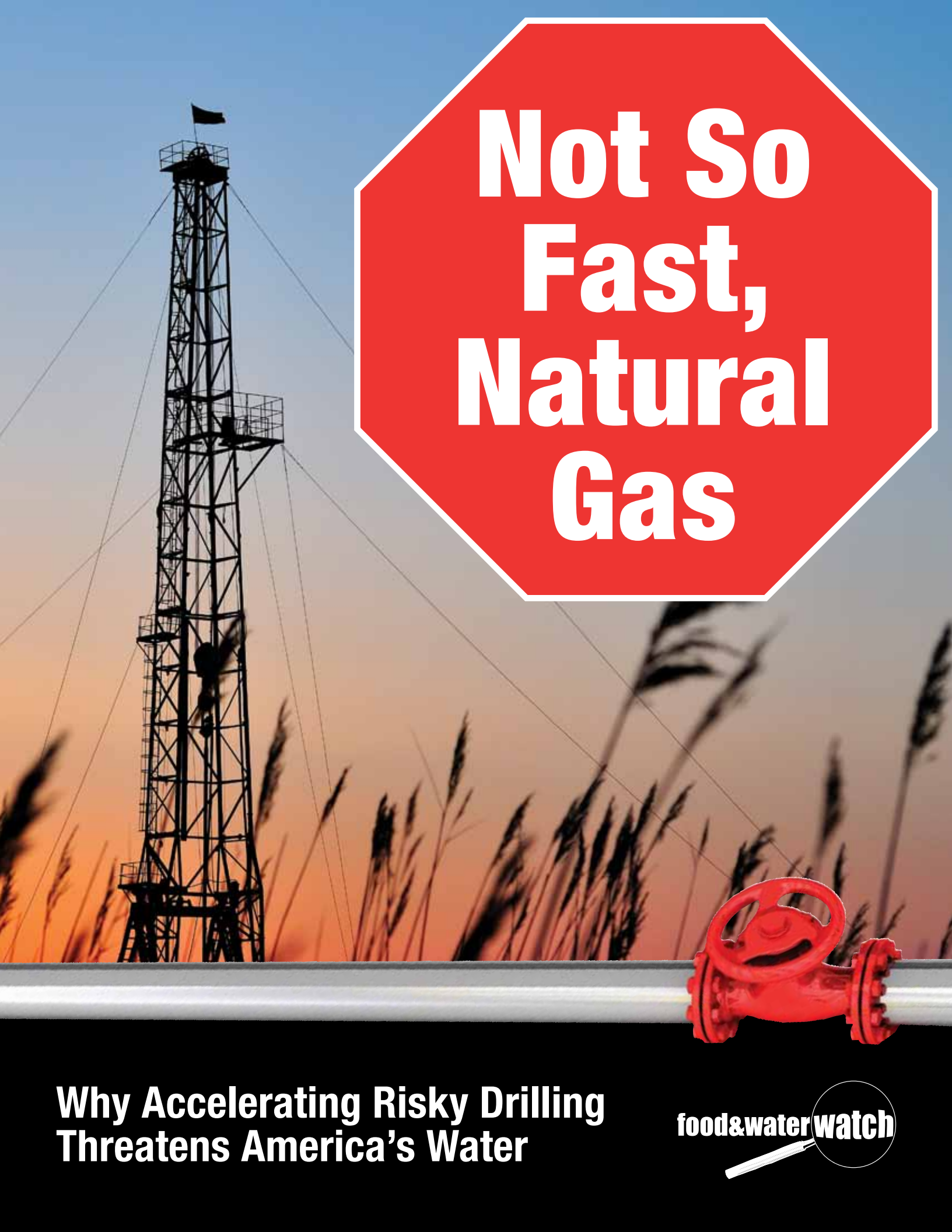


Not So Fast, Natural Gas

Why Accelerating Risky Drilling Threatens America's Water

food&water watch

About Food & Water Watch

Food & Water Watch works to ensure the food, water and fish we consume is safe, accessible and sustainable. So we can all enjoy and trust in what we eat and drink, we help people take charge of where their food comes from, keep clean, affordable, public tap water flowing freely to our homes, protect the environmental quality of oceans, force government to do its job protecting citizens, and educate about the importance of keeping shared resources under public control.

Food & Water Watch
1616 P St. NW, Suite 300
Washington, DC 20036
tel: (202) 683-2500
fax: (202) 683-2501
info@fwwatch.org
www.foodandwaterwatch.org

California Office
25 Stillman Street, Suite 200
San Francisco, CA 94107
tel: (415) 293-9900
fax: (415) 293-8394
info-ca@fwwatch.org

Not So Fast, Natural Gas

Why Accelerating Risky Drilling Threatens America's Water

Executive Summary

After witnessing BP's devastating Deepwater Horizon oil spill in the Gulf of Mexico, some industry analysts are suggesting that domestic natural gas is a good onshore alternative. But the damage that a rapid expansion of the industry could do to America's water could be our next energy disaster.

Even before the oil spill, drillers had begun using a potentially harmful method for extracting natural gas known as "hydraulic fracturing"—"fracking" for short. Advances in this technology now allow drillers to extract gas on a large scale from previously hard-to-reach rock formations — specifically from shales and other "tight" (denser, less porous) rocks. The energy industry, convinced of an impending shale gas revolution, has increased its investments in natural gas and begun advertising and lobbying to sell its product. Meanwhile, small towns near gas deposits are witnessing a mad rush to drill near and in their communities.

Unfortunately, without oversight to protect the public, this rapid expansion of the shale gas industry poses a great threat to America's water — and the people who drink it. The same hydraulic fracturing technology that is driving the industry's expansion threatens the country's water resources.

In order to extract gas from shale and other unconventional sources, drillers shoot a mixture of water, chemicals and sand into the ground; some of these fluids remain underground after extraction and can seep into groundwater. The rest is recovered as wastewater and must be disposed of in some way.

Many of the hydraulic fracturing chemicals are toxic. If hydraulic fracturing fluids leak into groundwater, they can contaminate nearby drinking water sources. The wastewater produced with the gas contains toxic fracturing chemicals as well as high levels of Total Dissolved Solids — dissolved matter that may indicate further contamination. The water may also contain possibly radioactive elements it picks up underground.

Disposing of this wastewater safely poses problems. Undiluted fracturing chemicals and wastewater can further contaminate water supplies through accidental spills and leaks. And, when fracturing loosens gas, it can cause methane to migrate into nearby household wells — which can cause wells and houses to explode. Although the industry has long claimed that hydraulic fracturing is safe, scores of documented cases of water contamination near natural gas drilling sites indicate otherwise.

The expansion of hydraulic fracturing affects small communities most profoundly across rural America. The residents are not protected from the industry's impacts on their water and thus far have struggled to get the attention of their politicians. Few states strictly regulate hydraulic fracturing, and the federal government exempted it from the section of the Safe Drinking Water Act that protects water from underground injections, among other laws that protect America's air and water, in the Energy Policy Act of 2005. Congress passed these exemptions after intensive lobbying from former Vice President Dick Cheney and the energy industry.

Now, major rivers that serve as drinking water sources are in danger. In fact a recent report declared the Upper Delaware River in Pennsylvania and New York and the Monongahela River in Pennsylvania and West Virginia to be two of the top 10 endangered rivers in the country due to the potential contamination from natural gas drilling in the Marcellus Shale.

As many local residents and policymakers have brought attention to the dangers of drilling, some progress has been made to protect water. New York is strengthening its state-level regulations and New York City is calling for a moratorium on further drilling in its watershed. Other entities, such as Flower Mound, Texas, and the Delaware River Basin Commission, have called for moratoriums on new permits. Congress has charged the U.S. Environmental Protection Agency (EPA) with preparing a report about this process and its potential hazards. Even some shareholders of drilling companies have signed resolutions questioning hydraulic fracturing because of their concerns about its impacts on water. But with more wells drilled every day, greater efforts must be made to keep America's water safe.

The federal government must require companies to disclose the contents of their chemicals and comply with laws that prevent the contamination of underground drinking water. No further drilling should occur until the impacts on water are fully understood and regulations are in place to protect the public from those impacts. Meanwhile, the United States should be pursuing new, renewable alternative energy sources that avoid damage to the country's water resources, human health and the environment.

