The Costs of Fracking

The Price Tag of Dirty Drilling's Environmental Damage

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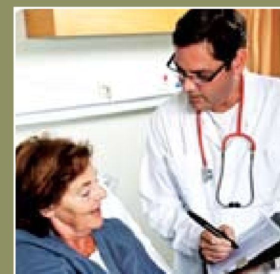

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Table of Contents

Executive Summary 1

Introduction 5

Fracking: The Process and its Impacts 7
Defining "Fracking" 7
The Fracking Process 8
Fracking and the New Gas/Oil Rush 10

The Costs of Fracking 12
Drinking Water Contamination 12
Health Problems 15
Damage to Natural Resources 19
Impacts on Public Infrastructure and Services 24
Broader Economic Impacts 29

Who Pays the Costs of Fracking? 32

Accounting for the True Costs of Fracking: Conclusion and Recommendations 35

Notes 37

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Executive Summary

Over the past decade, the oil and gas industry has fused two technologies—hydraulic fracturing and horizontal drilling—to unlock new supplies of fossil fuels in underground rock formations across the United States. "Fracking" has spread rapidly, leaving a trail of contaminated water, polluted air, and marred landscapes in its wake. In fact, a growing body of data indicates that fracking is an environmental and public health disaster in the making.

However, the true toll of fracking does not end there. Fracking's negative impacts on our environment and health come with heavy "dollars and cents" costs as well. In this report, we document those costs—ranging from cleaning up contaminated water to repairing ruined roads and beyond. Many of these costs are likely to be borne by the public, rather than the oil and gas industry. As with the damage done by previous extractive booms, the public may experience these costs for decades to come.

The case against fracking is compelling based on its damage to the environment and our health alone. To the extent that fracking does take place, the least the public can expect is for the oil and gas industry to be held accountable for the damage it causes. Such accountability must include up-front financial assurances sufficient to ensure that the harms caused by fracking are fully redressed.

Fracking damages the environment, threatens public health, and affects communities in ways that can impose a multitude of costs:

Drinking water contamination – Fracking brings with it the potential for spills, blowouts and well failures that contaminate groundwater supplies.

- Cleanup of drinking water contamination is so expensive that it is rarely even attempted. In Dimock, Pennsylvania, Cabot Oil & Gas reported having spent $109,000 on systems to remove methane from well water for 14 local households, while in Colorado, cleanup of an underground gas seep has been ongoing for eight years at a likely cost of hundreds of thousands of dollars, if not more.

- The provision of temporary replacement water supplies is also expensive. Cabot Oil & Gas reported having spent at least $193,000 on replacement water for homes with contaminated water in Dimock, Pennsylvania.

- Fracking can also pollute drinking water sources for major municipal systems, increasing water treatment costs. If fracking were to degrade the New York City watershed with sediment or other pollution, construction of a filtration plant would cost approximately $6 billion.

Health problems – Toxic substances in fracking fluid and wastewater—as well as air pollution from trucks, equipment and the wells themselves—have been linked to a variety of negative health effects.

- The National Institute of Occupational Safety and Health recently warned that workers may be at elevated risk of contracting the lung disease silicosis from inhalation of silica dust at fracking sites. Silicosis is one of a family of dust-induced occupational ailments that imposed $50 million medical care costs in the United States in 2007.

- Residents living near fracking sites have long suffered from a range of health problems, including headaches, eye irritation, respiratory problems and nausea—potentially imposing economic costs ranging from health care costs to workplace absenteeism and reduced productivity.

- Fracking and associated activities also produce pollution that contributes to the formation of ozone smog and particulate soot. Air pollution from gas drilling in Arkansas' Fayetteville Shale region imposed estimated public health costs of more than $10 million in 2008.

Natural resources impacts – Fracking converts rural and natural areas into industrial zones, replacing forest and farm land with well pads, roads, pipelines and other infrastructure, and damaging precious natural resources.

- The clearance of forest land in Pennsylvania for fracking could lead to increased delivery of nutrient pollution to the Chesapeake Bay, which already suffers from a vast nutrient-generated dead zone. The cost of reducing the same amount of pollution as could be generated by fracking would be approximately $1.5 million to $4 million per year.

- Gas operations in Wyoming have fragmented key habitat for mule deer and pronghorn, which are important draws for the state's $340 million hunting and wildlife watching industries. The mule deer population in one area undergoing extensive gas extraction dropped by 56 percent between 2001 and 2010.

- Fracking also produces methane pollution that contributes to global warming. Emissions of methane during well completion from each uncontrolled fracking well impose approximately $130,000 in social costs related to global warming.

Impacts on public infrastructure and services – Fracking strains infrastructure and public services and imposes cleanup costs that can fall on taxpayers.

- The truck traffic needed to deliver water to a single fracking well causes as much damage to local roads as nearly 3.5 million car trips. The state of Texas has approved $40 million in funding for road repairs in the Barnett Shale region, while

Pennsylvania estimated in 2010 that $265 million would be needed to repair damaged roads in the Marcellus Shale region.

- The need for vast amounts of water for fracking is helping to drive demand for new water infrastructure in arid regions of the country. Texas' official State Water Plan calls for the expenditure of $400 million on projects to support the mining sector over the next 50 years, with fracking projected to account for 42 percent of mining water use by 2020.

- The oil and gas industry has left thousands of orphaned wells from previous fossil fuel booms. Taxpayers may wind up on the hook for the considerable expense of plugging and reclaiming orphaned wells—Cabot Oil & Gas claims to have spent $730,000 per well to cap three shale gas wells in Pennsylvania.

- Fracking brings with it increased demands for public services. A 2011 survey of eight Pennsylvania counties found that 911 calls had increased in seven of them, with the number of calls increasing in one county by 49 percent over three years.

Broader economic impacts – Fracking can undercut the long-term economic prospects of areas where it takes place. A 2008 study found that Western counties that have relied on fossil fuel extraction are doing worse economically compared with peer communities and are less well-prepared for growth in the future.

- Fracking can affect the value of nearby homes. A 2010 study in Texas concluded that houses valued at more than $250,000 and within 1,000 feet of a well site saw their values decrease by 3 to 14 percent.

- Fracking has several negative impacts on farms, including the loss of livestock due to exposure to spills of fracking wastewater, increased difficulty in obtaining water supplies for farming, and potential conflicts with organic agriculture. In Pennsylvania, the five counties with the heaviest Marcellus Shale drilling activity saw an 18.5 percent reduction in milk production between 2007 and 2010.

As with previous fossil fuel booms that left long-term impacts on the environment, there is every reason to believe that the public will be stuck with the bill for many of the impacts of fracking.

Defining "Fracking"

In this report, when we refer to the impacts of "fracking," we include impacts resulting from all of the activities needed to bring a well into production using hydraulic fracturing, to operate that well, and to deliver the gas or oil produced from that well to market. The oil and gas industry often uses a more restrictive definition of "fracking" that includes only the actual moment in the extraction process when rock is fractured—a definition that obscures the broad changes to environmental, health and community conditions that result from the use of fracking in oil and gas extraction.

- Existing legal rules are inadequate to protect the public from the costs imposed by fracking. Current bonding requirements fail to assure that sufficient funds will be available for the proper closure and reclamation of well sites, and do nothing at all to ensure that money is available to fix other environmental problems or compensate victims. Further, weak bonding requirements fail to provide an adequate incentive for drillers to take steps to prevent pollution before it occurs.

- Current law also does little to protect against impacts that emerge over a long period of time, have diffuse impacts over a wide area, or affect health in ways that are difficult to prove with the high standard of certainty required in legal proceedings.

The environmental, health and community impacts of fracking are severe and unacceptable. Yet the dirty drilling practice continues at thousands of sites across the nation. Wherever fracking does occur, local, state and federal governments should at least:

- **Comprehensively restrict and regulate** fracking to reduce its environmental, health and community impacts as much as possible.

- Ensure **up-front financial accountability** by requiring oil and gas companies to post dramatically higher bonds that reflect the true costs of fracking.

Introduction

In Appalachia, more than 7,500 miles of streams are polluted with acid mine drainage—the legacy of coal mining. Many of those streams still run orange-colored and lifeless decades after mining ended. The ultimate cost of cleaning up acid mine drainage in Pennsylvania alone has been estimated at $5 billion.[1]

Texas has more than 7,800 orphaned oil and gas wells—wells that were never properly closed and whose owners, in many cases, no longer exist as functioning business entities.[2] These wells pose a continual threat of groundwater pollution and have cost the state of Texas more than $247 million to plug.[3]

In the western United States, uranium mining and milling have contaminated both water and land. The cost to taxpayers of cleaning up the uranium mills has been estimated at $2.3 billion, while the cost of cleaning up abandoned mines has been estimated at $14 million per mine.[4]

Over and over again, throughout American history, short-term resource extraction booms have left a dirty long-term legacy, imposing continuing costs on people and the environment years or decades after those who profited from the boom have left the scene.

