/business/article/State-shuts-33-wells-injecting-oil-wastewater-6574845.php; http://www.biologicaldiversity.org/news/press_releases/2014/fracking-10-06-2014.html.

[85] Jamie McEvoy and Susan Gilbertz, MSU-Billings Dept. of Earth Sciences, *The Energy-Water-Health Nexus: An Overview of Initial Research on the Environmental and Public Health Impacts of Oil and Gas Production in Richland County, Montana* (Webinar Nov. 19 2014), attended by author Willis Weight.

[86] Amy Dairymple, *10,000 Bakken wells drilled, 50,000 to go, Helms says*, Oil patch Dispatch (Aug. 14, 2015), http://oilpatchdispatch.areavoices.com/2015/08/14/10000-bakken-wells-drilled-50000-to-go-helms-says/.

[87] *Id.*; Rod Caldwell (USGS), Carroll College presentation (Helena, Mont.) (Dec. 1, 2014).

[88] Fact 1, Myths & Misconceptions, http://earthquake.usgs.gov/research/induced/myths.php; Ker Than, *Oklahoma earthquakes linked to oil and gas wells, Stanford researchers say*, Stanford Report (June 18, 2015), http://news.stanford.edu/news/2015/june/okla-quake-drilling-061815.html.

[89] Debra K. Higley, *Core Porosity, Permeability, and Vitrinite Reflectance Data from the Lower J Cretaceous Sandstone in141 Denver Basin Coreholes,* U.S. Dept. of the Interior Geological Survey (1988), http://pubs.usgs.gov/dds/dds-069/dds-069-p/OF88_527/Pordata.pdf.

Fracking Fluid

Fracking fluid, which is injected into rock formations at high pressure to cause cracks in the rock, is comprised of various chemicals and additives. Fracking fluid mostly consists of water – 98.5%-99.5% -- that comes from surface or groundwater or from previously used water, which may be contaminated before being used for fracking. After the fracking fluid returns to the surface – something only about half of the water will do – it is definitely contaminated. The extent of the contamination varies depending on the additives used. Montana does not require industry to disclose the specific chemicals in flowback water. Flowback water cannot be used for other uses unless it is first treated.[90] Treating flowback water is about as expensive as storing, handling, and injecting it.[91] Only about 2% of fracking wells treat flowback water.[92] Chemical changes from the initial supply to flowback water are shown in Table 5.[93]

The chemicals in Table 5 are shown in milligrams per liter (mg/L), which is the same as parts per million (ppm), the usual measure of contaminants in water. In contrast, industry represents chemicals as a percentage of fracking fluid, stating that chemicals represent only about .5%-1.5% of the overall fluid. Percentages are parts per hundred, as opposed to the more common measure of parts per million. A "pinch" of a substance represents about 1/16 of a teaspoon. One part per million (ppm) is what you get if you put that pinch into two barrels (84 gallons). One percent, or one part per hundred, is *ten thousand times* that amount.

[90] David R. Stewart, Presentation at the Treatment for Beneficial Use of Produced Water and Hydraulic Fracturing Flowback Water, *U.S. EPA Technical Workshop on Wastewater Treatment and Related Modeling For Hydraulic Fracturing* (Apr. 18, 2013).

[91] Dave Stewart, *Analytical Testing for Hydraulic Fracturing Fluids—Water Recovery and Reuse, EPA Workshop for Analytical Chemistry* (Feb. 2013).

[92] Dave Stewart, Chief Science Officer for Energy Water Solutions LLC in Fort Collins, Colorado (personal communication, Oct. 2014).

[93] David R. Stewart, Presentation at the Treatment for Beneficial Use of Produced Water and Hydraulic Fracturing Flowback Water, *U.S. EPA Technical Workshop on Wastewater Treatment and Related Modeling For Hydraulic Fracturing* (Apr. 18, 2013).

Table 5
Water Quality of Water Before and After Its Use in Fracking Fluid[94]

	Supply Water (mg/L)	Flowback Water (mg/L)
pH	8.5	4.5 - 6.5
Calcium	22	22,200
Magnesium	6	1,940
Sodium	57	32,300
Iron	4	539
Barium	0.22	228
Strontium	0.45	4,030
Manganese	1	4
Sulfate	5	32
Chloride	20	121,000
Methanol	Negligible	2,280
Total Organic Carbon	Negligible	5,690
Total Suspended Solids	Negligible	1,211

The differences between supply waters and flowback waters in Table 5 are striking. If flowback waters are not treated they will be unusable. In addition, a myriad of undisclosed "industry secret" chemicals are added prior to fracking. They are disclosed generally, as a percentage of the fluid used, but many specific chemicals are not revealed, nor are the precise amounts of particular chemicals.

The EPA identified 1,076 chemicals used in fracking fluid, including acids, alcohols, aromatic hydrocarbons, hydrocarbons, and surfactants.[95] It found that the number of chemicals used per well ranged from four to 28 per well, with a median of 14.[96] Although chemical use varies widely, the EPA noted that methanol, hydrotreated light petroleum distillates and hydrochloric acid were used in 65% or more fracking wells.[97]

This is consistent with an analysis done by Willis Weight, the author of this section. Dr. Weight went to the chemicals section of www.FracFocus.org, created a list of chemicals, and searched for a random well in Richland County. A list of wells appeared and a recent one dated 11/27/2014 was selected for an analysis (API number 25-083-23274-00-00).[98] This well used 2,780,388 gallons of fracking fluid. 83.767% of the fracking fluid was fresh water, which equals 2,329,047 gallons. We do not know where that 2.3 million gallons of fresh water came from, or whether it was surface water or groundwater.

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94 *Id.*
95 U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, ES-11 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.
96 *Id.*
97 *Id.*
98 You can go to http://www.fracfocusdata.org/DisclosureSearch/ and type in this API number to find the same well.

13.815% of the fracking fluid was made up of proppant, which equals 384,110 gallons. Other water (of unknown quality) comprises 1.027% (28,555 gallons) for a total of 98.609%. The remainder is a secret recipe of chemicals, which amounts to about 1.391%, or 38,675 gallons. Dr. Weight selected hydrochloric acid, which was rated as 0.17685% of the fracking fluid. This amounts to 4,917 gallons, or 1,769 ppm. This chemical alone renders this particular fracking fluid unusable for other purposes.

A list contrasting produced water, sea water, and potable well water from the Fort Union Formation, typical of the water folks in eastern Montana drink, is shown in Table 6.

Table 6

Comparison of Produced Water With Seawater and Potable Fort Union Water[99]

	Fort Union Drinking Water (mg/L)	Sea Water (mg/L)	Bakken Produced Water (mg/L)
Calcium	199	400	22,700
Magnesium	97	1,300	1,420
Sodium	39	10,600	88,100
Potassium	5	380	7,850
Bicarbonate	534	140	147
Sulfate	464	2,600	158
Chloride	9	19,000	208,000
Other	22	99	4,123
Total Dissolved Solids	1,369	400	332,498

Given the high volume of produced water that fracking creates, should Montana have a plan or policy in place for what to do with these waters? Without a plan, Montana runs the risk of contaminating both drinking and irrigation water.

Recently, the National Groundwater Association field-tested 33 randomly selected domestic and 25 nearby production wells in the Williston Basin for evidence of negative impacts from oil and gas activities on domestic water supply wells.[100] The objective was to establish baseline conditions in the Williston Basin. Basic water quality parameters were analyzed along with isotope and other parameters to determine groundwater age of the water being used

99 Rod Caldwell (USGS), Carroll College presentation (Helena, Mont.) (Dec. 2014).

100 McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

domestically. Industry heralded the results, which showed no water quality problems.[101] Notably, carbon-14 dating shows that the water supplying domestic wells in this area is more than 1,000 years old. All of the water samples therefore predate 1950s oil and gas drilling activities. Groundwater moves very slowly. It may take decades or centuries for contamination to appear depending on the location of a spill or casing failure. While the study results are good news for current water users in the Williston Basin, the age of the groundwater raises some questions.

Another recent study confirms that groundwater contamination may not appear until decades after surface contamination.[102] In this study, designed to sample and evaluate impacts of oil and gas activities on domestic wells, no petroleum parameters were identified in domestic well sources, but investigators found a prevalence of detectable arsenic. When the investigators asked locals where the arsenic came from, they were told about a government program to kill grasshoppers in the 1920s that placed arsenic-laden pesticides on the surface near domestic wells. That arsenic is now showing up in wells almost 100 years later.

Researcher McMahon found the closest distance between an oil and gas production well and a domestic water well randomly selected in the Williston Basin study was about 0.5 km (1650 feet) away, and the median distance was 4.6 km (~15,000 feet).[103] Given the number of surface spills, leaks, and blowouts that occur, and McEvoy's finding of arsenic 90 years later, petroleum products may not appear in groundwater for decades. What actions can and should we take to protect our water resources? It may be worth studying the ideal setback distance between oil and gas wells and domestic wells.

Additionally, wastewater is often stored in open pits prior to injection. If storage pits are vulnerable to flooding, negative environmental impacts can occur.

Injection can also lead to contamination. As mentioned earlier, billions of gallons of wastewater was injected into high-quality aquifers in Central California.[104] Even one mishap like this could have a significant impact on Montana's water resources.

It is important to evaluate whether Montana's fracking industry is prepared to deal with accidents, and the impacts of wear and tear as wells age. Is there a hotline for reporting accidents? The 2011 Montana Legislative Audit of MBOGC specifically found that the board "must improve its inspections and enforcement processes to more effectively regulate the

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[101] Zachary Cikanek, *API: EPA hydraulic fracturing review confirms safety*, American Petroleum Institute (June 4, 2015), http://www.americanpetroleuminstitute.com/news-and-media/news/newsitems/2015/june-2015/api-epa-hydraulic-fracturing-review-confirms-safety.

