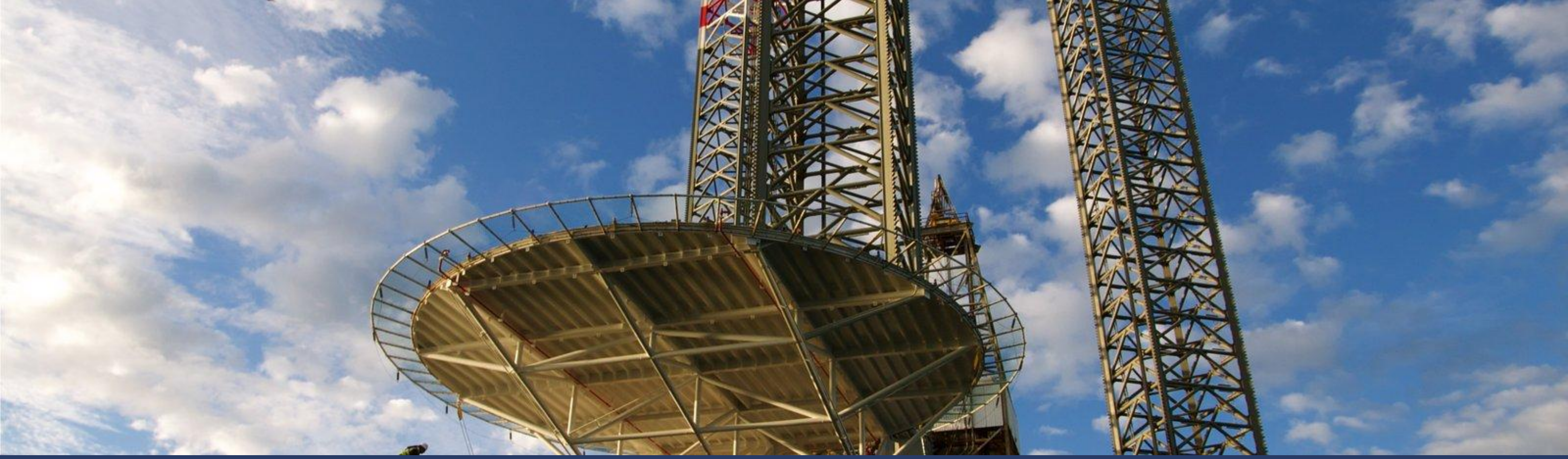

Benefits and Risks of Massive Fracking

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Ground Truth Trekking

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Misleading Memes in the Fracking Debate

If it seems hard to make sense of massive fracking, that's because it is. Anti- and pro-fracking camps have saturated the fracking debate with misleading, incomplete, and "spun" information. Key data are often trade secrets, and independent scientific research is sparse.

We've collected and explained some of the more common misconceptions:

"These scary sounding chemicals in fracking fluid must be very toxic."

Many chemicals appear to be harmless in very low concentrations, and may occur at background levels higher than in fracking fluids. Many common substances have exotic-sounding chemical names.

Acute toxicity is however not necessary to make water unpalatable or disrupt aquatic life.

“These everyday, commonly used chemicals in fracking fluid are harmless.”

Not if they’re in very high concentrations, or in an environment that can’t handle them.

“Water from fracked rocks is leaking into aquifers.”

Research on this is ongoing. Most freshwater aquifers are within ~1,500 feet of the surface. Most petroleum reservoirs are more than a mile (http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process) underground, placing them a long ways (often miles) below groundwater.

However, improper wastewater disposal or well casing failure can contaminate groundwater, during fracking operation.

“Most oil wells are fracked, and have been since the 1940s.”

True, but with a type of fracking which is unlike the “massive” fracking which is currently controversial.

“Fracking is producing unprecedented amounts of contaminated water.”

Oil wells have always produced large volumes of contaminated brine.

“In the movie Gasland…”

Gasland is an anti-fracking movie. It does not scientifically examine fracking - and “burning tapwater” can occur naturally in areas with a lot of shallow natural gas.

“Logically, if you think about it…”

Fracking is a technical engineering practice used in geological environments thoroughly alien to our daily experience. “Common sense” can be misleading.

“Fracturing the earth is just clearly a bad idea”

The earth’s upper crust is riven with fractures and faults. Introducing more fractures at a geologically small scale is not necesarily a problem.