Policy Recommendations

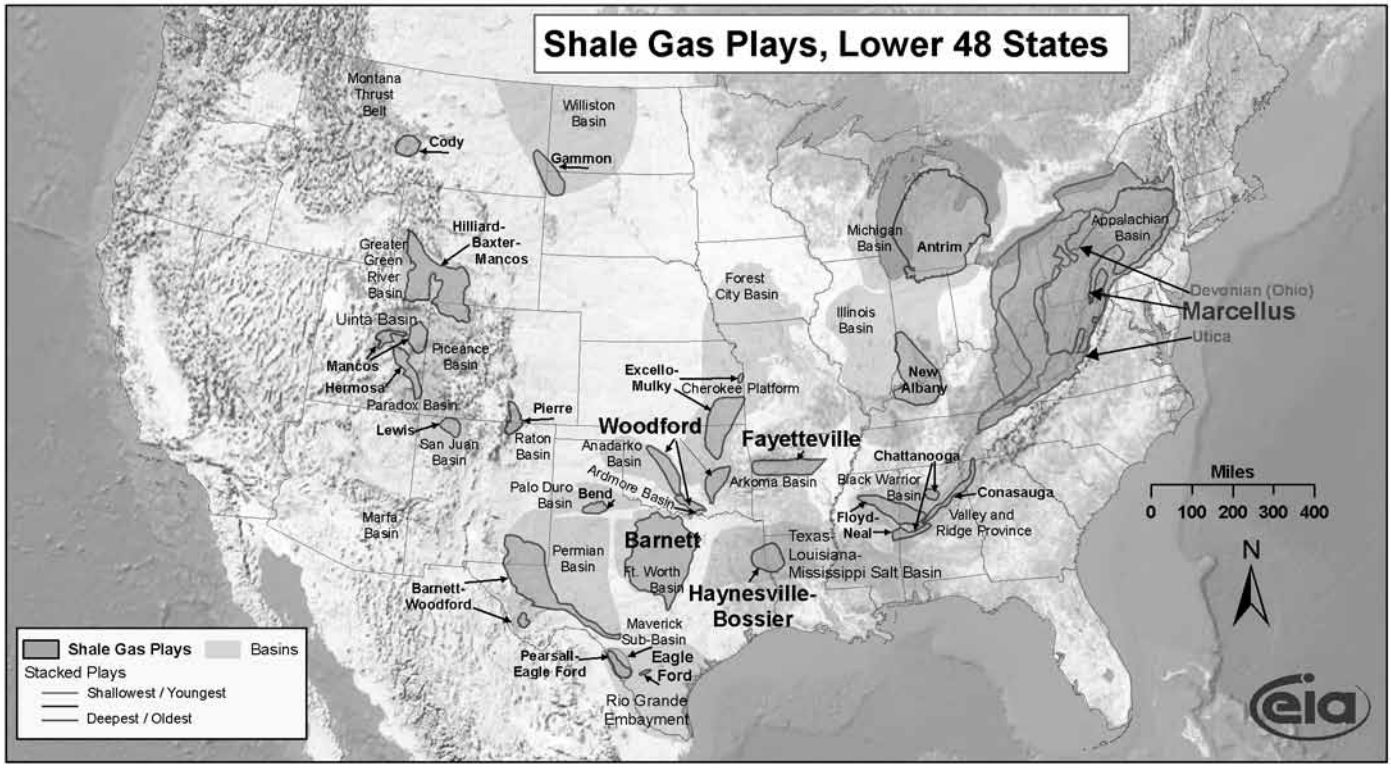
The federal government should pass the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act (H.R. 2766, S. 1215) to close the loophole that excludes hydraulic fracturing from regulation under the Safe Drinking Water Act.

States should pass legislation to require the natural gas industry to report the chemicals used for hydraulic fracturing or to implement other measures to protect water quality and the health of residents.

Congress should place a moratorium on issuing new permits for hydraulic fracturing until after the EPA publishes its study on the effect of hydraulic fracturing on water quality, expected in 2012.

The EPA should conduct additional studies on hydraulic fracturing to examine its effects on human health and the environment.

Congress should establish a new federal regulatory agency to oversee the fossil fuel industries. Recent tragedies — the oil spill in the Gulf, the mine explosion in West Virginia, and the serious problems posed by hydraulic fracturing — reveal that the existing federal agencies are simply not protecting the American people. This new agency would focus on protecting public health, worker safety and the environment.



A map of all the shale gas extraction sites in the country, created by the U.S. Energy Information Administration and last updated in March 2010. More information is available at www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm.

The continued security and economic health of the United States depends on a sustainable supply of both energy and water. These two critical resources are inextricably and reciprocally linked; the production of energy requires large volumes of water while the treatment and distribution of water is equally dependent upon readily available, low-cost energy. The nation's ability to continue providing both clean, affordable energy and water is being seriously challenged by a number of emerging issues.

– Sandia National Laboratories

Introduction

Clean energy should not put lives in danger. Nothing illustrates this better than the massive oil spill from BP's Deepwater Horizon offshore oil rig in the Gulf of Mexico, which has highlighted the damage that unsafe energy production can do to our well-being when it pollutes our water. Yet some industry analysts are using the spill in the Gulf to suggest that the United States should invest in another energy source that also poses great risk to water: natural gas.[1]

Today, the growing natural gas industry in the United States promises an abundant, onshore, domestic source of fuel that produces fewer carbon emissions than coal and oil when burned — a quality that industry groups use to justify selling the product as "clean."[2] But new methods of drilling for natural gas reveal that it is far from a clean source of energy. While recent well and pipeline explosions in Pennsylvania, West Virginia and Texas have brought attention to the immediate dangers of the fossil fuel production,[3] a less obvious but perhaps even more problematic side effect is the damage that drilling for natural gas can do to local water — and to the health of the people who drink it.

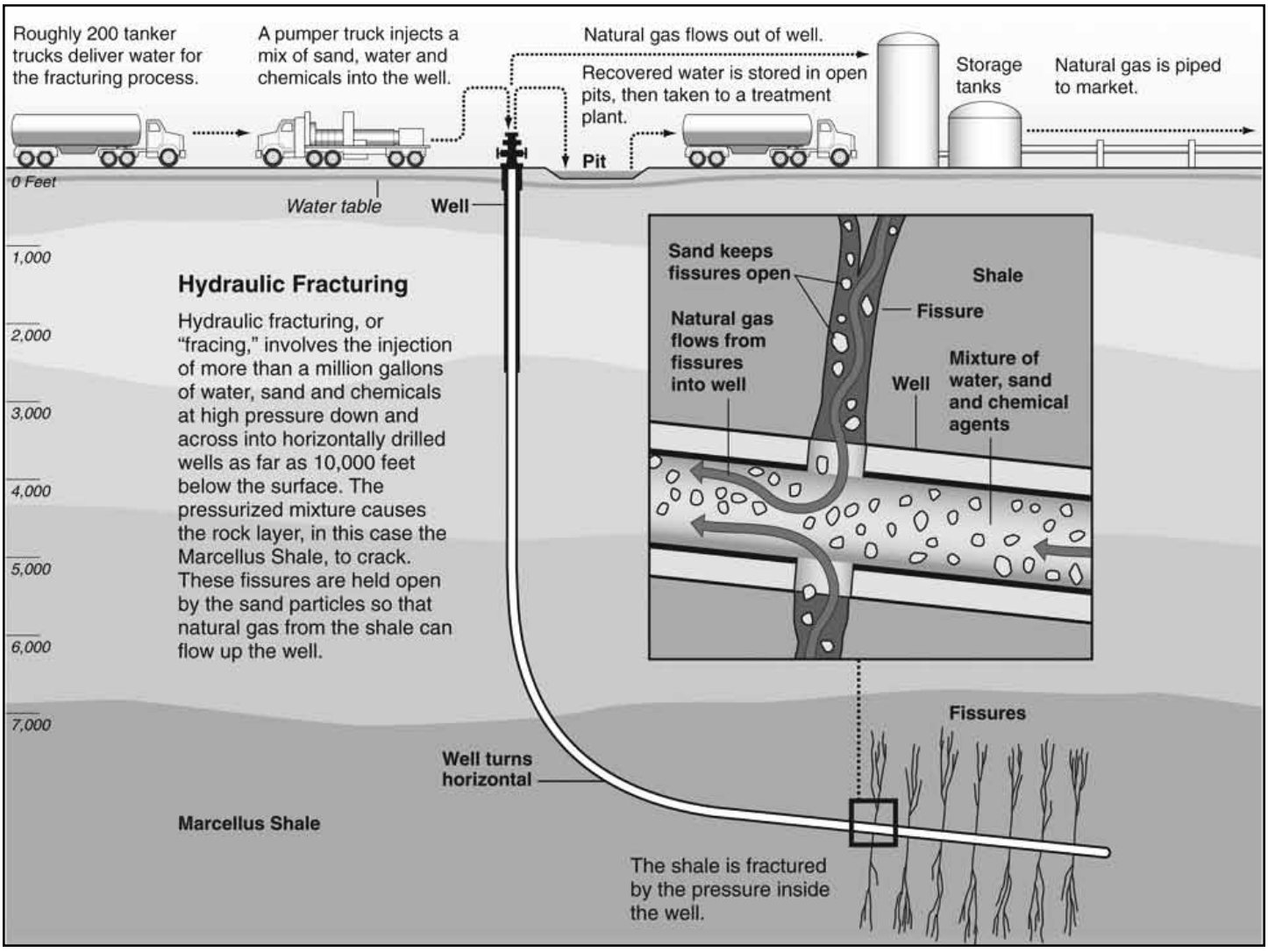
The great danger that the current rapid expansion of the natural gas industry poses to domestic water resources is a key example of why the United States must ensure that new energy policies protect public water, and why the country should be aggressively seeking new clean energy alternatives — not supporting hydraulic fracturing for natural gas.

The Rise of Natural Gas

Even before the oil spill in the Gulf brought attention to natural gas as a potential source of onshore energy, the natural gas industry in the United States was poised to expand. As recently as 2005, the CEO of ExxonMobil at the time had declared, "Gas production has peaked in North America."[4] But by 2008, many in the industry expected that to change drastically. Navigant Consulting's 2008 "North American Natural Gas Supply Assessment," prepared for a group that promotes natural gas, described a recent "rapid escalation" in new production, which it predicted would continue — especially in areas where there are shale rock formations.[5]

The change in outlook did not occur because new gas deposits were discovered, but because it suddenly seemed economical to extract gas on a large scale from sources that were previously inaccessible. Historically, most natural gas production came from "conventional" source rocks such as limestone and porous sandstone.[6] In these rock formations, gas is loosely held and can flow freely from pores in the rock. Many of the wells used were known as "vertical wells," drilled straight into the ground.[7] Many early wells "were never able to produce a marketable quantity of natural gas."[8]

Other rock formations such as "tight" (dense, less porous) sands, coal beds and shale contained gas, but it was held too tightly within those rocks to make its way into the traditional wells without additional stimulation.[9] More recently, however, drillers found a way to access these hard-to-reach, "unconventional" gas sources using a method called hydraulic fracturing, sometimes referred to as "fracking" for short.



