

Considering Shale Gas Extraction in North Carolina: Lessons from Other States

DISCUSSION DRAFT

Accepted for publication in the Spring 2012 issue of
Duke Environmental Law & Policy Forum

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November 2011

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We would like thank Richard Newell of Duke's Nicholas School of the Environment and Susan Tierney of the Natural Gas Subcommittee of the Secretary of Energy Advisory Board for their helpful review comments.



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EXECUTIVE SUMMARY

In 2009, the North Carolina Geologic Survey announced the presence of shale gas in the Deep and Dan river basins underlying 12 counties, including Lee, Chatham, and Moore. Unlike “conventional” natural gas resources, shale gas resources are contained within relatively impermeable source rock, meaning that the gas does not migrate out of the source rock and into a reservoir where drillers can easily access it. Large-scale production has only become economically viable in recent years due to advances in horizontal drilling and hydraulic fracturing techniques, which can dramatically increase the flow of gas.¹

On June 23, 2011, North Carolina Governor Beverly Purdue signed Session Law 2011-276, directing the Department of Environment and Natural Resources (DENR) to conduct a study and hold public hearings on the issues of horizontal drilling and hydraulic fracturing (sometimes called “hydrofracking” or “fracking”) for natural gas extraction. This step is significant, because North Carolina law currently prohibits both horizontal drilling and the injection of waste into wells, including hydraulic fracturing fluids, creating a *de facto* ban on hydraulic fracturing. The state has no other active oil and gas industry. The law followed a robust debate regarding natural gas exploration in the state, and the legislature may revisit the issue once DENR releases its study.

Because North Carolina has no active oil and gas production, it has no comprehensive regulatory program for the oil and gas industry. Policy makers now have the opportunity to evaluate concerns regarding shale gas extraction, including the environmental and economic impacts on local communities, and to determine whether this activity is appropriate for the state. The experiences of other states can provide valuable insight into the risks that accompany this activity, although the relative importance of each risk depends on local conditions, and the policy landscape is still evolving. The policy decisions that other states have made in an attempt to mitigate those risks can inform North Carolina lawmakers as they consider whether to allow shale gas extraction and, if so, how to regulate the industry.

This paper does not take a position on the effectiveness of any state's regulatory program or on the merits of natural gas exploration in North Carolina. Instead, it focuses on the range of environmental issues that North Carolina lawmakers will need to understand if they consider allowing natural gas production through horizontal drilling and hydraulic fracturing.

Many states with shale gas resources are experiencing dramatic increases in gas production. Policy makers in these states are developing regulatory structures to address the local and regional impacts of shale gas extraction, which is a relatively new practice. This paper groups the challenges faced by these states in three broad categories:

1. **Pre-drilling Information Needs and Regulatory Structure:** In many states, existing oil and gas regulatory programs allow shale gas extraction. Some of these states are retrospectively identifying a need for comprehensive baseline data and sufficient staff and funding to accommodate the rapidly growing shale gas industry. This section addresses the need for **baseline data regarding water quality, disclosure of chemicals used during hydraulic fracturing, and the development and funding of a regulatory program.**
2. **Regulation of Drilling Operations:** Shale gas extraction has the potential to damage the environment and compete with other land uses throughout each stage of drilling and production. Some states are now revisiting their regulations to account for increased risks associated with hydraulic fracturing and horizontal drilling. This section addresses issues associated with normal operations including: **impacts on water supply, land use impacts and property rights, impacts from wastewater storage, treatment and disposal, and air quality impacts.**
3. **Addressing Spills and Other Accidents:** Accidents and equipment failures can cause leaks, spills, and environmental contamination even under the most effective regulatory program. This section addresses risks associated with shale gas production, including **incidents during the**

drilling process, such as well blow-outs and well casing and cementing failures, and improper disposal or spills of wastes, including **drill cuttings and mud**. It describes how states are responding to reduce the occurrence of spills and accidents and discusses how states are handling **spill-response planning and liability**.