“In this one case…”

Anecdotal cases do not necessarily equate to broad patterns.

“The straight facts say…”

Lying with facts is easy. The book "How to Lie with Statistics" (http://en.wikipedia.org/wiki/How_to_Lie_with_Statistics) provides useful tips on doing it with hard numbers.

"This authority (Greenpeace, Shell Oil, Wyoming DNR, EPA, University, etc.) says…"

Many authoritative-sounding sources have their own biases, funding sources, or "horses in the race." There's a lot of emotion and money at stake in the fracking debate.

"Wikipedia says…"

Wikipedia is a perilous source for information on controversial subjects, since there is no organized fact checking, and interested parties routinely engage in spin-doctoring.

Don't get us wrong: we LOVE Wikipedia… it's just not a technically reliable source.

High volume or "massive" fracking has various benefits and risk. The full geological and environmental effects of it are not yet well understood, but it has clearly had a major impact on the global economy and geopolitical landscape.

Massive fracking turns oil shale into a source of petroleum. It was pioneered in the United States, and other key players like China and Russia are trying to catch up. Shale oil has changed the global energy dynamic, and massive fracking is at the heart of the shale oil revolution.

Fracking's potential impacts range from transforming local economies, to increasing U.S. energy security, to permamently contaminating aquifers. Some impacts are intrinsic to fracking anywhere in the world, but others are special to certain geologies, or to the specific role U.S. fracking currently plays in the world's oil economy.

Within the specific structure of U.S., the shale oil industry and associated policies may be creating major long-term harm to society, despite short-term benefits.

Aspects of massive fracking covered in this article:

- **Energy Security& Geopolitics**
- **Reduced Oil Prices**
- **Water Contamination**
- **Impact on Natural Gas Use**
- **Earthquakes**
- **System Hazard of the Shale Oil Industry**
- **Fracking Brine: Toxic or Not?**

For a discussion of the differences between massive fracking and small-scale petroleum well fracking, see our article on **Fracking in Alaska. (/Issues/AlaskaOilandGas/hydraulic-fracturing-fracking-in-alaska.html)**

_ **AUTHOR'S NOTE:** Finding clear and reliable information on massive fracking is difficult. It is a subject of intense controversy, major players have large financial stakes in it, opposition is ardent, and the public discourse is often “spun” by marketing and salesmanship techniques. Scientific research has lagged behind the speed with which fracking has proliferated. We continue to update this article as we find new information which meets our standards for quality and credibility._

Energy Security & Geopolitics

Reliance on foreign oil has long been a concern in the United States economy. At present, fracking makes the U.S. less reliant on foreign energy sources - and thereby generates wealth and reduces America’s interests in overseas energy supply areas, notably the Middle East. Many other countries (http://en.wikipedia.org/wiki/Hydraulic_fracturing_by_country) are now experimenting with the technique, notably China and several nations in Europe and the Commonwealth. All of these countries have the potential, at least theoretically, to increase their energy security with fracking.

U.S. energy independence also reduces the leverage of other petroleum-producing states such as Russia and Iran, with whom the U.S. and EU currently have troubled relations. Unconventional oil development in the U.S. and allied nations has the potential to provide U.S. allies with more secure energy supplies and to increase U.S. influence. For instance, the strife in Ukraine earlier this year has highlighted the reliance of the EU on Russian natural gas.

Control of energy supplies is a major geopolitical lever, and increased energy independence of consumer nations can be a threat to supplier nations. For instance, their is credible cause and some evidence to suggest that Russia is very threatened by increased European energy independence, and has moved to stymie fracking development in Europe for this reason. Europe has little internal energy production, and Russia's major role as an energy supplier to Europe both give it strong influence in Europe, and help fund the Russian petroleum-dependant goverment.

Following the rapid emergence of strong and well-organized opposition, massive fracking has been severely restricted or banned throughout much of Europe. This includes in some Eastern European nations which have no history of effective and well-organized environmental movements, but which are heavily reliant on Russia energy. The head of NATO has alleged (http://www.foreignpolicy.com/articles/2014/06/20/russias_quiet_war_against_european_fracking) that Russian influence underlies these events. Vladimir Putin has spoken strongly against fracking, while Russia has simultaneously sought to aggressively develop it's own shale fracking.