Today, America is in the midst of a new resource extraction boom, one driven by a process colloquially known as "fracking." In just over a decade, fracking has spread across the country, unlocking vast supplies of previously inaccessible oil and gas from underground rock formations.

The costs of fracking—in environmental degradation, in illness, and in impacts on infrastructure and communities—are only just now beginning to be understood and tallied. It is also now becoming clear that the nation's current system of safeguards is incapable of protecting the public from having to shoulder those sizable costs in the years and decades to come.

The burdens imposed by fracking are significant, and the dangers posed to the environment and public health are great. If fracking is to continue, the least the American people should expect is for our laws to ensure that those who reap the benefits also bear its full costs.

The landscapes of Appalachia, Texas and the American West are living testaments to the need to hold industries accountable for cleaning up the damage they cause. As fracking unleashes yet another extractive boom, the time has come to ensure that this history does not repeat itself in the 21st century.

Fracking: The Process and its Impacts

Over the past decade, the oil and gas industry has married two technologies—horizontal drilling and hydraulic fracturing—to create a potent new combination that is being used to tap fossil fuels locked in previously difficult-to-reach rock formations across the United States. This technology, known as high-volume horizontal hydraulic fracturing—or, colloquially, "fracking"—has broad implications for the environment and public health.

Defining "Fracking"

Public debates about fracking often descend into confusion and contradiction due to a lack of clarity about terms. To the oil and gas industry, which seeks to minimize the perceived impacts, "fracking" refers only to the actual moment in the extraction process where rock is fractured by pumping fluid at high pressure down the well bore. Limiting the definition of fracking in this way also allows the oil and gas industry to include its long history of using hydraulic fracturing in traditional, vertical wells—a process with fewer impacts than the technology being used in oil and gas fields today—to create a false narrative about the safety of fracking. It is only according to this carefully constructed definition that ExxonMobil CEO Rex Tillerson could say, as he did in a Congressional hearing in 2011, that "[t]here have been over a million wells hydraulically fractured in the history of the industry, and there is not one, not one, reported case of a freshwater aquifer having ever been contaminated from hydraulic fracturing."[5]

Just as only a small portion of an iceberg is visible above the water, only a small portion of the impacts of fracking are the direct result of fracturing rock. Each step in the process of extracting oil or gas from a fracked well has impacts on the environment, public health and communities. Thus, any reasonable assessment of fracking ***must*** include the full cycle of extraction operations before and after the moment where rock is cracked open with fluid under high pressure.

In this report, when we refer to the impacts of "fracking," we include impacts resulting from all of the activities needed to bring a well into production using hy-

Fracking imposes a range of environmental, health and community impacts. Above, a fracking well site is built in a forested area of Wetzel County, W.Va. Credit: Robert Donnan

draulic fracturing, to operate that well, and to deliver the gas or oil extracted from that well to market.

The Fracking Process

Fracking is used to unlock gas or oil trapped in underground rock formations, allowing it to flow to the surface, where it can be captured and delivered to market. Fracking combines hydraulic fracturing, which uses a high-pressure mixture of water, sand and chemicals to break up underground rock formations, with horizontal drilling, which enables drillers to fracture large amounts of rock from a single well.

The combination of hydraulic fracturing with horizontal drilling has magnified the environmental impacts of oil and gas extraction. Whereas traditional, low-volume hydraulic fracturing used tens of thousands of gallons of water per well, today's high-volume hydraulic fracturing operations use millions of gallons of water, along with a different combination of sand and chemical additives, to extract gas or oil.

A vast amount of activity—much of it with impacts on the environment and nearby communities—is necessary to bring a fracking well into production and to deliver the gas extracted from that well to market. Among those steps are the following:

Well Site Preparation and Road Construction

Before drilling can begin, several acres of land must be cleared of vegetation and leveled to accommodate drilling equipment, gas collection and processing equipment, and vehicles. Additional land must be cleared for roads to the well site, as well as for any pipelines needed to deliver gas to market.

Materials Assembly

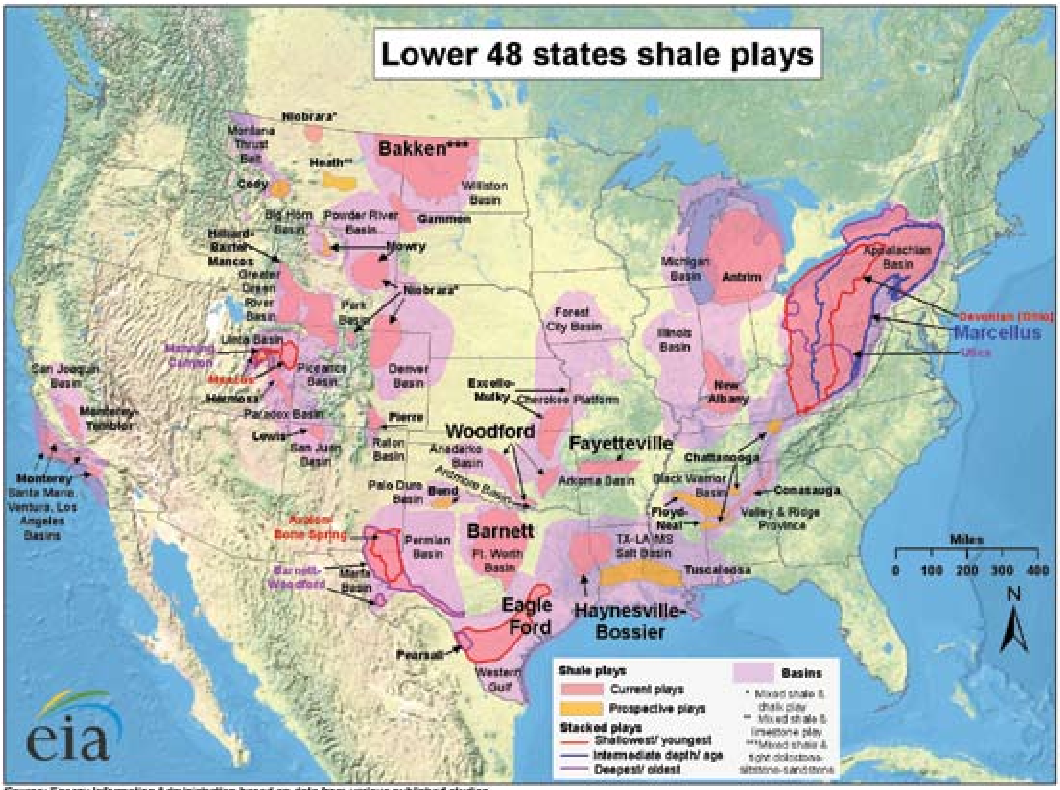
Hydraulic fracturing requires massive amounts of water, sand and chemicals—all of which must be obtained and delivered to the well site. Water for fracking comes either from surface waterways, groundwater or recycled wastewater from previous fracking activities, with millions of gallons of water required for each well. The special grade of sand used in fracking must be extracted from the ground—often from silica mines in the upper Midwest—and transported to the well site. Water, sand and other materials must be carried to well sites in trucks, tearing up local roads, creating congestion, and producing local level air pollution.

Drilling and Hydraulic Fracturing

Once the necessary machinery and materials are assembled at the drilling site, drilling can begin. The well is drilled to the depth of the formation that is being targeted. In horizontally drilled wells, the well bore is turned roughly 90 degrees to extend along the length of the formation. Steel "casing" pipes are inserted to stabilize and contain the well, and the casing is cemented into place. A mix of water, sand and chemicals is then injected at high pressure—the pressure causes the rock formation to crack, with the sand propping open the gaps in the rock. Some of the injected water then flows back out of the well when the pressure is released ("flowback" water), followed by gas and water from the formation ("produced water").

Equipment is put in place in preparation for hydraulic fracturing at a well site in Troy, Pa. In hydraulic fracturing, a combination of water, sand and chemicals is injected at high pressure to fracture oil or gas-bearing rock formations deep underground. Credit: New York Department of Environmental Conservation

Figure 1. Shale Gas and Oil Plays[6]



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Gas Processing and Delivery

As natural gas flows from the fracked well, it must be collected, purified and compressed for injection into pipelines and delivery to market.