A graphic illustrating how hydraulic fracturing is conducted in the Marcellus Shale. Created by Al Granberg, courtesy of ProPublica. More information available at www.propublica.org/special/hydraulic-fracturing-national. Note: This image does not depict the natural faults and fractures which can also exist under the ground near drilling sites. If the fissures produced from drilling (see image) were to intersect with these naturally occurring cracks in the ground, liquids or gases could migrate through the rock formations and potentially contaminate water.

In this method, drillers inject hydraulic fluids — a mixture of water, chemicals and sand — into the wells to create pressure that cracks the rocks, allowing the gas to escape and flow into the wells.[10] This stimulation technique became capable of producing even more gas when it was combined with a newer drilling technique known as "horizontal wells." Instead of simply drilling vertically into the ground as had been common in conventional extraction, the end of a horizontal well curves directionally into the rock formation, which means the well has the potential to reach into more fractures and extract more gas.[11]

Hydraulic fracturing has been used in Pennsylvania since the 1960s, and horizontal wells have been drilled in Texas since 1929.[12] But it was only recently that they became more economical to use on a large scale.[13] First, the efficacy of the technology improved.[14] Then, the prices of gas went up, which made it appear more profitable to drill.[15] Finally, after intensive lobbying by the industry, the Energy Policy Act of 2005 exempted the industry from federal regulations that would protect drinking water from hydraulic fracturing.[16] The passage of this legislation meant that drillers could use the technology without federal oversight of any potential water contamination, so companies didn't have to follow the safest practices.[17] Hydraulic fracturing suddenly became much more profitable.

According to Navigant Consulting, although conventional natural gas production declined between 1998 and 2007, overall production increased due to the industry's ability to tap into unconventional sources.[18] In the decade from 1998 to 2008, gas from unconventional sources grew from 28 percent to 46 percent of the total U.S. production.[19] The biggest increase in unconventional production came from shale. According to the energy consulting group IHS CERA, shale gas increased from 1 percent to 20 percent of the U.S. natural gas supply between 2000 and 2010.[20]

The "Shale Gas Revolution"

Seeing this, some industry experts are predicting that gas from unconventional sources is a major "game changer," partly because of hydraulic fracturing's potential to produce gas from shale.[21] These rock formations are buried deep beneath the ground, and hydraulic fracturing is the preferred method to obtain gas from them.[22] There are over 20 active shale gas "plays," or sites targeted for extraction, in the United States,[23] but it only recently seemed economically sensible to tap into them on a large scale. Some, such as the Barnett Shale in Texas, have already seen a great deal of development.[24] But others, such as the Marcellus Shale in the northeast, have just begun to see large-scale drilling with the advent of hydraulic fracturing and price incentives that make drilling seem worthwhile.[25]

Industry estimates of how much gas could be produced in the United States have skyrocketed because of this new ability to tap into shale. In 2008, Navigant Consulting claimed that U.S. Energy Information Administration numbers greatly underestimated the amount of gas available from this source.[26] Many such industry estimates hinge on the Marcellus Shale being a large new source of gas. Scientists at Penn State and State University of New York at Fredonia published research indicating that the Marcellus Shale could be a "Super Giant gas field."[27] According to the United States Geological Survey, this estimate would mean that the formation could produce enough gas to supply the total U.S. natural gas demand for two years, although another estimate by Chesapeake Energy indicated that it could supply the total U.S. demand of gas for about 15 years at current rates of consumption.[28]

Such numbers have generated a great deal of enthusiasm in the energy industry for natural gas. The 2010 IHS CERA conference, where policymakers and energy company CEOs get together to talk about the energy business, had everyone talking about natural gas.[29] The chairman of the energy consulting group that put on the conference wrote in the *Wall Street Journal* that natural gas will be the "the biggest energy innovation of the decade" and bring forth a shale gas "revolution."[30] By the end of 2009, ExxonMobil, the same company that had declared natural gas a dud in 2005, signed a deal to buy out XTO Energy to become the biggest natural gas producer in the country.[31]

The Industry Lobby

Now that the industry is investing in natural gas, it is also investing its energy in selling it. T. Boone Pickens, a billionaire oil tycoon, turned his attention from wind energy to natural gas in a series of dramatic television advertisements and a nationwide tour.[32] Chesapeake Energy, one of the largest natural gas producers in the United States, helped start the American Clean Skies Foundation in 2007, which educates policymakers and the public about the benefits of natural gas.[33] The American Natural Gas Alliance came together to present a unified voice before Congress — and has spent $1.6 million on lobbying since it started in 2009.[34]

Marketers and lobbyists also argue other potential merits of natural gas besides its theoretical abundance. Some mention that domestic gas could reduce dependence on foreign oil.[35] And, despite the environmental impacts associated with its production, natural gas appeals to policymakers worried about climate change because it emits fewer carbon emissions when burned than coal or oil. Most recently, in the aftermath of the Deepwater Horizon oil spill in the Gulf of Mexico, natural gas proponents are presenting domestic shale as a good onshore alternative to offshore drilling.[36]

Not-So-Clean Energy

Legislators creating energy policies are increasingly concerned with fighting climate change by finding new "clean" energy sources that can reduce national carbon emissions.

Natural gas proponents often call the fuel a "clean" energy source because it creates fewer carbon emissions than traditional fossil fuels when burned. For example, America's Natural Gas Alliance says natural gas is "twice as clean as coal."[37] When burned, natural gas emits half as much carbon dioxide as coal and 70 percent as much as oil.[38]

But calling natural gas "clean" compared to the worst carbon offenders is misleading. Natural gas, like all fossil fuels, emits carbon when burned. In fact, the fuel was responsible for a fifth of all energy-related carbon dioxide emissions in the United States in 2008.[39]

More importantly, even if the gas emits fewer carbon emissions when the end product is burned, the production of natural gas could be just as bad as other fossil fuels when it comes to contributing to climate change. In 2010, Professor Robert Howarth at Cornell University conducted a preliminary analysis that concluded the greenhouse gas footprint of natural gas could be similar to diesel oil and coal, and may be worse in terms of global warming.[40] One reason for this finding is that natural gas production, like all fossil fuel industries, is an energy-intensive process. The total carbon footprint of the fuel must include emissions from the energy used to make wells, transport and create pipelines for the gas, treat the waste, and perform all other processes related to drilling,[41] not just the emissions released when the fuel is burned. Also, natural gas production releases methane into the atmosphere, which is a gas 30 times worse than carbon dioxide when it comes to contributing to global warming.[42] In 2007, the natural gas industry released more methane than the coal industry — and that was before the recent aggressive expansion.[43]

Other sources of energy are cleaner than natural gas. ExxonMobil was told to pull a commercial off the air in England because it made the claim that natural gas is "one of the world's cleanest fuels."[44] The Advertising Standards Authority, a watchdog group, took issue with the claim because while it may be cleaner than coal and oil, the commercial also mentioned wind and solar — which certainly emit fewer greenhouse gases.[45]

Further, characterizing natural gas as clean ignores all of the other environmental and health impacts that come along with the drilling itself. Like all fossil fuel production, drilling for natural gas is a polluting industrial process that consumes energy and can damage air, water, infrastructure, and people's health and well-being.

The Mad Rush to Drill

As all this hype has hit the media and Capitol Hill, small towns near gas plays all around the country have seen a mad rush to drill near their communities. For example, Colorado has long produced natural gas; it gave out a record number of permit applications in 2008.[46]

The maddest rush to drill has been in areas near gas-bearing shale. This trend began when hydraulic fracturing and horizontal wells increased production in the Barnett Shale in Forth Worth, Texas, just in the past few years. According to Navigant Consulting, developments in the use of hydraulic fracturing and horizontal wells eventually led to a 3,000 percent jump in production between 1998 and 2007.[47]

Seeing the Barnett as an example, drillers have turned their attention to the Antrim Shale in Michigan, the Fayetteville Shale in Arkansas, the Woodford Shale in Oklahoma, the Haynesville Shale in Louisiana, and the Marcellus Shale, a huge rock formation that lies under large portions of Pennsylvania, New York, Ohio and West Virginia, as well as parts of Virginia, Maryland and Kentucky.[48]

The Marcellus Shale has attracted the most attention from developers. Range Resources-Appalachia, LLC began to tap into the play in 2003 and began to produce Marcellus gas in 2005.[49] Since then, Range Resources has gained permits for more than 150 wells in just one county, and many companies have followed its lead.[50] In the decade prior to 2008, it was common to have 10 active rigs in Pennsylvania.[51] That number was up to 40 by 2008.[52] As of September 2008, Pennsylvania's Bureau of Oil and Gas Management indicated that 277 wells had been drilled and it had given out another 518 permits.[53] In 2009, the number of permits granted jumped 300 percent.[54] This trend sees no sign of stopping. According to the Pennsylvania Department of Environmental Protection, companies reported drilling 575 Marcellus wells just in the first half of 2010, bringing the total Marcellus wells reported drilled in Pennsylvania to 1,597.[55]

There is a lot of money at stake in the success of these wells. According to the *Financial Times*, spending on shale went from 15 percent to 50 percent of total gas exploration and production investments in 2009.[56] One expert told the *New York Times* that he predicted more than 20 oil and gas companies would invest $700 million in the Marcellus Shale, and up to half of that would be in Pennsylvania.[57] In the search for gas, companies such as Chesapeake Energy, Anadarko Petroleum, and Cabot Oil and Gas are leasing millions of acres of local lands. The cost of leasing mineral rights in Pennsylvania jumped from $300 an acre in mid-February 2008 to $2,100 in April that same year. [58]

But while drillers see dollar signs, many local residents, organizations and policymakers see disaster. Like most fossil fuel

production, natural gas drilling is a harmful industrial process replete with environmental damage and risks to public health. It turns out that the same hydraulic fracturing technology driving the growth of the industry greatly threatens the country's water resources.