Environmental as well as energy soverignty concerns may argue for U.S. domestic fracking development, as well. The United States also has some of the most stringent and well-enforced petroleum pollution regulations of any major oil-producing nation. Onshore U.S. oil production competes with oil production in nations where regulations & enforcement are much more permissive, and where petroleum development often has much more severe environmental damages - like the Persian Gulf states, Venezuela, Iran, Russia, India, Nigeria, Brazil, Mexico, and Argentina. At the same time, the system dynamics of the shale oil industry (discussed later) suggest that current shale oil development in the U.S. may be creating major, long-term water contamination liabilities.

Reduced Oil Prices

At least in the short-term, U.S. shale oil production has helped drive down global oil prices. The result is cheaper oil products, and by extension, lower prices (or higher profit margins) on things oil is used to produce. Since oil contributes to the production of almost everything in our society, that might translate to lower costs-of-production for a vast spectrum of goods - including food, imports, and everyday services.

Fracking-related oil price reductions are potentially very short-lived. Shale oil wells run dry after several years. Without equally economical replacement wells, oil prices may rebound to previous levels quickly. The 1973 oil crisis (http://en.wikipedia.org/wiki/1973_oil_crisis) demonstrated the risks of this, when people and industry had adapted to cheap oil, and suddenly were faced with expensive oil.

In the short term, however, low oil prices will likely boost the U.S. and world economies. Low oil prices will also place pressure on states and nations which rely heavily on oil for their revenues.

The environmental risks associated with petroleum production, and perhaps with fracking in particular, are coupled with the enviornmental imapct of increased world oil usage. Cheap oil prices prevent the restructuring of the world economy to use less oil. Therefore, from the perspective of climate change, low oil prices may be a long-term bad thing, insofar as they allow us to delay the “necessary pain.”

Water Contamination

Much environmental concern about fracking focuses on water contamination issues. Scientific study of these risks is inconclusive, as of 2014. Opponents of fracking cite concerns that fracking uses large volumes of water, that it can leave that water contaminated, and that it may cause additional contamination of groundwater. The potential risks are a subject of vigorous debate and ongoing study.

In practice, most fracking occurs at depths greater than 6,000 feet, (http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process) far below the freshwater aquifers that humans use. There are occasions when fracking has been used on much shallower petroleum reservoirs - notably in Pavillion, WY, (http://www2.epa.gov/region8/pavillion) where petroleum was only 1,200 feet underground, and water wells lay within hundreds of feet of the reservoir.

A 2013 Duke University study (http://www.eenews.net/assets/2013/06/25/document_ew_01.pdf) in Pennsylvania linked elevated levels of methane in well water to the proximity of massive fracking operations. A 2014 Department of Energy study (http://www.petroleumnews.com/pnads/202132205.shtml) found that fractures created in the same formation did not extend up beyond the petroleum reservoir into the overlying aquifer, suggesting that fears of fracking fluids or reservoir hydrocarbons & brine migrating upward from the fracking sites themselves into groundwater aquifers may be unfounded in many operations. Another 2014 study (http://dfw.cbslocal.com/2014/09/15/new-study-looks-at-fracking-groundwater-contamination/) purports to have found evidence that faulty well casings are the cause of fracking-associated contamination, echoing past speculation (http://online.wsj.com/news/articles/SB10001424052702304537904577277814040731688) that well casings are may be rupturing during fracking.

The EPA is currently conducting a nationwide fracking study (http://www2.epa.gov/hfstudy) on water risks, scheduled (http://truth-out.org/news/item/20039-fracking-unfocus-how-the-epas-long-awaited-hydraulic-fracturing-study-could-miss-the-mark) for release in 2016. The EPA also issued a draft report (http://www2.epa.gov/sites/production/files/documents/EPA_ReportOnPavillion_Dec-8-2011.pdf) in 2011 on water contamination in Pavillion, WY, which concluded that the contamination was the result of drilling operation. The Pavillion investigation was handed over (http://www.reuters.com/article/2013/06/20/us-usa-epa-fracking-idUSBRE95J1AN20130620) to the state prior to issuance of a final report. In August 2014, Wyoming issued a draft report finding (http://trib.com/business/energy/wyoming-report-pavillion-gas-wells-properly-drilled-more-study-needed/article_2ebe8849-98be-522d-ab51-0719d1edc710.html) that the petroleum wells had been properly drilled, but that more study was needed.