Wastewater Management and Disposal

Flowback and produced water must be collected and disposed of safely. Wastewater from fracking wells is often stored onsite temporarily in retention ponds or tanks. From there, the fluid may be disposed of in an underground injection well or an industrial wastewater treatment plant, or it may be treated and re-used in another fracking job.

Plugging and Reclamation

To prevent future damage to the environment and drinking water supplies, wells must be properly plugged and the land around them restored to something approaching its original vegetated condition. This involves plugging the well with cement, removing all unnecessary structures from the well pad, and replanting the area.

Fracking and the New Gas/Oil Rush

From its beginnings in the Barnett Shale region of Texas at the turn of the 21st century, the use of fracking has spread across the United States with breathtaking speed. A decade later, the combination of high-volume hydraulic fracturing with horizontal drilling has been used in thousands of oil and gas wells across the country—despite persistent questions about the impact of the technology and supporting activities on the environment, public health and communities.

Roughy half of U.S. states, stretching from New York to California, sit atop shale or other rock formations with the potential to produce oil or gas using fracking. As fracking has made oil and gas extraction viable in more of these formations, it is bringing drilling closer to greater numbers of people as well as precious natural resources.

- Between 2003 and 2010, more than 11,000 wells were drilled in the Fort Worth basin of Texas' Barnett Shale formation.[7] The Barnett Shale underlies one of the most populous regions of the state—the Dallas-Fort Worth Metroplex—and drilling has taken place in urban and suburban neighborhoods of the region.

- In Pennsylvania's Marcellus Shale, more than 6,300 shale gas wells have been drilled since 2000; permits have been issued that would allow for more than 2,400 additional wells to be drilled.[8] A 2011 analysis by PennEnvironment Research & Policy Center found that 104 day care centers and 14 schools in Pennsylvania were located within a mile of a shale gas well; that figure is certainly higher today.[9]

- In Colorado, fracking has taken off in the oil-producing Niobrara Shale formation. Weld County, Colorado, located just north of Denver and just east of Fort Collins, has seen the permitting of more than 1,300 horizontal wells since the beginning of 2010.[10]

Oil and gas companies are aggressively seeking to expand fracking to places where more people live (including the city of Dallas) and to treasured natural areas (including the Delaware River Basin, which provides drinking water for 15 million people). Wherever this new gas rush is allowed, it will impose significant impacts on the environment, public health and communities. To add insult to injury, these impacts also come with heavy price tags that will all too often be borne by individual residents and their communities. The following section of this report provides a breakdown of fracking impacts along with examples of the real-life costs already being imposed on America's environment and our communities.

The Costs of Fracking

A great deal of public attention has been focused on the immediate impacts of fracking on the environment, public health and communities. Images of flaming water from faucets, stories of sickened families, and incidents of blowouts, spills and other mishaps have dramatically illustrated the threats posed by fracking.

Residents of Dimock, Pennsylvania, are among those who have reported drinking water contamination in the wake of nearby fracking activity. Here, discolored water from local wells illustrates the change in water quality following fracking. Photo: Hudson Riverkeeper

Less dramatic, but just as important, are the long-term implications of fracking—including the economic burdens imposed on individuals and communities. In this paper, we outline the many economic costs imposed by fracking and show that, absent greatly enhanced mechanisms of financial assurance, individuals, communities and states will be left to bear many of those costs.

Drinking Water Contamination

Fracking can pollute both groundwater and surface waterways such as rivers, lakes and streams. In rural areas, where the bulk of fracking takes place, residents may rely on groundwater for household and agricultural use. Alternative sources of water—such as municipal water supplies—may be unavailable or prohibitively expensive.

Fracking has polluted drinking water sources in a variety of ways.

- Spills and well blowouts have released fracking chemicals and flowback or produced water to groundwater and surface water. In Colorado and New Mexico, an estimated 1.2 to 1.8 percent of all gas drilling projects result in groundwater contamination.[11]

- Waste pits containing flowback and produced water have frequently failed. In New Mexico, substances from oil and gas pits have contaminated groundwater at least 421 times.[12]

- Faulty well construction has caused methane and other substances to find their way into groundwater.[13]

Recent studies have suggested that fracking may also pose a longer-term threat of groundwater contamination. One study used computer modeling to conclude that natural faults and fractures in the Marcellus Shale region could accelerate the movement of fracking chemicals—possibly bringing these contaminants into contact with groundwater in a matter of years.[14] In addition, a recent study by researchers at Duke University found evidence for the existence of underground pathways between the deep underground formations tapped by Marcellus Shale fracking and groundwater supplies closer to the surface.[15] The potential for longer-term groundwater contamination from fracking is particularly concerning, as it raises the possibility that contamination will become apparent only long after the drillers responsible have left the scene.

Among the costs that result from drinking water contamination are the following:

Groundwater Cleanup

Groundwater is a precious and often limited natural resource. Once contaminated, it can take years, decades or even centuries for groundwater sources to clean themselves naturally.[16] As a result, the oil and gas industry must be held responsible for restoring groundwater supplies to their natural condition.

Methane contamination of well water poses a risk of explosion and is often addressed by removing it from water at the point of use. In Dimock, Pennsylvania, Cabot Oil & Gas reported having spent $109,000 on methane removal systems for 14 local households in the wake of drilling-related methane contamination of local groundwater supplies. In addition, the company spent $10,000 on new or extended vent stacks to prevent the build-up of methane gas in residents' homes.[17] Such measures do not remove methane from groundwater supplies, but merely eliminate the immediate threat to residents' homes.

"In Dimock, Pennsylvania, Cabot Oil & Gas reported having spent $109,000 on methane removal systems for 14 households."

Removing other toxic contaminants from groundwater is so costly that it it rarely attempted, with costs of hundreds of thousands of dollars or more.

In 2004, improper cementing of a fracking well in Garfield County, Colorado, caused natural gas to vent for 55 days into a fault terminating in a surface waterway, West Divide Creek.[18] In response to the leak, the company responsible for drilling the well, Encana, engaged in regular testing of nearby wells and installed equipment that injects air into the groundwater, enabling chemical contaminants in the water to become volatile and be removed from the water, using a process known as air sparging. These activities began in 2004 and were still ongoing as of mid-2012.[19]

The cost of groundwater remediation in the Garfield County case is unknown, but likely runs into the hundreds of thousands of dollars, if not more. A 2004 Environmental Protection Agency (EPA) document, referring to the work of a federal roundtable on environmental cleanup technologies, estimated the cost of air sparging at $150,000 to $350,000 per acre.[20] Adjusting for inflation, and assuming that the extent of the seep was correctly estimated by Encana at 1.3 acres, one could estimate the cost of the sparging operation in 2012 dollars at $248,000 to $579,000.[21] In addition, as of May 2012, Encana and its contractors had collected more than 1,300 water samples since the seep began.[22] Again, the cost of this sampling and testing is unknown, but could be conservatively estimated to be in the tens of thousands of dollars. Cabot Oil & Gas, for example, incurred $700,000 in water testing expenses in the wake of concerns about groundwater contamination from a fracking well in Dimock, Pennsylvania.[23]

The Colorado example shows that the process of cleaning up contaminated groundwater can take years to complete, underscoring the need for protections to ensure that drillers have the financial wherewithal to fulfill their obligations to clean up pollution.

Water Replacement

As noted above, the process of cleaning up contaminated groundwater can take years. In the meantime, residents must be provided with clean, temporary sources of drinking water.

"Cabot Oil & Gas provided at least $193,000 worth of water to homes affected by contamination."

The Colorado and Pennsylvania examples above demonstrate the high cost of supplying replacement water to households dependent on contaminated wells. In Colorado, Encana offered "complete water systems and potable water delivery" to homes within a two-mile area of the West Divide Creek gas seep, at an estimated cost of $350,000.[24] These deliveries continued into 2006. In Pennsylvania, Cabot Oil & Gas provided at least $193,000 worth of water to homes affected by contamination there.[25] A permanent solution to water issues in Dimock—the extension of municipal water to the neighborhood—was estimated to cost $11.8 million.[26]

Water Treatment Costs Due to Surface Water Contamination

Fracking and related activities may reduce the quality of rivers and streams to the point where municipalities must invest in additional water treatment in order to make water safe to drink.

"Should gas drilling require drinking water to undergo additional treatment, New York would be required to build one of the world's largest filtration plants at an estimated cost of $6 billion."