[102] Jamie McEvoy and Susan Gilbertz, MSU-Billings Dept. of Earth Sciences, *The Energy-Water-Health Nexus: An Overview of Initial Research on the Environmental and Public Health Impacts of Oil and Gas Production in Richland County, Montana* (Webinar Nov. 19 2014), attended by author Willis Weight; *see also* McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

[103] McMahon et al., *Quality and Age of Shallow Groundwater in the Bakken Formation Production Area, Williston Basin, Montana and North Dakota*, Ground Water (Nov. 13, 2014), http://www.ncbi.nlm.nih.gov/pubmed/25392910.

[104] Hollin Kretzmann, *Documents Reveal Billions of Gallons of Oil Industry Wastewater Illegally Injected Into Central California Aquifers*, Center for Biological Diversity (Oct. 6, 2014), http://www.biologicaldiversity.org/news/press_releases/2014/fracking-10-06-2014.html.

state's 17,600 active oil and gas wells."[105] It is essential that MBOGC continue to improve its oversight of the industry.

Another water-related issue concerns the location of oil and gas drilling compared to the Prairie Potholes and Central Flyway.[106] There is an inevitable conflict between the support natural wetlands provide to migratory birds and environmental risks associated with drilling and fracking.

Unless flowback water is treated, it is lost to future use, thus reflecting the number one concern expressed by the previously described energy-related stakeholders: water availability.[107] Treated water has mixed reviews[108] but according to Dave Stewart, Chief Science Officer for Energy Water Solutions LLC in Fort Collins, Colorado, treatment can be nearly as cost effective and much less troublesome than trying to handle and dispose of wastewater streams.[109] According to Stewart, only about 2% of fracked wells use water treatment as an option to handle flowback and other wastewaters. Texas is taking a hard look at this because of its ongoing water scarcity issues. Apache Oil is recycling 100% of its produced water in the Permian Basin of Texas, and Anadarko and Shell are buying wastewater from local communities to be used as source water.[110] The EPA reports that about 5% of the water used in fracking fluid is recycled.[111]

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[105] *Performance Audit: Board of Oil and Gas Conservation Regulatory Program*, Legis. Audit Division (Sept. 2011), http://leg.mt.gov/content/Publications/Audit/Report/11P-04.pdf at S-1.

[106] http://www.flyways.us/flyways/info. See also http://www.fws.gov/mountain-prairie/contaminants/documents/reservepits.pdf.

[107] Heather Cooley and Kristina Donnelly, "Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction," Pacific Institute (June 2012), http://pacinst.org/pacinst/wp-content/uploads/sites/21/2013/02/full_report5.pdf.

[108] Jim Malewitz and Neena Satija, *In Oil and Gas Country, Recycling Can Be an Extremely Hard Sell,* N.Y. Times (Nov. 21, 2013), http://www.nytimes.com/2013/11/22/us/in-oil-and-gas-country-water-recycling-can-be-an-extremely-hard-sell.html?_r=0.

[109] Personal communication, Oct 2014.

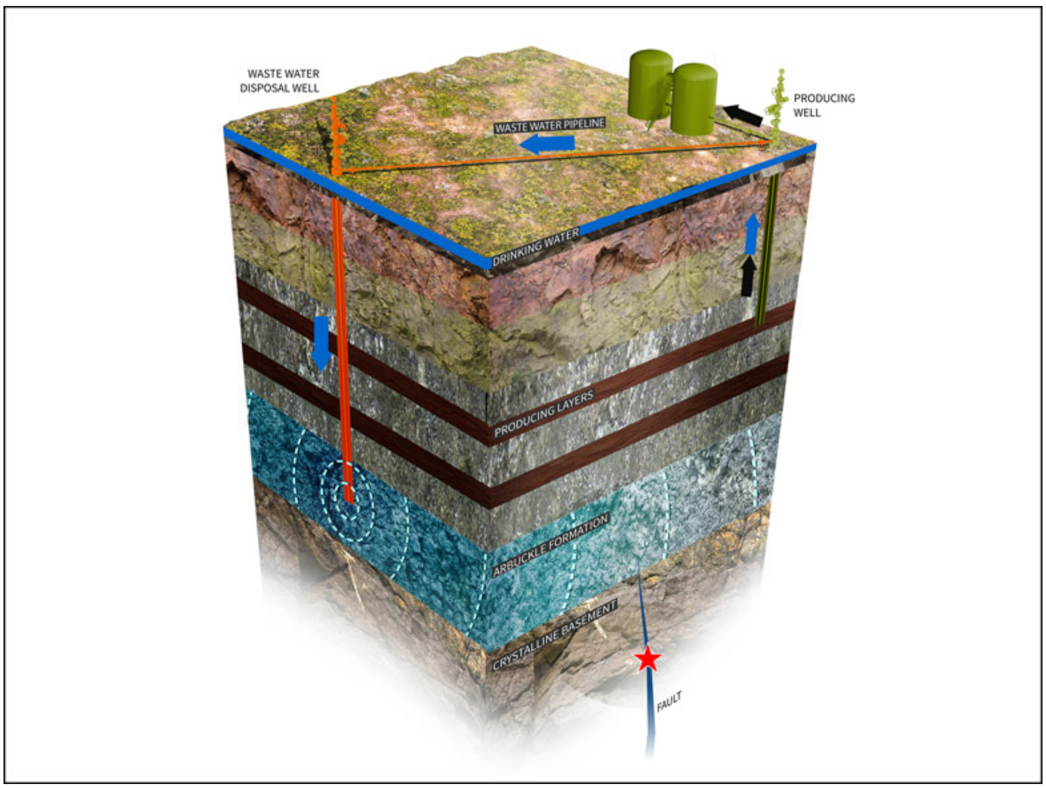
[110] http://www.colorado.edu/geography/class_homepages/geog_4501_s14/ceres_frackwaterbynumbers_021014.pdf; James Osborne, *Fracking companies begin slow shift to recycling wastewater,* Dallas Morning News (Aug. 9, 2014), http://www.dallasnews.com/business/energy/20140809-fracking-companies-begin-slow-shift-to-recycling-wastewater.ece.

[111] U.S. EPA, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, ES-8 (External Review Draft), U.S. Environmental Protection Agency, EPA/600/R-15/047 (June 2015), http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

Seismic Effects from Wastewater Injection

According to the U.S. Geological Service (USGS), fracking does not increase the risk of earthquakes, but injecting wastewater into deep rock layers that have never before been disturbed does. [112] Two Stanford scientists whose work led to the USGS' conclusions found that almost all of the water injected into Oklahoma bedrock was produced from conventional oil and gas wells, not from fracking. The scientists theorize that wastewater disposal increases pore pressure in the disposal zone and propagates earthquakes, sometimes miles away from the injection site. The amount of wastewater being injected into the Arbuckle formation in Oklahoma increased from 20 million barrels a year in 1997 to about 400 million barrels a year in 2013.[113] This has resulted in a change in the frequency of >4 magnitude earthquakes from one per decade before 2009 to more than 24 >4 magnitude earthquakes in 2014 alone.[114]

Cross-Section Showing Wastewater Disposal



[112] U.S. Geological Survey, *Fact 1, Myths & Misconceptions* ("wastewater injection can raise pressure levels more than enhanced oil recovery, and thus increases the likelihood of induced earthquakes"), http://earthquake.usgs.gov/research/induced/myths.php; Ker Than, *Oklahoma earthquakes linked to oil and gas wells, Stanford researchers say*, Stanford Report (June 18, 2015), http://news.stanford.edu/news/2015/june/okla-quake-drilling-061815.html.
[113] Ker Than, http://news.stanford.edu/news/2015/june/okla-quake-drilling-061815.html.
[114] F. Rall Walsh III & Mark D. Zoback, *Oklahoma's recent earthquakes and saltwater disposal,* Science Advances (June 18, 2015), http://advances.sciencemag.org/content/1/5/e1500195 .

Air Quality

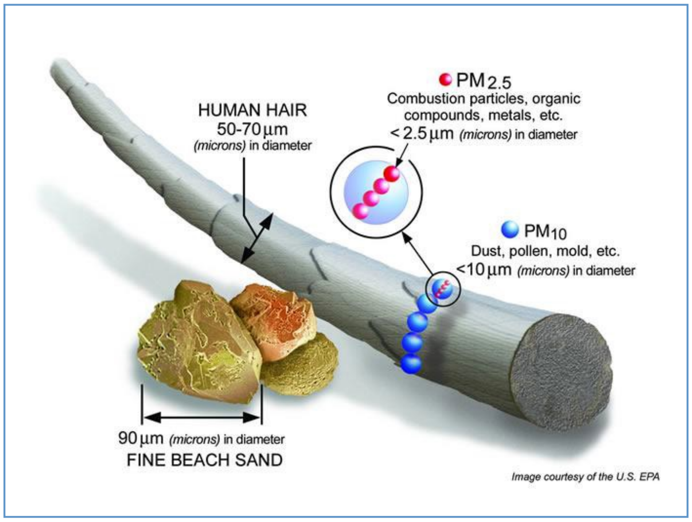
Introduction

Air-quality issues can arise at various stages in the fracking process. From site preparation and drilling to transportation, storage, disposal of wastewater and chemicals, and long-term production and remediation issues, chemicals and particulates are released into the air. In addition, greenhouse gases such as methane may be released, sometimes in large quantities.

