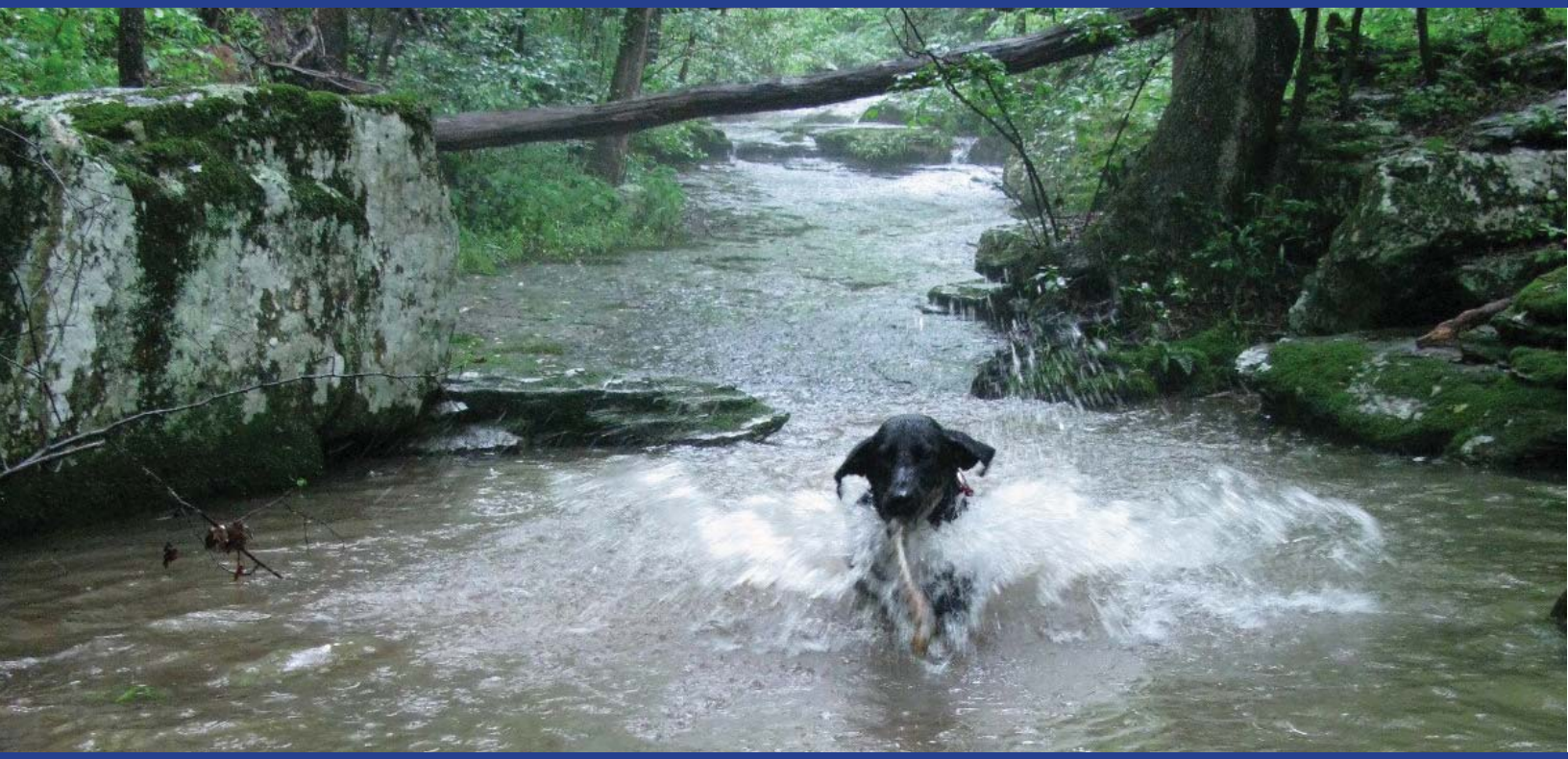

Arkansas in the Balance: Managing the Risks of Shale Gas Development in the Natural State

Arkansas Public Policy Panel

February 2011

Front cover photos:

Top: "Fetchin' in Ozark Streams" *Flickr user OakleyOriginals, licensed under the Creative Commons Attribution 2.0 license*

Bottom: Heavy concentration of diesel in a stream 250 yards downstream of a spill on a gas well pad—Highway 10 near Greenwood. *Arkansas Department of Environmental Quality (ADEQ) Investigation Report*

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Introduction

Natural gas development in Arkansas brings with it economic opportunity, but also significant threats. The individual property rights of many Arkansans are being encroached upon by gas companies. Arkansas's natural ecosystems and the air, land, and water which we all depend upon for survival—some of the most pristine and abundant in the world—are at serious risk. Gas development must be balanced in a responsible approach that takes advantage of the opportunities created by the industry but also protects Arkansans from the risks of development—a balance that Arkansas has yet to find.

This report has two broad purposes. The first is to provide information to the citizens of Arkansas about the environmental impacts and property rights issues associated with natural gas extraction. The second is to provide a partial set of recommendations for how gas development can be done responsibly while safeguarding Arkansans and their natural environment.

The Fayetteville Shale Play and other areas containing natural gas are potentially economically beneficial to Arkansas. New technology now allows us access to previously unreachable reserves of natural gas.

However, healthy human populations, clean drinking water, individual property rights, intact and functioning ecosystems, healthy fish and wildlife populations, and abundant access to natural landscapes are not only the rights of every Arkansan; they are significant contributing factors to Arkansas's economy and quality of life.

Natural gas is often considered a "clean fuel" because it burns cleaner than oil or coal. If not conducted properly, however, the processes of natural gas

This confluence of two Ozark creeks shows sedimentation from a pipeline crossing flowing into the clear water typical of Ozark streams. Excess sediment kills fish and causes increases in algae and toxic substances in lakes and streams that support wildlife, attract tourists and provide drinking water.

extraction, production, and transportation, can severely and adversely impact human health, water, air, land, agriculture, wildlife, and local economies.

Natural gas development poses many potential threats, from the point when land is leased by the operating company until well closure and reclamation at the end of gas production.

The massive scale of this industry, combined with a general lack of adequate oversight, is the greatest cause for concern. Approximately 7,000 wells already exist within the Arkoma Basin in Arkansas, and more than 14,000 are now projected for the Fayetteville Shale area. These wells can reach as much as a mile in depth and can also travel a little over a mile horizontally under the earth.

Deep layers of shale are fractured apart with explosives and water under high pressure. The water is combined with a chemical mixture designed to aid in the release of natural gas. Some of the chemicals and water remain in the wells indefinitely, while 30 to 70 percent of the mixture returns to the surface. The mixture is further contaminated with salts, chlorides, and hydrocarbons that it has been exposed to underground. Some of this contaminated water will need to be stored safely in hazardous waste disposal sites for decades after the industry is gone.

During the life of the Fayetteville Shale, hundreds of millions of gallons of fresh water will be pumped from lakes, streams and ponds to fracture wells, and thousands of acres of land will be cleared for well pads, roads and pipelines. Without proper care, clearing land causes erosion of steep slopes and washes sediment into the water. Sediment severely impacts the health of streams and the wildlife that depend on them.

As a result of natural gas development, the formerly pristine Ozark landscape is being transformed on a large scale. Colorado still bears the scars and is dealing with waste from mining operations that took place more than 100 years ago. The situation in that state stands as a lasting example of not doing it right.

Nearly every landowner in several counties will be affected by the gas industry in the next few years. Landowners across the region are already complaining of being forced to allow drilling on their property against their will and of having their property rights abused by the gas companies.

Federal regulatory authorities cannot be looked to for help. In 2005, the oil and gas industry was exempted from the Clean Air and Clean Water Acts. Arkansas, like many other states, must act on its own to protect these resources.

There is hope, however. The industry can develop natural gas in Arkansas much more responsibly. "Do it right" campaigns are being led by citizens across the nation. Other states and localities are taking action to protect their resources while developing gas fields. States are addressing these problems by implementing new regulations to close loopholes in federal regulations, increasing the amount of permit fees and exacting fines for violations. Cities and counties are enacting local ordinances to protect their health and environment. Arkansas can do the same.

Our most valuable natural resources—notably, clean water and land—will last forever if we protect them. We must make sure that the property rights of Arkansas residents are respected and that Arkansas's billion dollar agricultural, recreational, and tourism industries are protected.

If we move forward together and plan responsibly, we can meet the challenges before us. We hope the natural gas industry will join us as a partner in implementing solutions. It is clear that some companies are doing a much better job than others, but the industry as a whole must take responsibility. Blame should no longer be shuffled off to subcontractors and the bad actors of industry. Those with the capacity to do it right must lead the rest. The production of natural gas will only increase in Arkansas. Responsible energy development is essential in order to preserve the natural legacy of our state.

Executive Summary

The life cycle of a natural gas well in the Fayetteville Shale poses many different potential threats to water quality, water quantity, air quality, human health, wildlife, natural landscapes and individual property rights. We examine the threats at each stage in the process and conclude with recommendations of measures by which Arkansas can continue to reap the benefits of responsible gas development while protecting its people and the natural resources they depend on.

Phase One: Leasing

Many Arkansas landowners do not have adequate information about their rights when gas company lawyers and representatives negotiate leases. The gas companies can even force unwilling landowners to lease their land for development against their will through a practice called forced integration. Most Arkansans, who hold only surface rights, have even less protection. Gas companies, in most cases, dictate decisions such as where wells are located (as near as 200 feet from homes), how many wells are drilled, and the hours that company operators are on their property. Landowners are not even given notice about what and when company activities occur on their land.

Phase Two: Exploration

Exploration begins with a seismic survey that is completed by recording sonic vibrations from explosives or thumper trucks that shake the ground.

Exploration can have significant environmental impacts. Drinking water wells have clouded or dried up after nearby seismic tests, according to landowners who say the tests stir sediment and create fissures that change groundwater flows. Significant land disturbances can occur during exploration. Sometimes land is cleared more aggressively than necessary, using heavy equipment such as bulldozers and causing significant erosion when less intrusive practices would suffice.

Exploration by companies has also raised significant property rights issues. Landowners complain that gas

The Fayetteville Shale

Approximately 14,000 gas wells are predicted for the Fayetteville Shale area (in black on the map below), a geological formation approximately 350 million years old, containing an unconventional gas reservoir. Unconventional reservoirs are shale or tight sand formations that require fracturing—a process whereby they are broken apart underground using explosives or high pressure water and chemical mixtures—to release gas. The Fayetteville Shale ranges in thickness from 50 to 550 feet and lies 1,500 to 6,500 feet beneath the surface. It is very similar to the Barnett Shale in the Fort Worth area of Texas and the Caney Shale found on the Oklahoma side of the Arkoma Basin.

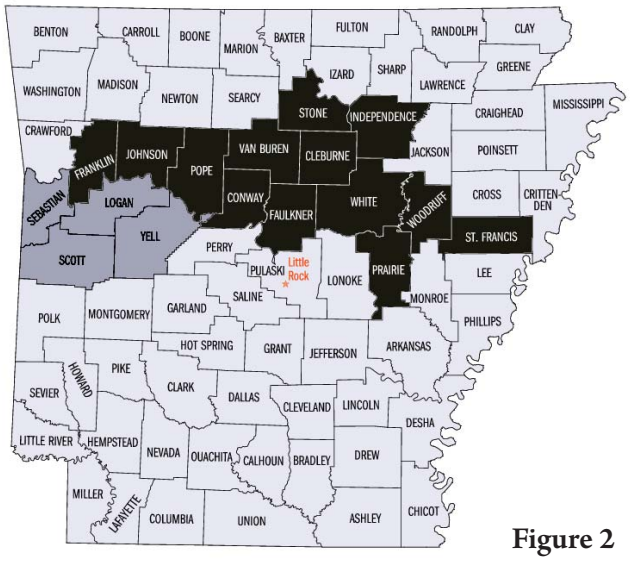


Figure 2

The Fayetteville Shale underlies the northern part of the Arkansas side of the Arkoma Basin (in dark gray), which already has approximately 7,000 wells. Several other shallower formations of sandstone and shale that overlie the Fayetteville Shale have been producing natural gas from conventional gas wells for a number of years around Booneville and other areas.

Some of the water bodies likely to be affected by natural gas development in the Fayetteville Shale include the Mulberry River, the Little Red River, and Greers Ferry Lake.

company contractors often come onto land without permission; clear land without permission or fair compensation; trample crops; leave livestock gates open or destroy fences; trench fields with heavy equipment; and interrupt farm and family activities by entering their property without warning.

Phase Three: Site Preparation, Drilling, Fracturing, and Production

Drilling for natural gas carries significant risks of chemical contamination. Potentially significant health impacts on residents who live near shale gas production have been found in numerous studies in other states, though much more monitoring and study is needed. Water that returns to the surface carries with it toxic chemicals and compounds such as benzene, a known human carcinogen, and metals such as mercury, lead and arsenic. These hazardous pollutants are not monitored sufficiently to ensure public health.

Controversy surrounds the hydraulic fracturing methods used in unconventional gas wells, which some feel threatens aquifers with contamination deep under the earth where the fracturing occurs. However, most geologists believe that chemical contamination from the fracture process, deep below the nearest aquifers, is not the major pathway of water contamination.

The much greater danger of contamination from unconventional wells is from casings or other equipment failing, causing leaks of fluids or gases into aquifers higher in the drill shaft, and even leaking in from spills of chemicals on the surface. Reports from across the nation indicate contamination of water wells and aquifers from these sources.