In the context of each of these challenges, this paper summarizes both the issues that may arise as a result of natural gas drilling and the regulatory approaches taken by other states, including pending regulation. In addition, the paper discusses recommendations of the State Review of Oil and Natural Gas Environmental Regulations (STRONGER), a non-profit partnership of the federal government, industry, and states that conducts reviews of existing state oil and gas regulations, and recommendations of the U.S. Department of Energy's Secretary of Energy Advisory Board (SEAB) Shale Gas Subcommittee. This information can provide a foundation for North Carolina policy makers, citizens, and industry leaders to evaluate and avoid or mitigate negative impacts.

I. INTRODUCTION

In 2009, the North Carolina Geologic Survey announced the existence of shale gas underlying the Deep and Dan river basins in 12 counties, including Lee, Chatham, and Moore.² Following the Geologic Survey's initial announcement, several small companies began leasing mineral rights from landowners in Lee County, and the state legislature began to consider the policy changes that would be necessary to develop the shale gas resource. To this end, on June 23, 2011, Governor Beverly Perdue signed Session Law 2011-276, which directs the Department of Environment and Natural Resources (DENR) to conduct a study and hold public hearings on the issues of horizontal drilling and hydraulic fracturing for gas extraction. The study is due to the legislature by May 2012. Specifically, DENR must investigate and report on the following: North Carolina's potential oil and gas resources; methods of exploration and production; impacts on infrastructure and water resources; environmental, economic, and social impacts; administrative issues associated with a regulatory program; consumer protection and legal issues; and other issues considered pertinent.³ DENR's study will address some categories of environmental impacts of natural gas extraction in North Carolina not addressed in this paper, including stormwater management, impacts on fish and wildlife, and reclamation of drilling sites. S.L. 2011-276 followed a robust debate regarding natural gas exploration in the state, and the legislature may revisit the issue once DENR releases its study.

North Carolina has no active oil and gas production and no comprehensive regulatory framework for this industry. North Carolina law has long prohibited both horizontal drilling and underground injection of waste products. While these laws were implemented before the use of hydraulic fracturing to produce natural gas, the current law creates a *de facto* ban on hydraulic fracturing in the state.⁴ If North Carolina lawmakers choose to create a regulatory structure for shale gas extraction, they have the opportunity to address potential environmental, health, and safety risks at the outset. The experiences of other states can provide valuable insight into the risks that accompany this activity, and the policy decisions that other states have made in an attempt to mitigate those risks can inform North Carolina lawmakers as they consider whether and under what conditions to allow shale gas extraction.

This paper describes the potential environmental and land use impacts associated with shale gas production, and summarizes the regulatory approaches taken as other states work toward the goal of producing natural gas while protecting the environment and the health and safety of their citizens. The paper also discusses recommendations of the State Review of Oil and Natural Gas Environmental Regulations (STRONGER), a non-profit partnership of the federal government, industry, and states that conducts reviews of existing state oil and gas regulations, and recommendations of the U.S. Department of Energy's Secretary of Energy Advisory Board (SEAB) Shale Gas Subcommittee. These experiences and recommendations can help inform decision making in North Carolina, keeping in mind that industry practices and regulatory approaches are rapidly evolving, and there is significant regional variation in the geology of shale deposits.

This paper does not take a position on the effectiveness of any state's regulatory program or on the merits of natural gas exploration in North Carolina.

II. SHALE GAS OVERVIEW

A. What Is Shale Gas?

Conventional natural gas reservoirs form when gas migrates toward the earth's surface from organic-rich source rock and becomes trapped by a layer of impermeable rock. Producers can access the gas by drilling vertical wells into the area where the gas is present, allowing it to flow to the surface. Shale gas resources, however, are contained within relatively impermeable source rock, meaning that the gas does not migrate out of the source rock and into a reservoir where drillers can easily access it. Horizontal wells paired with hydraulic fracturing allow for natural gas recovery in areas where it was previously uneconomical.

Because its widespread extraction is relatively new, shale gas, along with tight gas and coalbed methane, is often referred to as “unconventional” natural gas.