Hydraulic fracturing is now used in 90 percent of oil and natural gas wells in the United States.[60] Both vertical and horizontal wells in the Marcellus Shale that produce "economic volumes" of gas typically use hydraulic fracturing.[61] Any new wells in shale rock formations that will produce large quantities of gas will more than likely require the process. With the planned huge expansion of the industry and little government oversight, this could deplete and contaminate water on an unprecedented scale.

The Dangers of Hydraulic Fracturing

In order to create the fractures that break the natural gas free, drillers inject millions of gallons of hydraulic fluids made up of water, chemicals and sand into underground rock formations.[62] The chemicals, which include acids, biocides, corrosion inhibitors, defoamers, emulsifiers, gellants, resins, surfactants and viscosifiers,[63] help the water to create cracks in the rock, while the sand, or "proppants," help the gas move through by keeping the cracks in the rock open.[64] This process poses water-related environmental and health risks for many reasons.

It Can Deplete Local Water

The huge volume of water needed to drill wells and fracture the rocks can draw down local water sources. It takes 250,000 gallons of water to drill a typical horizontal well in the Barnett Shale.[65] Then, it takes more water to fracture it — in fact, about 90 percent of water used by the natural gas industry to complete a well in that region is used for fracking.[66] In a vertical well, a single frack can take from half a million to more than a million gallons of water; a horizontal well frack can require several million gallons.[67] According to Chesapeake Energy, a typical frack in a deep horizontal well in the Barnett Shale takes 3.8 million gallons of water.[68]

These millions of gallons of water must come from somewhere. Either the companies use local ground or surface water resources, or they truck it in from outside sources. In the Barnett Shale, 56 percent comes from groundwater, 43 percent comes from surface water and the remaining amount, less than 1 percent, is reused or recycled water.[69] In the Susquehanna River Basin, 55 percent of water used for natural gas drilling comes from surface water, and 45 percent from local water utilities.[70]

According to the New York Department of Environmental Conservation, water withdrawals for drilling can have a wide range of impacts on local water, including stream flow reduction, degradation of stream uses, harm to aquatic life, aquifer depletion and inadequate water supply during times of drought.[71] Trucking in water to the wells increases traffic on rural roads, strains local infrastructure and affects the quality of life in the communities.

These types of impacts are of particular concern in water-stressed areas, such as the Southwest, where a great deal of drilling occurs.[72] But even in areas where drillers assume that there are plentiful water resources, the large quantities of water demanded by the industry can take a toll. Already, streams in Pennsylvania have dried up since natural gas drillers came to town.[73]

Even in areas where drillers assume that there are plentiful water resources, the large quantities of water demanded by the industry can take a toll.

Top 20 Producers of Natural Gas

According to the Natural Gas Supply Association, an industry trade group, the top 20 natural gas producers in the United States during the first quarter of 2010 were:

1 XTO Energy (Cross Timbers Oil)
2 Anadarko
3 Chesapeake Energy
4 BP
5 Devon Energy
6 Encana
7 ConocoPhillips
8 Chevron
9 ExxonMobil
10 Royal Dutch Shell plc
11 Williams Energy (Barrett Res.)
12 EOG Resources
13 Southwestern Energy Co.
14 Occidental
15 Apache
16 Petrohawk Energy Corporation
17 El Paso Energy
18 Newfield Exploration
19 Ultra Petroleum
20 Questar Corp.[59]

It Can Contaminate Local Water

Perhaps an even bigger concern are the effects the fracturing chemicals can have on local water quality and public health. According to the Groundwater Protection Council and ALL Consulting, a normal concentration of chemicals is between 0.5 and 2 percent.[74] This means that a standard horizontal well frack using 3 million gallons of water could contain from 15,000 to 60,000 gallons of chemicals.

Drillers do not want to reveal what chemicals they use because they consider it a trade secret.[75] The industry is not required by the federal government to disclose the type or quantity of chemicals it uses, and only 10 drilling states require companies to list this information.[76] Because of this, it is difficult to know exactly what chemicals might make their way into nearby water sources. However, independent research by The Endocrine Disruption Exchange (TEDX) compiled a list of 435 fracturing products containing 344 chemicals in February 2009.[77]

While the exact composition of some of the chemicals could not be determined, many were identified are toxic. A further analysis by TEDX examined 41 products used in Pennsylvania fracturing operations. Of the 63 chemicals in these products, 22 chemicals could not be identified. Of the 41 remaining chemicals, 98 percent were associated with skin, eye or sensory organ effects, 95 percent could cause respiratory effects, 83 percent are associated with gastrointestinal or liver effects, 69 percent could damage the brain, 67 percent could have cardiovascular effects, and 69 percent could have "other" effects such as changes in weight, teeth and bone, or death. In addition, 45 percent were volatile, which means they could be released into the air and cause further harm if inhaled, swallowed or put in contact with skin.[78]

After fracking, some of the fluids that contain these chemicals come back up out of the well. The industry calls this wastewater "produced water." Much of this water may be made up of hydraulic fluids, although some may be water from the rock formation — it is impossible to distinguish how much is which.[79] The Groundwater Protection Council and ALL Consulting reported that produced water can make up less than 30 percent to more than 70 percent of the injected water volume.[80] The rest of the fluids remain underground.[81]

If these toxic chemicals leak into underground water sources when they are injected into the ground, they can damage water quality in surrounding water sources.[82] Groundwater contamination is especially dangerous because it is difficult to clean up and is poorly monitored and regulated.[83] Since chemicals can move slowly through underground water sources, contamination can go undetected for long periods of time.[84]

The industry has long claimed that hydraulic fracturing is safe because they believe the water that is not recovered will stay in rock formations buried deep under the ground where

it cannot reach drinking water sources.[85] Industry representatives point to a study by the EPA published in 2004 that concluded that hydraulic fracturing does not present harm to drinking water to support their claim.[86]

However, an overwhelming body of evidence indicates that this conclusion, and the industry claim, are not true. New evidence indicates that hydraulic fracturing fluids from gas drilling sites can make its way into local wells. In Wyoming, 11 out of 39 wells tested around the town of Pavillion in 2009 revealed contamination with chemicals that the EPA said were potentially connected to gas drilling.[87] Residents of Dimock, Pennsylvania, sued Cabot Oil & Gas Corporation in November 2009 for allegedly contaminating their wells, making them sick.[88] Cases of methane leaking into wells near drilling sites may be evidence that drinking wells are connected to underground water sources. If the gas can move through rocks and contaminate local wells, it is likely that fracking water can, too. A study by Garfield, Colorado, indicated that many wells near drilling sites were contaminated with methane, among other chemicals.[89]

The likelihood that chemicals from fracking will end up in water sources can be affected by the nature of the geology in the area. For example, karst is a type of rock formation through which groundwater can move quickly.[90] If contaminants enter karst aquifers, they can easily spread into groundwater sources.[91] This is a concern related to fracking in New York, because there are rock formations in the ground near the Marcellus Shale that geologists believe could be karstic.[92]

Natural faults and fractures are another geological factor that can affect the danger to water from fracking. Naturally occurring cracks under the ground can increase risks from drilling because if man-made fractures intersect with these natural fractures, liquids or gases could move from one rock formation to another, and possibly through to underground water sources.[93] This is a danger wherever there are many natural faults and fractures in the geology. For instance, New York State has many natural faults and fractures.[94] The New York City Department of Environmental Conservation cited this as one of its major concerns regarding drilling near New York City's pristine watershed, especially given that many of these structures have not been thoroughly considered in previous analyses of the safety of fracturing. [95]

The danger could be exacerbated by the combination of horizontal wells with fracturing, as is proposed in the Marcellus Shale region. James Northrup, having been in the energy business for 30 years, characterizes horizontal hydrofracturing as similar to "the explosion of a massive pipe bomb underground."[96] He says that "the horizontal hydrofracturing of shale gas is a potential delivery mechanism for toxic chemicals and natural gas into aquifers."[97] This is because a horizontal well travels some length through a rock formation, which means it can create more fractures than a vertical well. Because it creates more fractures, there is a higher chance that the man-made fractures will intersect with naturally occurring faults and fractures that already exist under the ground.[98] In fact, the New York City Department of Environmental Conservation said that the "migration of fracking chemicals and/or poor quality formation water into overlying groundwater, watershed streams, reservoirs, and directly into tunnels is a reasonably foreseeable risk."[99]

Paul Rubin, a hydrogeologist in New York, says that the interconnection of natural faults and fractures makes fracking dangerous even if the fluids used did not contain toxic chemicals because it could facilitate the connection of deep saline or radioactive fluids in the earth with freshwater sources.[100] According to his analysis, ignoring the interconnection of natural faults and fractures is a "recipe for environmental disaster throughout Otsego County and the Appalachian basin."[101]

Even at the time of the EPA's 2004 study, a whistleblower at the agency submitted his own analysis, which declared that the conclusions of the study were "scientifically unsound and contrary to the purposes of the law," and that five of the seven members of the peer review panel that approved it "appear to have conflicts of interest and may benefit from EPA's decision not to conduct further investigation or impose regulatory conditions."[102] The head of the agency later reviewed the study and found that it was a literature review, lacking actual new testing.[103] After public outcry and federal hearings, Congress commissioned the EPA to produce a new study to reevaluate the impacts of hydraulic fracturing on water. The report is expected to be released to the public in 2012.[104]