The most significant impacts of fracking on rivers and streams used for drinking water come not from individual spills, blowouts or other accidents, but rather from the effects of fracking many wells in a given area at the same time. Widespread fracking can damage waterways through water withdrawals from river basins, the dumping of fracking wastewater into rivers, or increased sedimentation resulting from land clearance for well pads, pipelines and other natural gas infrastructure.

Damage from widespread fracking may require water utilities to invest in expensive additional treatment. New York City's water supply, for example, comes from upstate New York watersheds that are sufficiently pristine that water filtration is not required. Should gas drilling—or any other polluting activity—require additional treatment, New York would be required to build one

The disposal of fracking wastewater in open pits contributes to air pollution, while leakage from improperly lined pits has contaminated groundwater and surface water. Chemicals present in fracking wastewater have been linked to serious health problems, including cancer. Credit: Mark Schmerling

of the world's largest water filtration plants. New York has already had to take this step for one major source of drinking water, spending $3 billion to build a filtration plant for the part of the watershed east of the Hudson River.[27] The cost of doing the same for areas west of the Hudson, which sit atop the Marcellus Shale formation, was estimated in 2000 to be as much as $6 billion.[28]

Health Problems

Fracking produces pollution that affects the health of workers, nearby residents and even people living far away. Toxic substances in fracking chemicals and produced water, as well as pollution from trucks and compressor stations, have been linked to a variety of negative health effects. Chemical components of fracking fluids, for example, have been linked to cancer, endocrine disruption, and neurological and immune system problems.[29]

The legal system often offers little relief for those whose health is impacted by chemically tainted air or water. In order to prevail in court, an individual affected by exposure to toxic chemicals must prove that he or she has been exposed to a specific toxic chemical linked to the health effects that they are experiencing *and* that the exposure was caused by the defendant (as opposed to the many other sources of possible exposure to toxic chemicals that most people experience every day).[30] Meeting that high legal standard of proof is costly—usually requiring extensive medical and environmental testing and expert testimony—and difficult, given corporate attorneys' track record of exploiting gaps in scientific knowledge to cast doubt on claims of harm from toxic chemical exposures. As a result, many citizens whose health has been affected by fracking may be discouraged from taking their complaints to court.

Individuals and taxpayers, therefore—rather than polluters—may bear much of the financial burden for health costs resulting from fracking.

Nearby Residents Getting Sick

Emissions from fracking wellsites contain numerous substances that make people sick.

In Texas, monitoring by the Texas Department of Environmental Quality detected levels of benzene—a known cancer-causing chemical—in the air that were high enough to cause immediate human health concern at two sites in the Barnett Shale region, and at levels that pose long-term health concern at an additional 19 sites. Several chemicals were also found at levels that can cause foul odors.[31] Less extensive testing conducted by the Pennsylvania Department of Environmental Protection detected components of natural gas, particularly methane, in the air near Marcellus Shale drilling operations.[32] Air monitoring in Arkansas has also found elevated levels of volatile organic compounds (VOCs)—some of which are also hazardous air pollutants—at the perimeter of hydraulic fracturing sites.[33]

"Residents living near fracking sites have long suffered from a range of health problems, including headaches, eye irritation, respiratory problems and nausea—imposing economic costs ranging from health care costs to workplace absenteeism and reduced productivity."

Residents living near fracking sites have long suffered from a range of health problems, including headaches, eye irritation, respiratory problems and nausea.[34] In western Pennsylvania, for example, residents living near one fracking well site have complained of rashes, blisters and other health effects that they attribute to a wastewater impoundment.[35] An investigation by the investigative journalism website ProPublica uncovered numerous similar reports of illness in western states.[36]

A recent study by researchers at the Colorado School of Public Health found that residents living within a half-mile of natural gas wells in one area of Colorado were exposed to air pollutants that increased their risk of illness.[37] The report noted that "health effects, such as headaches and throat and eye irritation reported by residents during well completion activities occurring in Garfield County, are consistent with known health effects of many of the hydrocarbons evaluated in this analysis."[38]

These health impacts are unacceptable regardless of the economic cost. But they also have significant economic impacts, including:

- Health care costs, including inpatient, outpatient and prescription drug costs;
- Workplace absenteeism;
- "Presenteeism," or reduced productivity at work.[39]

Major health problems such as cancer are obviously costly. The average case of cancer in the United States in 2003 imposed costs in treatment and lost productivity of approximately $30,000.[40]

The economic impacts of less severe problems such as headaches and respiratory symptoms can also add up quickly. Each day of reduced activity costs the economy roughly $50 while a missed day of work costs approximately $105.[41] The economic value to individuals of avoiding one exposure to hydrocarbon odors per week is approximately $26 to $36 per household.[42] As fracking continues to spread, particularly in areas close to population centers, the number of residents affected by these health problems—already substantial—is likely to increase.

Worker Injury, Illness, and Death

Fracking is dangerous business for workers. Nationally, oil and gas workers are seven times more likely to die on the job than other workers, with traffic accidents, death from falling objects, and explosions the leading causes of death. Between 2003 and 2008, 648 oil and gas workers nationwide died from on-the-job injuries.[43] Workers at fracking well sites are vulnerable to many of these same dangers, as well as one that is specific to fracking: inhalation of silica sand.

Silica sand is used to prop open the cracks formed in underground rock formations during fracking. As silica is moved from trucks to the well site, silica dust can become airborne. Without adequate protection, workers who breathe in silica dust can develop an elevated risk of contracting silicosis, which causes swelling in the lungs, leading to the development of chronic

"The National Institute of Occupational Safety and Health recently warned that workers at fracking sites may be at risk of contracting the lung disease silicosis from inhalation of silica dust. Silicosis is one of a family of dust-induced occupational ailments that imposed $50 million in medical care costs in 2007."

Fracking can be a dangerous business for workers. The National Institute for Occupational Safety and Health recently found dangerous levels of airborne silica at fracking sites in several states, while workers also risk injury from traffic accidents, falling objects, explosions and other hazards. Workers, their families and the public often bear much of the costs of workplace illness and injury. Credit: Mark Schmerling cough and breathing difficulty.[44] Silica exposure can also cause lung cancer.[45]

A recent investigation by the National Institute for Occupational Safety and Health (NIOSH) found that workers at some fracking sites may be at risk of lung disease as a result of inhaling silica dust. The NIOSH investigation reviewed 116 air samples at 11 fracking sites in Arkansas, Colorado, North Dakota, Pennsylvania and Texas. Nearly half (47 percent) of the samples had levels of silica that exceeded the Occupational Safety and Health Administration's (OSHA) legal limit for workplace exposure, while 78 percent exceeded OSHA's recommended limits. Nearly one out of 10 (9%) of the samples exceeded the legal limit for silica by a factor of 10, exceeding the threshold at which half-face respirators can effectively protect workers.[46]

Silicosis is one of a family of dust-induced occupational ailments (including asbestosis and black lung disease) that have long threatened the health of industrial workers. A recent study estimated that this category of occupational disease imposed costs in medical care alone of $50 million in 2007.[47]

Workers, their families and taxpayers are often forced to pick up much of the cost of workplace illnesses and injuries. A 2012 study by researchers at the University of California, Davis, estimated that workers compensation insurance covers only about 20 percent of the total costs of workplace illness and injury, with government programs such as Medicaid and Medicare, as well as workers and their families, bearing much of the burden in health care costs and lost productivity.[48]

Air Pollution Far from the Wellhead

Air pollution from fracking also threatens the health of people living far from the wellhead—especially children, the elderly and those with respiratory disease.

Fracking produces a variety of pollutants that contribute to regional air pollution problems. VOCs in natural gas formations contribute to the formation of ozone "smog," which reduces lung function among healthy people, triggers asthma attacks, and has been linked to increases in school absences, hospital visits and premature death.[49] Some VOCs are also considered "hazardous air pollutants," which have been linked to cancer and other serious health effects. Emissions from trucks carrying water and materials to well sites, as well as from compressor stations and other fossil fuel-fired machinery, also contribute to the formation of smog and soot that threatens public health.

"Air pollution from drilling in Arkansas' Fayetteville Shale in 2008 likely imposed public health costs greater than $10 million in 2008."