To drill and fracture a shale gas well, operators first drill down vertically until they reach the shale formation. Within the target shale formation, the operators drill horizontally and create a lateral well through the shale rock. In Pennsylvania’s Marcellus Shale formation, for example, a typical horizontal well may extend from 2,000 to 6,000 feet and sometimes approaches 10,000 feet.⁵ Once the horizontal well is complete, producers pump fracturing fluid into it at a pressure sufficient to create fractures in the rock formation; these fractures allow the gas to flow from the pockets in the formation to the well.⁶ Fracturing fluid is composed of up to 99% water, but it also contains chemical additives and propping agents (also called “proppants”).⁷ The chemicals added to fracturing fluid include friction reducers, surfactants, gelling agents, scale inhibitors, pH-adjusting agents, corrosion inhibitors, antibacterial agents, and clay stabilizers.⁸ Injecting propping agents, typically sand, into the fractures created by the fluid injection ensures that the fractures remain open during extraction.⁹ Operators can re-fracture a well many times to stimulate the flow of additional gas from the same formation.¹⁰

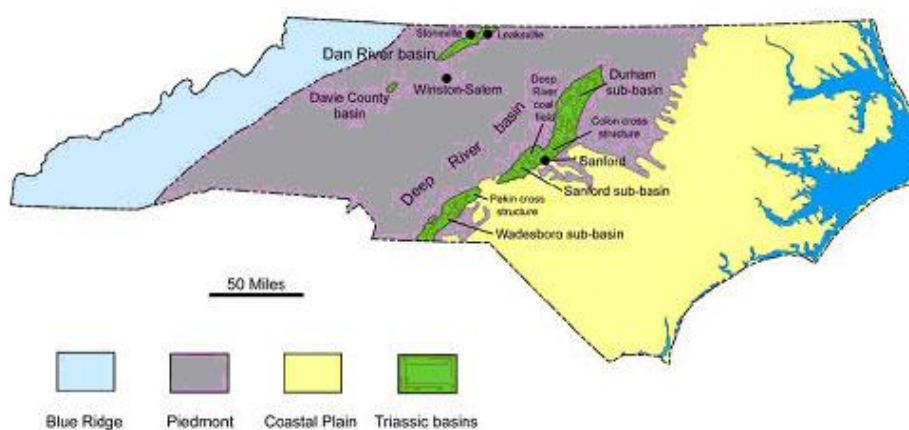
B. The Expansion of Shale Gas Extraction

The extraction of natural gas from shale formations is one of the fastest growing trends in American on-shore domestic oil and gas production.¹¹ Unconventional natural gas is expected to contribute an increasingly large percentage of domestic natural gas production in the coming years.¹² The U.S. Energy Information Administration predicts an almost four-fold increase in shale gas production between 2009 and 2035.¹³

The boom in natural gas production can be attributed to technological improvements in directional drilling and hydraulic fracturing. The combination of the two activities maximizes the extraction of natural gas from unconventional sources. The activity in Pennsylvania’s Marcellus Shale basin is a prime example of the rapid expansion of shale extraction in recent years: 195 wells were drilled in 2008; 768 wells, in 2009; and 1386, in 2010.¹⁴

C. Shale Gas Resources in North Carolina

North Carolina state geologists recently identified a layer of shale rock that may contain producible natural gas resources in the Triassic strata of both the Deep River and Dan river basins.¹⁵



Source: North Carolina Geologic Survey

To date, exploratory drilling has not found commercially producible oil or gas anywhere in the state.¹⁶ However, test results from several wells in Lee County have documented the presence of natural gas.¹⁷ In

2011, the North Carolina Geologic Survey (NCGS) estimated the natural gas potential of the 59,000 acres below Lee, Moore, and Sanford counties and sent the results to the United States Geologic Survey (USGS) for a second opinion.¹⁸ The NCGS estimate has not been made public, and USGS has not yet produced its own estimate.¹⁹

North Carolina's natural gas-producing potential is small compared with that of other states. The Marcellus Shale basin comprises 60.8 million acres underneath Pennsylvania, New York, and West Virginia, three orders of magnitude larger than the Sanford sub-basin's 59,000 acres.²⁰ The second largest shale gas plays, the Haynesville and Barnett shale basins, span 5.8 million and 3.2 million acres, respectively.²¹

North Carolina's shale rock formations differ from the shale gas plays currently active in the United States in that they formed from organic matter associated with a freshwater environment rather than a marine environment.²² It is unclear how North Carolina's freshwater formations would affect the shale gas production process, including the types of chemicals used during the drilling and fracturing process, and the potential negative impacts of materials removed from the well along with natural gas, such as drill cuttings and produced water.