It Can Cause House and Well Explosions

The presence of methane in household wells is troubling because it indicates that water from hydraulic fracturing may have contaminated drinking water; however, the methane itself is also a health hazard. Although the gas evaporates out of the water, it can build up in air. It is not safe to breathe large quantities of methane — inhaling the fumes can cause nausea, vomiting, dizziness and suffocation.[105] The gas can also cause a more immediate danger: It is highly flammable.[106]

Some residents near gas drilling sites have found that they can light water from their taps on fire,[107] and the presence of gas in homes has caused fatal accidents. In 2004, a house in Jefferson County, Pennsylvania, exploded, killing three people. Other nearby communities in Pennsylvania have experienced contaminated and exploding wells, gas leaking into nearby rivers and drinking water, and properties no longer fit to inhabit because of the gas buildup.[108] By May 2010, the Pennsylvania Department of Environmental Protection (DEP) had seen more then 50 instances of methane-related accidents where drilling was the likely source of the methane.[109] The Ohio Department of Natural Resources also implicated a malfunctioning well and hydraulic fracturing in its analysis of a 2007 house explosion.[110]

Industry representatives often say that gas in wells could come from a source other than natural gas drilling.[111] But, as the oil and gas liaison for Garfield County told the journalism nonprofit ProPublica, "It is highly unlikely that methane would have migrated through natural faults and fractures and coincidentally arrived in domestic wells at the same time oil and gas development started, after having been down there … for over 65 million years."[112]

It Produces Toxic Wastewater

Hydraulic fracturing produces problematic wastewater that is difficult to dispose of safely. This wastewater can contain hydraulic fracturing chemicals, as well as large quantities of "Total Dissolved Solids" — a measurement of the amount of matter dissolved in water, used by EPA as a measurement of contamination. The water picks up these solids from its journey underground, which may include radioactive elements found naturally in rock.[113] The high level of Total Dissolved Solids can make the wastewater five times as salty as seawater.[114] If this water seeps back into the environment, it can harm local water sources. In 2009, the Pennsylvania DEP found that wastewater from the natural gas industry was apparently contaminating the Monongahela River.[115] The DEP addressed the issue at the time by lowering discharges and unlocking nearby dams to dilute the contamination. [116] It also investigated whether natural gas wastewater may have contributed to the death of fish in a creek that feeds into the same river.[117]

A common method of disposing of this oil and gas produced water is by underground injecting — putting it in disposal wells in rock formations under the ground.[118] This may pose risks to groundwater. Another method that drillers use is to send their wastewater to sewage plants, which then treat and dilute the product and release it back into surface waters. Although this method has been used in Pennsylvania, standard wastewater treatment plants are not equipped to deal with large quantities of that sort of waste.

In 2008, Pennsylvania's oil and gas wells produced 9 million gallons of wastewater a day; by 2011, the DEP predicts they will create 19 million.[119] As of October 2009, drilling companies in the state were trucking their wastewater to multiple treatment plants.[120] This is not a sustainable solution. According to ProPublica, no wastewater treatment plant in Pennsylvania can currently remove Total Dissolved Solids from the water, and it is unlikely that any new plants will be able to do so by 2011.[121]

Not Just Water: Air Pollution, Too

Water contamination is not the only health hazard from natural gas drilling that has harmed people's lives. The industry also brings air pollution.

Residents near the Barnett Shale, where much natural gas drilling has already happened, have seen the effects of air pollution. For example, the small town of Dish Texas is located near 11 natural gas compression stations in the Barnett Shale area. The mayor, hearing complaints from residents, brought their concerns about smell, noise and health problems to state legislators, to no avail. Residents even complained of headaches and blackouts and reported neurological defects and blindness in horses.[133]

The town hired a private environmental consultant, who found that air samples contained high levels neurotoxins and carcinogens.[134] The Texas Commission on Environmental Quality (TCEQ) also found toxins in the air near wells in the Barnett Shale gas field. Benzene, a chemical that can cause immune disorders and cancer, was found at levels of 500 to 1,000 parts per billion — more than five times higher than the TCEQ's limit.[135] Privately funded tests found that air samples also included large quantities of carbon disulfide, which can cause neurological problems.[136]

Another study showed that natural gas production creates smog-forming compounds and greenhouse gas emissions. It found that the natural gas and oil industry in the Barnett Shale area created more smog-forming emissions than the motor vehicles in the same area, with greenhouse gas emissions equivalent to two 750 MW coal-fired power plants.[137]

Wastewater can further contaminate local water if there are accidents on drilling sites that allow its uncontrolled release into the environment. When one well exploded in Pennsylvania, "sending a gas plume 75 feet into the air and wastewater cascading onto the ground," it took 16 hours before the wastewater leak was stopped.[122] Similarly, a waste pit in Colorado leaked 1.6 million gallons, which migrated through the ground and later reached the Colorado River.[123]

The fracking chemicals, too, can get into the environment if they are accidentally spilled. In Louisiana, 16 cattle died after drinking a "mysterious fluid" near a drilling rig.[124]

It Can Have Wide-Ranging Health and Environmental Effects

An overwhelming body of evidence shows that natural gas drilling can harm local water quality — whether from the fracturing itself or from associated accidents. ProPublica found more than 1,000 documented cases of contaminated water near drilling sites around the country.[125] Along with these cases of contamination have come many unexplained illnesses, both in humans and animals.[126]

So far, local residents in small communities have borne the brunt of water contamination from gas drilling. Further development could have even more widespread effects because water is connected through watersheds. In its 2010 Most Endangered Rivers report, American Rivers declared the Upper Delaware River in Pennsylvania and New York and the Monongahela River in Pennsylvania and West Virginia to be two of the top 10 endangered rivers in the country due to the potential contamination from natural gas drilling in the Marcellus Shale.[127] ProPublica reported that developing gas and other energy deposits along the Colorado River could contaminate the river and put the water supply of one out of 12 Americans at risk.[128]

New York City is concerned about the potential impacts on the drinking water of its millions of residents. Currently, New York City does not have to filter its drinking water because its reservoirs and the rivers in the Catskill Mountains that supply its water are so clean. New York City's chief accountant said drilling near these sources could damage water quality, which would force the city to build a new $10 billion water treatment plant and raise water rates by 30 percent.[129]

NYC officials asked for protective perimeter around its six Catskill reservoirs and connecting infrastructure.[130] After much public opposition to drilling, one company, Chesapeake Energy announced that it had no intention to drill natural gas wells in New York City's watershed.[131] However, the company said it still believed that drilling in any watershed was safe.[132]

Government failures

A company voluntarily moving to refrain from drilling is an anomaly. With millions of dollars in profits at stake, the companies that drill for gas are not making the choices that are best for public water if there are no regulations in place forcing them to do so — especially when drilling near small communities with little political clout. Unfortunately, current government laws and regulations do not protect the public from the impacts of gas drilling.

Since the federal government does not regulate hydraulic fracturing, that task is left to the states. Different states vary in the regulations they have in place to protect residents from drilling, and the resources that they have available to actually enforce those laws. Some states, such as Colorado, have moved to tighten their regulations, but gaps remain.[138] Only 10 states surveyed require that fracturing chemicals be disclosed. No states require that drillers document the amount of fluid left underground after fracturing.[139]

Meanwhile, the federal government has not passed additional protections since the industry's recent expansion. In 2005, the energy lobby, led by then-Vice President Dick Cheney convinced Congress to pass the Energy Policy Act of 2005, which exempted the industry from a number of federal regulations that protect air, water and public health. Cheney was CEO of the energy company Halliburton from 1995 to 2000 and the company has been a major proponent of hydraulic fracturing. Since then, the natural gas industry has been exempted from the section of the Safe Drinking Water Act that allows the U.S. Environmental Protection Agency to regulate the injection of toxic chemicals underground.[140] This means that the federal body charged with protecting human health and the environment cannot regulate the impacts of hydraulic fracturing on groundwater.

Legislators have introduced bills in the House and Senate that, if passed, would close this loophole in the Safe Drinking Water Act — referred to as the "Halliburton" loophole.[141] This Fracturing Responsibility and Awareness of Chemicals (FRAC) Act would give the EPA the authority to regulate hydraulic fracturing under the Safe Drinking Water Act and would require companies to publicly disclose the chemicals that they use in fracking — an important first step in understanding the impacts of the industry.[142] While this legislation has strong support from consumer and environmental organizations, it has already faced strong opposition from the industry.[143]

Local and State Activism

While the federal government is standing idly by, many local policymakers and organizations are taking action to protect their water and lives from natural gas drilling.

The "Halliburton Loophole"

One of the ways that the U.S. Environmental Protection Agency (EPA) protects water under the Safe Drinking Water Act is through its Underground Injection Control (UIC) program, which creates regulations for how to safely place liquids underground through injection wells.[144]

Prior to 1997, the EPA had decided not to regulate hydraulic fracturing through its UIC program. However, when the Legal Environmental Assistance Foundation (LEAF) sued EPA, the Eleventh Circuit Court of Appeals ruled that the hydraulic fracturing of coals in Alabama should be regulated by the EPA's UIC program under the authority of the Safe Drinking Water Act.[145]

In 2005, the Energy Policy Act changed the section of the Safe Drinking Water Act that gives EPA authority to run its UIC program to specify that hydraulic fracturing does not qualify as "underground injection"[146] — despite the fact that the process involves shooting large quantities of liquids into the ground. This specifically removed hydraulic fracturing from EPA regulation of underground injection.