A study evaluating the potential health effects of 632 chemicals used during natural gas operations determined that more than 75% of these chemicals can affect the skin, eyes, and other sensory organs, including the respiratory system.[115] Approximately 25% of these chemicals can cause cancer or mutations.[116] Including health professionals in policy and legislative discussions regarding oil and gas development provides an important perspective that will benefit all Montanans.

Air Emissions – Particulate Matter

The first air emission associated with fracking is particulate matter (PM). The Environmental Protection Agency (EPA) monitors six primary pollutants associated with the Clean Air Act.[117] These primary pollutants -- carbon monoxide, lead, nitrogen compounds or NOx, ozone, particulate matter ($PM_{2.5}$ and PM_{10}), and sulfur dioxide -- are part of the National Ambient Air Quality Standards (NAAQS), and are monitored in every state. The PM numbers 2.5 and 10 refer to the size of particulates in microns or micrometers. The smaller the particulate, the more easily it can interact with lung tissue.



[115] Theo Colborn at al., *Natural Gas Operations from a Public Health Perspective,* Human and Ecological Risk Assessment; An International Journal 17:5, 1039-1056 (2011), http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/fracking%20chemicals%20from%20a%20public%20health%20perspective.pdf.

[116] Theo Colborn at al., *Natural Gas Operations from a Public Health Perspective,* Human and Ecological Risk Assessment; An International Journal 17:5, 1039-1056 (2011), http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/fracking%20chemicals%20from%20a%20public%20health%20perspective.pdf; K.S. Korfmacher et al., *Public Health and High Volume Fracturing,* New Solutions 13-31 (2013), http://www.ncbi.nlm.nih.gov/pubmed/23552646.

[117] National Ambient Air Quality Standards (NAAQS), http://www3.epa.gov/ttn/naaqs/criteria.html.

Montana has a National Ambient Air Quality Standards site located near Gates of the Mountains.

During the drilling process, workers can be exposed to PM from drilling additives in dust and aerosols and clay particles in drilling mud as sacks are split open and poured. Once the target zone has been reached via vertical drilling and horizontal drilling begins, the casing is

National ambient air monitoring station near Gates of the Mountain, Montana, where the six EPA primary pollutants are monitored.

cemented into place and the development process begins. Explosive charges are directed to a given interval within the horizontal section and set off to provide openings through the casing and provide initial fractures into the rock formation. This process is repeated over almost the entire length of the horizontal section, each time potentially releasing dust and particulates.

Second, fracking fluids contain a mixture of water, proppants, and chemicals.[118] Best practices require that specific intervals are isolated with packers so the effect of the pressure from injected fluids is constrained to the desired interval. If this best management practice (BMP) is not followed, then the protective cement outside the well-bore casing becomes broken and provides a pathway for fugitive gases to migrate. Proppants, which hold fractures open, are

[118] What Chemicals Are Used, FracFocus.org, https://fracfocus.org/chemical-use/what-chemicals-are-used.

composed of silica sand or ceramic beads.[119] The amount of sand in each well depends on the location of the fracking well and the characteristics of the rock being fracked.[120]

In order to perform properly during the injection process, proppant material must be uniform in size and shape. Silica sand is typically mined and then processed through washing and screening to remove the finest particles.[121] The sand is then dried and screened again by being placed in a drum and blasted with hot air. A final cooling step and screening is done to sort the material into sizes suitable for fracking purposes.

Fracking sand used as a proppant (Minnesota Environmental Board).

Silica dust surrounding worker conducting sand transfer operations. (NIOSH).

Health impacts from silica sand are well known, including silicosis, which creates fibrotic nodules and scarring of the lung, and other diseases including emphysema, chronic obstructive pulmonary disease, tuberculosis, and lung cancer.[122]

Exposure limits are expressed in terms of amount of particulates present in parts per million per volume of air (usually a cubic meter). For example, the National Institute for Occupational Safety and Health (NIOSH) recommends a 10-hour time-weighted exposure limit of 0.05 parts per million (which can be adjusted to 0.15 ppm for a 24-hour period).[123] In addition, NIOSH has identified seven primary sources of silica dust exposure during hydraulic fracturing operations and provides a safety alert on its website.[124] NIOSH presents the published results of 116 full worker-shift air samples from 11 hydraulic fracturing sites in five states, including North Dakota, showing 79% of the air samples were above the recommended exposure limit.

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[119] *What is Frac Sand?*, Geology.com, http://geology.com/articles/frac-sand/.
[120] Feng Liang et al., *A Comprehensive Review on Proppant Technologies,* Petroleum (Nov. 2015), http://www.sciencedirect.com/science/article/pii/S2405656115000693; U.S. Geological Service, *Trends in Hydraulic Fracturing Distributions and Treatment Fluids, Additives, Proppants and Water Volumes Applied to Wells Drilled in the United States from 1947 through 2010*, Scientific Investigations Report 2014-5131, http://pubs.usgs.gov/sir/2014/5131/pdf/sir2014-5131.pdf.
[121] Minnesota Envtl. Quality Board, *Report on Silica Sand* (Mar. 20, 2013), https://www.eqb.state.mn.us/sites/default/files/documents/23.%20March%20Final%20Silica%20Sand%20report.pdf.
[122] Minnesota Envtl. Quality Board, *Report on Silica Sand* (Mar. 20, 2013), https://www.eqb.state.mn.us/sites/default/files/documents/23.%20March%20Final%20Silica%20Sand%20report.pdf; Ian Bridge, *Crystalline Silica: A review of the dose response relationship and environmental risk*, Air Quality and Climate Change (2009), vol. 43[1]:17-23, http://www.superquarry.org.au/wp-content/uploads/2011/02/Bridge-2009-environmental-silicosis-risk045.pdf.
[123] *Worker Exposure to Silica During Hydraulic Fracturing*, U.S. Dept. of Labor, https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html; *see also A Guide to Working Safely with Silica*, NIOSH, http://www.cdc.gov/niosh/pdfs/silicax.pdf.
[124] *Id.*

A major problem with silica dust is that once it lodges in the lungs, the associated diseases are incurable.[125] Animals as well as humans are vulnerable to these diseases if exposed to silica-dust-producing operations.[126]

Air Emissions – Volatile Chemicals

In addition to water and proppants, a host of chemicals are included in the fracking fluid cocktail, many of which are carcinogenic or pose health hazards if exposure occurs. One of those carcinogenic chemicals is benzene.[127] Benzene is the basic building block of many chemicals and products and is a known carcinogen.[128] It is a colorless sweet-smelling liquid that evaporates very quickly (described as being "volatile") and is extremely flammable.

At least four workers have died from acute inhalation exposure to benzene in the Williston Basin since 2010.[129] The Occupational Safety and Health Administration (OSHA) limits employees' maximum exposure to benzene at one part per million over an eight-hour period, and their maximum short-term exposure to no more than five ppm over a 15-minute period.[130] Respiratory exposure to benzene, even at low levels, is linked to blood disorders, leukemia, and immune system effects.[131] EPA acute exposure guidelines range from an exposure time of 10 minutes (130 ppm) to acute exposure over an 8-hour shift (9 ppm). Higher levels may result in death.[132]

A flowback technician gauging a flowback tank through a hatch at the top of the tank. (CDC photo).

[125] Ian Bridge, *Crystalline Silica: A review of the dose response relationship and environmental risk*, Air Quality and Climate Change (2009), vol. 43[1]:17-23, http://www.superquarry.org.au/wp-content/uploads/2011/02/Bridge-2009-environmental-silicosis-risk045.pdf.
[126] *Id.*
[127] *What Chemicals Are Used*, FracFocus.org, https://fracfocus.org/chemical-use/what-chemicals-are-used.
[128] Centers for Disease Control and Prevention, *Facts About Benzene* (Feb. 2013), http://www.bt.cdc.gov/agent/benzene/basics/facts.asp; *see also* Ashley Andersen et al., *Human Health Effects of Hydraulic Fracturing Fluid BTEX Components in Drinking Water* (2012), https://www.uvm.edu/~wbowden/Teaching/Risk_Assessment/Resources/Public/Projects/Project_docs2012/Final_Reports/Group1FinalReport.pdf.
[129] http://blogs.cdc.gov/niosh-science-blog/2014/05/19/flowback/.
[130] 29 C.F.R. 1910.1028(c)(1); Occupational Health and Safety Administration, *General Industry Digest* 45, OSHA 2201-08R (2015), https://www.osha.gov/Publications/osha_2201.pdf.
[131] Centers for Disease Control and Prevention, *Facts About Benzene* (Feb. 2013), http://www.bt.cdc.gov/agent/benzene/basics/facts.asp.
[132] *Acute Exposure Guideline Levels for Airborne Chemicals*, U.S. EPA, http://www.epa.gov/oppt/aegl/pubs/results72.htm. Exposure related to fracking is described by http://des.nh.gov/organization/commissioner/pip/factsheets/ard/documents/ard-ehp-3.pdf and http://blogs.cdc.gov/niosh-science-blog/2014/08/21/flowback-2/.

Air Emissions – Ozone

Another primary pollutant monitored and regulated by the EPA is ozone (O_3), or ground-level ozone. Ozone is not a substance that comes out of a tailpipe or a plume from oil and gas activities. It occurs as the result of a chemical reaction among nitrogen oxide compounds (NOx), volatile organic carbon compounds such as toluene and xylene, and sunlight.[133] In other words, ozone is created when certain chemicals are released into the air and interact with sunlight.

The creation of ozone typically occurs in cities during summertime conditions,[134] but can also occur during winter in rural areas adjacent to energy development. The combination of cold temperatures, sunny days, inversion conditions, and snow-covered ground leads to ideal conditions for the creation of ground-level ozone.[135] This phenomenon has been documented in the Uintah Basin in northern Utah, where ground-level ozone levels exceeded the EPA ambient air-quality standard of 75 parts per billion at 12 of 18 monitoring sites during December 2013 through March 2014.[136] Because Montana has the potential to match the wintertime conditions of the Uintah Basin study during energy development, the formation of ground-level ozone is a significant possibility.