D. Current State of the Law in North Carolina

Large-scale unconventional natural gas extraction presents new environmental challenges for states to address. These challenges include securing critical baseline data on pre-drilling water quality, funding regulatory programs, minimizing risks of spills and contamination, assuring attainment of federal ground-level air quality standards, and identifying options for wastewater treatment. States are responding to these challenges with a range of policies and regulations aimed at reducing the environmental impacts of shale gas extraction while keeping the costs of extraction as low as possible.

Because North Carolina has no active oil and gas industry, it has no comprehensive oil and gas regulatory program. If N.C. lawmakers choose to allow shale gas production, they could learn from the experiences of other states, with the understanding the relevant practices and regulations are constantly evolving. In developing its regulations, North Carolina would have the opportunity to design a comprehensive and streamlined program that addresses the environmental and public health risks associated with shale gas extraction. In addition to developing a regulatory program, the state would have to decide whether to house it within an existing agency such as DENR or create an independent regulatory commission.

III. PRE-DRILLING: INFORMATION NEEDS AND REGULATORY STRUCTURE

A. Baseline Data on Water Quality

Baseline data are critical for evaluating whether shale gas production is a source of water contamination and, if so, at what stage of the extraction process. The ability to compare water samples collected before, during, and after each stage of drilling allows industry and regulators to identify and address problems early. Baseline data can also help both landowners and industry avoid lengthy litigation regarding the source of pollution.

To our knowledge, no state has collected comprehensive baseline data prior to shale gas production and at each stage of the drilling process. However, some states are beginning to respond to the need for additional scientific information by encouraging information gathering before the drilling of new wells and the disclosure of chemicals used during the fracturing process. Because North Carolina's existing law creates an effective ban on shale gas extraction, the state has the opportunity to require collection of critical baseline information and establishment of protocols for resource monitoring throughout the drilling process before allowing any shale gas well to be drilled.

1. Experiences in other states

Numerous claims have been made that hydraulic fracturing has resulted in the contamination of private water wells and other groundwater resources.²³ Landowners near shale gas operations have reported the presence of odors, silt, discoloration, methane gas, and chemicals such as benzene, mercury, naphthalene, and selenium in their tap water.²⁴ Without reliable baseline data, regulators find it difficult to distinguish between cases of pre-existing contamination and cases of contamination traceable to hydraulic fracturing. Gathering baseline data is complicated by the fact that many wells in rural areas are private, and the ability of state or federal agencies to conduct baseline studies is therefore limited by private property rights and the willingness of private landowners to participate.

The task of determining whether shale gas production causes contamination is further complicated by the fact that various pollutants are associated with the process, and multiple pathways exist for those pollutants to reach water supplies. Over years of gas production, a single well can produce millions of gallons of waste fluids that can contain many pollutants. These pollutants include naturally occurring chemicals derived from formation water in addition to chemicals added to fracturing fluid.^{25,26}

The migration of methane and other gases to nearby private drinking water wells is an additional concern with hydraulic fracturing. Shale gas is typically more than 90% methane.²⁷ A recent peer reviewed study conducted by researchers at Duke University provides the first systematic evidence that methane exists in high concentrations in drinking water near shale gas wells in Pennsylvania and New York. The methane found in those wells has a similar geochemical makeup to that found in shale gas reservoirs, as opposed to methane that occurs naturally in some shallow waters.²⁸ The study did not determine the exact mechanism of methane contamination or whether the methane in the drinking water resulted from leaky well casings or migration from a depth associated with hydraulic fracturing.