This exemption has been dubbed the "Halliburton loophole" because of the role that the company Halliburton appears to have played in its passage.[147] Halliburton has long been a proponent of hydraulic fracturing. The company says that it "performed the first commercial application of hydraulic fracturing" in 1949 and "has always led the industry in developing and applying new fracturing technology."[148] Former Vice President Dick Cheney served as the CEO of Halliburton from 1995 to 2000, and critics accused him of keeping financial ties to the company while he was in office.[149] In his role as vice president, he served as chairman of an energy task force, the National Energy Policy Development Group, which outlined a new national energy policy in a report titled, "Reliable, Affordable and Environmentally Sound Energy for America's Future."[150] In the process of leading this task force, Cheney held many secret meetings with the heads of energy companies.[151] So it was not surprising to see an exemption for hydraulic fracturing show up in legislation after Vice President and his task force recommended it. According to ProPublica, the exemption was pushed through without hearings by the Republican majority in Congress, and passed as part of the Energy Policy Act of 2005.[152]

The exemption from the Safe Drinking Water Act is only one of many exemptions from federal rules that the energy industry enjoys. (See box entitled Exemptions from other regulations on page 10 for more information).

Some states are strengthening their regulations. In 2008, New York, under pressure from its largest city, moved to

Exemptions from Other Federal Regulations

The Safe Drinking Water Act was not the only law designed to protect public water that was circumvented by the Energy Policy Act of 2005. The Energy Policy Act also changed the Clean Water Act to broaden oil and gas industry exemptions from needing permits for stormwater discharges.[153]

The industry enjoys a wide range of other federal exemptions as well. One analysis found that the oil and gas industry escapes regulations through loopholes in the Safe Drinking Water Act; Clean Water Act; Clean Air Act; Comprehensive Environmental Response, Compensation and Liability Act; Resource Conservation and Recovery Act; National Environmental Policy Act and Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act.[154]

Our Next Disaster?

Some human health hazards from natural gas drilling are even more immediately obvious than air and water pollution. In June 2010 in West Virginia, seven workers were burned when a well exploded.[167] That same week in Pennsylvania, a well exploded, blasting flames and spewing 35,000 gallons of wastewater.[168]

With technical and safety failures in the offshore drilling rigs in the gulf at the forefront of the media's attention, these recent events have some media outlets questioning whether natural gas is really a safe alternative to offshore drilling. It turns out the culprit in the Pennsylvania explosion was a malfunctioning "blowout preventer" — the same piece of faulty equipment that failed to prevent the BP oil spill.[169]

require companies to reveal the chemicals they use,[155] and its governor commanded that the state update its environmental review process.[156] Meanwhile, many activists and policymakers have called for moratoriums on further drilling. New York City and many New York-based environmental organizations pushed their state legislator James Brennan to call for a moratorium on drilling in the city's watershed.[157] The Pennsylvania House "overwhelmingly" passed legislation to halt additional drilling in state parks in May 2010 — the same month that Flower Mound Town Council in Texas suspended all new gas well permits.[158] And just a few weeks later, the Delaware River Basin Commission extended a recent ban on new gas drilling to include "exploratory" wells.[159]

Even some who stand to profit from the drilling are questioning whether it is a good idea. The shareholders in major oil and gas companies believe that there is financial risk in an investment that causes environmental damage — especially since many states may start strengthening their regulations. In 2010, 26 percent of ExxonMobil shareholders voted for a proposal that would require the company to study the risks of hydraulic fracturing, but the company board rejected the proposal.[160] This was impressive, considering that it gained five times more votes than the usual shareholder support for a first-time environmental resolution.[161] One industry expert said that 10 percent support for similar resolutions is considered "remarkable."[162] Even more remarkable, the shareholders' opposition was so strong that they filed a notice with the U.S. Securities and Exchange Commission stating their opposition to the company's behavior.[163]

Shareholders of other companies, such as Cabot Oil & Gas and EOG Resources Inc., have voted on similar resolutions.[164] The Sisters of St. Francis of Philadelphia brought forth a resolution at Chesapeake Energy Corp.[165] The most successful vote against fracking occurred at William Cos. Inc., where 42 percent of shareholders voiced concern about the practice.[166]

These steps towards raising awareness and stopping drilling are a good start, but with more permits allocated and wells drilled every day, more needs to be done to protect ground and surface water from natural gas production.

Conclusion

By one estimate, the Marcellus Shale could meet the current U.S. demand for natural gas for two years. By another, it could supply 15 years worth of fuel. But how long would it take local communities and their watersheds to recover from all the damage that could occur with that gas production? And what happens when the gas runs out?

The long-term safety of water is far more important than the amount of money that some companies can make drilling for natural gas in the short run. That is why federal regulations must protect the public from the impacts of natural gas drilling with hydraulic fracturing. Companies must be required to disclose the chemicals they use. They must be subject to regulation if they are injecting chemicals into the ground that could affect water quality, and that regulation must apply to all states. The companies must be held accountable for their wastewater. Meanwhile, there should be a moratorium on hydraulic fracturing until its effects on water quality are fully understood and there are laws in place to protect watersheds from the full extent of those impacts.

The offshore disaster in the Gulf must not encourage a mad rush to pursue another harmful, poorly understood fossil fuel energy production method onshore. That is why the United States must seek new energy production methods that avoid harm to water — not hydraulic fracturing for natural gas.

Policy Recommendations

- The federal government should pass the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act (H.R. 2766, S. 1215) to close the loophole that excludes hydraulic fracturing from regulation under the Safe Drinking Water Act.
- States should pass legislation to require the natural gas industry to report the chemicals used for hydraulic fracturing or to implement other measures to protect water quality and the health of residents.
- Congress should place a moratorium on issuing new permits for hydraulic fracturing until after the EPA publishes its study on the effect of hydraulic fracturing on water quality, expected in 2012.
- The EPA should conduct additional studies on hydraulic fracturing to examine its effects on human health and the environment.
- Congress should establish a new federal regulatory agency to oversee the fossil fuel industries. Recent tragedies — the oil spill in the Gulf, the mine explosion in West Virginia, and the serious problems posed by hydraulic fracturing — reveal that the existing federal agencies are simply not protecting the American people. This new agency would focus on protecting public health, worker safety and the environment.

Endnotes

1 Heinrich, Erik. "After an oil calamity, is it time for natural gas?" *Time*. June 15, 2010.

2 America's Natural Gas Alliance. [Website] "Clean." Available at www.anga.us/why-natural-gas/smart-energy-choice/clean/. Accessed on June 17, 2010. Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 5.

3 Lohan, Tara. [Blog] "Our Next Disaster? 3 Natural Gas Accidents in 1 Week." Change.org Environment. June 8, 2010.

4 "Exxon says N. America gas production has peaked." *Reuters*. June 21, 2005.

5 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 15.

6 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 15.

7 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council.* Cincinnati, Ohio. September 21-24, 2008 at 7-8.

8 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council.* Cincinnati, Ohio. September 21-24, 2008. At 6.

9 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 15.

10 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council.* Cincinnati, Ohio. September 21-24, 2008 at 8; Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology.* Vol 38, No. 1. Spring 2008 at 10.

11 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council.* Cincinnati, Ohio. September 21-24, 2008. at 8.

12 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology.* Vol 38, No. 1. Spring 2008 at 10.

13 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 10.

14 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 9.

15 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 9.

16 Lustgarten, Abrahm. "Natural Gas Politics." *Propublica*. May 26, 2009; U.S. Environmental Protection Agency. Underground Injection Control Program. "Hydraulic Fracturing." October 1st, 2009.

17 Lustgarten, Abrahm. "Natural Gas Politics." *Propublica*. May 26, 2009; U.S. Environmental Protection Agency. Underground Injection Control Program. "Hydraulic Fracturing." October 1st, 2009.

18 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 8.

19 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 8.

20 IHS CERA. "Fueling North America's Energy Future: The Unconventional Natural Gas Revolution and the Carbon Agenda." (Special Report). 2010 at ES-1.

21 Wynn, Gerard and Ben Hirschler. "DAVOS-Shale gas is U.S. energy "game changer"-BP CEO." *Reuters*. January 28, 2010.

22 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 15.

23 U.S. Energy Information Administration. [Map] "Shale Gas Plays Lower 48 States." March 10, 2010.

24 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 41.

25 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology.* Vol 38, No. 1. Spring 2008 at 2.

26 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 6.

27 Penn State Live. "Unconventional natural gas reservoir could boost U.S. supply." January 17, 2008.

28 Soeder, Daniel J. and William M. Kappel. U.S. Department of the Interior, U.S. Geological Survey. "Water resources and natural gas production from the Marcellus Shale." (Fact Sheet 2009-3032). May 2009.

29 Tronche, John-Laurent. " 'Unconventional gas revolution' hot topic at conference." *Fort Worth Business Press* (Texas). March 15, 2010.

30 Yergin, Daniel and Robert Ineson. "America's Natural Gas Revolution." [Opinion] *The Wall Street Journal.* November 2, 2009.

31 Clark, Andrew. "Exxon Mobil move into natural gas with $41bn buyout of XTO Energy." *The Guardian.* December 14, 2009.

32 Krauss, Clifford. "Forget Wind. Pickens Turns Focus to Gas." *The New York Times*. January 14, 2010.

33 Casselman, Ben. "Natural-Gas Producers Launch Lobbying Group." *The Wall Street Journal.* February 25, 2009.

34 Casselman, Ben. "Natural-Gas Producers Launch Lobbying Group." *The Wall Street Journal.* February 25, 2009; Snyder, Jim. "Natural gas lobby challenging coal." *The Hill*. March 1, 2010.

35 America's Natural Gas Alliance. [Website] Available at www.anga.us/why-natural-gas/. Accessed on Jun 18, 2010.

36 Panchuck, Kerri. "Pickens pushes natural gas after oil spill." *Dallas Business Journal*. June 15, 2010; "Could Mackenzie gas gain momentum from Gulf oil spill?" *Alaska Dispatch*. May 7, 2010.

37 America's Natural Gas Alliance. [Website] "Clean." Available at www.anga.us/why-natural-gas/smart-energy-choice/clean/. Accessed on June 17, 2010.