The potential cumulative effect of even small leaks at 7,000 current and more than 14,000 new drill sites is significant. Casing failures and leaks will occur. Such failures, which are likely to contaminate nearby water sources, will have lasting negative impacts. The EPA recently launched a two year study, in order to answer questions about the risks of fracturing technology.

Erosion and sedimentation of streams resulting from poor construction practices are among the industry's greatest impacts. Erosion from well pad, pipeline and road construction releases massive amounts of sediment into Arkansas lakes and streams. This is an issue of great concern, because sediment smothers fish eggs, kills other aquatic organisms, carries toxic pollutants, disrupts natural processes, and fouls water supplies. Sediment problems will also significantly impact other industries, such as tourism and recreation.

Gas companies, pipeline companies, and their contractors have already been cited for numerous violations of safeguards, including improper disposal of waste, failure to obtain necessary permits, and polluting the waters of the state. Water bodies such as the Little Red River, Greers Ferry Lake, and many underground aquifers remain at risk.

Landowners are not informed about what chemicals are used on their land, how much is used, or how they

Figure 3

Barnett Shale gas drilling rig near Alvarado, Texas.

are disposed of. Many gas field residents are concerned about their drinking and irrigation water but cannot afford to test their water for toxic substances. The secrecy with which gas companies guard the details about their chemical and water use and disposal makes testing even more difficult and expensive.

Water quantity, especially in dry years, is also a major concern. This type of gas production requires millions of gallons of water each time a well is stimulated. This will add up to billions of gallons of water being consumed out of Arkansas watersheds and aquifers. These withdrawals of water are nearly unregulated, and there is no way of knowing exactly how much is being consumed or what the impact of losing that much water means to Arkansas. In-stream flow studies must be done to determine how much water can be safely removed from streams without causing harm to aquatic life. Industry claims of negligible impact are unsubstantiated.

Much is known about the serious human health effects of some of the gas emissions coming from every well pad, drill site, and pipeline, but little is known about the exposure rates of people living in affected areas and monitoring of these emissions is negligible. Regulators do not account for the concentrated impact of dozens of well sites in close proximity to homes, farms, and wildlife. Additionally, dust from hundreds of heavy trucks, water tankers, chemical trucks, and enormous equipment on rural dirt roads is a serious concern.

Drilling mud, which can contain natural gas and other flammable materials, leaking from tanks at a land farm that has since been shut down.

The industry is also forever changing Arkansas's landscape, clearing hundreds of square miles for drill pads, pipelines, and roads. The state does not require companies to develop plans to minimize impacts even though some private homes and farms are nearly surrounded by wells.

Phase Four: Transportation

Construction of roads and pipelines will also require the long-term clearing of tens of thousands of acres of land. Erosion of these disturbed land surfaces will forever change the Ozark landscape and pollute lakes and streams.

Although pipelines are monitored for leaks, the leaks may go undetected even with the most stringent guidelines. Pipelines cross rivers and sometimes travel through aquifers, posing very real risks to water quality should a leak occur. Even though pipeline explosions have occurred in other states, emergency first responders in the Fayetteville Shale are neither trained nor equipped to handle such emergency situations.

Phase Five: Waste Disposal

Much of the water pumped into a well comes back out and contains hazardous elements. Both surface and groundwater are at risk of contamination by pollutants from gas wells, many of which can affect human health. Waste may be held in reserve pits, applied to land, or disposed of in injection wells. Numerous industry violations of Arkansas's current disposal laws have already occurred.

Volatile compounds can disperse from the surface of holding ponds waiting for disposal. Improperly contained waste can enter air or water. Unsecured pits can also become a hazard for wildlife, domestic animals, and humans.

Gas companies are not required to report where they have injected water, what chemicals they added, how much they used, how much they recaptured, how much was left in the well, what levels of contamination the recaptured water contained, or how they disposed of the

contaminated water. Waste is currently disposed of in injection wells in south Arkansas, Oklahoma and Texas. More injection wells have been proposed for central Arkansas as well.

Phase Six: Closure and Reclamation

Arkansas had 1,777 abandoned wells in 2006. We will have many more in the years ahead. Arkansas needs to ensure that gas companies put up sufficient bonds to pay for closure and reclamation of wells that exhaust their productive use.

Recommendations

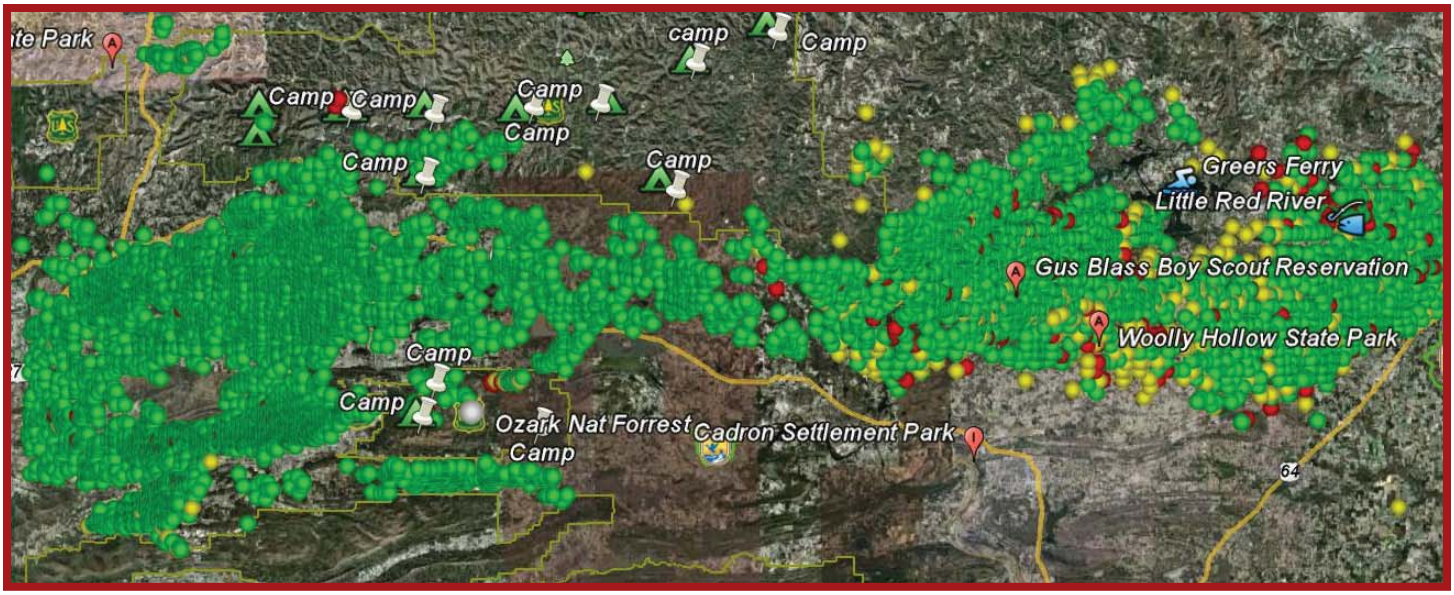
The changes we recommend include:

- **Improve protections for private landowners,** including more information about their rights and the best management practices they should expect from gas companies, better notification when gas company officials will be on their land, and disclosure of gas company practices and chemicals used on their property.
- **Improve disclosure from gas companies** so the public knows the amounts and types of chemicals used, assurance that chemical waste disposed of properly, the source of water used in the process, the level of contamination of the produced water, how much water is left inside the well, and the fate of the remaining contaminated water after the fracture process.
- **Require gas companies to reduce the noise from their operations** to preserve the peace of rural communities.
- **Monitor and regulate air emissions from the gas industry,** especially in places where many wells and compressors are concentrated near populated areas, and require the companies to use all cost effective measures to reduce air emissions.
- **Protect water quality from contamination** by the gas industry by requiring the gas industry to follow their own best management practices; testing of private water wells that are near proposed gas wells before and after drilling occurs; strengthening regulations and monitoring to ensure that chemicals do not contaminate water at any stage of the drilling process; strengthening regulations that ensure the drill shafts do not corrode or leak into underground aquifers; and requiring the industry to reduce the erosion impacts of the thousands of miles of pipelines, roads and drilling pads.
- **Improve inspection and enforcement** at gas drilling sites to make sure each well is inspected at least once a year and more often during critical stages of development to ensure that violations are caught and quickly corrected. The report recommends that Arkansas agencies create a fee system for gas drillers to pay for better inspection and enforcement programs so Arkansas tax payers are not asked to subsidize the industry.
- **Increase bonding requirements** to make sure Arkansans do not have to pay for the clean up and closure of abandoned mines.

Concentrated Impacts

A well pad requires clearing 3 to 10 acres of land, though multiple wells can be drilled from a single pad. Roads and pipelines leading to every well require additional land to be cleared, often causing erosion on the steep slopes of the Ozarks. Each well requires about 3 million gallons of water, and the chemicals used in the process are not released to the public.

The impact of a single well on land, water, property and health may be small, but the cumulative impact of 7,000 wells in close proximity—and many more to come—will be huge if proper measures are not taken to mitigate these impacts.



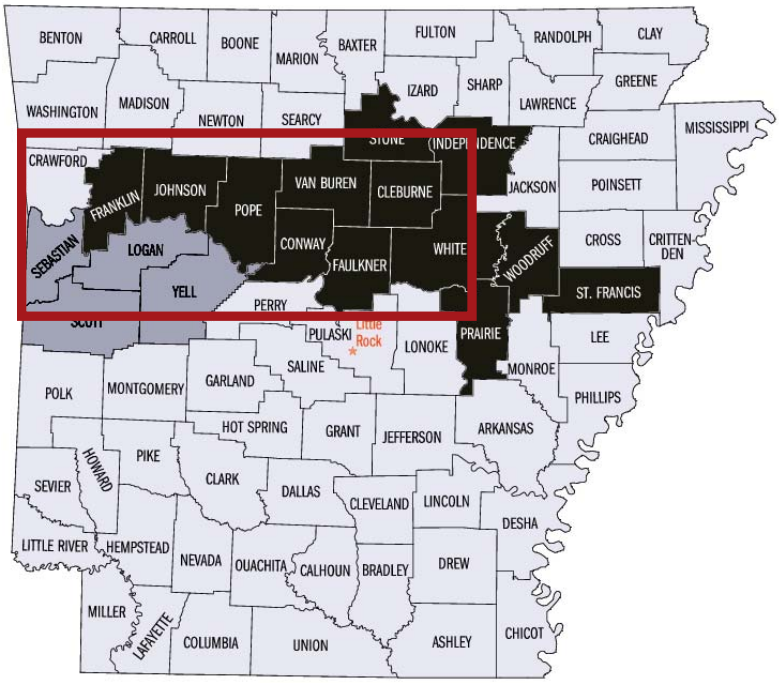


Figure 5

Each dot on this map represents a gas well in the Fayetteville Shale area.

Threats Through the Life Cycle of a Natural Gas Well

The life cycle of a shale natural gas well moves through several stages:

1. Leasing the land
2. Exploration
3. Site preparation, drilling, fracturing and production
4. Transportation of the gas
5. Waste disposal
6. Closure and reclamation

Each of these steps involve significant threats to water quality, water quantity, air quality, natural landscapes, wildlife, human health, and individual landowners' property rights. Best Management Practices (BMPs) have been established by industry and selected government agencies to minimize the negative impacts of these activities; however, compliance is voluntary, and most onsite employees lack sufficient training to properly implement them.

Some of the toxins created by the gas industry will linger in the environment long after the wells are gone. Gas wells have the highest levels of production in their first few years, with progressively smaller production in subsequent years as the well ages. Most sources say that the life span of a natural gas well in the Fayetteville Shale is between 10 and 30 years. Some extreme industry optimists say the area might last as long as 60 years, but this is not the typical experience of modern unconventional gas wells.

The risks associated with each stage of gas production need to be managed so that landowners—and other Arkansans who rely on clean water and other natural resources—are protected for now and generations to come.

Figure 6

A closed reserve pit leaking black, discolored seepage. Drilling fluids stored in reserve pits are supposed to be properly disposed of—rather than buried in the pit—when it is closed out.

Best Management Practices (BMPs): Unfulfilled Promises

The gas industry claims to follow Best Management Practices (BMPs) in Arkansas in order to prevent damage to human health, land, air and water, but much evidence points to the contrary. The introduction to Arkansas Best Management Practices for Fayetteville Shale Natural Gas Activities states:

> All energy and energy-support companies are encouraged to voluntarily use Best Management Practices (BMPs) in their exploration, drilling and reclamation activities. BMPs are innovative, dynamic, and improved environmental practices applied to activities (in this case gas exploration, drilling and production) to help ensure that activities are conducted in an environmentally responsible manner. BMPs allow energy companies to increase energy production while reducing the level of additional environmental impacts. This document was developed by a multi-agency workgroup to ensure all Arkansans benefit from the additional energy and the conservation of important public resources such as wildlife, rare plants, clean air and water, and aesthetic values while achieving the goals of state and federal laws that protect these resources.

BMPs recommend measures to prevent erosion, keep sediment out of streams, drill properly, handle chemicals properly, dispose of waste properly, and avoid ecologically sensitive areas.

Unfortunately for most landowners, BMPs are wholly voluntary and are only effective when followed. A great deal of damage has already been caused by pipelines crossing steep slopes and streams in the Ozarks without regard to BMPs. In many cases erosion has been allowed to continue without mitigation.

While private landowners must rely on gas companies' voluntary compliance with BMPs, federal agencies have been frustrated in efforts to enforce them even when they are required.