Improper disposal of fracking wastewater and “produced” water (water extracted with oil and gas) is a potentially very serious problem. The State of California recently found that drillers had illegally injected 3 billion gallons of contaminated fluid (http://rt.com/usa/194620-california-aquifers-fracking-contamination/) into a freshwater aquifer which is used for human consumption and irrigation. Likewise disposal of briney water from any petroleum operation into surface waters can cause serious contamination, whether it is fracking fluid or produced water. Groundwater from miles below the earth’s surface invariably contains disolved material, from hydrocarbons to metals to radioactive elements, which in its natural concentrations is harmful to surface life.

Alaska’s risk of fracking-related water contamination is unclear. In the case of the Great Bear field, Great Bear Petroleum LLC has identified (http://www.petroleumnews.com/pntruncate/312301231.shtml) the probable fracking zones as 9,000 to 11,000 feet underground - well below the surface aquifer. The water source and disposal methods which might be used on the Great Bear have not been established, as the project is still exploratory.

Groundwater contamination is a particularly notable risk, since we have no plausible technology to “clean” aquifers. Once an aquifer is polluted, it will never again be clean on a human timescale. The economic and social costs of aquifer pollution may be major in the future, as contamination extends through the aquifer and removes it from agricultural, industrial, and human-consumption use.

Impact on Natural Gas Use

JACKUP RIG IN HOMER — The Endeavor jackup rig arrived from Singapore, and is under contract with Buccaneer and Kenai Offshore Ventures. — Get Photo (/photos/jackup-rig-in-homer/)

Fracking of oil shale has made natural gas cheaper in the U.S., and in the last decade natural gas appears to have offset coal use for electricity generation. Increased natural gas use at least partly displaces other fossil fuels, reducing human output of pollutants and greenhouse gases - if energy use remains constant, and fugitive emissions can be controlled.

Since 2004, natural gas use for electricity generation has risen (http://marketrealist.com/2014/10/why-natural-gas-injections-affect-thermal-coal-demand/) from 18% to ~28% of all generation capacity, while coal has lost the same amount. The competition (http://www.iea.org/publications/insights/coalvsgas_final_web.pdf) between coal and natural gas in the U.S. electricity generation mix is sensitive to many factors, only one being price. Although in practice the equation is not as simple as “more gas automatically equals less coal burned,” increased natural gas production has the overall potential to offset the use of other energy sources, one of which is coal.

Overall, the development of gas-bearing oil shales could hypothetically boost global natural gas and crude oil production (or at least partly offset production declines in conventional oil and gas fields). This may be particularly important for the U.S. and China, which are the world’s two leading consumers of coal, (http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=2) and which also possess the world's largest reserves of oil shale.

Natural gas is the least polluting fossil fuel; when burned it produces far less toxic pollution (http://naturalgas.org/environment/naturalgas/) and only half as much fossil carbon as coal. However, if natural gas escapes during extraction or transport, it can have a huge climate impact, and methane seeping from leaky equipment can be a major contributor to atmospheric greenhouse gases (for example during coal bed methane extraction (http://time.com/3487638/four-corners-arizona-new-mexico-colorado-methane-gas-global-warming-climate-change-utah/)). These "fugitive emissions" are a cause of great concern because methane - the main component of natural gas - is a greenhouse gas over 20 times more potent (http://epa.gov/climatechange/ghgemissions/gases/ch4.html) than carbon dioxide on a 100-year timescale.

Oil, Water, and Chemical Spills

The spillage of oil, fracking fluids, and chemicals is a major environmental concern. By nature, shale oil operations involve drilling from numerous drill pads, meaning that there are many potential locations for accidents and spills. Handling and disposal of fracking chemicals and used fluid (known as "brine") imposes a new complexity and risk.

TANKS AT THE DRIFT RIVER OIL TERMINAL — Drift River Oil Terminal (/Issues/AlaskaOilandGas/Drift-River-Oil-Terminal.html) — Get Photo (/photos/tanks-at-the-drift-river-oil-terminal/)

However, conventional petroleum operations must often handle enormous volumes of briny water, known as “produced water,” which comes out of petroleum reservoirs along with oil, so the handling of tainted water is not new to the petroleum industry.