2. Overview of regulatory action

Some states are creating or expanding incentives for industry to test wells or are using state funds to pay for tests. In addition, states facilitate the collection of data by requiring companies to disclose the chemicals used in fracturing fluid, which allows for pre-drilling tests to look for the specific chemicals injected into the ground during hydraulic fracturing.

a. Pre-drilling water quality testing

The U.S. Department of Energy's Secretary of Energy Advisory Board (SEAB) Shale Gas Subcommittee recently released its draft recommendations to reduce the environmental impact and improve the safety of shale gas production. One of these recommendations is that state regulators adopt requirements for background water quality measurements and reporting of results prior to shale gas production activity.²⁹ States are addressing the need for baseline data by creating mandatory and voluntary pre-drilling well-testing programs or by establishing a presumption of liability if a pollutant associated with hydraulic fracturing is found within a certain distance to the well.³⁰

- **Mandatory testing:** In Ohio, state permitting geologists have the authority to require operators to collect water quality samples before drilling takes place and to submit laboratory tests to the state.³¹
- **Voluntary testing:** Colorado recently announced a water-sampling program jointly administered by industry and the state. The voluntary program will test groundwater supplies before and after hydraulic fracturing operations at a landowner's request. A third party will collect the samples, with oversight from the state Department of Public Health and Environment.³²
- **Presumptive liability:** West Virginia and Pennsylvania both assume that a drilling operator is legally responsible for water contamination within 1,000 feet of a well if the contamination occurs within a specified timeframe (e.g., in Pennsylvania, the contamination must occur within six months). The operator must demonstrate otherwise to avoid liability. Consequently, well operators have an incentive to regularly pre-test water supplies within the area of presumptive

liability.³³ Both Pennsylvania and West Virginia are considering expanding the range to 2,500 feet, and Pennsylvania may expand the timeframe to one year.³⁴

b. Disclosure of chemicals used in fracturing fluid

Fracturing fluid can contain up to 40 chemical additives, which vary depending on the operator's preferences and the geologic characteristics of the site.³⁵ The U.S. House of Representatives Committee on Energy and Commerce recently found that 750 chemicals were used in hydraulic fracturing processes between 2005 and 2009.³⁶ Of those, 29 chemicals are known or possible human carcinogens that are regulated under the federal Safe Drinking Water Act because of the risk to human health or listed as hazardous air pollutants under the federal Clean Air Act.³⁷

Although the chemical makeup of fracturing fluids has long been protected as a trade secret, some states now require varying degrees of disclosure:

- Partial disclosure: Arkansas, Colorado, Michigan, and Pennsylvania have partial disclosure policies. For example, Michigan now requires compilation of material safety data sheets (MSDSs) for additives used in fracturing fluids and posts the data online for public review.³⁸ (The U.S. Occupational Safety and Health Administration requires that the data sheets, which contain information on the properties of a chemical and potential harms, be made available to employees who handle potentially harmful substances, local emergency response planning officials, and fire departments.³⁹) MSDSs do not contain proprietary information, including the chemical ingredients of many fracturing fluid additives. In Arkansas, regulators post information online about chemicals used in each well. However, approved trade secrets are listed only by chemical family.⁴⁰
- Full disclosure to regulators, but partial or no disclosure to the general public: Texas and Wyoming require that well operators provide regulators with a list of all chemicals used in hydraulic fracturing in the state and keep that list up to date.⁴¹ Both states prohibit disclosure of proprietary information, and companies can still apply for the right to omit certain details.⁴²
- Disclosure above a certain threshold: As of June 2009, Colorado requires operators to maintain an inventory of all chemicals used in hydraulic fracturing fluids if more than 500 pounds of the chemical are used in a single quarter.⁴³ If a substance is considered a trade secret, companies must list the name of the trade secret substance, but not its chemical ingredients. The inventory is available to regulators on request, and vendors of trade secret additives must provide full information to health care professionals if needed for treatment or diagnosis. At the request of the governor, Colorado regulators recently proposed to strengthen the state's disclosure rules. The draft rules would require that operators post well-by-well information about the chemicals used online within 90 days of hydraulic fracturing. For trade secret chemicals, operators would list the chemical family.⁴⁴

In California, the General Assembly is considering legislation to require the disclosure of a complete list of chemicals used in hydraulic fracturing fluid.⁴⁵ If this legislation passes, it will be the first disclosure policy that provides no exception for trade secrets.