Ozone can trigger coughing, chest pain, wheezing, and throat irritation, and can worsen existing respiratory illnesses, including asthma, bronchitis, or emphysema.[137] Children may be particularly sensitive.[138] Ozone inflames the linings of the lungs, and extended or repeated exposure can scar the lungs.

Ozone is monitored in several Montana communities including Sidney, Birney, Broadus, and Malta.[139]

Air Emissions – Methane

Oil and gas development releases natural gas, which is composed of methane plus minor amounts of propane, ethane, butane, and pentane.[140] Methane absorbs the Earth's radiant heat 25 times more effectively than carbon dioxide, although it persists in the atmosphere for only about 12 years while carbon dioxide persists for 50-100 years.[141] Incoming solar radiation heats the surface of the Earth, and the resulting radiant heat heads back to outer space unless it becomes trapped by gases that absorb the heat. The concentrations of methane and carbon

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133 Samuel Oltmans et al., *Anatomy of wintertime ozone associated with oil and natural gas extraction activity in Wyoming and Utah*, Elementa Science of the Anthropocene (2014), http://elementascience.org/article/info:doi/10.12952/journal.elementa.000024.

134 *Ground Level Ozone*, U.S. EPA (undated), http://www3.epa.gov/ozonepollution/.

135 *Id.*

136 Utah Dept. of Envtl. Quality, *Ozone in the Uinta Basin*, http://www.deq.utah.gov/locations/U/uintahbasin/ozone/overview.htm.

137 *Ground Level Ozone*, U.S. EPA (undated), http://www3.epa.gov/ozonepollution/.

138 *Id.*

139 Local Air Quality Conditions, AirNow.gov, http://www.airnow.gov/index.cfm?action=airnow.local_state&stateid=27.

140 *What is Natural Gas?*, NaturalGas.org, http://naturalgas.org/overview/background/.

141 *Overview of Greenhouse Gases,* U.S. EPA, http://epa.gov/climatechange/ghgemissions/gases/ch4.html.

dioxide in our atmosphere are approximately 1.8 parts per million (ppm) and 400 ppm respectively, although they are rising.[142]

When fracking fluids -- water, proppants, and chemical additives -- are injected into a specific zone isolated from the rest of the borehole by a packer system, the pressures exceed the tensile strength of the rock and the rock fractures into an extensive network extending outward into the formation. The fractures are held open by the proppant, thus providing a pathway for oil and gas to migrate to the borehole. If the packer isolation practice is not followed, the *entire* length of the borehole becomes exposed to these exceedingly high pressures. The intense pressure causes the steel pipe to expand while the surrounding cement outside the casing becomes broken up and does not serve its function of providing a protective seal.[143] This opens a pathway for fugitive gases to migrate up the borehole and escape into the atmosphere. Those fugitive gases include methane.

Flaring of natural gas in North Dakota. (Montana DEQ personnel).

This is especially likely to happen with older, abandoned wells. According to a study conducted by Stanford University, an estimated 400,000 gas wells in the United States are leaking more natural gas than estimated by the EPA.[144] Methane from fracking sites can connect with older frack wells and abandoned wells.[145] Another study suggests some of these older wells are huge emitters, releasing thousands of times more methane than other wells.[146] Importantly, these wells continue to release gases for decades. Research also suggests that older gas wells and pipelines are not the only ones leaking gas.[147]

Oil and gas development results in natural gas being brought to the surface. If the site has no pipelines or other infrastructure to store, handle, or deliver the produced gas to a pipeline, it is commonly "flared" -- or burned off -- as a waste product.[148] During the flaring process the volume of methane is reduced; however, carbon dioxide is released along with a number of

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142 Climate Change Indicators in the United States, EPA (June 2015), http://www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html.

143 Erik B. Nelson & Dominique Guillot (eds.), *Well Cementing* (Schlumberger 2006), http://www.slb.com/resources/publications/books/well_cementing.aspx.

144 Mark Golden, *America's natural gas system is leaky and in need of a fix, new study finds*, Stanford News (Feb. 13, 2014), http://news.stanford.edu/news/2014/february/methane-leaky-gas-021314.html.

145 *Methane from fracking sites can flow to abandoned wells, new study shows,* PhysOrg (Oct. 20, 2015), http://phys.org/news/2015-10-methane-fracking-sites-abandoned-wells.html.

146 John Sullivan, *Abandoned wells can be 'super-emitters' of greenhouse gas,* News at Princeton (Dec. 9, 2014), http://www.princeton.edu/main/news/archive/S41/80/71G06/index.xml?section=topstories.

147 Christopher Joyce, *Scientists Track Down Serious Methane Leaks in Natural Gas Wells,* Nat'l Public Radio (Dec. 9, 2014), http://www.npr.org/2014/12/09/369536783/sloppy-fracking-practices-result-in-large-methane-leaks-study-finds.

148 Air Quality, Intermountain Oil and Gas BMP Project, University of Colorado Law School, http://www.oilandgasbmps.org/resources/air_quality.php.

volatile organic compounds (VOCs) and other hazardous air pollutants such as benzapyrene.[149]

Benzapyrene is one of the compounds in cigarette smoke, and is connected with lung cancer.[150] A series of articles on flaring in Texas documents the billions of cubic feet of natural gas wasted from flaring and venting, and the thousands of tons of VOCs released into the air.[151] The practice of flaring was widespread in Canada until it was curbed through stricter regulations in 2000.[152]

Flaring is regulated to a minor degree in Montana, but the air quality regulations are related to hydrocarbon control, and depend on the infrastructure at or near the site.[153] Emissions are rated based upon British thermal units per standard cubic foot (BTU/scf), where the average gross heating value of natural gas ranges from 950-1050 BTU/scf.[154] In Montana, if volatile organic compounds (VOCs) emitted from oil and gas wellheads exceed 500 BTU/scf, then the gas must be routed to a gas pipeline.[155] If the wellhead is more than a half-mile away from a pipeline or capturing structure, it must be flared.[156] Flaring in the Bakken area can be seen from outer space.[157] That bright orange area in the satellite image where the Bakken is was not visible from space before 2007.

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149 *Id.*

150 M.F. Denissenko et al., *Preferential formation of benzo[a]pyrene adducts at lung cancer mutational hotspots in P53*, Science (Oct. 18, 1996), http://www.ncbi.nlm.nih.gov/pubmed/8832894.

151 John Tedesco & Jennifer Hiller, *Flares in Eagle Ford Shale wasting natural gas*, San Antonio Express-News (Aug. 2014), http://www.expressnews.com/business/eagleford/item/Up-in-Flames-Day-1-Flares-in-Eagle-Ford-Shale-32626.php.

152 Ian Bickis, *In a few weeks, a generator in North Dakota will fire up, powered by nothing more than wastewater from an oilwell,* Calgary Herald (June 14, 2105), http://calgaryherald.com/storyline/in-a-few-weeks-a-generator-in-north-dakota-will-fire-up-powered-by-nothing-more-than-waste-water-from-an-oilwell.

153 Admin. Reg. of Montana 36.22.1220, Associated Gas Flaring Limitation, http://www.mtrules.org/gateway/RuleNo.asp?RN=36%2E22%2E1220; Admin. Reg. of Montana 17.8.1603, Emission Control Requirements for Oil and Gas Well Facilities, http://deq.mt.gov/dir/legal/Chapters/Ch08-toc.mcpx.

154 Natural Gas Combustion, EPA, http://www.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf.

155 Admin. Reg. of Montana 17.8.1603, Emission Control Requirements, http://deq.mt.gov/dir/legal/Chapters/Ch08-toc.mcpx.

156 *Id.*

157 Robert Krulwich, *A Mysterious Patch of Light Shows Up in the North Dakota Dark*, Nat'l Public Radio (Jan. 17, 2013), http://www.npr.org/sections/krulwich/2013/01/16/169511949/a-mysterious-patch-of-light-shows-up-in-the-north-dakota-dark.

Satellite image of Interstate 94 from Billings, Montana to Minneapolis, Minnesota showing flaring in the Bakken area and lights from major urban areas. http://www.theawl.com/2011/12/north-dakota-the-rise-of-an-american-petrostate.

Methane is an asphyxiant, which means it reduces or displaces the normal oxygen found in air. This can produce a range of physiological responses in humans depending on the percent of oxygen displaced, including breathing difficulties and increased heart rate, fatigue, nausea and vomiting, convulsions, respiratory collapse, and death.[158]

If methane enters an aquifer it can be carried by groundwater and discharged into a stream. It is possible to monitor streams that are sustained by groundwater discharge for potential impacts from fracking.[159] The question is what monitoring efforts should be in place to evaluate any potential impacts from fracking activities to Montana's streams.