The U.S. Fish and Wildlife Service (FWS) can require that BMPs be followed in some areas under their authority to protect threatened and endangered species and their habitats under the Endangered Species Act. Several endangered species are at risk within the area of the Fayetteville Shale. The speed and scale of industry drilling and pipeline and road construction make it impossible to prevent environmental damage before it occurs; remediation necessitates multiple site visits to make sure it is conducted correctly.

FWS personnel, while investigating hundreds of miles of pipeline in the tributaries of the Little Red River upstream of Greers Ferry Reservoir, have cited numerous violations of the Endangered Species Act and the Clean Water Act. Gas companies have dragged their feet to solve problems even when they have been found in violation of enforceable BMPs, requiring constant oversight by FWS. FWS has no power to enforce protections outside of areas covered by the Endangered Species Act.

Figure 7

A sediment plume which extends from a drilling pad flows to a nearby creek because of an improperly installed and ineffective silt fence. Thousands of drilling pads are projected for the Fayetteville Shale.

Locked Out: One Landowner's Story

Figure 8

Johnny Wiedower's gate, locked by the gas company without notice or key.

Johnny Wiedower owns his mineral rights and willingly signed a lease with the gas company. Johnny is an easygoing and accommodating landowner who understands things from a working man's perspective through his job with the highway department. The Wiedower property lies on the banks of Cadron Creek near the town of Guy, Arkansas. Since signing the lease, the Wiedower family has experienced many problems with the gas company.

Johnny is worried that his well water may have been contaminated by fracturing operations. When he asked the company to test his water, they refused, telling him that his water was fine and there was no reason to test it. He does not trust the company's assertion and would like the quality of his water verified by an independent source.

Further, the gas company locked Johnny out of his own land. Johnny keeps a gate on his property unlocked so that a neighbor can access an adjoining property and that recreational visitors can access Cadron Creek. All he asked was for his gate to be closed to keep the cattle inside. The gas company also accesses the property by this gate. One day Johnny returned home to find the gate padlocked and a new gas company sign on the gate. He had been given no notice and no key to the gate onto his own property.

After contacting the company, he was called home twice about problems with his gate before a key was delivered. The company left the gate open while they serviced the gas well. Johnny's neighbor and another person entered while the gate was open and were trapped when the gas company left and locked the gate. Johnny was forced to leave work and come home. Still without a key to his own property, Johnny had to cut the chain to let them out.

Like most landowners with gas wells on their property, Johnny's family is stressed and worried. He considers the trash, bad roads, and the incidents with the gate as nuisances. He worries about the hidden costs to the value of his property as his quiet country home becomes an industrial zone. He worries too about the loss of things that he cannot put a price tag on, like the natural beauty of Cadron Creek and, most of all, the legacy he will leave his children. He wishes he had known more about his rights before he signed the lease with the gas company.

Phase One: Leasing

For purposes of leasing, land is partitioned into 640-acre units (one square mile). Prior to exploration for oil and gas, companies send a representative, sometimes referred to as a landman, to acquire leases from landowners.

Gas companies need more than 50% of the mineral rights owners in a unit to agree to gas development before they can proceed. Company landmen offer signing bonuses to mineral rights owners who sign leases with the company—these are in addition to the future royalties that every mineral-right owner receives based on their percentage holding in the unit. These signing bonuses vary widely, as do the terms of the leases agreed to between the company and the mineral-right owner.

Savvy landowners who also own their mineral rights can negotiate better terms for how the company will treat them and their land. But many landowners are asked to sign contracts without the benefit of reliable, unbiased information about their options. Most often, they are not well informed about their rights, and unknowingly cede significant legal advantages to the gas companies.

Threats to Property Rights

Once more than 50% of the landowners in a unit sign a contract, the remaining owners are legally required to allow natural-gas development through forced integration granted by the Arkansas Oil and Gas Commission. Landowners who are forced to integrate have almost no negotiable position with the industry.

Company representatives sometimes threaten land owners with the prospect of forced integration if they hold out for a better price or decide not to allow the industry on their property. Individuals owning both surface and mineral rights may opt to sign in order to negotiate terms for surface activity, knowing that otherwise they could be forced to allow development without a say in how the surface would be impacted. Owners with only surface rights—the case with many Arkansans—have no negotiable position regarding the gas development because mineral rights outweigh surface rights in Arkansas law.

The industry has the legal right to place a gas well within 200 feet of homes—less than a football field in distance—with all of the associated disruptions and risks to health and environment. Landowners have little say in how the development is carried out on their properties unless they negotiated specific terms into their lease. Important decisions—where wells are located, how many wells are drilled, the hours that company operators are on their property, to name a few—are almost always contractually dictated by the gas companies without so much as landowner notification of activity on their property. Landowners report stress and inability to sleep due to round-the-clock noise.

Figure 9

Gas wells, roads and pipelines dominate the landscape north of Booneville. This part of western Arkansas has been under gas development for some time, and shows what the larger Fayetteville Shale area may look like as the gas industry grows.

Phase Two: Exploration

Exploration begins with a seismic survey. Microphones are laid on the ground in a grid to record sonic vibrations as charges are exploded in shallow "shot holes." As an alternative, the ground may be "thumped" by a specialized truck to generate vibrations. The recordings are charted to map the subsurface characteristics.

The sheer scale of the Fayetteville Shale development, with more than 14,000 new wells projected for an area only a few counties in size, raises many concerns about the impacts of exploration even though this phase is of short duration and most effects are likely to be temporary.

Threats to Water Quality

Very little is done to control the erosion that occurs when vehicles create new paths across streams and into remote areas. The seismic cables that crisscross waterways are potentially hazardous for recreational boaters and fishermen. Landowners have also reported that wells and springs have clouded or dried up following seismic tests, which stir sediment and create fissures that can change groundwater flows.

Figure 10

A gas flare at a well near Clinton. Flares waste natural gas and release toxins into the air.

Threats to Natural Landscapes

While exploring for gas, companies lay cable across the landscape and their trucks and ATVs trample vegetation. Sometimes land is cleared more aggressively than necessary and with heavy equipment such as bulldozers when less intrusive practices would suffice. The clearing for seismic testing is often done without regard to the environmental impact of the activities.

Threats to Wildlife

The noise and land disturbance that accompany exploration create stress for wildlife, interfering with foraging, breeding, and rearing of young. While endangered species have some protection under the law, there is no provision to protect other wildlife or wildlife habitat. Sediment from excessive erosion poses a major threat to fish and other aquatic life.

Threats to Property Rights

Landowners complain that gas company contractors often come onto land without permission or even notice; clear land without permission or adequate compensation; trample crops; leave livestock gates open or destroy livestock fences; trench fields with heavy equipment; interrupt farm and family activities without warning; and generally exhibit no consideration of private landowner rights.

Chemicals stored in this dry chemical area are spilling onto the ground.

Phase Three: Site Preparation, Drilling, Fracturing, and Production

Site Preparation

Once a company selects a new well site, it builds a road to the location. Workers clear two to five acres of land and build a drilling pad by leveling the site and bringing in gravel—not always an easy task in the Arkansas Ozarks. They then build a large retaining pond, which they are required to line with plastic or heavy clay to contain drilling fluids. They also erect storage tanks to hold the drill fluids, fuel for the equipment, and various drilling and fracturing chemicals. Finally, they erect the drilling rig. Hundreds of heavy trucks will rumble over county backroads to deliver the equipment and water. Temporary pipelines are often built across miles of terrain to deliver fresh water that will be consumed in the drilling and fracturing process.

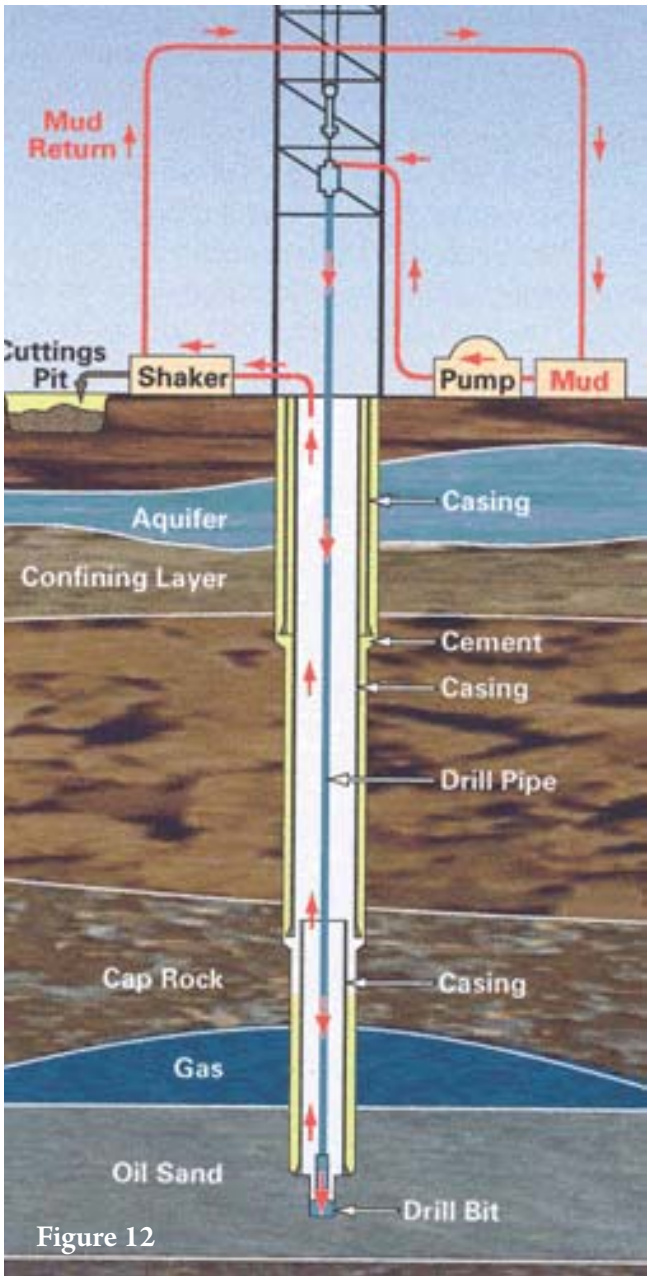
Bore Hole Drilling

In the beginning, a new well is "spudded in" by air drilling for the initial 500 feet, a protective casing is installed, and cement is pumped into the space between the well casing and the wall of the bore hole. If proper guidelines are followed, this protects freshwater aquifers from being infiltrated and contaminated by drilling and fracturing fluids later in the process.

The main drilling rig then drills to depths exceeding 6,000 feet—over a mile—into the shale layer, utilizing drilling mud and linking together a metal shaft of pipes that, provided they function properly, protect interceding layers of groundwater from contamination. If placement is good and faults are not present, intervening layers of impermeable rock also prevent fluids from reaching overlying aquifers. However, industry discussions of this technology overlook the environmental impact due to the presence of unmapped fissures and the infrequent but statistically unavoidable casing failures and leaks.

Horizontal Drilling

After the vertical bore hole is complete, the drill is turned horizontally to produce a lateral shaft in the shale layer measuring up to 6,000 feet (a little over a mile), extending the well under acres of surface land and associated property lines. Additional horizontal laterals can be drilled from new well heads using a common well pad. The new lateral shafts extend into undeveloped shale areas that require additional fracturing for gas recovery. Placing multiple well heads on one pad creates less surface disruption than requiring a pad for each well.



Drilling the traditional vertical shaft is only the first part of unconventional fracture drilling.

Careful seismic testing is needed to assure that there are no faults and that the shale layers are not uplifted close to an aquifer.

Fracturing

After the main and horizontal shafts are drilled, explosive charges are lowered into the well and detonated, fracturing the shale in all directions. Between two and five million gallons of fresh water are mixed with chemicals and pumped into the well at high pressure, forcing fractures to open and allowing gas to escape. The chemicals that the industry uses often contain oils, gels, acids, alcohols, and manmade organic compounds—much of it toxic to human health and wildlife.

Graded sand or other "proppants" are also injected to hold the fractures open and free gas. (Some of this sand is mined in Arkansas, resulting in collateral environmental impact.) Fractures radiate in many directions; recent studies indicate that they may migrate much further than originally supposed.

As much as 30 to 70 percent of the water and chemicals used in the fracturing process stay underground, presumably safely within the well and not migrating to contaminate freshwater sources. The other 30 to 70 percent of the water and chemical mixture used to fracture the well returns to the surface, often more contaminated than what was injected because it picks up salt deposits (brine), heavy metals, and other contaminants as it passes through layers of deep rock formations. This returned water (commonly referred to as "produced water") is temporarily stored in open retaining pits before being trucked offsite for disposal (see Waste Disposal, pg. 25).

No one knows the precise amounts of water and chemicals used in fracturing nor the proportions left underground in the well (as opposed to that trucked offsite for disposal) since the natural-gas industry is not required to track information on the volume of chemicals and water they use nor where it ends up.

Production

During the production phase a reduced-size well pad remains in place. Gas is metered into gathering lines, then compressed and sent on through transmission lines. When the rate of production falls, the well may be fractured again to stimulate further production. Depending on its characteristics a well is likely to be fractured five or more times during its lifespan, consuming millions of gallons of water for each operation. Produced water, containing toxins, may continue to emerge from the well during production and will need to be stored and disposed of properly as well.

New drilling techniques don't just go down in a straight line, but also expand out horizontally, potentially increasing risks of underground contamination.