38 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 5.

39 U.S. Energy Information Administration. "Emissions of Greenhouse Gases in the U.S. 2008 Overview." December 8, 2009 at 2.

40 Howarth, Robert. Cornell University. "Preliminary Assessment of the Greenhouse Gas Emissions from Natural Gas Obtained by Hydraulic Fracturing." (Draft). March 17 2010.

41 Howarth, Robert. Cornell University. "Preliminary Assessment of the Greenhouse Gas Emissions from Natural Gas Obtained by Hydraulic Fracturing." (Draft). March 17 2010.

42 National Science Foundation. "Questions and Answers on Potentially Large Methane Releases from Arctic, and Climate Change." March 4, 2010; U.S. Energy Information Administration. "Emissions of Greenhouse Gases in the U.S. 2008 Overview." December 8, 2009 at 4.

43 Bracmort, Kelsi et al. Congressional Research Service. "Methane Capture: Options for Greenhouse Gas Emission Reduction." September 17, 2009 at 14.

44 Plunkett, John. "ExxonMobil to contest ban on ad for liquefied natural gas." *The Guardian*. September 3, 2008.

45 Plunkett, John. "ExxonMobil to contest ban on ad for liquefied natural gas." *The Guardian*. September 3, 2008.

46 Dennison, Doug. Olsson Associates. Prepared for Colorado Natural Areas Program, Colorado Department of Natural Resources. [Powerpoint] "Geology of Colorado's Major Oil and Gas Basins." Williams, David. "Major gas-producing states debating Colorado-style drilling regulations." *The Colorado Independent*. May 21, 2010.

47 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 10.

48 Navigant Consulting. "North American Natural Gas Supply Assessment." Prepared for American Clean Skies Foundation. July 4, 2008 at 10.

49 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology*. Vol 38, No. 1. Spring 2008 at 9.

50 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology*. Vol 38, No. 1. Spring 2008 at 9.

51 Moss, Kerry. National Park Service, U.S. Department of the Interior. "Potential Development of the Natural Gas Resources in the Marcellus Shale." December 2008 at 3.

52 Moss, Kerry. National Park Service, U.S. Department of the Interior. "Potential Development of the Natural Gas Resources in the Marcellus Shale." December 2008 at 3.

53 Moss, Kerry. National Park Service, U.S. Department of the Interior. "Potential Development of the Natural Gas Resources in the Marcellus Shale." December 2008.

54 Turner, Ford. "State-issued Marcellus shale gas well drilling permits increase 300% in 2009. *The Patriot-News*. November 4, 2009.

55 Pennsylvania Department of Environmental Protection. Bureau of Oil and Gas Management. Staff Communication. Email on file at Food & Water Watch. June 29, 2010.

56 Dizard, John. "Shale gas numbers may not add up." *The Financial Times*. November 1, 2009.

57 Krauss, Clifford. "There's Gas in Those Hills." *New York Times*. April 8, 2008.

58 Krauss, Clifford. "There's Gas in Those Hills." *New York Times*. April 8, 2008.

59 Natural Gas Supply Association. "Top 40 Producers: U.S. Natural Gas Production." June 9, 2010.

60 Carillo, Victor. Texas Railroad Commission, Representing the Interstate Oil and Gas Compact Commission. Testimony in front of House Energy and Commerce Committee, 109th Congress. February 10, 2005.

61 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council*. Cincinnati, Ohio. September 21-24, 2008 at 8.

62 Arthur, J.D.; Bohm, B., and Layne, M. "Hydraulic fracturing considerations for natural gas wells of the Marcellus shale." Prepared for presentation at *The Ground Water Protection Council*. Cincinnati, Ohio. September 21-24, 2008 at 10. Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 58-60.

63 The Endocrine Disruption Exchange. "Products and Chemicals Used in Fracturing." February 2009.

64 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology*. Vol 38, No. 1. Spring 2008 at 10.

65 Chesapeake Energy. [Factsheet] "Water Use in Barnett Deep Shale Gas Exploration." March 2010.

66 Hayes, Tom. [Powerpoint] "Water Use and Conservation in Barnett Shale Energy Development." Presented at Oklahoma Independent Petroleum Association Symposium, Oklahoma City, OK. April 3, 2008 at 15.

67 Harper, John. "The Marcellus Shale—An Old "New" Gas Reservoir in Pennsylvania." Bureau of Topographic and Geologic Survey. *Pennsylvania Geology*. Vol 38, No. 1. Spring 2008 at 11-12.

68 Chesapeake Energy. [Factsheet] "Water Use in Barnett Deep Shale Gas Exploration." March 2010.

69 Hayes, Tom. [Powerpoint] "Water Use and Conservation in Barnett Shale Energy Development." Presented at Oklahoma Independent Petroleum Association Symposium, Oklahoma City, OK. April 3, 2008 at 16.

70 Hoffman, Jennifer. [Powerpoint] Susquehanna River Basin Commission. "Natural Gas Development." January 29, 2010 at 15.

71 New York State Department of Environmental Conservation Division of Mineral Resources. "Draft Supplemental Generic Environmental Impact Statement on the Oil Gas and Solution Mining Regulatory Program; Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeatbility Gas Reservoirs." September 2009 at 6-4 to 6-8.

72 Soedoer, Daniel J. and William M. Kappel. U.S. Department of the Interior, U.S. Geological Survey. "Water resources and natural gas production from the Marcellus Shale." (Fact Sheet 2009-3032). May 2009 at 4.

73 The Pittsburgh Channel WTAE 4. "Team 4: Pa. Streams Drained Dry By Drillers." November 13, 2008.

74 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 61.

75 Lustgarten, Abrahm. "Does Natural-gas Drilling Endanger Water Supplies?" *Bloomberg Businessweek*. November 11, 2008.

76 U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. "State Oil and Natural Gas Regulations Designed to Protect Water Resources." May 2009 at 25.

77 The Endocrine Disruption Exchange. "Products and Chemicals Used in Fracturing." February 2009.

78 The Endocrine Disruption Exchange (TEDX). "Chemicals Used in Natural Gas Fracturing Operations: Pennsylvania." April 2009.

79 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 67.

80 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 66.

81 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 67.

82 New York State Department of Environmental Conservation Division of Mineral Resources. "Draft Supplemental Generic Environmental Impact Statement on the Oil Gas and Solution Mining Regulatory Program; Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeatbility Gas Reservoirs." September 2009 at 6-16.

83 U.S. Environmental Protection Agency. "Groundwater Cleanup at Superfund Sites." (EPA 540-K-96 008).December 1996 at 3; *See* Food & Water Watch. "Unmeasured Danger: America's Hidden Groundwater Crisis." July 2009.

84 U.S. Environmental Protection Agency. Office of Research and Development Office of Water. "Wellhead Protection: A Guide for Small Communities." (EPA 625-R-93-002) February 1993.

85 Yergin, Daniel and Robert Ineson. "America's Natural Gas Revolution." [Opinion] *The Wall Street Journal*. November 2, 2009.

86 Sapien, Joaquin. "EPA Administrator Forecasts Potential Shift on Bush-Era Drilling Loophole." *Propublica*. May 22, 2009.

87 Hurdle, John. "U.S. finds water polluted near gas-drilling sites." *Reuters*. August 8, 2009.

88 Hurdle, Jon. "Pennsylvania residents sue over gas drilling." *Reuters*. November 20, 2009.

89 URS Corporation. "Phase I Hydrogeologic Characterization of the Mamm Creek Field Area in Garfield County." Prepared for Board of County Commissioners, Garfield County Colorado. March 23, 2006 at ES-3.

90 Division of Drinking and Gound Waters. Ohio Environmental Protection Agency. "Ohio Karst Areas." September 11, 2007.

91 Division of Drinking and Gound Waters. Ohio Environmental Protection Agency. "Ohio Karst Areas." September 11, 2007; Taylor, Charles and Earl Greene. US Geological Survey. "Quantitative Approaches in Characterizing Karst Aquifers."

92 Weary, D.J. "Preliminary Map of Potentially Karstic Carbonate Rocks in the Central and Southern Appalachian States." (U.S. Geological Survey Open-File Report 2008-1154) (Available online only). 2008.

93 Lawtis, Steven. New York City Department of Environmental Protection. (Letter). Re: Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (dated 9/30/2009). Submitted to NYSDEC Bureau of Oil & Gas Regulation. December 22, 2009 at 7.

94 New York State Department of Environmental Conservation. "Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program. Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs." September 2009 at 4-26.

95 Lawtis, Steven. New York City Department of Environmental Protection. (Letter). Re: Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (dated 9/30/2009). Submitted to NYSDEC Bureau of Oil & Gas Regulation. December 22, 2009 at 7.

96 Northrup, James. Otsego 2000. "The Unique Environmental Impacts of Horizontally Hydrofracking Shale." August 18, 2010.

97 Northrup, James. Otsego 2000. "The Unique Environmental Impacts of Horizontally Hydrofracking Shale." August 18, 2010.

98 Northrup, James. Otsego 2000. "The Unique Environmental Impacts of Horizontally Hydrofracking Shale." August 18, 2010.

99 Lawtis, Steven. New York City Department of Environmental Protection. (Letter). Re: Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (dated 9/30/2009). Submitted to NYSDEC Bureau of Oil & Gas Regulation. December 22, 2009 at 8.

100 Rubin, Paul. Hydroquest. Comments on the Scope of EPA's Proposed Study of Hydraulic Fracturing. August 10, 2010.

101 Rubin, Paul. Hydroquest. Comments on the Scope of EPA's Proposed Study of Hydraulic Fracturing. August 10, 2010.

102 Wilson, Weston. EPA Employee. [Letter] EPA Allows Hazardous Fluids to be Injected into Ground Water: A report on EPA's failure to protect America's ground water from the impacts of oil and gas production. October 8, 2004.