Climatic Effects – Drought

Four years in a row of meager rainfall, consistently high record-breaking temperatures, and no snowpack have left California's reservoirs well below normal. The official water management authority has issued an allocation strategy for the 2015-2016 season that will meet only 20% of agriculture's and cities' needs.[160]

According to weather records from the National Oceanographic and Atmospheric Association (NOAA), winter temperatures seem to be getting warmer, with the 2015 winter being the

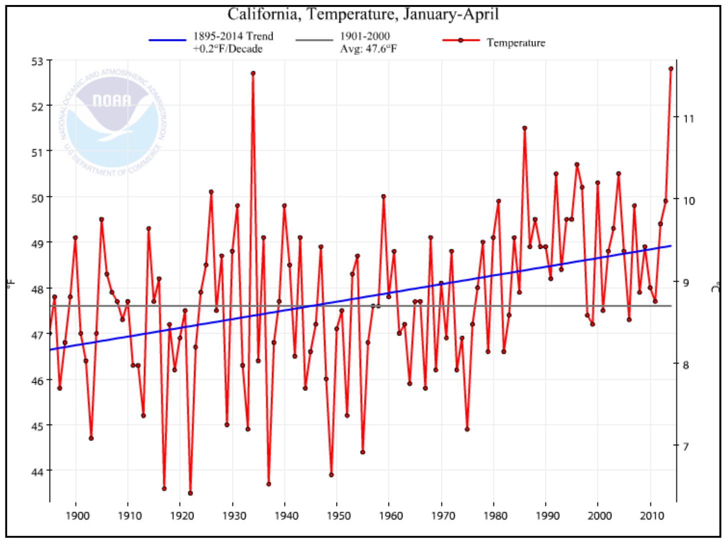
158 Asphyxiant definition, http://www.ilpi.com/msds/ref/asphyxiant.html.

159 V. M. Heilweil et al., *A Stream-Based Methane Monitoring Approach for Evaluating Groundwater Impacts Associated with Unconventional Gas Development*, Ground Water (July-Aug. 2013), http://www.ncbi.nlm.nih.gov/pubmed/23758706.

160 Jeff Nesbit, *Climate Change Caused California Drought,* U.S. News & World Report (Apr. 14, 2015), http://www.usnews.com/news/blogs/at-the-edge/2015/04/14/climate-change-and-the-california-drought.

warmest one observed in more than 119 years.[161] Several weather stations, especially in southern California, have been setting new records for the earliest 100-degree day readings. Warmer temperatures increase evaporation, reduce snowpack, change snow to rain, and dry out soils.[162] Some experts say this is the worst drought to hit California in about 1,200 years.[163]

Drought is a perennial concern in Montana as well. In a recent 10-year study using NASA satellite data, international scientists evaluated the stresses being placed on the world's largest aquifers from agriculture, growing populations, and industries such as mining.[164] They observe that water levels are dropping all over the world. It takes thousands of years to fill aquifers from snowmelt and rainfall. While California is the most troubled spot in the United States, it is not the only troubled spot.



In the western United States, a number of states are struggling with medium, severe, and extremely severe water stress in areas where oil and gas activities are underway. Severe stress equates to 40%-80% of the available surface water and groundwater already being allocated for agricultural, municipal, and industrial needs, while extreme stress occurs when more than 80% of the available surface water and groundwater is already allocated. Parts of central Montana are in the extreme water stress category, as is most of Wyoming and nearby parts of Idaho.[165]

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[161] Daniel Swain, *Rainy season ends in California; exceptional drought continues to intensify,* Calif. Weather Blog (June 1, 2014), http://www.weatherwest.com/archives/1531.

[162] Jeff Nesbit, *Climate Change Caused California Drought,* U.S. News & World Report (Apr. 14, 2015), http://www.usnews.com/news/blogs/at-the-edge/2015/04/14/climate-change-and-the-california-drought.

[163] Daniel Griffin & Kevin Anchukaitis, *How unusual is the 20120-2014 California drought?,* Geophysical Research Letters (Dec. 28, 2014), http://onlinelibrary.wiley.com/doi/10.1002/2014GL062433/abstract (published through the peer-reviewed Water Resources Research).

[164] Todd C. Frankel, *New NASA data show how the world is running out of water*, Wash. Post (June 16, 2015), http://www.washingtonpost.com/blogs/wonkblog/wp/2015/06/16/new-nasa-studies-show-how-the-world-is-running-out-of-water/.

[165] Monika Freyman, *Hydraulic Fracturing and Water Stress: Water Demand by the Numbers,* Ceres (Feb. 2014), http://www.colorado.edu/geography/class_homepages/geog_4501_s14/ceres_frackwaterbynumbers_021014.pdf.

Economic Questions

Oil and gas plays an important role in Montana's economy. Montana had an estimated 17,600 active oil and gas wells in 2011.[166] The Federal Reserve Bank in St. Louis estimated Montana's Gross Domestic Product (GDP) at $44 billion in 2014, up from less than $20 billion in 1997.[167]

The oil and gas industry supports 43,000 jobs in Montana, or 6.7% of the state's total employment. The average salary in the oil and gas sector is $81,226, compared to $36,499 for all sectors.[168] The industry contributes $4.5 billion to the Montana economy, which is 10.8% of the state's total economic activity.[169] Additionally, oil refining employed more than 1,000 people in 2013, and added more than $1 billion to Montana's GDP.[170]

Agricultural services and products contributed $4.2 billion of revenue in 2012 to the Montana economy. Products include beef, wheat, barley and an increasing variety of other commodities.[171] Other big industries in Montana include construction, manufacturing, tourism, education and government.[172]

The Montana Board of Oil and Gas Conservation publishes an annual report, which is an excellent source of information about the industry.[173] According to its most recent report, 2014 oil production was 29,868,90 barrels, up 1.8% from 2013. Gas production not associated with oil production was 39,479, 122 million cubic feet (MCF) in 2014, up slightly from the prior year. The board issued permits for 272 wells, and reissued 318 permits.[174]

Montana crude oil production follows an interesting pattern. There is no production in western Montana. Northeastern Montana produces the highest volumes, with the northern, south central, southeastern and central regions lagging by a large margin. The top five oil-producing counties are (in order) Richland, Fallon, Roosevelt, Sheridan and Dawson; top producers of gas not associated with oil production are Phillips, Fallon, Blaine, Hill and Toole.[175]

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166 *Performance Audit: Board of Oil and Gas Conservation Regulatory Program*, Legis. Audit Division (Sept. 2011), http://leg.mt.gov/content/Publications/Audit/Report/11P-04.pdf.
167 *Total Gross Domestic Product for Montana,* Econ. Research, Fed. Reserve Bank of St. Louis (June 10, 2015), http://research.stlouisfed.org/fred2/series/MTNGSP; *see also Oil and Natural Gas Stimulate Montana Economic and Job Growth*, Amer. Petroleum Inst. (2014), http://www.api.org/~/media/files/policy/jobs/oil-gas-stimulate-jobs-economic-growth/map/montana.pdf.
168 *Id.*
169 *Id.*
170 Treasure State Journal 2014, Mont. Petroleum Assoc., http://www.montanapetroleum.org/assets/TS114-WEB.pdf.
171 *Ag Facts: Montana's Largest Industry*, Mont. Dept. of Agriculture (Feb. 21, 2014), http://agr.mt.gov/agr/Consumer/AgFacts/.
172 *Economy at a Glance: Montana*, U.S. Dept. of Labor, Bureau of Labor Statistics (Nov. 18, 2015), http://www.bls.gov/eag/eag.mt.htm.
173 Annual Review 2013, Dept. of Natural Resources and Conservation of the state of Montana, Oil and Gas Conservation Division, http://www.bogc.dnrc.mt.gov/annualreview/AR_2013.pdf. The 2014 Annual Report is not yet available on line but was supplied to the author by Mr. Jim Halvorson, Administrator and Petroleum Geologist of the MBOGC.
174 *Id.*
175 *Id.* at 12.

According to the Montana Department of Revenue, oil and gas production taxes totaled $135.8 million in 2014.[176] The total tax collected for all natural resource activities in 2014 was $206.2 million, meaning oil and gas accounted for about 66% of the total.[177] Oil and gas revenues represent 5%-6% of Montana's general fund; not surprisingly, the projected price of a barrel of oil has been a key issue in many recent budget battles.

Although Montana government relies heavily on the oil and gas industry, the geographic distribution of the industry is an important consideration in understanding how the industry is perceived by Montanans. To a resident of western Montana, the industry might seem nonexistent unless the person happens to follow the biennial turmoil at the Montana Legislature. For instance, recent sessions have featured recurring arguments about whether industry is paying its proper share of the infrastructure demands of the oil and gas industry.[178]

Regardless of where one lives, stories about social impacts in the oil areas are hard to miss. For those landowners who still own their mineral rights and are collecting royalty checks, cash in hand is wonderful. For others, the loss of a way of life and potential contamination of the environment weigh as heavy negatives. Many Montanans are torn.

Whereas conventional oil and gas wells typically produce for about 20 years, the typical life of a fracking well is approximately five years.[179] In the Bakken, "a well that starts out pumping 1,000 barrels a day will decline to just 280 barrels by the start of year two, a shrinkage of 72%."[180] More than half the reserves of a Bakken fracking well are depleted by year three.[181] The shale industry must therefore continually drill new wells just to keep production constant. In the words of a Forbes magazine author, "The spread of rigs and jobs that seemed such a certainty, and such a staple of our recovery, may be a fading vision."[182]

Local or State Control?

Zoning has always been a function of local government. When a noisy gas well interrupts residents' quiet time at home, they complain to their local governmental officials – mayors, city council members, county commissioners. Similarly, when parents fear their children are being exposed to methane gas from wells near schools, they complain to their city or town officials. Oil and gas wells in Montana have so far not been drilled adjacent to houses and schools. But it is possible for such a thing to happen, and based on its response in other states, the industry will aggressively fight attempts to limit developers' rights to drill wherever they want.