Fracking is a significant source of air pollution in areas experiencing large amounts of drilling. A 2009 study in five Dallas-Fort Worth-area counties experiencing heavy Barnett Shale drilling activity found that oil and gas production was a larger source of smog-forming emissions than cars and trucks.[50] Completion of a single uncontrolled natural gas well produces approximately 22.7 tons of volatile organic compounds (VOC) per well—equivalent to the annual VOC emissions of about 7,000 cars—as well as 1.7 tons of hazardous air pollutants and approximately 156 tons of methane, which contributes to global warming.[51]

Well operations, storage of natural gas liquids, and other activities related to fracking add to the pollution toll, playing a significant part in regional air pollution problems. In Arkansas, for example, gas production in the Fayetteville Shale region was estimated to be responsible for

2.6 percent of the state's total emissions of nitrogen oxides (NO_x).[52] An analysis conducted for New York State's revised draft environmental impact statement on Marcellus Shale drilling posited that, in a worst case scenario of widespread drilling and lax emission controls, shale gas production could add 3.7 percent to state NO_x emissions and 1.3 percent to statewide VOC emissions compared with 2002 emissions levels.[53]

The public health costs of pollution from fracking are significant. The financial impact of ozone smog on public health has been estimated at $1,648 per ton of NO_x and VOCs.[54] Applying those costs to emissions in five counties of the Dallas-Fort Worth region with significant Barnett Shale drilling, the average public health cost of those emissions would be more than $270,000 *per day* during the summer ozone season.[55] In Arkansas, the nearly 6,000 tons of NO_x and VOCs emitted in 2008 would impose an annual public health cost of roughly $9.8 million.[56]

Various aspects of fracking also create particulate—or soot—pollution. A 2004 EPA regulatory impact analysis for new standards for stationary internal combustion engines often used on natural gas pipelines and in oil and gas production, for example, estimated the benefit of reducing one ton of particulates under 10 microns in diameter (PM_{10}) at $8,028 per ton.[57] Using this figure, the economic benefit of eliminating PM_{10} emissions from Arkansas' Fayetteville Shale would be roughly $5.4 million per year.

Air pollution from drilling in Arkansas' Fayetteville Shale in 2008, therefore, likely imposed public health costs greater than $10 million in 2008, with additional, unquantified costs imposed in the form of lost agricultural production and lower visibility.

Damage to Natural Resources

Fracking threatens valuable natural resources all across the country. Fracking converts rural and natural areas into industrialized zones, with forests and agricultural land replaced by well pads, roads, pipelines and natural gas infrastructure. The effects of this development are more than just aesthetic, as economists have increasingly come to recognize the value of the services that natural systems provide to people and the economy.

Threats to Our Rivers and Streams

Damage to aquatic ecosystems has a direct, negative impact on the economy. The loss of a recreational or commercial fishery due to spills, excessive withdrawals of water, or changes in water quality caused by the cumulative effects of fracking in an area can have devastating impacts on local businesses.

"The clearance of forest land in Pennsylvania for fracking could lead to increased delivery of nutrient pollution to the Chesapeake Bay, which suffers from a nutrient-generated dead zone. The cost of reducing an amount of pollution equivalent to that produced by fracking would be approximately $1.5 million to $4 million per year."

In Pennsylvania, for example, fishing had an estimated economic impact of $1.6 billion in 2001.[58] Allocating that impact to the roughly 13.4 million fishing trips taken in Pennsylvania each year (as of the late 1990s) would result in an estimated impact of $119 per trip.[59]

The Monongahela River, shown here at Rices Landing, Pa., has been affected by discharges of fracking wastewater and by water withdrawals for fracking. A 2011 Army Corps of Engineers report concluded that "the quantity of water withdrawn from streams [in the Monongahela watershed] is largely unregulated and is beginning to show negative consequences." Credit: Jonathan Dawson

Spills, blowouts and other accidents related to fracking have caused numerous fish kills in Pennsylvania. In 2009, a pipe containing freshwater and flowback water ruptured in Washington County, Pennsylvania, triggering a fish kill in a tributary of Brush Run, which is part of a high-quality watershed.[60] That same year, in the same county, another pipe rupture at a well drilled in a public park killed fish and other aquatic life along a three-quarter-mile length of a local stream.[61]

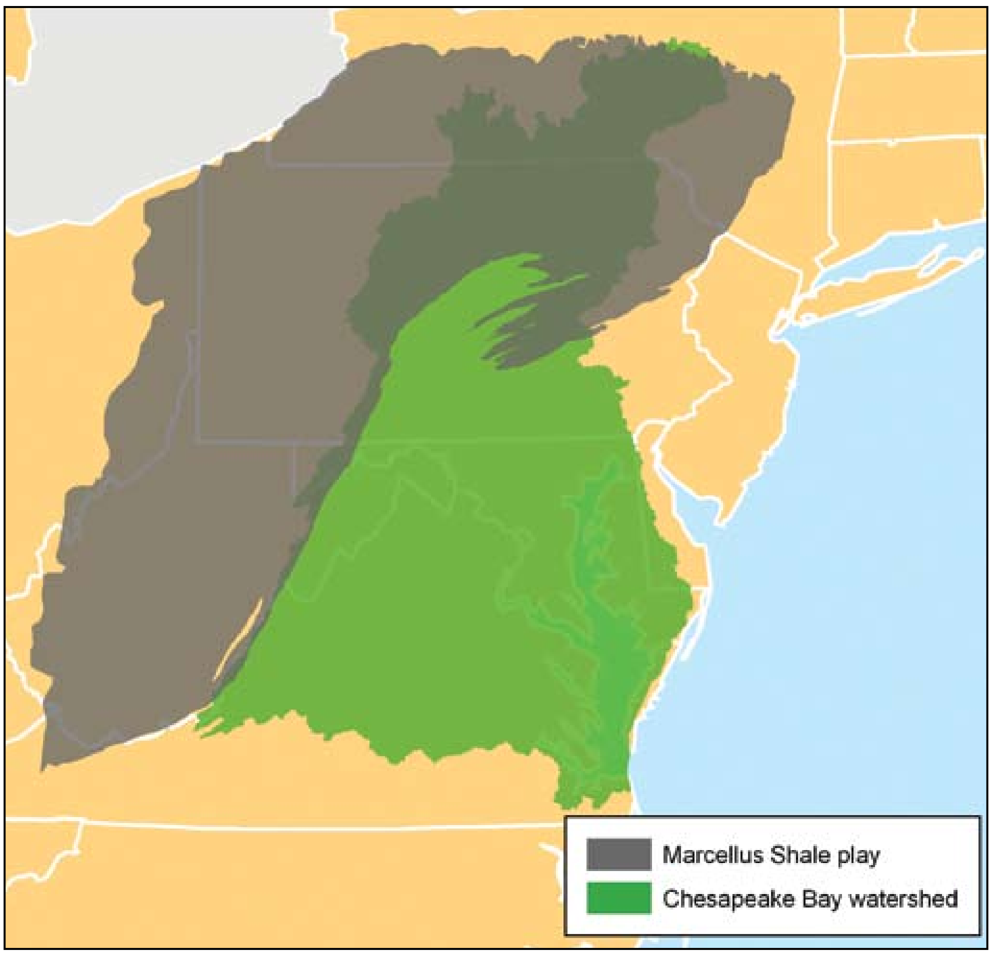
The clearing of land for well pads, roads and pipelines can increase sedimentation of nearby waterways and degrade the ability of natural landscapes to retain nutrients. A recent preliminary study by the Academy of Natural Sciences of Drexel University found an association between increased density of natural gas drilling activity and degradation of ecologically important headwaters streams.[62]

Excessive water withdrawals also play havoc with the ecology of rivers and streams. In Pennsylvania, water has been illegally withdrawn for fracking numerous times, to the extent of streams being sucked dry. Two streams in southwestern Pennsylvania—Sugarcamp Run and Cross Creek—were reportedly drained for water withdrawals, triggering fish kills.[63]

Water withdrawals also concentrate pollutants, reducing water quality. A 2011 U.S. Army Corps of Engineers study of the Monongahela River basin of Pennsylvania and West Virginia concluded that, "The quantity of water withdrawn from streams is largely unregulated and is beginning to show negative consequences."[64] The Corps report noted that water is increasingly being diverted from the relatively clean streams that flow into Corps-maintained reservoirs, limiting the ability of the Corps to release clean water to help dilute pollution during low-flow periods.[65] It described the water supply in the Monongahela basin as "fully tapped."[66]

On a broader scale, the clearance of forested land for well pads, roads and pipelines reduces the ability of the land to prevent pollution from running off into rivers and streams. Among the waterways most affected by runoff pollution is the Chesapeake Bay, where excessive runoff of nutrients such as nitrogen and phosphorus causes the formation of a "dead zone" that spans as much as a third of the bay in the summertime.[67] The Chesapeake Bay watershed overlaps with some of the most intensive Marcellus Shale fracking activity, creating the potential for additional pollution that will make the bay's pollution reduction goals more difficult to meet.