B. Regulatory Structure and Agency Resources

On private property and non-federal public lands, U.S. states are the primary regulators of oil and gas extraction. Accordingly, the states must develop, staff, and fund their regulatory programs. In recent years, the rapid expansion of shale gas extraction has led to a corresponding increase in permit applications for natural gas extraction, putting a strain on regulators responsible for active shale gas plays. If North Carolina lawmakers allow hydraulic fracturing in the state, they will have to (a) select an existing agency or create a new authority to carry out a regulatory program and (b) ensure an adequate level of funding.

1. Experiences in other states

Some states with active shale gas plays have had difficulty keeping up with the rapid proliferation of new wells.⁴⁶ According to regulators in Pennsylvania and West Virginia, shale gas production implicates new and expanded environmental considerations and thus requires more attention than conventional drilling permits.⁴⁷ In some states, such as Oklahoma, regulatory agencies deploy field inspectors to oversee key aspects of the drilling process, such as casing and cementing the well.⁴⁸ In other states, such as West Virginia, operators are required to notify the regulatory agency before they begin casing and cementing, but the law does not require an inspector to be onsite during that process.⁴⁹ A sharp increase in new permits, without a corresponding increase in regulatory staff, decreases the percentage of operations that inspectors can observe.

In many states, the increased administrative burden of regulating an active shale gas industry is coinciding with a period of decreased funding. Although state lawmakers have not yet decided who would regulate shale gas drilling in North Carolina, one likely candidate, the Department of Environment and Natural Resources, has faced recent budget cuts. In its 2011–2012 budget, North Carolina cut funding to the department by 12%, resulting in the elimination of 160 agency jobs.

2. Overview of regulatory action

In states where shale gas extraction is expanding rapidly and increasing the administrative burden on regulatory agencies, lawmakers have turned to the natural gas industry to help cover the costs of increased regulatory activities through fees and severance taxes.

- Permit fees: States typically charge permit fees for oil and gas activities. Pennsylvania, for example, recently increased fees for conventional wells and created a new fee covering horizontal well applications.⁵⁰
- New fee structures: Ohio recently increased fees to support permitting, monitoring, and enforcement activities.⁵¹ Rather than simply increasing permitting fees, however, the state chose to break down those fees to reflect the administrative burden of each particular well. For example, a brine disposal fee applies when produced water is injected into a disposal well.⁵²
- Severance tax on natural gas: Most states with an active oil and gas industry levy a severance tax on natural gas after it is removed from the ground, though this revenue is often sent to the state's general fund or dedicated to conservation or local governments.⁵³ Indiana is one state that uses a severance tax to directly fund the administration of its oil and gas program. Indiana appropriates money to the Department of Natural Resources to administer the oil and gas regulatory program and to research exploration for, development of, or wise use of oil and gas resources in the state.⁵⁴

IV. REGULATION OF DRILLING OPERATIONS

A. Impacts on Water Supply

The Groundwater Protection Council, a non-profit association of state groundwater regulators, estimates that drilling and hydraulic fracturing requires between 2 million and 4 million gallons of water per well, and Pennsylvania's Marcellus Shale Advisory Commission found that a single well sometimes uses more than 5 million gallons per fracturing.⁵⁵ The volume of water required varies by geologic formation, depth, and lateral length of a well, and the number of times it must be fractured. As a result, some wells use significantly more water than others.

Natural gas producers frequently draw water for drilling and hydraulic fracturing from nearby surface waters, including rivers and lakes.⁵⁶ Some drilling operations also take water directly from groundwater or municipal water supplies. Others reuse flow-back fluid and produced water from previous drilling operations for at least a portion of their water supply, though the ability to recycle produced water as a source for hydraulic fracturing fluid is limited by the quality of the produced water.⁵⁷

The water required to bring a shale gas well on line is used within a moderately short timeframe. Although it may amount to a relatively small percentage of a typical area's water supply, if the drilling and production occurs in a time of drought or low stream flow it can create pressure on other uses, including municipal water supplies, water used for industrial operations such as cooling power plants, and water for irrigation in farming.⁵⁸

North Carolina is a relatively water-rich state, but the amount of water needed to fracture a well in the Deep or Dan river basins of North Carolina is not known. North Carolina's potential shale gas resources are primarily located within the fastest-growing region of the state—a large swath between Raleigh and Charlotte – where water demands are rapidly increasing.⁵⁹