Most spills associated with fracking are small, although large spills occasionally occur. U.S. spills from petroleum operations rose by 17% (http://www.eenews.net/stories/1059999364) in 2013, and appear to have outpaced the actual increase in drilling rigs. Some industry commentary has attributed this to more stringent reporting requirements, while environmentalists have blamed poor practices. Other commentary has observed that the structure of U.S. drilling permits encourages companies to drill as many wells as possible before their permit expires - a system which encourages hasty well completion and therefore errors.

Spillage may be elevated in fracking operations not due to intrinsic aspects of fracking, but due to immaturity of practices (i.e. “We haven’t been donig this for very long”) or to production pressures (i.e. “Get it done fast”). Fracking operations are also associated with an increase in large-truck accidents, according to a 2013 Pennsylvania study, (http://documents.foodandwaterwatch.org/doc/Social_Costs_of_Fracking.pdf) probably due to the larger number of trucks on the road, servicing many drill pads and transporting water, chemicals, personnel and equipment.

Earthquakes

Fracking has been scientifically linked to triggered earthquakes (http://rt.com/usa/171092-2500-fracking-earthquakes-oklahoma/). Triggered earthquakes occur when human disruptions allow the earth’s crust to release stored stress. In the case of fracking, this is mostly likely caused by the injection of wastewater into the ground, where it increases the pressure of the fluid in the rock formation, effectively lubricating rock. The actual fracking process itself is not currently believed to trigger seismicity (or at least, it is believed to trigger only a small fraction of the events observed at fracking sites).

Research into fracking-related earthquakes is ongoing. A scientists have found a significant link between fracking operations and earthquakes in Oklahoma (http://earthquake.usgs.gov/research/induced/), Ohio (http://www.sciencedaily.com/releases/2015/01/150105182448.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sc %28Latest+Science+News+--+ScienceDaily%29), and British Columbia. (http://www.alaskahighwaynews.ca/news/lng/fracking-caused-220-earthquakes-in-area-ogc-1.1724318) A recent study in Texas found a direct causative link (http://www.sciencedaily.com/releases/2015/04/150421132039.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sc %28Latest+Science+News+--+ScienceDaily%29) (i.e. fluid injection and removal caused earthquakes).

Thus far, documented fracking-triggered earthquakes have all been small (http://www.energyfromshale.org/articles/fracking-and-earthquakes), and most will probablyy continue to be small, although larger earthquakes could be triggered in the right geological circumstances. The chances of trigging major earthquakes increases where fracking is used in geologically unstable regions (ex: California, the Pacific Northwest, Alaska), as opposed to in geologically stable regions (ex: the Dakotas, Texas, Pennsylvania).

System Hazard of the Shale Oil Industry

The structure of the shale oil industry and policy in the United States may be incentivizing practices which cause permanent harm to the common good or to 3rd parties (such as landowners and watershed users) for the short-term gain of key beneficiaries. This stems from the current *shale oil industry* in the United States, as opposed to from the technical process of massive fracking.

U.S. petroleum leases incentive the rapid drilling many wells, and drillers finish them as quickly as possible. This reinforces the natural motivation to create wells as cheaply as possibly, and to conduct operations quickly ("time is money"). Subsurface resource rights (http://frackwire.com/mineral-rights/) further complicate the picture, as U.S. law also currently grants shale oil developers with subsurface resource rights the freedom access and conduct operations on surface property overlying their claims. In practice, this can mean that surface rights (landowning) is subjugated to subsurface rights (petroleum exploitation). It may also mean that local landowners may lose use of common goods (such as groundwater or clean streams) due to the activities of oil shale developers drilling on their land against their will.

The so-called "Haliburton Loophole" (http://www.nytimes.com/2009/11/03/opinion/03tue3.html?_r=0) in the 2005 Energy Bill exempts fracking fluids from the Clean Water Act, the primary protection of U.S. waters against pollution. The law still regulates wastewater injection and disposal (http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydroreg.cfm). Theoretically, deep fracking fluids are not a risk to surface water, and need not be regulated as such, in the same sense that spacecraft need not follow the same emission guidelines as airplanes, when using their engines outside the atmosphere. This does introduce the handling and use of chemicals which would not be considered safe in the environment if spilled, similar to petroleum itself.