A rapid expansion of shale gas drilling could contribute an additional 30,000 to 80,000 pounds per year of nitrogen and 15,000 to 40,000 pounds per year of phosphorus to the bay, depending on the amount of forest lost.[68] While this additional pollution represents a small fraction of the total pollution currently reaching the bay, it is pollution that would need to be offset by reductions elsewhere in order to ensure that the Chesapeake Bay meets pol-



Many waterways in the Marcellus Shale region drain into the Chesapeake Bay. The loss of forests to natural gas development could add to pollution levels in the bay, threatening the success of state and federal efforts to prevent the "dead zone" that affects the bay each summer. Sources: Skytruth, U.S. Energy Information Administration, Chesapeake Bay Program

Pronghorn antelope are among the species that have been affected by intense natural gas development in Wyoming. Credit: Christian Dionne

lution reduction targets designed to restore the bay to health.[69] Based on an estimate of the cost per pound of nitrogen reductions from a recent analysis of potential nutrient trading options in the Chesapeake Bay watershed,[70] the cost of reducing nitrogen pollution elsewhere to compensate for the increase from natural gas development would run to approximately $1.5 million to $4 million per year.

Habitat Loss and Fragmentation

Extensive natural gas development requires the construction of a vast infrastructure of roads, well pads and pipelines, often through remote and previously undisturbed wild lands. The disruption and fragmentation of natural habitat can put species at risk.

Hunting and other forms of outdoor recreation are economic mainstays in several states in which fracking is taking place. In Wyoming, for example, non-resident hunters and wildlife watchers pumped $340 million into the state's economy in 2006.[73] Fracking, however, is degrading the habitat of several species that are important attractions for hunters and wildlife viewers.[74]

A 2006 study found that the construction of well pads drove away female mule deer in the Pinedale Mesa area of Wyoming, which was opened to fracking in 2000, and that the deer stayed away from areas near well pads over time. The study suggested that natural gas development in the area was shifting mule deer from higher quality to lower quality habitat.[75] The mule deer population in the area dropped by 56 percent between 2001 and 2010 as fracking in the area continued and accelerated.[76]

Concerns have also been raised about the impact of natural gas development on pronghorn antelope. A study by the Wildlife Conservation Society documented an 82 percent reduction in high-quality pronghorn habitat in Wyoming's natural gas fields, which have historically been key wintering grounds.[77]

The Wyoming Game & Fish Department assigns "restitution values" for animals illegally killed in the state, with pronghorn valued at $3,000 per animal and mule deer at $4,000 per animal.[78] The decline of approximately 2,910 mule deer estimated to have occurred in the Pinedale Mesa between 2001 and 2010, using this valuation, would represent lost value of more than $11.6 million, although there is no way to determine the share of the decline attributable to natural gas development alone.[79]

"The decline of approximately 2,910 mule deer in the Pinedale Mesa, using this valuation, would represent lost value of more than $11.6 million."

The impact of fracking on wildlife-based recreation is, of course, only one of many ways in which harm to species translates into lasting economic damage. Wildlife provides many important ecosystem goods and services. (See next page.) Birds, for example, may keep insect and rodent populations in check, help to distribute seeds, and play other roles in

Loss of Ecosystem Services

Forests and other natural areas provide important services—they clean our air, purify our water, provide homes to wildlife, and supply scenic beauty and recreational opportunities. Many of these services would be costly to replicate—for example, as noted on page 14, the natural filtration provided by the forests of upstate New York has thus far enabled New York City to avoid the $6 billion expense of building a water filtration plant to purify the city's drinking water.

In recent years, economists have worked to quantify the value of the ecosystem services provided by various types of natural land. The annual value of ecosystem services provided by deciduous and evergreen forests, for example, has been estimated at $300 per acre per year.[71] Researchers with The Nature Conservancy and various Pennsylvania conservation groups have projected that 38,000 to 90,000 acres of Pennsylvania forest could be cleared for Marcellus shale development by 2030. The value of the ecosystem services provided by this area of forest, therefore, ranges from $11.4 million to $27 million per year.[72] Widespread land clearance for fracking jeopardizes the ability of the forest to continue to provide these valuable services.

Other natural features affected by fracking—including groundwater, rivers and streams, and agricultural land—provide similar natural services. The value of all of those services—and the risk that an ecosystem's ability to deliver them will be lost—must be considered when tallying the cost of fracking.

Oil and gas development fragments valuable natural habitat. Above, the Jonah gas field in Wyoming.
Credit: Bruce Gordon

the maintenance of healthy ecosystems. Adding these impacts to the impacts on hunters, anglers and wildlife-watchers magnifies the potential long-term costs of fracking from ecosystem damage.

Contribution to Global Warming

Global warming is the most profound challenge of our time, threatening the survival of key species, the health and welfare of human populations, and the quality of our air and water. Fracking produces pollution that contributes to the warming of the planet in greater quantities than conventional natural gas extraction.

"Emissions of methane during well completion from each uncontrolled fracking well impose approximately $139,000 in social costs related to global warming."

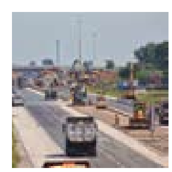
Fracking's primary impact on the climate is through the release of methane, which is a far more potent contributor to global warming than carbon dioxide. Over a 100-year timeframe, a pound of methane has 21 times the heat-trapping effect of a pound of carbon dioxide.[80] Methane is even more potent relative to carbon dioxide at shorter timescales.

Leaks during the extraction, transmission and distribution of natural gas release substantial amounts of methane to the atmosphere. Recent air monitoring near a natural gas field in Colorado led researchers at the National Oceanic and Atmospheric Administration and the University of Colorado, Boulder, to conclude that about 4 percent of the extracted gas was lost to the atmosphere, not counting the further losses that occur in transportation.[81]

Research by experts at Cornell University suggests that fracking is even worse for the climate than conventional gas production. Their study finds that methane leakage from fracking wells is at least 30 percent greater than, and perhaps double, leakage from conventional natural gas wells.[82]

Global warming threatens costly disruption to the environment, health and infrastructure. Economists have invested significant energy into attempting to quantify the "social cost" of emissions of global warming pollutants—that is, the negative impact on society per ton of emissions. A 2011 EPA study estimated the social cost of methane as lying within a range of $370 to $2,000 per ton. Each uncontrolled fracking well produces approximately 156 tons of methane emissions.[83] At a modest discount rate (3 percent) the social cost was $895 per ton in 2010.[84] Emissions of methane during well completion from a single uncontrolled fracking well, therefore, would impose $139,620 in social costs related to global warming.[85] This figure does not include emissions from other aspects of natural gas extraction, transmission and distribution, such as pipeline and compressor station leaks. Leakage from those sources further increases the impact of fracking on the climate—imposing impacts that may not be fully realized for decades or generations.

Impacts on Public Infrastructure and Services



Fracking imposes both immediate and long-term burdens on taxpayers through its heavy use of public infrastructure and heavy demand for public services.

Road Damage

Fracking requires the transportation of massive amounts of water, sand and fracking chemicals to and from well sites, damaging roads. In the northern tier of Pennsylvania,

Fracking requires millions of gallons of water and large quantities of sand and chemicals, all of which must be transported to well sites, inflicting damage on local roads. Above, a well site in Washington County, Pa. Credit: Robert Donnan

each fracking well requires approximately 400 truck trips for the transport of water and up to 25 rail cars' worth of sand.[86] The process of delivering water to a single fracking well causes as much damage to local roads as nearly 3.5 million car trips.[87]

"The state of Texas has convened a task force to review the impact of drilling activity on local roads and has approved $40 million in funding for road repairs in the Barnett Shale region."

Added up across dozens of well sites in a given area, these transportation demands are enough to lead to a noticeable increase in traffic—as well as strains on local roads. Between 2007 and 2010, for example, the amount of truck traffic on three major northern Pennsylvania highways increased by 125 percent, according to a regional transportation study. The study concluded that state and local governments will have to repave many roads every 7 to 8 years instead of every 15 years.[88]

The state of Texas has convened a task force to review the impact of drilling activity on local roads and has approved $40 million in funding for road repairs in the Barnett Shale region.[89] A 2010 Pennsylvania Department of Transportation document estimated that $265 million would be required for repair of roads affected by Marcellus Shale drilling.[90] Pennsylvania has negotiated bonding requirements with natural gas companies to cover the cost of repairs to local roads and some other states have done the same, but these requirements may not cover the full impact of fracking on roads, including impacts on major highways and the costs of traffic delays and vehicle repairs caused by congested or temporarily degraded roads.