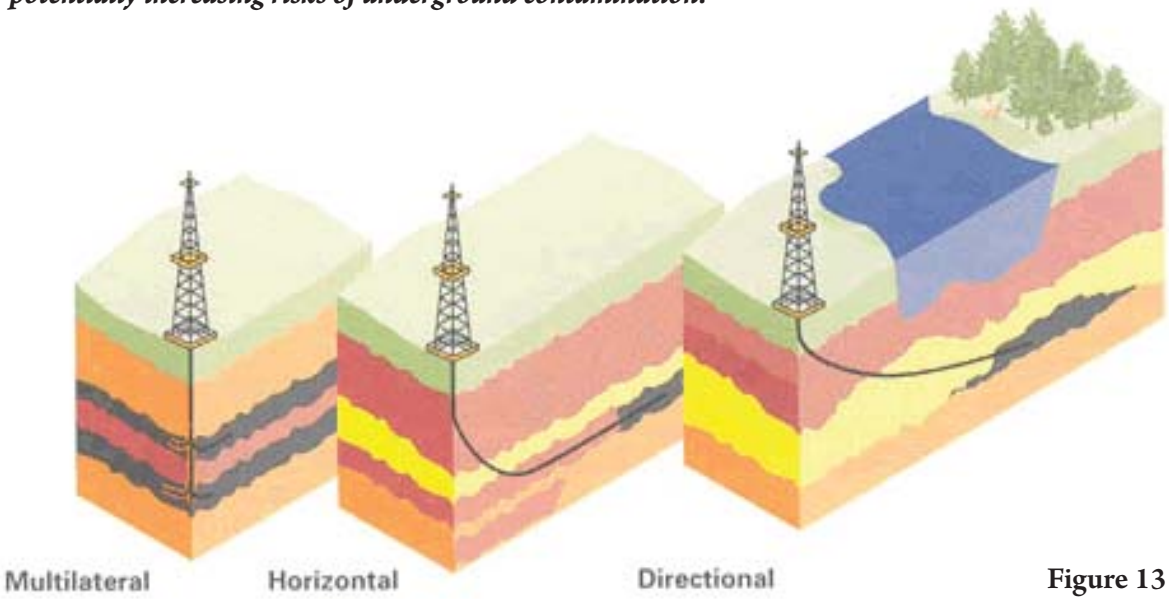


Figure 13

Threats From Site Preparation, Drilling, Fracturing, and Production

Threats to Water Quality

Some of the chemicals used in the fracturing process are toxic. Although industry claims purport that the concentration of these toxic chemicals is low and therefore harmless, many of them are dangerous even in low concentrations. Further, the cumulative effect of the total volume of chemicals is substantial considering the number of wells in the Fayetteville shale and the volume of material used in each well. Spills of these chemicals, even under the best conditions, are inevitable; even a few small leaks among the projected 14,000 drill sites could create a significant cumulative impact. Surface streams, rivers, lakes, ponds, and wetlands are vulnerable to hazardous spills.

In 2010, in order to address growing public concerns about contamination of water wells and other underground water sources, the Environmental Protection Agency was tasked with evaluating the potential risks to surface and underground sources of drinking water from hydraulic fracturing. The gas industry strongly denies that groundwater has been affected. The study is due to be released in 2012.

Robert Howarth, PhD of Cornell University expressed some important questions in a letter to the EPA concerning the upcoming study of fracturing methods:

> "It is certain that shale gas development has contaminated groundwater and drinking water wells with methane, the mechanism or mechanisms leading to this contamination remain uncertain. Is the contamination primarily the result of poor well construction and cementing? Do the high pressures of hydraulic fracturing aggravate problems with poor well construction and cementing? Is there also potential for hydraulic fracturing to increase flow paths to the surface aside from the well itself, as for example by interacting with natural fractures and fissures? These are topics which should be part of the EPA study."

The possible migration of fracturing fluids deep underground and beyond the well site is a subject for debate. Wells go very deep and then turn horizontally

Water Bodies at Risk

Figure 14

Greers Ferry Lake, the Little Red River, the Mullberry River, Cadron Creek and the Arkansas River are only some of the key Arkansas water bodies at risk of contamination.

Sediment: Muddy Streams, Fewer Fish and More Expensive Drinking Water

Gas development in the Fayetteville Shale is causing massive sediment pollution of streams and lakes. Although the gas industry has Best Management Practices that could alleviate the problem, they are seldom followed. Instead, the scale and speed of development in the Fayetteville Shale is compounding the effects of bad practices by gas companies.

Sediment clouds water and has serious implications for the health of lakes and streams in Arkansas. It causes increased growth of algae. Toxic substances bond to sediment and are carried into lakes and streams, which dramatically increases treatment costs for drinking water. A murky Greers Ferry Lake—and other popular Ozark lakes and streams—will cease to attract tourists, sportsmen, and retirees, weakening the economy of the whole region.

Some sediment is natural. Trees fall into streams, and banks erode washing mud into creeks and rivers. How much sediment is naturally delivered to a stream depends on the local geology, soil, and vegetation. Ozark streams have historically had very low levels of sediment, and the fish and other organisms living in them have evolved to require clear water in order to thrive. Excess sediment kills fish and other aquatic life. Roads and other development add sediment pollution to streams as well and our state has done an insufficient job of preventing it.

Excessive sediment from erosion is the number one pollutant in the nation. Once again, the enormous size and speed of the new development brought by the natural gas industry is causing a vast increase in sediment loads to already stressed streams—yet the gas companies, in most cases, are doing very little to control it.

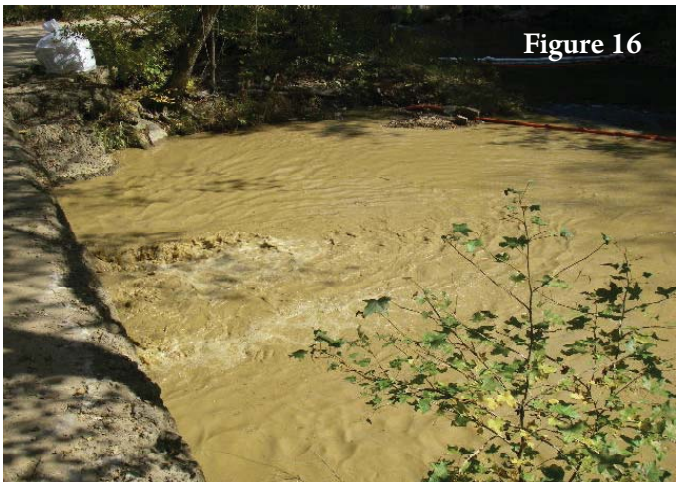
Figure 15. ***Samples from Grassy Creek: upstream of a dam built by the pipeline company (left), and after the dam was removed (right).***

into the shale formation under confining layers of rock which should prevent fluids from migrating upwards into aquifers. Most geologists agree that deep wells, such as those used in the Fayetteville Shale, are not likely to contaminate groundwater beneath confining layers of rock.

However, serious risk of contamination lies higher in the drill shaft where bore holes pass through intervening layers which contain aquifers. Surface and underground water sources will be contaminated if fluids escape from failed well casings into areas above the confining layers. Well casings will need to remain structurally sound for decades to come to protect drinking water supplies. The consequences of even a few failings could be enormous.

With thousands of wells being constructed in a short time period it is guaranteed that some casings will fail. We know that the water going into those wells is contaminated when it returns from the well. It is important that we insure as few failures as possible by requiring and enforcing the most protective casing rules and that we monitor closely to catch and correct spills quickly.

The gas industry strongly resists baseline test of water wells. Recent information disclosed in EPA documents indicates that injected fluids travel further underground than originally supposed. EPA studies also indicate that fracturing has exposed aquifers to fracturing fluids, salt



Mud washed out from gas company activities pours over a low water bridge on the once-clear Grassy Creek, smothering aquatic life.

Drilling fluids leaking and running off of a well pad will end up in a nearby lake or stream.

An open pipe leading from a drilling pad discharges into a ditch. The contents of drilling waste is not disclosed to the public.

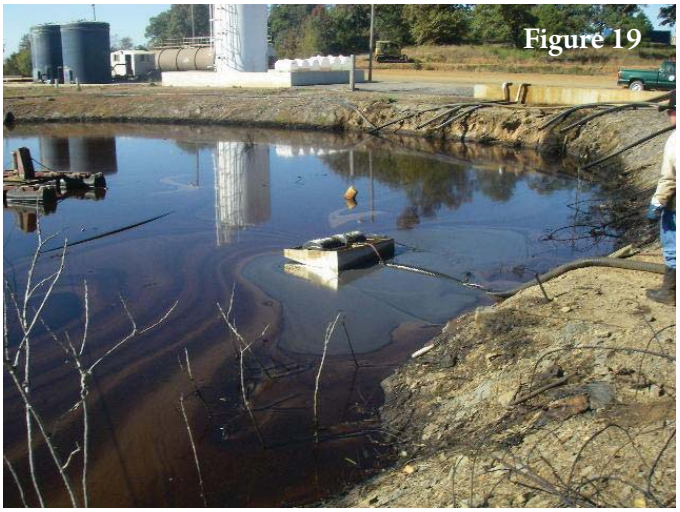
water, and hydrocarbons such as dissolved gas or oil. A 2008 article in Scientific American, "Drill for Natural Gas, Pollute Water," concluded that the oil and gas industry has blocked scientific investigation of claims that fracturing technology is putting groundwater at risk.

Groundwater contamination is a controversial topic because it can be difficult to prove the source of contamination. The natural gas industry hotly contests claims that groundwater has been affected by drilling and fracturing. Residents and regulators alike do not have access to basic information on the specific chemicals and quantities used.

Pollution from sediment runoff resulting from poor implementation of stormwater controls and reclamation plans poses further risks, as do the intrusions of well pads, facilities, and other infrastructure on steep slopes that are prone to erosion. Impacts from the increased sediment runoff include interrupted food chain, clouding streams, reduced fish habitat, and reduced clarity in rivers like the Little Red and lakes such as Greers Ferry. Sediment harms tourism and increases treatment costs for municipal drinking water.

Reserve pits frequently leak or overflow despite rules that require them to be lined with a material that prevents the fluid from making contact with surface or groundwater. Pits are located at each drill site and contain contaminated water from the drilling process as well as drill-bit cuttings and oil. Although operators are legally required to report these leaks and incidents to the Arkansas Department of Environmental Quality (ADEQ), only one such agent has consistently self-reported several leaks and spills in the last two years. Leaks at other sites were discovered only because of complaints from the public.

While the well is actively producing gas, the potential exists for leaks and spills from fluids kept on site or transported, as well as accidents due to casing failure and overflow or leakage from reserve pits.



A holding pond for waste that can be disposed of by land application was contaminated by a tank of oil and toxic drilling waste, which must be put into injection wells.

How much water?

According to the Department of Energy, a gas well requires an average of 3 million gallons per well. Conventional wells are injected with water more than once during their production. It is unclear whether or not this will be true of unconventional wells like those in the Fayetteville Shale.

The industry claims that the volume of water necessary to drill and fracture gas wells in the Fayetteville shale represents a very small percentage of the total water resources used in the geographic area. It is true that other water uses are great. The largest water users in the Fayetteville Shale area are irrigation, power generation and, municipal/public water supply, but there are several important differences between how water is used by the natural gas industry and these other uses.

Water used for irrigation runs off of fields, evaporates into the air or is taken up by plants. Water used in power generation is cooled and returned to lakes and streams or is evaporated. Public water supplies are eventually treated and returned to the environment. On the other hand, much of the water used in drilling and fracturing is contaminated and must be safely disposed of in deep injection wells, effectively removing it from further use.

Many of the areas where companies want to drill are in the mountainous Arkansas Ozarks. This is a region of thin soil which holds little water. In dry seasons, Ozark Mountain streams depend on small amounts of rain and water which filters down mountain slopes. If these streams are dewatered-as Cadron Creek was in 2007-fish and other aquatic organisms die, affecting not only the stream, but all of the people and wildlife which depend on it.

Threats to Water Quantity

While water quality is an obvious cause of concern, the large quantity of water needed for drilling and fracturing gas wells—in the hundreds of millions of gallons of freshwater over the life of the Fayetteville Shale—is also a concern. Arkansas has abundant high-quality water and according to gas industry comparisons of their own water use to quantities of water used by municipalities, agriculture and other industries, their uses do not appear excessive. However, in mountainous areas of the Fayetteville Shale region, water supplies can be scarce, particularly during dry seasons. Even small amounts of water removed from streams during dry conditions can destroy aquatic life. In addition, much of the water used in gas well operations, unlike in most other uses, is lost forever due to contamination.

In the Fayetteville Shale, operators get water by two means: from existing ponds through the construction of reservoirs up to more than 30 acres; and by pumping water from rivers and streams, including pristine streams and Extraordinary Resource Waters such as Cadron Creek and Little Red River. No guidelines currently exist to limit the amount of water withdrawn from a body of water. In dry periods streams and farm ponds have been pumped dry. These kinds of withdrawals of water put a tremendous strain on a stream's ability to support life.

The need to obtain adequate water supplies to meet its drilling needs has led the gas industry to build a large number of effectively unregulated small reservoirs to capture rainwater. Water held in these ponds is water that will never reach a stream. Because so many reservoirs are positioned high in the watersheds of small tributaries, this loss of water can change the natural flow of these rivers and streams and negatively impact their ability to sustain aquatic life. This is particularly true during times of drought, such as that experienced in the summer of 2010.