103 Fowler, Tom. [Blog] "EPA Administrator defends hydraulic fracturing study." *Houston Chronicle*. April 28, 2010.

104 Fowler, Tom. [Blog] "EPA Administrator defends hydraulic fracturing study." *Houston Chronicle*. April 28, 2010.

105 Matheson Tri-Gas. Material Safety Data Sheet. Methane, Compressed Gas. December 11, 2008.

106 Matheson Tri-Gas. Material Safety Data Sheet. Methane, Compressed Gas. December 11, 2008.

107 Boyd, Shaun. CBS 4 Denver. "Flammable water founding Ft. Lupton Home." March 20, 2009.

108 Wilbur, Tom. "Pa. seeks stronger drilling rules to combat methane migration." *Ithaca Journal*. May 23, 2010.

109 Wilbur, Tom. "Pa. seeks stronger drilling rules to combat methane migration." *Ithaca Journal*. May 23, 2010.

110 Ohio Department of Natural Resources Division of Mineral Resources Management, "Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio." September 1, 2008 at 5.

111 Lustgarten, Abrahm. "Colorado study links methane in water to drilling." *Propublica*. April 22, 2009.

112 Lustgarten, Abrahm. "Colorado study links methane in water to drilling." *Propublica*. April 22, 2009.

113 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 70.

114 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

115 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

116 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

117 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

118 Groundwater Protection Council and ALL Consulting. "Modern Shale Gas Development in the United States: A Primer." Prepared for U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. April 2009 at 69.

119 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

120 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

121 Sapein, Joaquin. "With Natural Gas Drilling Boom, Pennsylvania Faces an Onslaught of Wastewater." *Propublica*. October 3, 2009.

122 Worden, Amy. "Gas spews from N.W. Pa. well rupture." *Philadelphia Inquirer.* June 5, 2010.

123 Lustgarten, Abrahm. "How the West's Energy Boom Could Threaten Drinking Water for 1 in 12 Americans." *Propublica*. December 21, 2008.

124 Lustgarten, Abrahm. "16 Cattle Drop Dead Near Mysterious Fluid at Gas Drilling Site." *Propublica*. April 30, 2009.

125 Lustgarten, Abrahm. "Buried Secrets: Is Natural Gas Driling Endangering U.S. Water Supplies?" *Propublica*. November 13, 2008.

126 Lustgarten, Abrahm. "Buried Secrets: Is Natural Gas Driling Endangering U.S. Water Supplies?" *Propublica*. November 13, 2008.

127 American Rivers. "America's Most Endangered Rivers." 2010 Edition.

128 Lustgarten, Abrahm. "How the west's energy boom could threaten drinking water for 1 in 12 Americans." *Propublica*. December 21, 2008.

129 Lustgarten, Abrahm. "Fractured Relations—New York City Sees Drilling as Threat to its Water Supply." *Propublica*. August 6, 2008; Lustgarten, Abrahm. "NYC: Gas drilling will raise the cost of water by 30 percent." *Propublica*. December 16, 2008

130 Lustgarten, Abrahm. "Fractured Relations—New York City Sees Drilling as Threat to its Water Supply." *Propublica*. August 6, 2008.

131 Chesapeake Energy. [Press Release] Chesapeake Energy Corporation Confirms Decision not to Drill for Natural Gas in the New York City Watershed." October 28, 2009.

132 Chesapeake Energy. [Press Release] Chesapeake Energy Corporation Confirms Decision not to Drill for Natural Gas in the New York City Watershed." October 28, 2009.

133 Burnett, John. "Health issues follow natural gas drilling in Texas." *National Public Radio*. November 3, 2009.

134 Burnett, John. "Health issues follow natural gas drilling in Texas." *National Public Radio*. November 3, 2009.

135 Lee, Mike. "State worried about air pollution near Barnett Shale wells." *Star-Telegram* (Texas). November 22, 2009.

136 Lee, Mike. "State worried about air pollution near Barnett Shale wells." *Star-Telegram* (Texas). November 22, 2009.

137 Armendariz, Al. Environmental Defense Fund. "Emissions from natural gas production in the Barnett Shale area and opportunities for cost-effective improvements." January 26, 2009 at 1.

138 Williams, David. "Major gas-producing states debating Colorado-style drilling regulations." *Colorado Independent*. May 21, 2010.

139 U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory. "State Oil and Natural Gas Regulations Designed to Protect Water Resources." May 2009 at 25.

140 Safe Drinking Water Act: 42 U.S.C. 300(h)d; Lustgarten, Abrahm. "Natural Gas Politics." *Propublica*. May 26, 2009; U.S. Environmental Protection Agency. Underground Injection Control Program. "Hydraulic Fracturing." October 1st, 2009.

141 Lustgarten, Abrahm. "FRAC Act—Congress Introduces Twin Bills to Control Drilling and Protect Drinking Water." *Propublica*. June 9, 2009; New York Times [Editorial]. "The Halliburton Loophole." November 2, 2009.

142 Text of S. 1215: Fracturing Responsibility and Awareness of Chemicals (FRAC) Act. Introduced in Senate June 9, 2009.

143 Lustgarten, Abrahm. "FRAC Act—Congress Introduces Twin Bills to Control Drilling and Protect Drinking Water." *Propublica*. June 9, 2009

144 U.S. Environmental Protection Agency. "Protecting Drinking Water Through Underground Injection Control." Drinking Water Pocket Guide #2. (EPA 816-K-02-001) January 2002.

145 U.S. Department of Energy. National Energy Technology Laboratory. Strategic Center for Natural Gas. "More Restrictive Regulation (Hydraulic Fracturing) Could Impact Natural Gas Supply." June 2001.

146 Energy Policy Act 2005. Public Law 109-58. August 8, 2005. Sec. 322.

147 New York Times [Editorial]. "The Halliburton Loophole." November 2, 2009.

148 Halliburton. [Press Release] "Halliburton Celebrates 50-Year Anniversary of Process that "Energized" Oil and Gas Industry." June 21, 1999.

149 Murphy, Jarrett. "Cheney's Halliburton Ties Remain." *CBSNews*. Washington, September 26, 2003.

150 Abramowitz, Michael and Steven Mufson. "Papers detail industry's role in Cheney's energy report." *The Washington Post*. July 18, 2007; National Energy Policy Development Group. "National Energy Policy: Report of the National Energy Policy Development Group." May 2001.

151 Milbank, Dana and Justin Blum. "Document says oil chiefs met with Cheney task force." *Washington Post*. November 16, 2005.

152 Lustgarten, Abrahm. "Natural Gas Politics." *Propublica*. May 26, 2009.

153 Kosnik, Renee. Oil and Gas Accountability Project/Earthworks. "The oil and gas industry's exclusions and exemptions to major environmental statutes." October 2007 at 2.

154 Kosnik, Renee. Oil and Gas Accountability Project/Earthworks. "The oil and gas industry's exclusions and exemptions to major environmental statutes." October 2007 at 2.

155 Lustgarten, Abrahm. "New York State Tightens Drilling Controls." *Propublica*. July 22, 2008.

156 Lustgarten, Abrahm. "Governor Signs Drilling Bill But Orders Environmental Update. *Propublica*. July 23, 2008.

157 Battey, Allison. "N.Y. plans to consider law limiting natural gas drilling." *Propublica*. September 9, 2008.

158 Vitali, Greg. "Halt state forest gas leases." *The Philadelphia Inquirer*. May 23, 2010; Hundley, Wendy. "Flower Mound puts end to new gas drilling." *The Dallas Morning News.* May 29, 2010.

159 Bauers, Sandy. "Delaware River panel extends its gas-drilling ban." *The Philadelphia Inquirer*. June 15, 2010.

160 As You Sow. *PR Newswire*. "ExxonMobil Shareholders Strongly Supprt Disclosure of Natural Gas 'Fracking Risks." May 26, 2010.

161 As You Sow. *PR Newswire*. "ExxonMobil Shareholders Strongly Supprt Disclosure of Natural Gas 'Fracking Risks." May 26, 2010.

162 Maykuth, Andrew. "Activist nuns bringing fracking to a vote." *Philadelphia Inquirer.* June 6, 2010.

163 U.S. Securities and Exchange Commission, Washington D.C. As You Sow. "Shareholder Rebuttal to the ExxonMobil Opposition Statement Regarding Hydraulic Fracturing."

164 Maykuth, Andrew. "Activist nuns bringing fracking to a vote." *Philadelphia Inquirer.* June 6, 2010.

165 Maykuth, Andrew. "Activist nuns bringing fracking to a vote." *Philadelphia Inquirer.* June 6, 2010.

166 Maykuth, Andrew. "Activist nuns bringing fracking to a vote." *Philadelphia Inquirer.* June 6, 2010.

167 Maykuth, Andrew. "Pa. suspends gas drilling at Marcellus rupture site." *The Philadelphia Inquirer*. June 7, 2010.

168 Maykuth, Andrew. "Pa. suspends gas drilling at Marcellus rupture site." *The Philadelphia Inquirer*. June 7, 2010.

169 Maykuth, Andrew. "Pa. suspends gas drilling at Marcellus rupture site." *The Philadelphia Inquirer*. June 7, 2010.

Food & Water Watch
Main Office
1616 P St. NW, Suite 300
Washington, DC 20036
tel: (202) 683-2500
fax: (202) 683-2501
info@fwwatch.org
www.foodandwaterwatch.org

California Office
25 Stillman Street, Suite 200
San Francisco, CA 94107
tel: (415) 293-9900
fax: (415) 293-8394
info-ca@fwwatch.org