Increased Demand for Water

The millions of gallons of water required for hydraulic fracturing come from aquifers, surface waterways, or water "recycled" from previous frack jobs.

In some areas, fracking makes up a significant share of overall water demand. In 2010, for example, fracking in the Barnett Shale region consumed an amount of water equivalent to 9 percent of the city of Dallas' annual water use.[91] An official at the Texas Water Development Board estimated that one county in the Eagle Ford Shale region will see the share of water consumption devoted to fracking and similar activities increase from zero a few years ago to 40 percent by 2020.[92] Unlike other uses, water used in fracking is lost to the water cycle forever, as it either remains in the well, is "recycled" (used in the fracking of new wells), or is disposed of in deep injection wells, where it is unavailable to recharge aquifers.

"Texas adopted a State Water Plan in 2012 that calls for $53 billion in investments in the state water system, including $400 million to address unmet needs in the mining sector (which includes hydraulic fracturing)."

Water withdrawals for fracking can harm local waterways (see page 20) and increase costs for agricultural and municipal water consumers (see page 31). They may also lead to calls for increased public investment in water infrastructure. Texas, for example, adopted a State Water Plan in 2012 that calls for $53 billion in investments in the state water system, including $400 million to address unmet needs in the mining sector (which includes hydraulic fracturing) by 2060.[93] Fracking is projected to account for 42 percent of water use in the Texas mining sector by 2020.[94]

Earthquakes

Fracking also has the potential to affect public infrastructure through induced earthquakes resulting from underground disposal of fracking wastewater. A recent report by the National Research Council identified eight cases in which seismic events were linked to wastewater disposal wells (not necessarily all for fracking wastes) in Ohio, Arkansas and Colorado.[95] In Ohio, which has become a popular location for the disposal of wastewater from Marcellus shale drilling, more than 500 million gallons of fracking wastewater were disposed of in underground wells in 2011.[96] That same year, the Youngstown, Ohio, area experienced a series of earthquakes, prompting Ohio officials to investigate potential links between the earthquakes and a nearby injection well. While the study did not determine a conclusive link between the injection well and the earthquakes, it did find that "[a] number of coincidental circumstances appear to make a compelling argument for the recent Youngstown-area seismic events to have been induced (by the injection well)."[97]

"The earthquakes raise concerns about the potential for damage to public infrastructure as well as private property."

The earthquakes that have occurred thus far have not caused significant damage, but they raise concerns about the potential for damage to public infrastructure (such as water and sewer lines) as well as private property.

Cleanup of Orphaned Wells

Gas and oil companies face a legal responsibility to plug wells properly when they cease to be productive and to "reclaim" well sites by restoring them to something approaching their original vegetated condition. The oil and gas industry, however, has a long track record of failing to clean up the messes it has made—leaving the public to pick up the tab.

Pennsylvania alone has more than 8,000 orphaned wells drilled over the last century and a half, and the Pennsylvania Department of Environmental Protection is unaware of the location or status of an additional 184,000 wells.[98]

Orphaned wells are not a problem of the past; newer wells can be orphaned by their operators, too, and left to taxpayers to clean up. Nearly 12,000 coal-bed methane wells in Wyoming were idle as of 2011, neither producing nor plugged.[99] Wyoming officials are concerned that several companies that operate coal-bed methane wells may file for bankruptcy if natural gas prices do not rebound or if the companies cannot sell off some assets to raise capital to comply with state environmental protections. If that were to happen, the state could be forced to plug and remediate the idled wells.

"A 2011 study of a Marcellus Shale well by researchers with the University of Pittsburgh estimated the cost of site reclamation (including reclamation of retention ponds and repairs to public roads) at $500,000 to $800,000 per well site."

Another way in which the public may face exposure to costs is when a well plug fails, requiring attention years later. Chemical, mechanical or thermal stress can cause the cement to

Volunteer firefighters respond to a fire in a wastewater pit at an Atlas Energy Resources well site in Washington County, Pa., in March 2010. Fracking places increased demands on emergency responders, creating new dangers that require additional training, and increasing demands for response to traffic accidents involving heavy trucks. Credit: Robert Donnan crack or loosen and allow contamination from saline aquifers or gas-bearing layers to reach freshwater aquifers. The risk of plug failure increases over time.[100] In some states, such as Pennsylvania, plugging and reclamation bonds are released one year after a well is plugged, leaving the state with no way to hold drillers accountable for the cost of plugging wells that fail later.

The Pennsylvania Department of Environmental Protection estimates that plugging a 3,000 foot-deep oil or gas well and reclaiming the drill site costs an average of $60,000.[101] However, some well reclamation costs have exceeded $100,000.[102] And Cabot Oil & Gas Corporation claims to have spent $730,000 per well to cap three shale gas wells in Pennsylvania.[103] A 2011 study of a Marcellus Shale well by researchers with the University of Pittsburgh estimated the cost of site reclamation (including reclamation of retention ponds and repairs to public roads) at $500,000 to $800,000 per well site.[104]

While estimates of the costs of plugging and remediation of fracked wells vary, those costs almost always exceed a state's bonding requirements. Pennsylvania's recently revised bonding requirements, for example, require drillers to post maximum bonds of only $4,000 per well for wells less than 6,000 feet in depth and $10,000 per well for wells deeper than 6,000 feet, creating the potential for the public to be saddled with tens or hundreds of thousands of dollars in liability for plugging and reclamation of abandoned wells whose owners have gone bankrupt or walked away from their responsibilities.[105] The experience of previous resource extraction booms and busts suggests that the full bill for cleaning up orphaned wells may not come due for decades.

In parts of the country, fracking takes place in close proximity to homes, schools and hospitals, creating the potential for conflict. A Texas study has found that some homes near fracking well sites have lost value. Above, a natural gas flare near homes in Hickory, Pa. Credit: Robert Donnan

Emergency Response Needs

Increasing traffic—especially heavy truck traffic—has contributed to an increase in traffic accidents and fatalities in some areas in which fracking has unleashed a drilling boom, as well as an increase in demands for emergency response. In the Bakken Shale oil region of North Dakota for example, the number of highway crashes increased by 68 percent between 2006 and 2010, with the share of crashes involving heavy trucks also increasing over that period. The estimated cost of those crashes increased by $31 million.[106]

"A 2011 survey in eight Pennsylvania counties found that 911 calls had increased in seven of them, with the number of calls increasing in one county by 49 percent over three years, largely due to an increase in incidents involving heavy trucks."

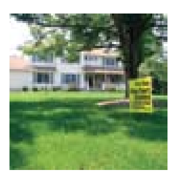
The need to address traffic accidents is one driver of increased need for emergency response in communities experiencing fracking. A 2011 survey by StateImpact Pennsylvania in eight counties found that 911 calls had increased in seven of them, with the number of calls increasing in one county by 49 percent over three years, largely due to an increase in incidents involving heavy trucks.[107]

Social Dislocation and Social Service Costs

The influx of temporary workers that often accompanies fracking also puts a squeeze on housing supplies, creating social dislocation that, in some cases, creates new demand for government social services. Rental prices have doubled or tripled in communities experiencing a boom in Marcellus Shale drilling.[108] Overheated local housing markets have driven lower income renters into substandard housing or homelessness. Elderly residents have faced a shortage of subsidized housing.[109] Requests for assistance from social service agencies have increased.[110] In Bradford County, Pa., the local children and youth services agency increased its spending on housing subsidies by 50 percent or $10,000 per year.[111] In the same county, a government agency purchased and distributed tents for use as temporary housing.[112] In Greene County, in southwestern Pennsylvania, the documented number of homeless jumped from zero to 40 in a single year.[113] Children of families that lose permanent housing may be at risk of being separated from their families and placed into foster care. A 2010 survey of Pennsylvania local governments in municipalities experiencing Marcellus Shale drilling activity found that more governments reported an increase in municipal expenditures since the onset of fracking than reported an increase in revenues.[114]

"In Greene County, in southwestern Pennsylvania, the documented number of homeless jumped from zero to 40 in a single year."

Broader Economic Impacts



Fracking imposes damage on the environment, public health and public infrastructure, with significant economic costs. But poorly thought-out resource extraction also has a legacy of undercutting the long-term economic prospects of the very "boomtowns" it creates.

A 2008 study by the firm Headwaters

Economics found that Western counties that have relied on fossil fuel extraction are doing worse economically compared with peer communities and are less well-prepared for growth in the future, due to a less-diversified economy, a less-educated workforce, and greater disparities in income.[115]

In addition, fracking can undermine local economies in many ways, including through its impacts on housing and agriculture.