Although companies are required by state law to register water removal from streams with Arkansas Natural Resource Commission, they often fail to do so. The result is a cavalier attitude toward water resources and a lack of transparency or accountability for how much water is being used, where, when, and what is done with the leftover contaminated water. Even if we had better data on where water was being drawn, Arkansas's out-of-date state water plan does not provide guidelines for

how much water can be safely removed from streams. In-stream flow science is available to make these determinations but has not yet been implemented in Arkansas.

Threats to Air Quality

Gas emissions from wells are a cause for concern but are minimally tracked, monitored and regulated. Gas released from wells contains many toxic compounds, yet the public currently has no access to records of amounts, concentrations, or types of gases released. The gas industry claims that the off-gasses from a single well are fairly minimal, but they do not take into account the cumulative effect of many wells concentrated in a small area, such as around homes and in valleys.

Many environmental concerns focus on "when things go wrong". However, even when all equipment is functioning perfectly, most pipeline control valves use a type of pneumatic controller that releases a small but continuous stream of natural gas into the atmosphere, along with any sulfur dioxide or other trace contaminants found in the gas. This unnecessary release of greenhouse gases can produce additional negative secondary effects such as noxious odors near inhabited places. Surprisingly, if companies were to sell this gas instead of releasing it, they would actually save money and increase long-term profits—simply by utilizing "zero emission" technologies that are now available. These alternate control valves, however, have not been widely employed, probably because they require a slightly higher initial investment.

Catastrophic Risks of Air Pollution

Some places in Arkansas have had well head blow-outs where no explosion occurred but large concentrations of gas were released in near proximity to homes. People and livestock were exposed to high concentrations of hazardous chemicals, often without notice or follow up. Gas line explosions in other states have cost human lives and caused significant property damage. Accidents are bound to happen with an industry like natural gas production, but Arkansas has conducted very little risk assessment on the impact of accidents on communities, how best to prevent accidents, and how to prepare for them. Many small Arkansas communities do not have the emergency equipment or trained personnel to respond to a significant accident.

Threats to Natural Landscapes

As a result of natural gas exploration, thousands of acres have already been cleared and thousands more are scheduled to be cleared in the near future. The cumulative impact, both ecologically and visually, will be massive. Failure to implement Best Management Practices has already caused soil erosion in these areas and is expected to continue if steps are not taken.

It is currently projected that more than 14,000 wells will be drilled in the Fayetteville Shale alone. Each pad will occupy two to five acres and require a road and a pipeline. The estimated number of future wells is frequently adjusted upward, which means the impact is projected to increase. Increased use of directional drilling could allow drillers flexibility when choosing a site and minimize the amount of land that is cleared, since multiple wells can be drilled from a single pad; the state, however, does not require companies to develop plans to minimize impacts. Given the total number of

Figure 20

A well pad clears two to five acres of Ozark Mountain forest near the South Fork of the Little Red River.

Landscape Disturbances

Hundreds of square miles in the Ozarks will be cleared for the gas wells planned in the Fayetteville Shale.

In 2007, projections for future wells within the region of the Fayetteville Shale stood at around 5,000. Each year the predicted number of wells creeps higher. In 2010, the projection reached 14,000.

Originally, a single well was drilled per pad. Now several wells can be located on a single pad, reducing the size of the overall footprint, however, the footprint for these wells is very large. A single pad may contain 2 to 14 wells and the size of the pad may vary from 3 to 10 acres. If we keep it simple and assume a 5-acre pad and 5 wells per pad, this translates to one well per acre. If the projection of 14,000 wells is correct we can estimate a 14,000-acre footprint for pads alone in Arkansas—and that does not count each pad's associated pipeline and access road, which will consume thousands more acres.

Clearing thousands of miles of road and pipeline right of way without proper erosion control is having a devastating impact on Ozark lakes and streams.

The Fayetteville/Greenville Expansion Project pipeline right-of-way is 167 miles long and will hold more than one pipeline. It will occupy approximately 26,000 acres. The most significant use of land, however, comes from gathering lines. These pipelines take gas from the wells to the main line. One company has reported 1,524 miles of gathering lines in the Fayetteville Shale region. This translates to more than 100,000 acres (156 square miles) of new land cleared, much of it through forest and across steep mountain slopes.

projected wells, the disruption to the Ozark landscape will be massive, even with well pad consolidation.

Threats to Wildlife

Thousands of acres of habitat will be lost if land is left unremediated. Toxic substances in the air, land, and water will endanger wildlife, and the release of sediment into streams smothers aquatic life. Gas industry demands on water resources in streams and ponds can leave fish and other aquatic life exposed to die in the sun. Dewatering a stream at any time of the year is damaging, but pumping it dry during the heat of the summer overwhelms the habitat.

Threats to Public Health

> Available studies show that exposure to air pollutants, toxic chemicals, metals, radiation, noise and light pollution cause a range of diseases, illnesses, and health problems, including psychological and social disruption. Neighborhoods, schools, and workers in close proximity to oil and gas activities may be at increased risk for cancer, cardiovascular disease, asthma, and other disorders due to uncontrolled or high exposures. Further research is needed to assess the health impact of oil and gas operations on surrounding communities.
>
> *—From a 2008 study by the University of Colorado-Denver, the Colorado School of Public Health, and Colorado State University titled: "Potential Exposure-Related Human Health Effects of Oil and Gas Development" (Colorado Health Study)*

According to the Colorado Health Study, potentially hazardous airborne chemicals associated with oil and gas extraction include particulate matter, nitrogen oxides, sulfur oxides, hydrogen sulfide, ground level ozone, and metals such as lead, arsenic, mercury, selenium, barium, cadmium, chromium and zinc. Although drilling permits may be granted based upon projected discharges and modeling, in the absence of actual, publicly available data, true exposures remain unknown. Condensates produced by gas wells can contain complex and aromatic

hydrocarbons (BTEX) that can affect human health. Glycol dehydrators, used to remove water from natural gas, can also produce BTEX leaks into the air.

Natural gas emissions that escape from production sites, disposal pits, or pipelines may contain many contaminants, notably methane and other hydrocarbons and hydrogen sulfide. Exposure to these substances can have serious health consequences.

There are numerous other risks to public health resulting from unmonitored activities:

- Drilling sludge brought to the surface can contain fracturing fluid, drilling mud, radioactive material from the subsurface land formation, hydrocarbons, metals, and volatile organic compounds.
- Sludge is often left to dry on the surface in waste pits, potentially contaminating air, water, and soil.
- Fluids held in reserve pits may overflow or leak through defective pit liners.
- Leaks and spills on drilling pads run off into ditches and streams.
- Cracks in casings or placement of drill sites near undiscovered fractures may lead to contamination of groundwater.

All landowners should insist on baseline testing of water sources on their property before drilling begins.

Current practices of monitoring data and baseline conditions for air, water, and human health conditions are inadequate and often completely absent, particularly in rural areas. Testing for contaminants is more expensive than many families can afford and may not be conclusive without good baseline data. The town of Dish, Texas is located near a large number of gas compression stations. Testing funded by the town showed high levels of exposure to toxins. The state of Texas then tested resident's blood and tissue. Concentrations of toxins were found to be only slightly elevated, but the effects of long-term exposure are still unknown.

As pressure for fossil fuel production increases and new technologies lead to oil and gas development in new areas, human proximity to production sites will increase. The likelihood that people will be exposed to the hazardous chemicals, emissions and pollutants associated with this activity will also increase.

Threats to Property Rights

Some residents feel that the financial benefits of shale development on their property outweigh the risks, but others do not. Residents who own property where natural gas mining is occurring report numerous violations of their property rights. Residents who suspect that their well water is contaminated must bear the cost of testing the water themselves and then take on the herculean task of challenging teams of lawyers from giant corporations. Unless they had the foresight and financial means to test their water before drilling, they are much less likely to produce hard proof that contamination was caused by gas company activities.

Many residents feel that the industry makes its own rules as to where, when, and how they can drill because there is very little effective landowner education. As their own properties are turned into industrial production sites—frequently against their will—residents face declines in their property values and find their rural ways of life threatened. Residents complain that the companies do not disclose what chemicals are used on their land, do not report spills of chemicals on their property, and treat them like troublemakers when they ask questions or express concerns.

Figure 22

Gas Compressor Noise: Health Effects

Noise levels have been measured at 70 decibels on the front porch of a home near a compressor station. That's about as loud as a vacuum cleaner running 24 hours a day, never stopping, everywhere you go on your rural farm. Technologies exist to greatly reduce compression noise, but companies resist implementing them due to cost.

Noise affects more than just hearing.
It is now known that unrelenting loud noise:

- increases blood pressure;
- has negative heart and cardiovascular effects;
- increases breathing rates;
- disturbs digestion;
- can cause an upset stomach or ulcer;
- can negatively impact a developing fetus, perhaps contributing to premature birth;
- disturbs sleep, even after the noise stops; and
- intensifies the effects of factors like drugs, alcohol, aging, and carbon monoxide.

Ongoing research continues to provide data suggesting the devastating effects of noise on health. Further research is investigating factors that may contribute to noise-induced hearing loss.

Noise is a particular nuisance to rural landowners in the Ozarks, many of whom love their land precisely because of the quiet solace that it offers.

Phase Four: Transportation Pipelines

Thus far, our discussion of the potential impacts has focused on what can happen during drilling; however, once the gas is out of the ground it must be delivered for sale. Wells will be connected to pipelines and then gathered into larger lines through compressor stations. One company reports over 5,000 miles of gathering lines will be constructed in the Fayetteville Shale for their use alone. Next, the gas will enter large cross-country transmission pipelines. These new pipelines are now being completed across Arkansas.

According to the Federal Energy Regulatory Commission (FERC) Environmental Impact Statement (EIS) for the Fayetteville/Greenville Expansion Project pipeline, 11 federally listed endangered and threatened species may live within the pipeline project area. FERC made extensive recommendations for Best Management Practices and remediation of pipeline construction impacts, which the company building the line agreed to implement. Granting of the permit was contingent upon these safeguards:

- Implementing the Upland Erosion Control, Re-vegetation, and Maintenance Plan;
- Following Wetland and Waterbody Construction and Mitigation Procedures;
- Following Best Management Practices;
- Following a Spill Prevention, Control, and Countermeasures Plan, a Hydrostatic Test Plan, a Storm Water Pollution Prevention Plan, and an Exotic and Invasive Species Plan.

All of these safeguards would minimize and mitigate impacts to resources during construction and operation of the proposed project.

The EIS also stated that no unstable seismic zones were found in the area of the pipeline. Given historical accounts of the New Madrid earthquake and the preparations being made by emergency planning

agencies as they prepare for possible future events in eastern Arkansas, these claims are at least questionable. Furthermore, on January 21, 2009, seismologists announced the existence of a newly discovered fault line near Marianna, Arkansas. More study will be needed to understand how this finding will impact pipeline integrity in the event of a significant earthquake.

In 2009 the pipeline project encountered great difficulty. Work had begun during one of the wettest seasons on record. Erosion controls, such as silt fences and water bars were repeatedly washed out by heavy rain, flushing huge amounts of sediment into Cadron Creek. Oil containment booms, temporary bridges, and other equipment also washed into the creek. Some of these items remained in the creek after they proved too difficult to extract.

Since that time the company has worked in good faith to restore the landscape and mitigate as much damage as possible. They have also implemented BMPs in eastern Arkansas to avoid damage to sensitive wetlands by tunneling under them. These precautions, taken at additional cost to the pipeline company, serve as an example to others of doing things right.

Gathering line construction practices are even worse. Companies have placed thousands of right-of-ways across steep slopes, valleys, and streams without regard for correctly implemented BMPs or adequate remediation.

Bad Practices

This stream crossing, with downed silt fences and broken pipeline, is contaminated with sediment from previous washouts and has a new road damming the creek with no protection from washing out again.

Threats to Water Quality

The industry is employing very few erosion control measures as companies build pipelines over steep and unstable terrain, resulting in huge erosion problems that lead to heavily silted streams and lakes in the Fayetteville Shale region. There is little oversight on these pipeline constructions projects; as a result, much of the pollution is unreported and unmitigated. State officials, citing gas industry exemptions from the clean water act, have not required water permits even though state law appears to give them ample authority.

Threats to Air Quality

Pipelines are monitored for leaks, but even with the most stringent guidelines leaks may go undetected, affecting nearby life and creating the possibility of explosions. Such events are rare but should be considered in planning for accident preparedness among local communities and first responders.

From Kalamazoo, Michigan, to San Bruno, California, pipeline leaks, spills, and explosions have raised

Best Practices

This stream crossing follows Best Management Practices, with silt fences placed parallel to the creek, a bridge that allows water flow and water bars on the slope to prevent erosion.

new questions about pipeline safety and the efficacy of existing permitting processes, standards, safety monitoring, and inspection resources. Congress is currently debating updates to the Pipeline Inspection, Protection, Enforcement and Safety (PIPES) Act that would address the systemic problems identified after recent tragic accidents.

Once again, zero emission valves should be used throughout the system to prevent chronic releases of gas to areas near pipelines and compressor stations.

Threats to Natural Landscapes

The main transmission pipeline is a 165-mile-long 36 inch diameter pipe. It is currently under construction across Conway, Faulkner, Cleburne, White, Woodruff, St. Francis, Lee, and Phillips Counties in Arkansas and Coahoma County in Mississippi. It will cross a number of environmentally sensitive streams and wetlands. According to the Federal Energy Regulatory Commission (FERC), the Fayetteville/Greenville Expansion Project will disturb approximately 5,018 acres of land, with 1,693 acres required for the permanent pipeline right-of-way and aboveground facilities. In addition, each of the thousands of well pads will require gathering pipelines to deliver gas to compressor stations before it is sent on to the main transmission line; as a result, even more land will be used. The Ozark landscape as we know it is already being transformed, with adverse effects on local industries such as tourism and real estate.