Well drillers themselves may have great difficulty identifying leakage of contaminated fluids from their own operations into the rocks and waters surrounding their wells, and it may be impossible for observers to know whether petroleum operations are contaminating local groundwater, such as via well leakabe or illegal wastewater injection. Where contamination of groundwater occurs, it may be impossible to prove to the source. This creates a situation where well-intentioned oil producers may nonetheless cause damage unwittingly, and where misconduct may be difficult to detect and punish. In both cases damage is likely to be irreversible, since no current technology can clean contaminated aquifers. Pollution of groundwater is a problem of uncontained perpetual waste, (/Issues/OtherIssues/perpetual-waste-storage-perpetuity.html) and may impose very large future costs on society by permanently removing contaminated water sources from human use.

Finally, according the financial use of time-discounting, future costs are assessed as being worth less than current costs. Business logic dictates that shale oil developers should consider the chances their operations will cause damage, the chance that it will be discovered, the chance they will be held accountable, and the fact that any bills for that will likely come far in the future. Future costs, being time-discounted, will either be accounted in the present as being less costly, or the company itself may have dissolved by that time. If so, its liabilities will be transferred to the State..

As such, the U.S. shaloe oil industry has features which appear to create strong downsides. This may be likened to a "Tragedy of the Commons" (http://en.wikipedia.org/wiki/Tragedy_of_the_commons)situation (see the classic 1968 paper (http://www.geo.mtu.edu/~asmayer/rural_sustain/governance/Hardin%201968.pdf)), in which the rational choices of individuals may be harmful to the good of society. The difficulty of identifying accidents and deliberate misconduct in shale oil operations, and the irrevsible and long-term nature of some damages, may be driving this harm to unusual levels. Society as a whole, including the future State, businesses, and private citizens, are likely to pay these external costs. (http://en.wikipedia.org/wiki/Externality)

Fracking Brine: Toxic or Not?

Hundreds of different chemical additives are used in the fracking industry, but typically only a handful in a given frack. Chemicals are used for many reasons, (http://fracfocus.org/chemical-use) such as altering water viscosity, chemically etching the rock formation, and retarding corrosion.

Public statements on the apparent toxicity of fracking brine are potentially misleading. In the publicity around fracking, supporters often describe chemicals used or absorbed as innocuous (a common example is guar gum, (http://

en.wikipedia.org/wiki/Guar_gum) used widely in food), and opponents cite the more hazardous substances (such as hydrochloric acid, benzene, arsenic, and radioactive elements (http://ehp.niehs.nih.gov/122-a50/)).

Such listings are not very helpful in determining actual risk, since they omit concentrations and environmental context. Common substances like table salt and guar gum can be environmentally harmful if released in high concentrations or in sensitive areas. Likewise, extremely toxic additives and absorbed chemicals like xylene, benzene, toluene, arsenic, radium, and thallium may be present in fracking fluid in concentrations lower than would be harmful, or in concentrations smaller than they are already found in the local environment, either due to natural occurrence or human activities.

Used fracking brine is typically water with a mix of added chemicals, plus additional chemicals absorbed underground or brought up by ancient groundwater liberated from the rock formation itself. There has been no systematic analysis of the content of brine, and the authors' knowledge of its toxicity is limited to specific cases and to their knowledge of produced water toxicity. Analysis has shown some samples of fracking brine to be dangerously toxic (http://ecowatch.com/2012/07/02/first-ever-fracking-test/) and radioactive, (http://www.dispatch.com/content/stories/local/2012/09/03/gas-well-waste-full-of-radium.html) and spills have been observed (http://insideclimatenews.org/news/20140716/saltwater-north-dakota-fracking-spill-not-whats-found-ocean) to kill local biota.

Oil wells have always produced large amounts of contaminated waterr (http://www.spe.org/industry/docs/reusingwater.pdf) since such water naturally occurs in petroleum reservoirs. It's not clear if any fundamentally new issues are arising in the handling of tainted fracking water, or many water contamination issues are arising from the movement of intensive petroleum operations into previously populated areas which have grown reliant on clean ground and surface waters. The additional risk of fracking additives is not uniform to all fracking mixtures, nor is it well established.