For example, the city of Dallas recently imposed sweeping regulations on fracking operations, including a setback requirement of 1,500 feet (0.46 km) from homes, businesses, schools and

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[176] Montana Dept. of Revenue, *Biennial Report July 1, 2012 – June 30, 2014*, http://revenue.mt.gov/Portals/9/publications/biennial_reports/2012-2014/BiennialReport-2012-2014.pdf.
[177] *Id.* at 15.
[178] *See, e.g., We Pay, Why Don't They?*, Montana Budget & Policy Center (Apr. 14, 2015), http://www.montanabudget.org/we-pay-why-dont-they/; Assoc. Press, *Oil and Gas Holiday Under Fire in Senate Committee*, Flathead Beacon (Mar. 10, 2015), http://flatheadbeacon.com/2015/03/10/oil-and-gas-tax-holiday-under-fire-in-senate-committee/. *But see Tax and Royalty Revenue*, Western Energy Alliance (undated), http://www.westernenergyalliance.org/knowledge-center/tax-royalty-revenue.
[179] Shawn Tully, *The shale oil revolution is in danger*, Forbes (Jan. 9, 2015), http://fortune.com/2015/01/09/oil-prices-shale-fracking/.
[180] *Id.*
[181] *Id.*
[182] *Id.*

churches.[183] The Dallas ordinance was followed by another surprise: a drilling moratorium in Denton, Texas.[184] Oil and gas industry representatives responded by quickly lobbying the Texas Legislature and obtaining a state law prohibiting not only local drilling bans, but any local regulation of drilling activities.[185]

Dallas and Denton are surprising because their ordinances challenge the image of Texas as a place where residents resist any governmental regulation of the oil and gas industry. Other places in the country are also weighing the risks and benefits of fracking and deciding whether the risks justify greater regulation. For example, a number of local governments in Pennsylvania, home to the Marcellus Shale play and some of the most intensive fracking activity anywhere in the country, have begun imposing limits on fracking. The Pennsylvania Supreme Court has approved these limits, finding that local government officials have a constitutional obligation to protect the right of Pennsylvania residents to a clean environment (similar to Montana's clean and healthful constitutional provision).[186]

The Marcellus Shale runs through a large section of New York, including underneath the Catskill Mountains, the source of much of New York City's domestic water. New York State has banned fracking altogether.[187]

In Colorado, the cities of Fort Collins and Longmont enacted local fracking bans, which have been challenged by the Colorado Oil and Gas Association. The issue is now pending before the Colorado Supreme Court.[188] Governor Hickenlooper, a former oil and gas geologist, pushed hard for a compromise that would recognize local authority in certain areas, but compromise proved elusive.[189]

Local Control in Montana

Montana Board of Oil & Gas Conservation

As discussed earlier, fracking in Montana is regulated by the Montana Board of Oil and Gas Conservation's (BOGC). Created in 1953, the MBOGC's statutory purpose is to "demonstrate to the general public the importance of the state's oil and gas exploration and production industry."[190]

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[183] Jim Malewitz, *Dallas City Council Tightens Gas Drilling Ordinance,* Texas Tribune (Dec. 11, 2013), http://www.texastribune.org/2013/12/11/dallas-city-council-tightens-gas-drilling-ordinanc/.

[184] Nicholas Sakelaris, *Denton imposes moratorium on gas drilling ahead of petition seeking ban*, Dallas Business Journal (May 7, 2014), http://www.bizjournals.com/dallas/news/2014/05/07/denton-imposes-moratorium-on-gas-drilling-ahead-of.html.

[185] Wade Goodwyn, *New Texas Law Makes Local Fracking Bans Illegal*, National Public Radio (May 20, 2015), http://www.npr.org/2015/05/20/408156948/new-texas-law-makes-local-fracking-bans-illegal.

[186] *Robinson Township v. Commonwealth of Pennsylvania*, 83 A.3d 901 (Penn. 2013).

[187] Matthew Hamilton, *Read: New York's ban on fracking is officially final*, Albany Times Union (June 29, 2015), http://blog.timesunion.com/capitol/archives/237883/new-yorks-ban-on-fracking-is-officially-final/; Thomas Kaplan, *Citing Health Risks, Cuomo Bans Fracking in New York State*, New York Times (Dec. 17, 2014), http://www.nytimes.com/2014/12/18/nyregion/cuomo-to-ban-fracking-in-new-york-state-citing-health-risks.html?_r=0.

[188] Karen Antonacci, *Longmont Fracking Ban to Go Before Colorado Supreme Court*, Time-Call Energy (Sept. 21, 2015), http://www.timescall.com/energy-news/ci_28851304/colorado-supreme-court-accepts-longmont-fracking-ban-case.

[189] Peter Marcus, *Governor: Fracking Concerns Fading*, Durango Herald (May 27, 2015), http://www.durangoherald.com/article/20150527/NEWS01/150529671/Hickenlooper-doubts-fracking-initiative--.

[190] Mont. Code Ann. § 82-11-111(7).

In 2011, BOGC inspectors conducted 4,430 inspections, and identified 501 deficiencies or violations (11.3%).[191] However:

- 58% of active wells hadn't been inspected in at least five years;
- Four wells were inspected more than 20 times, and
- 20% of wells with an identified deficiency or violation did not receive a follow-up inspection.

According to the 2011 report, the BOGC lacked a systematic approach to identifying wells that needed inspection, and had no protocol for inspecting and documenting its findings. The auditors concluded, "While inspecting every well every year is not realistic, a formal approach to inspections will provide risk-based priorities for inspectors to attain maximum effectiveness while ensuring fairness."[192] The auditors also found that inspectors did not consistently enforce the few mandatory timelines embodied in Montana's statutes and rules, that they applied different interpretations of those timelines, and that violations often had no timeline for compliance.[193]

In July 2011, the BOGC concurred in the audit's findings and indicating that it would improve.[194] It indicated its inspection manual would be updated, and it inspection forms would be standardized and moved to an electronic system. A follow-up audit in June 2013 found that these tasks had been worked on, and that a new manual with training had nearly been completed by staff at Montana Tech of the University of Montana.[195]

No Montana law restricts the placement of oil and gas wells; geography is the only constraint. The Montana BOGC considered rulemaking on standardized setbacks — minimum distances between new wells and houses, roads and various structures and facilities -- but at its August 2015 meeting, postponed a decision on the issue pending further study.[196]

Montana Environmental Protection Act (MEPA)

Environmental reviews conducted before wells are allowed to proceed are cursory at best. The Montana Supreme Court has approved a checklist approach in some situations—for example, once a box is checked that says there are no unique wildlife concerns, the inquiry is at an end.[197]

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[191] *Id.* at 13.
[192] *Id.* at 14.
[193] *Id.* at 23.
[194] Letter to Legislative Auditor Tori Hunthausen from BOGC Chair Linda Nelson and BOGC Administrator Tom Richmond (July 26, 2011), http://leg.mt.gov/content/Publications/Audit/Report/13SP-04-follow-up-orig-11P-04.pdf.
[195] Memorandum from Lisa Blanford, Performance Audit Manager, to Legis. Audit Comm. Members (June 2013), http://leg.mt.gov/content/Publications/Audit/Report/13SP-04-follow-up-orig-11P-04.pdf.
[196] Matt Volz, *Montana panel puts off decision on drilling buffer zones*, Associated Press (Aug. 12, 2015), http://missoulian.com/business/local/montana-panel-puts-off-decision-on-drilling-buffer-zones/article_6121fb22-333b-58e6-b5b2-6b7282ba66c4.html.
[197] *Montana Wildlife Fed'n v. Bd. of Oil & Gas*, 2012 MT 128, 36 Mont. 22, 280 P. 3d 877.

Zoning

Residents in Carbon and Stillwater counties recently petitioned county government for zoning regulations for oil and gas development.[198] The proposals would require developers to follow best management practices in drilling — techniques that have proven successful in mitigating negative impacts and are supported by science. In a letter to the Carbon County Commission written in response to the citizen-initiated zoning proposal, industry raised several arguments in opposition to the proposal.[199] The Carbon County Commission initially indicated its support for the citizens' petition,[200] then reversed itself, leading local landowners represented by Earthjustice to sue the commission.[201]

Conservation Districts

Conservation district ordinances are another potential tool for asserting local control in Montana. Conservation districts came into existence following the Dust Bowl, and are designed to protect water and soil.[202] Citizens may petition the Montana Department of Natural Resources and Conservation (DNRC) for the creation of a conservation district.[203] After holding a hearing, the DNRC makes a determination as to whether there is a need for a conservation district in the area, based on statutory criteria, and what the proposed boundaries of the district should be, and whether the district is administratively practicable.[204] If it finds there is a need, it must put the issue to the voters in the affected area for a referendum vote.[205]

Federal Regulation

In August 2013, the U.S. Government Accountability Office (GAO) released a report to members of Congress about well permitting and inspection on federal Bureau of Land

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198 Tom Lutey, *Neighbors petition Carbon County commission for zoning near Belfry well*, Billings Gazette (Aug. 20, 2014), http://billingsgazette.com/news/state-and-regional/montana/neighbors-petition-carbon-county-commission-for-zoning-near-belfry-well/article_141bc742-99a6-5605-90a9-c7386953a911.html.

199 Letter from Michael Dockery, Crowley Fleck, PLLP, to Board of County Commissioners of Carbon County, Montana (Dec. 12, 2014), https://davidjkatz.files.wordpress.com/2014/12/141212-silvertip-zoning-crowley-letter.pdf.

200 Eleanor Guerrero, *Carbon County approve citizen-initiated zone to check oil/gas development*, Carbon County News (Dec. 18, 2014), http://www.carboncountynews.com/content/carbon-county-approves-citizen-initiated-zone-check-oilgas-development.

201 Eleanor Guerrero, *Commissioners respond to Silvertip zoning lawsuit*, Carbon County News (Apr. 9, 2015), http://www.carboncountynews.com/content/commissioners-respond-silvertip-zoning-lawsuit. *Martinell v. Carbon County Commission*, DA 15-0469 (Montana Supreme Court).