Threats to Wildlife

The 11 endangered species in the path of natural gas development include:

- one mammal (Louisiana black bear);
- three bird species (interior least tern, ivory-billed woodpecker, and wood stork);
- one fish species (pallid sturgeon);
- four mussel species (fat pocketbook, pink mucket, scaleshell, and speckled pocketbook);
- one insect (American burying beetle);
- one plant species (pondberry).

In addition, one candidate fish species was identified: the yellow cheek darter. A number of state-listed plant and mussel species have also been identified within project areas. The presence of these federally protected species has helped ensure that BMPs are followed in areas where they exist. Areas without endangered species protection are not so fortunate.

Threats to Property Rights

The gas companies will use eminent domain, as necessary, to acquire right-of-ways for their pipelines, including thousands of miles of smaller gathering lines that will connect to the Fayetteville/Greenville Expansion Project pipeline. Once again landowners may be forced against their will to allow gas companies to disturb their farms and private property. Eminent domain is a well established legal tool for creating public infrastructure. It is used to establish right-of-ways for power lines and telephone lines that connect and benefit all citizens. Arkansas's eminent domain law deserves closer examination to ensure that private landowners are treated fairly in the process of major pipeline expansion.

Wildlife: A Special Concern

Fish and wildlife can be severely impacted by activities near gas wells and pipelines. The presence of humans and noise from trucks, machinery, and compressors cause stress in animals that compromises breeding and rearing of young.

Not only do sediment and other pollutants directly kill fish, they also kill the organisms that fish depend on for food. Freshwater mussels, which play an important role in cleaning and filtering water, are particularly sensitive to pollutants.

Industrial developers working in rural areas with rich wildlife need to minimize their impact and preserve as much undisturbed habitat as possible. The gas companies need much better planning to protect our distinctive Ozark wildlife.

Phase Five: Waste Disposal

Once the drilling is done, millions of gallons of wastewater—much of it contaminated with toxic chemicals—will need to be disposed of safely, effectively, and permanently. This presents a variety of concerns and threats.

Threats to Water Quality

Flow-back water and produced water—mostly residual water from the fracturing process—is usually held on site in a reserve pit, although at least one state, New Mexico, has required the oil and gas industry to move to closed loop systems that use tanks in place of pits. Water used for the initial drilling process that has no oil or other hydrocarbons is taken for disposal to a land farm where it is spread on the ground and contaminants removed by specialized techniques. Water that contains more toxic substances is disposed of in an injection well.

For the less contaminated water 11 permitted land farms operated in the state prior to 2008; two others were found to be operating without a permit and were closed. After ADEQ investigated complaints against two permitted facilities (Central Arkansas Disposal, near Searcy, and Fayetteville Shale Land Farms, near Carlisle), an emergency order was issued on Dec. 3, 2008 requiring both operations to stop accepting fluids for disposal until further notice, citing numerous violations. Conditions discovered by ADEQ staff prompted investigations of all other land farms operating in Arkansas. All of these were found to be out of compliance and were shut down pending a review of the permitting process.

It was determined that, on more than one occasion, Central Arkansas Disposal had pumped waste that contained oil and brine into a local unused irrigation reservoir and then deliberately allowed it to flush into Raft Creek. The subsequent fish kill was reported by citizens to the Arkansas Game and Fish Commission.

At Fayetteville Shale Land Farms, ADEQ found oil in the staging pond where drilling fluids are stored before being spread on the land. The permit prohibits disposal of oil at these sites.

In Montana and Wyoming, where produced water is dumped into streams that farmers rely on, salts in the produced water react with clay soils to change the soil structure, reducing productivity. So far there is no evidence that this has occurred in Arkansas, but the potential impact of this wastewater on agriculture remains a concern.

Figure 25

This land farm was shut down by ADEQ after releasing drilling toxins into a stream, killing fish.

More Bad Practices

An unlined pit containing petroleum products next to pits which were closed without removing liners and filled with drilling waste and debris.

One week after ADEQ discovered fluids overflowing from a pit, the discharged fluids had not been recovered and no one was on the site.

The 2009 Arkansas General Assembly approved tougher regulations for land farms with a bill that required disposal operations to have adequate financing to guarantee environmental safeguards when the owners close and fill large plastic-lined ponds that can cover up to several acres. New stricter regulations for the permitting and oversight of land farms were passed.

Volatile compounds can disperse from the surface of holding ponds waiting for disposal. Improperly contained waste can enter air or water. Unsecured pits can also become a hazard for wildlife, domestic animals, and humans. Some gas companies are moving to discharge their less contaminated fluids by other means instead of land farms, such as treating and recycling the water, but these alternatives are merely voluntary.

The more contaminated water, which cannot be land applied, is disposed of in Class II deep-injection wells meant to securely store the toxins for decades beneath the lowest underground source of drinking water. Class I wells are strictly regulated for the disposal of highly toxic waste. Class II injection wells hold a special designation created specifically for the oil and gas industry. They are similar to Class I wells but do not require records of specific materials disposed in them to be made public. Gas companies are currently transporting their fluids to deep-injection wells in south Arkansas, Oklahoma or Texas. Several new class II injection wells were built in central Arkansas, and more are on the drawing board.

Black, discolored seepage emanating from a closed out reserve pit.

Class II injection wells, like other deep wells, are subject to casing failures and leaks. Chances of failures are increased if pumping pressures are too high, putting underground aquifers at risk. The placement of these deep injection wells in areas with unstable geology can also put aquifers at risk of contamination.

A moratorium on new injection wells took place in 2010 pending investigation of their possible connection to a series of earthquakes in central Arkansas. While none of the earthquakes have produced damage, they call into question the potential for new underground fissures that may allow contamination of freshwater aquifers.

Threats to Human Health

Many communities depend on aquifers for drinking water; these sources could be lost for decades if a leak or spill occurs. The industry claims that the risk of this type of contamination is low, but as documented in other states the consequences are serious when it does occur. Regulations on casing standards and pumping pressure should be strictly enforced.

Threats to Property Rights

If contamination from the gas industry ever does affect significant waterways or aquifers, the property values in that region will certainly be negatively impacted. Landowners and businesses will lose substantial amounts of money, impacting local economies as a result.

Waste Disposal Injection Wells

Water that cannot be recycled through land application is disposed of in deep injection wells. Texas has over 33,000 injection wells, and the first of many new injection wells is now being planned for Arkansas.

Underground injection wells are permitted by the Arkansas Oil and Gas Commission and typically use a technology that injects liquid waste thousands of feet below the ground into porous formations. The liquid waste is held within the strata by pressure from overlying rocks. Underground injection involves drilling a well to a geological formation and pumping— or "injecting" —waste under high pressure to displace the native fluids or gases.

Merely transporting liquid hazardous waste from drill sites to injection wells carries significant risks of spills and accidents. In addition, there are several pathways by which wastes injected underground could contaminate water resources:

- injection of waste above aquifers containing drinkable water;
- leakage of waste through inadequate confining beds;
- leakage of waste through confining beds due to hydraulic fracture or faults;
- displacement of saline water into a potable aquifer;
- upward migration of liquid waste from the injection zone along the outside of the well casing;
- escape into potable aquifers due to well-bore and casing failures;
- vertical migration and leakage to land and aquifers through abandoned oil, gas, and other wells; and
- migration of toxic liquids beyond their confinement area due to improper injection pressures and geological shifts over time.

Information for this from: Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control (Washington, D.C., 1984), 190.

Figure 29

Social and Psychological Health Effects

The Colorado Health Study suggests a number of social and psychological concerns that may be associated with the intrusion of industrial activity into populated areas. These concerns include possible increases in domestic violence, drug use, and crime, along with sharp declines in home values and extreme housing shortages.

The literature also supports the concept that oil and gas boom-and-bust cycles have negative effects on the psychosocial welfare of a local population. Further data collection, analysis, and subsequent recommendations could mitigate the psychological and social impacts of oil and gas drilling.

People living in areas of high oil and gas production across the nation are banding together for mutual support. A common thread runs through these groups: feelings of frustration, helplessness, and rage. In Arkansas, Citizens Against Resource Exploitation (CARE) have come together to protest forced integration of property into production units in the Arkoma Basin near Booneville.

Even landowners who own their mineral rights find themselves having to deal with gas companies in unexpected ways. People living in peaceful rural settings suddenly find themselves thrust into an industrial zone. People who value their privacy deal with a constant traffic of big trucks, dust, and noise. Strangers walk or drive across their property without asking permission, often causing damage. Landowners are not informed that chemicals may be polluting their water; noise from compressor stations intrudes on the formerly quiet landscapes day and night.

Psychological studies show that both humans and animals suffer the greatest stress in situations where they have no sense of control. Members of CARE attempted to enact an ordinance to at least deal with the constant noise from compressor stations. They lost; companies claimed that the cost of installing additional baffles on compressors to suppress the noise was too expensive. Local government, fearing a loss of revenue, caved in.

Phase Six: Closure and Reclamation

One of the most frequently observed problems at oil and gas sites has been inadequate interim reclamation. Environmental degradation can begin as soon as ground is broken. Most companies do not begin land reclamation until they have finished operations and completed the well or finished laying pipelines. Beginning the reclamation process, which may last weeks or months, during this interim period can prevent degradation. For example, failure to reseed disturbed areas immediately with vegetation exacerbates problems like erosion and runoff and promotes weed introduction, all of which can make final reclamation more difficult.

Orphaned wells can be a problem as well, especially in difficult economic times when production and incomes decline, or when foreign interests who may be less reliable own large numbers of wells. In 2006, a report by the Interstate Oil and Gas Compact Commission (IOGCC) cited Arkansas as having 1,777 orphaned wells, while the state had expended almost $1.2 million to plug 209 wells, at an average cost of $5,636 per well. These costs are now covered by an annual well fee assessed to operators of wells in the state that generates approximately $250,000 a year.

The problem of orphaned wells can be linked to reclamation bonding. According to the IOGCC, Arkansas reduced its bonding in 1995 to between $3,000 and $15,000 per well, or a statewide blanket bond of $25,000 to $100,000, depending on the number of wells covered. Currently, bonds are insufficient to guarantee that the costs of orphaned wells will not be borne by Arkansas taxpayers.

State Laws and Oversight

Arkansas's oil and gas regulations are neither the best nor the worst in the nation. Like other states, Arkansas has stepped up to fill some of the gaps in federal protections. Regulations requiring stormwater management plans for drilling sites have been implemented, and reserve pit construction must meet standards designed to prevent leaks and spills. Of course regulations are only worthwhile if drill sites are inspected regularly to make sure they are being followed and if enforcement actions are swift enough to stop problems from getting worse and significant enough to deter similar repeated behavior in the future. Arkansas has added more water inspectors monitoring gas company activities, though it remains unclear if the state still has sufficient monitoring capacity to protect the public and environment. Improving Arkansas's regulations without improving our inspection and enforcement activities will not likely improve gas company practices.

While there are many potential sources of pollution of the state's waters, two well-documented sources are erosion and waste spills. ADEQ's 2004 Inventory of Impaired Water Bodies lists 423.4 miles of streams in Arkansas that cannot fully support their designated uses due to resource extraction activities. The agency's goal is stated in the document:

> The ultimate water quality goal is to have no impairment listed due to resource extraction activities and to prevent any potential sources of impairment from occurring due to resource extraction activities.

Discharges associated with gas well activities—produced water, drill cutting, and drilling fluid discharges—are considered point-source discharges (for example,) and can be significant localized contributions. Nonpoint-source (NPS) pollution can come from such sources as seeping and overflowing drilling site reserve pits and production pits or contaminated stormwater runoff from drilling production sites.

In the 2006-2010 NPS Management Plan Update, ADEQ reiterates the goal of no impairment and goes on to discuss the difficulty of their mission:

> The Arkansas Oil and Gas Commission (AOGC) has issued over 38,000 permits for oil, gas and brine wells. However, efforts to accurately locate and investigate all of these sites for potential storm water pollution problems cannot be accomplished without additional funding, personnel and time.

The plan relies on several measures: offering training programs to extraction industries on voluntary implementation of BMPs, encouraging watershed groups, making information available, and providing feedback.

ADEQ provides permits for reserve pits and is tasked with preventing pollution of state waters; yet only now is the agency beginning to make routine inspections of pits. While it conducted a few proactive visits, almost all of the more than 80 violation reports in the last two years on reserve pit leaks were generated from citizen complaints. ADEQ hired four more inspectors who work exclusively on shale issues to handle the increasing number of complaints. ADEQ now has 17 total water inspectors, only four of whom are dedicated exclusively to shale issues. However, even if all 17 inspectors did nothing but inspect gas well sites they would not be able to visit each site once a year, much less follow up on violations.

On a positive note, the Department of Energy has funded a set of Low-Impact Natural Gas and Oil (LINGO) projects. In 2006, the University of Arkansas Center for Advanced Spatial Technologies and Argonne National Laboratory jointly received a $500,000 grant to begin a project titled "Probabilistic Risk Based Decision Support for Oil and Gas Exploration and Production Facilities in Sensitive Ecosystems." A recent press release stated that the project will develop "web-based application modules that will assist natural gas production companies in creating plans for resource extraction in sensitive ecosystems. The modules will help these companies identify areas that are particularly susceptible to disturbance so that risks can be minimized in advance or sensitive areas can be avoided altogether." This Arkansas-based project will provide a model for

energy companies to use across the nation. Use of the program is voluntary.