Value of Residents' Homes at Risk

Fracking can reduce the value of nearby properties as a result of both actual pollution and the stigma that may come from proximity to industrial operations and the potential for future impacts. A 2010 study in Texas concluded that homes valued at more than $250,000 and within 1,000 feet of a well site saw their values decrease by 3 to 14 percent—there was no discernible impact on property values beyond that distance or for lower-priced houses.[116] A 2001 study of property values in La Plata County, Colorado, found that properties with a coalbed methane well had seen their sales value decrease by 22 percent.[117] Even where impacts on sales values are difficult to establish, chronic conditions caused by fracking—such as odor, traffic, noise, concerns about pollution of the air and water, earthquake concerns and visual impacts—may adversely affect residents' use and enjoyment of their homes.

"A 2010 study in Texas concluded that homes valued at more than $250,000 and within 1,000 feet of a well site saw their values decrease by 3 to 14 percent."

Properties on and near locations where fracking is taking place may also be more difficult to finance and insure, potentially affecting their value. Mortgage lenders and insurers have recently taken steps to protect themselves from fracking-related risks. Several mortgage lenders have begun to require extensive buffer zones around homes on land with gas leases before issuing a new mortgage or to refuse to issue new mortgages on land with natural gas leases.[118] For example, Brian and Amy Smith live across the street from a gas drilling site in Daisytown, Pa. In the spring of 2012, Quicken Loans denied their mortgage application, stating that "Unfortunately, we are unable to move forward with this loan. It is located across the street from a gas drilling site." The Smiths were also rejected by two other national lenders.[125]

In addition, in July 2012, Nationwide Insurance issued a statement clarifying that its policies do not cover damages related to fracking, noting that "the exposures presented by hydraulic fracturing are too great to ignore."[119] Nationwide's announcement drew attention to the fact that standard homeowners' insurance policies do not cover damage related to fracking.

Farms in Jeopardy

Fracking largely takes place in rural areas. Several aspects of fracking have the potential to harm farmers.

Direct exposure to fracking wastewater can harm livestock. Researchers at Cornell University have identified multiple instances of harm to animals associated with natural gas operations in Colorado, Louisiana, New York, Ohio, Pennsylvania and Texas. In one case examined by the researchers, 140 cows were exposed when the liner of a wastewater impoundment was slit, enabling wastewater to flow onto a pasture and into a pond the cattle used as a water supply. Of those 140 cows, approximately 70 died. Assuming an average cost per cow of $1,600[120], the loss of

"The loss of 70 cows from a single incident would have an impact of at least $112,000."

70 cows from a single incident would have an impact of at least $112,000. In addition to this direct replacement cost, exposure of livestock to contaminants from fracking is likely to cost farmers in other ways, for example, by impeding the ability of animals to reproduce or reducing the ability of a farmer to market his or her livestock.

Researchers at Penn State University have identified a link between increased drilling activity in the Marcellus Shale and decreased production at dairy farms in counties where drilling is taking place. The five counties in which drilling activity was the heaviest experienced an 18.5 percent reduction in milk production between 2007 and 2010.[121] The researchers did not reach a conclusion as to the cause of the decline. But another review of the community implications of fracking suggested that rising transportation costs caused by workforce competition with gas drilling has added a new economic challenge for dairy farmers.[122] The demise of farming in a community threatens to also bring down stores and industries that were built to support farmers, eroding a community's economic base.

In arid western states, some farmers face higher costs for water as a result of competing demands from fracking. A 2012 auction of unallocated water conducted by the Northern Water Conservation District saw natural gas industry firms submit high bids, with the average price of water sold in the auction increasing from $22 per acre-foot in 2010 to $28 per acre-foot in the first part of 2012.[123] For the 25,000 acre-feet of water auctioned, this would amount to an added cost of $700,000.

Fracking poses threats to farming, both directly through the potential loss of livestock due to exposure to toxic contaminants, and indirectly by increasing farmers' costs of doing business during the "boom" portion of the boom-bust cycle of development. Here, cows graze in Erie, Colorado, which has experienced fracking activity. Credit: Jill/Blue Moonbeam Studio.

Finally, farmers engaged in organic agriculture have raised concerns that fracking could make it more difficult for them to sell their products to health-conscious consumers. One New York City food co-op, for example, has already stated that they may stop purchasing agricultural products from New York state farms in areas where fracking takes place.[124]

Who Pays the Costs of Fracking?

The oil and gas industry is unlikely ever to be held accountable for many of the costs of fracking documented in this report—at least under current law.

Time and again in the history of the oil and gas industry, legal safeguards have proven inadequate to protect the environment and communities from exposure to long-term costs. The public can be exposed to many different and significant costs from fracking for several reasons:

- **Inadequate financial assurance.** The boom-bust cycle typical of the oil and gas industry means that many firms (or their subcontractors) may be unable or unwilling to fulfill their financial obligations to properly plug wells, reclaim land, remediate environmental problems, and compensate those harmed by their activities. State bonding requirements are intended to protect the public by ensuring that financial resources exist to cover the cost of well plugging and reclamation, but the amounts of those bonds are generally too low to pay for proper well closure, and state laws generally do not require drillers to obtain bonds to cover the cost of off-site environmental remediation or compensation to victims.

- **Delayed appearance of harm.** Some damages from fracking are apparent right away—for example, the appearance of tainted well water immediately after fracking of a nearby well. But other damages—especially ecosystem and health damages—may not appear for years or even decades, making it likely that the individuals and companies responsible will be long gone from the scene by the time the scope of the damage becomes apparent. This is particularly worrisome given concerns about the potential long-term impact of fracking and wastewater disposal on precious groundwater supplies.

- **Diffuse, regional impacts.** Some impacts of fracking only appear when many wells are drilled in a concentrated geographic area. For example, the erosion caused by clearance of a single well pad may not be enough to harm wildlife in a local stream, but the clearance of land for dozens of wells in the same area may have a harmful cumulative impact. In these cases, assigning legal responsibility for the damage to any single well may prove difficult or impossible.

- **Inability to access legal remedies.** Those who are harmed by fracking can face an uphill battle in the legal system. Litigation is frequently a lengthy, expensive, time-consuming and difficult road for citizens to pursue in seeking to resolve claims of damage from environmental conditions. This is particularly true with regard to health impacts. It is extraordinarily difficult, for example, to meet the legal standards of proof that an individual's illness was caused by exposure to a particular toxic chemical at a particular time. Even where property damage is concerned, such litigation typically requires expert analysis and testimony to prove causation and diminished value of the affected property.

As a result, many of the costs of fracking are often borne not by the companies that benefit, but by nearby residents, taxpayers, those whose enjoyment of clean air, clean water and abundant wildlife is impacted by fracking, and even by future generations.

Infographic design: Jenna Leschuk

Accounting for the True Costs of Fracking: Conclusion and Recommendations

Fracking harms the environment, public health and our communities in many ways.

If fracking is to continue, the minimum that citizens should expect is the enforcement of tough rules to reduce fracking damage and up-front financial assurances that guarantee that the oil and gas industry cleans up the damage it does cause and compensates any victims. Current laws, however, are inadequate to ensure that even this basic standard of protection is met. Failing to hold the oil and gas industry accountable not only leaves the public exposed to many types of costs, but it also creates a disincentive for the industry to take action to prevent accidents and environmental contamination.

Federal, state and local governments should **hold the oil and gas industry accountable for the costs of fracking** using a variety of financial tools, including:

- **Bonding** – Oil and gas companies should be required to post bonds (or other forms of financial assurance) sufficient to plug wells and reclaim well sites, pay for road repairs and other physical damage caused by fracking, remediate environmental contamination, fully compensate anyone harmed by activities at well sites, and address other costs imposed by fracking. Requiring drilling companies to post bonds for these expenses ensures that the oil and gas industry will be able to take care of its responsibilities to the public and the environment even amid the "boom-bust" cycles typical of the oil and gas industry.

- **Fees, taxes and other charges** – Bonding may not be the best solution for recouping every cost imposed by fracking. For example, natural gas companies could not be required to take out bonds to cover expenses related to a single well's contribution to global warming—the effect of which might be felt half a world away. While strong regulation should be used to limit the broader environmental, public health and community impacts of fracking, fees and other charges can also recoup for the public some of the costs imposed by fracking and create an economic incentive for the oil and gas industry to reduce its impact.

The mounting evidence of fracking's impact on our environment, health and communities is enough to spur reconsideration of when and under what circumstances it is permitted to take place. If fracking is permitted to continue, Americans deserve to know that the oil and gas industry—not the public at large—will pick up the tab.

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