202 The Montana Legislature has declared the policy underlying the conservation district statutes:

> It is hereby declared to be the policy of the legislature to provide for the conservation of soil and soil resources of this state, for the control and prevention of soil erosion, for the prevention of floodwater and sediment damages, and for furthering the conservation, development, utilization, and disposal of water and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, preserve wildlife, protect the tax base, protect public lands, and protect and promote the health, safety, and general welfare of the people of this state.

202 Mont. Code Ann. § 76-15-102.

203 Mont. Code Ann. § 76-15-201.

204 Mont. Code Ann. § 76-15-201 to -207.

205 Mont. Code Ann. § 76-15-207.

Management (BLM) land. It updated the report in 2014.[206] The number of new permits dropped significantly between 2007 and 2012, primarily due to a decline in coalbed methane well drilling. The majority of new fracking wells in shale formations are located on state and private land. As a general rule, fracking is not governed by federal law unless the wells are on or accessed through federal land.

BLM's environmental inspection prioritization process may not even identify oil and gas wells that pose the greatest environmental risk, because the agency's central oil and gas database does not include data on the classification and environmental inspection history of many wells.[207]

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[206] U.S. Government Accountability Office, *Oil and Gas: Updated Guidance, Increased Coordination, and Comprehensive Data Could Improve BLM's Management and Oversight* (May 2014), http://www.gao.gov/assets/670/662993.pdf.
[207] *Id.* at 33.

Landowner Questions

What Can You Do When Approached About Fracking?

As a landowner, you may be approached by an oil and gas developer who has acquired subsurface rights and is determining whether to develop. Usually, the landowner owns the surface rights, but not the subsurface or mineral rights. If you do own the subsurface rights, you can benefit directly from oil and gas development. Regardless, most Montana landowners want to ensure they will continue to have clean, safe water in the quantities necessary to fulfill their historic water rights, and be able to continue using their property without impingement from the developer.

This chapter is intended to assist landowners in considering their options when approached by a developer who wants to use their property for a fracking operation. Regardless of whether you receive income from the project, the project will have a significant impact on your land, on your family or families living on the property, and on your neighbors and their property. It is in your best interest to negotiate meaningful protections for your property and operations.

A fracking agreement between a landowner and a developer not only allows the developer to extract oil and/or gas from below the land, it usually allows the developer to engage in related activities such as road construction, drilling, storage of large quantities of chemicals, storage of waste water, as well as use of the landowner's water. Even with a lease or surface use agreement that attempst to manage the impacts, you will not be able to eliminate all risks. Here are some questions and concerns you should consider when negotiating an agreement with a developer of a fracking project.

Who Owns What?

Do you own both surface and mineral rights? In Montana it is possible (and in some places, common) to have a "split estate," where one person owns the surface rights and another owns the mineral rights. Ownership of mineral rights includes the right to develop the minerals, such as through fracking. If you own both the surface and mineral rights you are in a much better bargaining position with a developer.

A split estate is created when the surface rights and mineral rights are sold separately. A split estate is also created if the owner of both the surface and mineral rights leases the mineral rights to a developer. The developer, who is now the lessee of the mineral rights, has a right to use the surface of the land to develop the mineral resources. A surface owner is paid for the lease, but typically does not share in profits derived from the mineral estate unless the surface owner has a written agreement specifically providing for a portion of the profits. This is rare, but it can occur.

The first step is to determine exactly what type of interests you own. The most comprehensive way to do this is through a Mineral Title Report. Other documents can be helpful, including deeds, tax records and tax returns, and family records. You may decide to hire an attorney or former landman to do a mineral title review.

Oil and gas leases or easements must be read with care. Some -- especially older leases and easements -- give "blanket" access to all or nearly all of the landowner's lands and/or minerals. Most mineral developers are reluctant to renegotiate these leases or easements to limit their access, and things might run amok before a landowner realizes the limitations on their rights or the full extent of the damage to their property.

For those who own only the surface estate, the law does not always provide the best protection. Of the two estates to own, the surface estate is the more difficult to protect and preserve, and has the least opportunity for profit. The surface estate is considered servient to the mineral estate, which is the dominant estate. That means the mineral estate owner or lessee has an automatic right to access the surface estate to develop the mineral estate. These dual rights of access and development are not completely unrestricted. Access must be reasonable and not overly damaging or burdensome to the surface estate, and development must be reasonable. The standard is usually articulated as what a reasonable developer would do to develop the mineral estate, sometimes known as the Reasonable Producer Standard.

Finally, mineral developers must comply with the Montana Surface Owner Damage and Disruption Compensation Act.[208] This law requires developers to notify surface owners within a certain period of time prior to initiating development.[209] The parties then must try to come to terms of settlement for access and damage compensation.[210] However, if the parties cannot come to terms, the owner of the surface estate must sue the mineral developer in state district court for damages.[211] Here, the money and power dynamic tilts in favor of the mineral developer, who usually has more resources with which to fight a court battle.

Surface owners should know the nature and extent of potential or existing encumbrances on their land arising from the split estate. If mineral development appears possible, the surface owner should consider establishing a water quality and quantity baseline, and conducting semi-annual or annual reviews of each. If the surface estate has other valuable resources -- such as range, fishing, wildlife, cropland, etc. -- the owner should consider having land or biological studies done to quantify and qualify the status of the resources prior to development. If development causes damages later on, determining their extent is much easier with baseline information from which to measure change.

As a general rule, a surface estate owner should not take the first offer presented by a mineral developer, and should almost never enter into an agreement drafted solely by the mineral developer. Developers are looking to get the best terms at the lowest price. Despite developers' protestations to the contrary, surface estate owners can *and should* negotiate all terms of an offer from a developer.

The mineral estate is the easier of the two estates to own. If a landowner owns only the mineral estate, or simply has a royalty interest, the name of the game is to get the most royalty income at the earliest possible point in the mineral development and to keep that money flowing whether there is production, potential production, or the well is shut-in for any period of time. Depending on the value of the minerals to be developed and the eagerness of the mineral developer, mineral estate owners can also get signing or up-front bonuses so that they have money in hand before development ever starts.

For those who own both the mineral and surface estates, the mineral estate provides the leverage for ensuring protection of the surface estate. All of the same concerns outlined above

[208] Mont. Code Ann. 82-10-501 to -511.
[209] Mont. Code Ann. § 82-10-503.
[210] Mont. Code Ann. § 82-10-504, -507.
[211] Mont. Code Ann. § 82-10-508.

should be taken into account by a mineral and surface estate owner. Again, knowing the nature and extent of what you own, having water quality and quantity assessments done, and having range or biological studies conducted pre-development is key to being able to later determine and prove how much damage was done to your property by the developer.

Finally, much like the surface estate owner, the mineral estate owner should never take the first offer presented by a mineral developer, and should almost never enter into an agreement drafted solely by the mineral developer.

What Impacts Could Fracking Have on Your Current Land Use?

Fracking may result in the following:

- **Seismic Testing** – Such testing involves using special trucks (thumper trucks) or explosives to send seismic waves into the earth to assist the location of oil and gas reserves.

- **Site Preparation and Construction** – The types of construction that are likely to occur include but are not limited to:
    - The well site;
    - Roads leading to the site;
    - Pipelines to carry product to and from the site;
    - Wastewater or other waste pits;
    - Fences;
    - Compressors to compress products prior to transport;
    - Separators to purify products prior to transport; and,
    - Water storage or diversion works.

- **Well Drilling** – After the site is prepared, the developer will drill the well. Shale formations are typically very deep underground and involve vertical and horizontal drilling.

- **Fracking** – As discussed earlier, the developers inject a mixture of water, sand, and chemical additives into the well at very high pressures to create cracks, or fractures, in the bedrock.

- **Extraction** – The developer will extract the oil and/or gas products from the well. This part of the process can last for decades, but the process is too new to know how long a typical well will produce.

- **Flaring**: Depending on the location of the well and its proximity to a natural gas pipeline, the developer may burn off the natural gas that is released along with the oil.

- **Wastewater storage**: The produced water released from the bedrock as well as the flowback water that was initially injected cannot be used for any other purpose without first being treated. Most developers store the water in large ponds and eventually inject the water back into the ground. There is growing evidence that injection wells are largely responsible for the significant increase in earthquakes in the central United States (specifically, Oklahoma) since 2009.[212]

- **Well Plugging and Reclamation/Restoration** – At some point the well will stop producing enough oil and/or gas for the developer to earn profits, and the developer will abandon and plug the well. Depending on your agreement with the developer and the current state regulations, the developer has certain reclamation and/or restoration duties.

Prior to negotiating an agreement with the developer, you should fully understand the scope of the developer's project. This is best accomplished by discussing in detail the list of possible uses by the developer. It is very important that you (and your agent if you hire one) understand the full extent of the fracking project prior to beginning negotiations.

Once you understand the scope of the developer's fracking project, you can either negotiate to protect current uses, plan to modify future uses, or plan to seek compensation for damages to the property and/or your current uses of the property. It is important to remember that landowners who own both the surface and mineral rights have much better leverage to seek modification or compensation for damages due to impacts to their property.

For example, let's say that you run a cow/calf operation. A developer approaches you about developing well sites and wastewater pits in one of the main pastures you use for grazing. The construction may result in you losing an entire season of livestock grazing. Additionally, before returning to future grazing, the developer's operations will need to be sufficiently fenced to prevent livestock from getting into the well drilling or the wastewater operations.

If you own the mineral rights and the surface, you are in a much better position to request that the developer pay for other grazing, for example, or pay for hay to replace grazing during the construction phase. Further, you would have much better leverage to demand adequate fencing to protect livestock from the fracking operations. Without that leverage, you may not be able to get as much from the developer.