In November of 2010 two rules were passed by the AOGC that will improve regulation of the industry:

- Rule B-19 provides for better casing rules to protect groundwater and for disclosure of classes of chemicals used in the fracturing process.
- Rule B-17 specifies liners to be used in all pits at the drilling site and sets guidelines for how fluids are to be handled. It requires a storm water erosion and sediment control plan which will implement BMPs for all drilling sites that have the potential to pollute Extraordinary Resource Waters, Environmentally Sensitive Waters or Natural Scenic Waters. However, Rule B 17 does not require closed loop systems as do regulations in other states. Closed loop systems are much less likely to leak than pits. Rules are still needed to limit pits near residences, schools, and other places of human habitation.

Solutions in Other States

Across the nation other states are struggling with the same issues faced in Arkansas. Some, like Colorado, New Mexico and Wyoming, have been living with oil and gas development much longer than Arkansas and have suffered serious environmental impacts. Given the broad number of threats covered in this report, it is critical that efforts to promote development of the Fayetteville Shale be coupled with an equally strong emphasis on protecting the state's people, private property, natural resources and environment.

The role of government agencies is critical, as they plan for development, establish standards, issue permits, establish bond amounts, and enforce the law. Because the oil and gas industry has received special exemptions from so many federal environmental laws—including portions of the Clean Air Act; Clean Water Act; Comprehensive Environmental Response, Compensation and Liability Act (toxic site cleanup); and Resource Conservation and Recovery Act (waste management)—state agencies are the primary regulators, and the Arkansas Oil and Gas Commission and the Arkansas Department of Environmental Quality shoulder the main responsibility for oversight of the natural gas industry.

Local governments play important roles in many states as well. Cities and counties can control where development is allowed to occur, and some local governments enact ordinances that control noise and other operating conditions.

While no state has a comprehensive program that is lauded by gas field residents as adequately protective in all areas, many states have strengthened protections in some areas. Some of these states updated their policies after years of production in order to mitigate specific impacts. Others responded to public concerns early and worked to put new policies in place at the outset. All have had to struggle to create their own protections in the absence of uniform federal regulation. Many states with shale gas reserves, such as Oklahoma, Texas, New Mexico, Colorado, Kentucky, New York and Pennsylvania created regulations for these things among others: protection of water quality and quantity, disclosure of chemicals, protection of air quality, financial assurance and bonding, public health monitoring and protection, inspection and enforcement, noise reduction, reclamation, setbacks, land owner rights, waste disposal, wildlife and habitat protection, landscape disturbance, moratoria, and mandatory BMP's.

Fortunately, Arkansas can learn from the experiences of other states and their successes. As the Fayetteville Shale play has slowed due to lower prices of natural gas, our state's citizens, elected officials and regulators have the opportunity to craft a new model for responsible natural gas development. The Arkansas Oil and Gas Commission's new hydraulic fracturing chemical disclosure law is a first step in the right direction, but needs to be stronger.

While this report makes some recommendations for regulation and policy changes it does not attempt a complete list of solutions used in other states which could serve as a model for Arkansas. These will be examined in a future report which will cover the policies of other oil and natural gas producing states and make further recommendations for reforms to Arkansas's laws and regulations.

Recommendations

We support **responsible** development of shale gas reserves in Arkansas and the following changes to state and federal laws, regulations and policies governing oil and gas development will bring some balance between the need to develop the gas reserves and the need to protect Arkansas landowners and our environment. Most of what we are proposing is already being done in other states; none of it is a radical or an unreasonable demand for industry. These recommendations arose out of the concerns of many land owners about infringements of their rights and concerns about their air and water.

Figure 30

A remediated slope with Best Management Practices in place: stabilized, seeded and with water bars to minimize erosion.

At the State Level

1. **Landowners' Rights**

   Pass a landowners bill of rights that guarantees landowners certain protections when dealing with gas companies, including:

   - Adequate buffer zones (i.e. setbacks) between drilling sites and dwellings.
   - Full disclosure of all company activities on private property to the landowner or lease holder, including what chemicals are used, how much water is used, what waste is produced and how that waste is disposed. Landowners have a right to know what is happening on their property.
   - Adequate notice of all company activities on private property to the landowner or lease holder. Landowners shouldn't have gas company employees on their property without advance notice.
   - Mineral and/or surface owners should be supplied with accurate information about their rights and about the Best Management Practices the industry should follow on their land.
   - Compensation required for any surface impacts including diminished property values, lost crops, etc.

2. **Chemical Disclosure:**

   Gas companies should report to the public and state agencies the volumes and source of water used, type and volumes of chemicals used, quantity of fluid used in a well that remained in a well versus returned to the surface, and the disposal method for all drilling and hydraulic fracturing fluids. The public has a right to know this information and state enforcement officials need to know it to make sure the industry is following the laws of Arkansas.

3. **Noise**

   Reduce the noise from any gas drilling activity to 50 decibels at 200 feet of distance. The technology exists to do this and Arkansas landowners should not suffer from nuisance levels of noise in their rural communities.

4. **Air Quality Protection**

   - Monitor air quality near homes and when wells are concentrated in small geographic areas.
   - Require the industry to use all cost effective means of reducing air pollution.
   - Require air permits when the cumulative air emissions of many gas facilities concentrated in a small geographic area are likely to exceed what any

single source would be allowed to emit without a permit.

5. **Water Quality Protection**

- Stormwater permits that require use of Best Management Practices must be required for all oil and gas industry activities, including construction. Gas companies should be required to follow Best Management Practices when building roads, pipelines and drilling pads.

- More must be done to protect Arkansas's water from the toxins used in drilling and production – these practices need tougher rules, inspection and enforcement to protect the public.

- More must be done to ensure that landowners' private water supplies near drill sites are protected. Gas companies should be required to pay for testing private well water supplies before drilling begins near drinking water sources.

- The Arkansas Oil and Gas Commission should adopt Fayetteville Shale Play Gas extraction BMPs (FWS) and the Gold Book and require that they be implemented on a mandatory basis.

- The cumulative effects of increased gas production should be assessed and used as a gauge for granting permits. Phasing in development would minimize negative impacts. New phases would depend on success of reclamation and available water resources. The extremely large number of new wells and pipeline makes this important for the protection of land and water resources.

- In-stream flow studies should be conducted to determine how much water can be safely removed from streams without harming aquatic life. Water quantity in lakes and streams must remain sufficient to ensure that aquatic and riparian habitats and species survive and thrive. In addition to baseline studies, numeric water quality standards should be continually monitored and enforced.

- Recycling of water should be encouraged. The city of Clinton, Arkansas is exploring the possibility of creating a water recycling plant for produced water.

6. **Enforcement**

- Gas wells should be inspected at least annually and more often during drilling or fracturing, when millions of gallons of chemicals and contaminated water are handled on site. The industry should pay

Figure 31

This pipeline right of way has been seeded as an initial step in the process of remediating the slope.

impact fees to cover the cost of better inspections so Arkansas tax payers are not asked to subsidize responsible gas development.

» The Arkansas Department of Environmental Quality and the Oil and Gas Commission should prepare annual reports for the legislature and public about compliance with their permitting systems and the enforcement measures used to gain compliance from violators.

» More must be done to hold polluters accountable for correcting problems they've created and to prevent them from repeating mistakes again.

» Follow up-training in BMPs should be provided for violators. Companies with ongoing violations should not receive new operating permits.

» The size of permit fees and fines for violations should be increased sufficiently to create a disincentive for noncompliance. Furthermore, incentives should be given for those in compliance with regulations.

7. **Financial Assurance**

» Significantly increase well bonds to pay for closing and remediating abandoned wells.

» Direct a larger portion of the revenues from natural gas production to environmental protection measures; create a greater endowment to fund future initiatives to clean up abandoned sites and restore damaged sites.

At the Federal Level

1. Repeal the oil and gas industry exemptions to federal environmental and public health laws, such as the Clean Water and Clean Air Acts. Why should such a high-risk industry, as evidenced last summer in the Gulf of Mexico, have these kinds of special protections? Federal regulation puts all states on an equal footing.

2. Pass the Clean Water Restoration Act. This amendment to the Clean Water Act would restore protections for certain waters that were taken away in 2005. It would make it clear that all water bodies are protected by the Act.

3. Require the oil and gas production industry to report to the Toxic Release Inventory to provide information to the public about chemicals that may pose health risks. We have a right to know what is going into our environment.

Other Recommendations

1. Encourage local ordinances for cities and counties.

2. Pass legislation requiring local approval before issuing a permit to dispose of drilling wastes. Applications for disposal permits should be publicly posted so that communities can appeal a permit or adopt rules for disposal of drilling waste.

3. Provide for interagency cooperation in the oversight of gas and pipeline operations.

4. Independently monitor air, water, and soil that could be affected by oil and gas exploration and production sites. Monitoring includes recording baseline observations of existing conditions, and collecting various data and samples of air, water and soil, and measuring changes in the environment and contamination.

5. Assess the toxic exposures and health effects in families living near oil and gas exploration and production sites, including health inventory baseline studies of nearby residents before development begins.

6. Require that the health of field workers who travel from state to state be monitored since their risk of exposure to toxins is great.

7. Make all monitoring data available to the public.

Conclusions

All other industries (including other energy and resource extractive industries, such as coal and hard rock mining) must comply with environmental measures designed to protect human health and the environment. It is clear that gas exploration and production industries should be subject to these same standards.

Exemptions from federal laws have given the oil and gas industry privileges that are unjustified. In applying for permits to drill or build pipelines in Arkansas, oil and gas production and pipeline companies have promised adherence to Best Management Practices; yet many of these promises go unfulfilled, and serious damage has already occurred as a result.

The potential harm that will come from continued unchecked pollution by oil and gas companies is too great. State and local government must act quickly to prevent further damage to our air, land, and particularly our water.

Arkansas can expect millions of dollars from this business; gas industry profits will reach sums in the billions, yet no one has begun to calculate what the economic or environmental costs of this development will be. What will the costs be to public health? What will be the cost of remediation to our state if our natural resources are polluted? And what will be the cost if we lose those things which make our state so special—the species that live nowhere but here and the extraordinary natural beauty of Arkansas?

Arkansas has the opportunity now to enact protections while this major new development is still getting underway, to strike a better balance between resource development and protecting public health, air and water quality, and the natural places that are so important to our state. We still have the time, and we can afford do things right. Clean water and clean air benefit all Arkansans and if protected will sustain us for generations to come. We shouldn't allow them to be compromised by the rush to extract a resource which will only last short time. By working together to plan ahead and do things right, we can profit from this industry without losing what we have.

Figure 32

Mulberry River; clear after a heavy rain. This watershed is protected by National Forest.

Arkoma Basin

A large geological depression which extends from eastern Oklahoma through western and central Arkansas. Basins appear on a geologic map as a roughly circular or elliptical area. Basins are usually large in area, often hundreds of kilometers across. Structural basins are often important sources of coal, petroleum, and groundwater. The Arkoma Basin in Arkansas holds both conventional and unconventional sources of natural gas including the Fayetteville Shale.

BTEX

An acronym that stands for benzene, toluene, ethylbenzene, and xylenes. These compounds are some of the volatile organic compounds (VOCs) found in petroleum derivatives such as gasoline. Toluene, ethylbenzene, and xylenes have harmful effects on the central nervous system. BTEX contamination often occurs near petroleum and natural gas production sites, and gas stations and other areas with Underground Storage Tanks (USTs) or Above-ground Storage Tanks (ASTs) containing gasoline or other petroleum-related products. The amount of 'Total BTEX', the sum of the concentrations of each of the constituents of BTEX, is sometimes used to aid in assessing the relative risk or seriousness at contaminated locations and the need of remediation of such sites.

Clean Water Act

The primary federal law in the United States governing water pollution. Commonly abbreviated as the CWA, the act established the goals of eliminating releases to water of high amounts of toxic substances, eliminating additional water pollution. The principal body of law currently in effect is based on the Federal Water Pollution Control Amendments of 1972, which significantly expanded and strengthened earlier legislation. Major amendments were enacted in the Clean Water Act of 1977 enacted by the 95th United States Congress and the Water Quality Act of 1987.

Condensate

A low-density mixture of hydrocarbon liquids that are present as gaseous components in the raw natural gas produced from many natural gas fields. It condenses out of the raw gas if the temperature is reduced to below the hydrocarbon dew point temperature of the raw gas.

The natural gas condensate is also referred to as simply condensate, or gas condensate, or sometimes natural gasoline because it contains hydrocarbons within the gasoline boiling range. Raw natural gas may come from any one of three types of gas wells:[1][2]

- Crude oil wells – Raw natural gas that comes from crude oil wells is called associated gas. This gas can exist separate from the crude oil in the underground formation, or dissolved in the crude oil.
- Dry gas wells – These wells typically produce only raw natural gas that does not contain any hydrocarbon liquids. Such gas is called non-associated gas.
- Condensate wells – These wells produce raw natural gas along with natural gas liquid. Such gas is also non-associated gas and often referred to as wet gas.

Drilling Mud

A drilling fluid used to drill boreholes into the earth. Often used while drilling oil and natural gas wells and on exploration drilling rigs. Mud is pumped from the mud pits through the drill string where it sprays out of nozzles on the drill bit, cleaning and cooling the drill bit in the process. The mud then carries the crushed rock ("cuttings") up the annular space ("annulus") between the drill string and the sides of the hole being drilled, up through the surface casing, and emerges back at the surface. Cuttings are then filtered out and the mud returns to the mud pits. The returning mud can contain natural gases or other flammable materials. These can collect in and around the shale shakers area or in other work areas. There is a potential risk of a fire, an explosion or a detonation occurring if they ignite. In order to prevent this safety measures have to be taken. Safety procedures, special monitoring sensors and explosion-proof certified equipment has to be installed, e.g. explosion-proof certified electrical wiring or control panels. The mud is then pumped back down and is continuously re-circulated. After testing, the mud is treated periodically in the mud pits to give it properties that optimize and improve drilling efficiency.

Fayetteville/Greenville Expansion Project

This project will construct 165 miles of 36-inch-diameter gas pipeline in Conway, Faulkner, Cleburne, White, Woodruff, St. Francis, Lee, and Phillips Counties in Arkansas and Coahoma County in Mississippi. It will cross a number of environmentally sensitive streams and wetlands.

Forced Integration or Forced Pooling

Integration is a technique used by oil and gas development companies to organize an oil or gas field so that the minimum number of wells needed to access the resource are drilled. It is sometimes the case that not all mineral owners within a drilling unit are in agreement about development. In that case, a party interested in development can make an application for forced or involuntary integration. If forced integration is approved, then the drilling unit is developed with or without the consent of all mineral owners. Mineral owners not participating in the development in any manner are considered non-consenting owners.

The land to be force integrated must have been spaced for maximum ultimate production. All mineral owners must have received a reasonable offer to lease their interests and the oil and gas company must notify all mineral owners after which a hearing is held.

A mineral owner has five options in the context of forced integration. They can:

1. Lease their mineral interest.
2. Sell their mineral interest.
3. Participate materially in the development of the gas field.
4. Be a non-consenting owner.
5. Protest forced integration.

In the first four cases, it is likely that there will at least be some positive financial returns. Even a non-consenting owner receives royalties under state law. The size and nature of those returns will vary, however. The difference in these various options may be the degree to which the surface owner can influence the impacts on the surface. An attorney will probably be needed to negotiate minimal impacts.

Gathering Line

A special pipeline, frequently small in diameter, used to transport gas from the field to the main pipeline.

Hydraulic fracturing

A method used to create fractures in a rock formation which are typically maintained by a proppant, such as grains of sand or other material which prevent the fractures from closing. The method is informally called fracing (pronounced "fracking") or hydrofracing. The technique is used to increase or restore the rate which fluids, such as oil, gas or water, can be produced from the formation. By creating or restoring fractures, the reservoir surface area exposed to the borehole is increased and the fracture provides a conductive path connecting this reservoir surface area to the well, which effectively increases the rate that fluids can be produced from the reservoir formations.

Land Farms

Land farming is the controlled and repeated application of wastes to the soil surface, using microorganisms in the soil to naturally biodegrade hydrocarbon constituents, dilute and attenuate metals, and transform and assimilate waste constituents. Advantages of land farming include its simplicity and low capital cost, the ability to apply multiple waste loadings to the same parcel of land, and the potential to improve soil conditions. Concerns associated with land farming are its high maintenance costs (e.g., for periodic land tilling, fertilizer); potentially large land requirements; and required analysis, testing, demonstration, and monitoring. Elevated concentrations of hydrocarbons in drilling wastes can limit the application rate of waste on a site. Wastes containing salt must also be carefully applied to soil. Salt, unlike hydrocarbons, cannot biodegrade but may accumulate in soils, which have a limited capacity to accept salts. If salt levels become too high, the soils may be damaged and treatment of hydrocarbons can be inhibited. Salts are soluble in water and can be managed. Salt management is part of prudent operation of a land farm.

Play

An underground geologic formation in which hydrocarbon accumulations or the prospect of those accumulations occurs. The most common hydrocarbons making up a play are natural gas, oil and coal. A play is also often a general term for a large

region or basin of hydrocarbon accumulation used by energy companies to continue exploiting a given trend.

Produced Water

Oil and gas reservoirs have a natural water layer (formation water) that underlies the hydrocarbons. To achieve maximum oil recovery additional water is often injected into the reservoirs to help force the gas to the surface. Both the formation water and the injected water and additives are eventually produced (brought to the surface) along with the gas and therefore as the field becomes depleted the produced water content of the gas increases.

Proppant or Propping Agent

Sand, gravel, or particles of other material (such as sintered bauxite, ceramic beads or resin coated particles) suspended in drilling fluid during formation fracturing to keep (prop) open the cracks in the rock when the fluid is withdrawn.

Reserve Pit

A pond used for discarded drilling fluid; these small reservoirs are used for several reasons. Solids in the mud settle out and a suction hose may be placed in the reserve pit to have additional fluid available to pump into the wellbore in an emergency. In addition, in arid areas, a considerable amount of evaporation occurs, thus minimizing mud disposal volumes. At the end of drilling operations, and perhaps at intermediate times during drilling, the fluids and solids in the reserve pit must be carefully discarded, usually by transfer to a properly certified landfill. If the mud is benign, the solids (mostly clay), and liquids (water), may be plowed and tilled back into the local soil.

Shale

A common fine-grained sedimentary rock whose original constituents were clay minerals or muds. It is characterized by thin layers which break with an irregular curving fracture, often splintery and usually parallel to the bedding plane. Similar rocks are mud stone and silt stone.

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Figure Citations

Figure 1. This confluence of two Ozark creeks shows sedimentation from a pipeline crossing flowing into the clear water typical of Ozark streams. Excess sediment kills fish and causes increases in algae and toxic substances in lakes and streams that support wildlife, attract tourists and provide drinking water. *ADEQ Investigation Report*

Figure 2. Map of the Fayetteville Shale and Arkoma Basin. *Arkansas Public Policy Panel*

Figure 3. Barnett Shale gas drilling rig near Alvarado, Texas. *David R. Tribble, licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license*

Figure 4. Drilling mud, which can contain natural gas and other flammable materials, leaking from tanks at a land farm that has since been shut down. *ADEQ Investigation Report*

Figure 5. Each dot on this map represents a gas well in the Fayetteville Shale area. *Arkansas Oil and Gas Commission*

Figure 6. A closed reserve pit leaking black, discolored seepage. Drilling fluids stored in reserve pits are supposed to be properly disposed of—rather than buried in the pit—when it is closed out. *ADEQ Investigation Report*

Figure 7. A sediment plume which extends from a drilling pad flows to a nearby creek because of an improperly

installed and ineffective silt fence. Thousands of drilling pads are projected for the Fayetteville Shale. *ADEQ Investigation Report*

Figure 8. Johnny Wiedower's gate, locked by the gas company without notice or key. *Debbie Doss*

Figure 9. Gas wells, roads and pipelines dominate the landscape north of Booneville. This part of western Arkansas has been under gas development for some time, and shows what the larger Fayetteville Shale area may look like as the gas industry grows. *Google Maps satellite view*

Figure 10. A gas flare at a well near Clinton. Flares waste natural gas and release toxins into the air. *Joyce Hale*

Figure 11. Chemicals stored in this dry chemical area are spilling onto the ground. *ADEQ Investigation Report*

Figure 12. Drilling the traditional vertical shaft is only the first part of unconventional fracture drilling. *http://lingo.cast.uark.edu*

Figure 13. New drilling techniques don't just go down in a straight line, but also expand out horizontally, potentially increasing risks of underground contamination. *http://lingo.cast.uark.edu*

Figure 14. Greers Ferry Lake, the Little Red River, the Mullberry River, Cadron Creek and the Arkansas River are only some of the key Arkansas water bodies at risk of contamination. *Arkansas Public Policy Panel*

Figure 15. Figure 15. Samples from Grassy Creek: upstream of a dam built by the pipeline company (left), and after the dam was removed (right). *ADEQ Investigation Report*

Figure 16. Mud washed out from gas company activities pours over a low water bridge on the once-clear Grassy Creek, smothering aquatic life. *ADEQ Investigation Report*

Figure 17. Drilling fluids leaking and running off of a well pad will end up in a nearby lake or stream. *ADEQ Investigation Report*

Figure 18. An open pipe leading from a drilling pad discharges into a ditch. The contents of drilling waste is not disclosed to the public. *ADEQ Investigation Report*

Figure 19. Oil stored in frac tank. *ADEQ Investigation Report*

Figure 20. A well pad clears two to five acres of Ozark Mountain forest near the South Fork of the Little Red River. *Debbie Doss*

Figure 21. Clearing thousands of miles of road and pipeline right of way without proper erosion control is having a devastating impact on Ozark lakes and streams. *US Fish and Wildlife Service*

Figure 22. Debbie Doss

Figure 23. This stream crossing, with downed silt fences and broken pipeline, is contaminated with sediment from previous washouts and has a new road damming the creek with no protection from washing out again. *US Fish and Wildlife Service*

Figure 24. This stream crossing follows Best Management Practices, with silt fences placed parallel to the creek, a bridge that allows water flow and water bars on the slope to prevent erosion. *US Fish and Wildlife Service*

Figure 25. This land farm was shut down by ADEQ after releasing drilling toxins into a stream, killing fish. *ADEQ Investigation Report*

Figure 26. An unlined pit containing petroleum products next to pits which were closed without removing liners and filled with drilling waste and debris. *ADEQ Investigation Report*

Figure 27. One week after ADEQ discovered fluids overflowing from a pit, the discharged fluids had not been recovered and no one was on the site. *ADEQ Investigation Report*

Figure 28. Black, discolored seepage emanating from a closed out reserve pit. *ADEQ Investigation Report*

Figure 29. Injection Well Diagram. *US Environmental Protection Agency*

Figure 30. A remediated slope with Best Management Practices in place: stabilized, seeded and with water bars to minimize erosion. *US Fish and Wildlife Service*

Figure 31. This pipeline right of way has been seeded as an initial step in the process of remediating the slope. *US Fish and Wildlife Service*

Figure 32. Mulberry River; clear after a heavy rain. This watershed is protected by National Forest. *Debbie Doss.*

Appendix II: Regulators and Stakeholders

Federal

Bureau of Land Management (BLM)

Natural gas extraction on federally owned lands falls under the jurisdiction of the BLM. Permit procedures and guidelines for Best Management Practices (BMPs) are given in the BLM's "Gold Book." Gold Book standards ensure that all necessary precautions are taken to protect the environment on federal property. The BLM and the US Forest Service, as a stakeholder, must ensure compliance with National Environmental Policy Act (NEPA) and Endangered Species Act (ESA). They will perform an environmental impact analysis before the BLM can issue a permit to drill.

US Fish and Wildlife Service (FWS)

The US Fish and Wildlife Service has regulatory oversight for all activities funded, permitted, carried out, or otherwise authorized by federal agencies under the tenants of the ESA on or off federal land. The FWS enforces the provisions of section 9 of the ESA that prohibit the "take" of federally listed species. "Take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. "Harm" includes any act that modifies or degrades the habitat of a threatened or endangered species in a manner that significantly impairs essential behavioral patterns such as breeding, spawning, rearing, migrating, feeding or sheltering and results in death or injury. The FWS also is responsible for enforcing the provisions of the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. FWS works with private property owners under Safe Harbor agreements to protect endangered species. The Yellow Cheek Darter and the Speckled Pocketbook Mussel are protected within the Little Red River watershed.

US Army Corp of Engineers (COE)

The COE's oversight is given authority by the Clean Water Act under section 404 and gives them jurisdiction over projects such as dams and bridges and for prevention of sediment entering waterways.

Federal Energy Regulatory Commission (FERC)

FERC oversees transmission pipeline construction and issues the required permits.

Department of Transportation (DOT)

The DOT regulates transmission pipeline safety and oversees pipeline inspections. The Federal Emergency Management Agency may be involved also in floodplain areas.

State of Arkansas

Arkansas Oil and Gas Commission (AOGC)

The AOGC has regulatory control over most aspects of the Fayetteville Shale from seismic exploration through leasing, drilling, gathering lines, water disposal, well completion, production reports and well closure.

Arkansas Department of Environment Quality (ADEQ)

ADEQ regulates the construction, utilization and closure of reserve pits which are used for temporary storage of materials removed from the well bore during drilling operations. ADEQ issues permits for Land Application sites for the disposal of drilling fluids and inspects these sites. Although the Oil and Gas industry is exempt from federal requirements for storm water permits, it has been required to obtain a state permit from ADEQ since November of 2008. Industry is required by state law to prevent sediment runoff and or degradation of state waters under a general permit.

Arkansas Natural Resources Commission (ANRC)

The ANRC is responsible for wellhead and groundwater protection and issues permits for dams over 25 feet in height. ANRC also requires registration of surface water diversions more than one acre-foot. Natural lakes or ponds owned by one person are excluded. Permits must be obtained for withdrawals over 250 thousand gallons.

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She holds degrees in history, biology and education and has done additional work in physical geography, art and graphic design and writing. She also holds a masters degree in Psychology and has worked as a psychological examiner in the rural schools of central Arkansas for 15 years. Debbie has taught secondary courses in math and science and taught psychology as adjunct faculty at the University of Arkansas Community College at Morrilton. She now works as a volunteer and consultant on environmental issues and on building and designing canoe trails in eastern and southern Arkansas.

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The Arkansas Public Policy Panel is a statewide 501(c)(3) organization dedicated to achieving social and economic justice by organizing citizen groups around the state, educating and supporting them to be more effective and powerful, and linking them with one another in coalitions and networks. The Panel seeks to bring balance to the public policy process in Arkansas.

Back cover photo:
Pipeline and road on an extremely steep slope with no water bars or other Best Management Practices in place to control runoff . *US Fish and Wildlife Service*


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