After you have determined the scope of the fracking project and considered how this project may impact current operations, the next phase is to negotiate the agreement with the developer.

How Might Fracking Affect Your Water Rights?

Evaluating potential impacts to your water rights involves considering several questions.

- Can you lease or sell your water to a developer for fracking?

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212 Ground Water Protection Council and Interstate Oil and Gas Compact Commission, *Potential Injection-Induced Seismicity Associated with Oil & Gas Development: A Primer on Technical and Regulatory Considerations Informing Risk Management and Mitigation* (2015), http://iogcc.publishpath.com/Websites/iogcc/images/2015OKC/ISWG_Primer_Final-Web.pdf; U.S. Geological Survey, Induced Earthquakes, http://earthquake.usgs.gov/research/induced/; U.S.G.S. FAQs, *Earthquakes Induced by Fluid Injection,* http://www.usgs.gov/faq/taxonomy/term/9833; U.S.G.S., *Myths and Misconceptions*, http://earthquake.usgs.gov/research/induced/myths.php; Ker Than, *Oklahoma earthquakes linked to oil and gas wells, Stanford researchers say*, Stanford Report (June 18, 2015), http://news.stanford.edu/news/2015/june/okla-quake-drilling-061815.html.

- Can a developer replace or provide water wells or other sources of water to you as part of its operation?

As with ownership of the land, the first questions regarding water rights involve determining your ownership rights of water.

- Do you have surface water rights?
- Do you have groundwater rights?

The next questions address the scope of the developer's planned operations, e.g.:

- What are the developer's plans for obtaining water for the fracking operation? Is the developer being realistic about the amount of water needed?
- Does the developer have plans for obtaining water for other uses such as dust control?
- Has the developer applied for and received the appropriate permits or water rights?
- Where is the developer going to dispose of wastewater? For how long will the wastewater be stored? Will it be fenced or otherwise shielded from animals and people?
- What are the chemical compounds in the wastewater?
- Are there adequate protections so that contaminated wastewater does not contaminate the source from which you derive your water rights?
- If the developer is injecting wastewater back into the ground, does it have a permit to do so? How deep is the injection well for which it is permitted, and how far is that from your water source?

As discussed earlier, the oil and gas industry often refuses to divulge the precise chemicals used in its fracking fluid mixture, which means you are unlikely to get a full disclosure? answer to your question about possible contaminants in the wastewater. Lacking that information, it is impossible for you to do accurate baseline testing for potential contaminants.

Baseline Information

Begin by gathering baseline information on your own water rights and water quality, and also on the operator's plans for obtaining and using water for oil and gas operations and related work. This information will be useful in negotiating with landmen, and will be necessary to prove damages if impacts do occur.

1. **Identify your water rights for surface and ground water.**

   You can access public and private databases to find water right and land information. The DNRC, water rights consultants, and water rights attorneys can also assist with this research.

   - Gather and review all of your water right abstracts, and determine whether you have filed water rights for all of your wells and diversions.

   - Your water right abstracts will identify
     - flow rates,
     - places of use,

  - priority dates,
  - points of diversion, and
  - purposes for which the water can be used.
- If you have not filed notices of completion for your groundwater wells or exempt rights, you may want to talk with your local DNRC office about completing those forms in order to document and thereby be in a position to be able to protect these water rights.

Montana is a prior appropriation state. It is therefore essential to know the priority dates of your water rights, and to understand your priority relative to other users. Senior rights can place a "call" to stop junior users' withdrawal of water if the senior user's water rights are adversely affected or diminished by junior or new uses.

It is also important to understand the elements of your water rights if you decide to negotiate a temporary lease or sale of any of your water with the operator.

2. **Consider baseline testing of your water quality.**

The Montana Board of Oil and Gas requires baseline water-well water-quality testing on a case-by-case basis. Some operators perform this testing as a best practice. If you believe that your water quality has been adversely affected by oil and gas operations, baseline information collected prior to the start of operations will be useful to show any changes that have occurred, and correlate those changes with the fracking operations.

3. **Review any application materials for the operation on file with the Montana Board of Oil and Gas**.[213]

Developers must submit applications for permits from MBOGC, in which they should indicate the sources of water they intend to use. This information will help you determine whether the developer has water rights, and whether the proposed uses might cause adverse effects to your water use.

If a landman has been in contact with you about operations on or near your property, ask about the sources of water that the operator intends to use.

- Are the operations going to use freshwater exclusively, or will they be using some recycled water?
- Is it a closed loop system?
- Where will the water be obtained – from surface water or ground water, private owners or municipal water depots?
- What are the operator's plans for flowback or wastewater disposal?
- Where will the chemicals that are added to the fracking fluid be stored?

Gathering this baseline information will assist you with planning for the next phase, which may include discussions with a landman or other operator representative, especially if operations are planned on or near your property.

[213] DNRC Montana Board of Oil and Gas, http://bogc.dnrc.mt.gov.

Discussions And Negotiations

1. Some landowners negotiate with operators for water wells to replace or supplement existing water sources.
   - Some operators will drill or transfer ownership of water wells for the landowner as part of the negotiations on surface use.
   - Some landowners also negotiate leases or sale of their water for oil and gas operations, for purposes ranging from dust control to drilling operations.

2. If operations are planned on your land, think about negotiating setbacks from existing water sources such as wells, springs, streams, lakes, and ponds.
   - Including setback terms in lease agreements can help minimize impacts to these features.
   - Determine whether plans for chemical use and storage might create potential risks to your water sources that you want to address in negotiations and lease terms.

3. If you decide to lease or market any part of your water rights to the operator, make sure you properly own the water rights that you intend to sell.
   - Talk with your local DNRC office about proper procedures for leasing or transferring water rights.
   - Both you and the operator could be at risk for violating the Montana Water Use Act if you fail to follow the required procedures relating to leases and changes in your water rights.

Leasing Or Marketing Water To Operators

A Montana statute provides for temporary leasing of water rights, and other provisions address transfers and changes of your water rights.[214] If you are asked whether you will allow sources of your water to be used for oil and gas operations, you may want to investigate a temporary lease.

- The change and new appropriations processes can be challenging, time consuming, and expensive.
- The temporary leasing statute was intended to help mitigate some of these concerns.
- The best place to begin is the DNRC Regional Office for your location.[215]

Section 85-2-427, MCA, was passed by the 2013 Montana Legislature to address the needs of the oil and gas industry for water on a temporary basis.

- It was drafted by parties representing a variety of interests, including industry, landowners, and environmental groups.

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[214] Mont. Code. Ann. § 85-2-427.
[215] http://dnrc.mt.gov/divisions/water/water-rights/water-resources-regional-offices.

- The law provides a streamlined process for temporary use of water for purposes including oil and gas development and industrial uses.
- It allows water-rights owners to lease their water rights for two years during any consecutive 10-year period.
- The lease may not exceed 180 acre feet per year, and may be leased only during the period of diversion specified for the right.

Two important features of the law are intended to protect other water users on the source.

- The point of diversion for the right cannot be changed or moved. Water must be diverted at the water right owner's diversion point.
    - As a practical matter, water would usually be removed at the point of diversion by truck or other means and transported to the temporary use.
- The water right owner cannot irrigate the lands associated with the leased right, even if the water right owner has other water rights that could be used on those lands.

Municipalities have been marketing water for energy development through their municipal water rights.

- If the municipality creates a water depot within city boundaries or at the historic place of use, and does not expand its water right, then a change authorization is generally not required.
- Water depots are a significant source of water in the Bakken.

In some areas, it is possible to apply for a new permit to appropriate surface water, drill a new groundwater well, or apply for a change authorization to an existing water right.

- Exempt wells, which are under 35 gallons per minute and 10 acre-feet per year, may also be used in certain locations. At this time they are not subject to the notice and adverse effect requirements of new appropriations for larger wells.
- A filing with the DNRC is required within 60 days of use for exempt wells.

The administrative processes to complete a new appropriation of water or a change authorization require public notice, and the applicant must meet statutory requirements including a demonstration that other water users will not be adversely affected by the proposed new appropriation or change.

- The temporary leasing statute requires an analysis of potential adverse effects, but it can generally be completed in much less time than a new appropriation or change, often in three or four months.

The application form for the temporary lease is on the DNRC website. The fee to apply is $200.

Participating In Administrative Proceedings And Staying Informed

Public participation is an important feature of many Montana laws and proceedings related to water rights.

- Landowners who have questions or concerns about oil and gas operations should be aware of their opportunities and participate.

- Public notice is required in the new appropriation and change authorization process at DNRC, and usually involves newspaper publication and mailed notice to water users who could be adversely affected.
- The Montana Board of Oil and Gas also holds public proceedings, and provides opportunities for participation and comment.
    - If you are interested in keeping track of oil and gas activity around Montana, you can ask to be put on a mailing or email list for all proceedings coming before MBOGC.

Conclusion

Thank you for taking the time to read this document. Since we began working on this paper in early 2014, oil prices have stagnated and studies of fracking's impacts have proliferated. We are gathering more and more information about the potential impacts of fracking, which will enable Montanans to thoughtfully discuss and decide how best to regulate it in the future.

History tells us that oil prices will once again increase. Oil and gas developers will continue to develop those resources. Increasingly, the technical know-how exists to develop oil and gas in a way that maximizes positive impacts and minimizes negative ones. Whether the political will exists to accomplish this depends in large part on how informed and involved Montanans are in the conversation.

Our hope is that this paper will contribute to an informed discussion of that important question. Regardless of our differences, we all love this amazing state.