1. Experiences in other states

The current drought in Texas is a highly publicized example of how shale gas extraction can compete with other uses of water, including municipal uses and irrigation.⁶⁰ Although water availability varies from state to state, it is important to consider potential water supply impacts of shale gas extraction in any region. Southeastern states have experienced severe droughts in recent years, and the energy sector in North Carolina has struggled with water shortages during those times.^{61,62} North Carolina currently ranks among the top 10 states in the nation for energy-related water withdrawals.⁶³ Of the 15 billion gallons of water withdrawn daily in North Carolina, 14 billion gallons are used for cooling thermal electric power plants and producing hydroelectric power.⁶⁴

2. Overview of regulatory action

Other states, in addition to Texas, are considering policies to protect against water shortages, including strategies to encourage wastewater recycling and to provide additional oversight when water is withdrawn. The range of activities includes:

- Remove barriers to and create incentives for recycling wastewater: Some states have removed regulatory barriers to the reuse of produced water to encourage companies to recycle flow-back water. For example, the Susquehanna River Basin Commission (SRBC), which regulates areas of Maryland, New York, and Pennsylvania, generally prohibits diversion of water from one watershed to another.⁶⁵ The commission recently issued an executive order waiving the rule for all pad-to-pad transfers of flow-back fluid for the purpose of reuse.⁶⁶ Similarly, Louisiana only recently allowed recycling of flow-back fluids. However, the state now encourages recycling of produced water, rainwater, and drilling fluids for hydraulic fracturing purposes.⁶⁷ Recycling reduces the use of fresh water and the volume of waste. However, companies must remove some elements of wastewater before reuse, producing a brine concentrate that can be dangerous to people and the environment.⁶⁸
- Prioritize sources from which water can be withdrawn: In Louisiana, the Office of Conservation issued a nonbinding advisory that operators should not use water from the main drinking water aquifer but instead use lower-quality aquifers and other sources, such as recycled water.⁶⁹
- Require approval or reporting of withdrawals: The SRBC now requires approval for all water withdrawn for use in hydrocarbon exploration and production. Approval is contingent on the determination that its use will not cause significant adverse impacts to the water resources of the basin.⁷⁰ Louisiana requires operators to report all water used in hydraulic fracturing.⁷¹ Michigan requires operators to report where they plan to source fresh water using the Department of Environmental Quality's water withdrawal tool to ensure that nearby water wells and surface water will not be affected.⁷² Under New York's proposed regulations, operators will need a permit to withdraw large volumes of water for industrial and commercial purposes, including hydraulic fracturing.⁷³

STRONGER broadly recommends in its guidelines that states evaluate and address the availability of water needed for hydraulic fracturing in the context of competing uses and environmental impacts. It also suggests that states encourage the use of recycled or reused water.⁷⁴

B. Impacts on Communities and Landowners

With the rise of high-volume hydraulic fracturing and horizontal drilling, oil and gas exploration now occurs in new areas where state and local governments may not have experience regulating the industry.⁷⁵ States must decide how to address the interests of local governments and individual landowners, including the level to which state permitting programs allow local governments to control the conditions under which drilling occurs within their borders. Policy makers also face the task of ensuring that shale gas development does not interfere with existing land uses, such as residential uses, and with natural resources, such as timber harvesting. Regulating the natural gas industry would be a new role not only for North Carolina's state agencies, but also for local governments.

1. Experiences in other states

The cumulative impacts of natural gas drilling on communities can be significant, including increased truck traffic, loud noise, bright lights to facilitate 24-hour operations, and odors from chemicals used on site.⁷⁶ Municipalities in Pennsylvania and New York are attempting to utilize local zoning ordinances to prevent drilling from disturbing residents with excessive noise and light and from engaging in other activities they consider incompatible with existing land uses.⁷⁷ For example, some municipalities have attempted to control the parameters of a drilling operation by passing ordinances that make gas drilling a conditional use rather than a permitted use.⁷⁸ Permitted uses are allowed as a matter of right within a zoning district, whereas conditional uses are recognized as potentially consistent with the zone, but must be evaluated on a case-by-case basis. Conditional use permitting allows a municipality to exercise some control over the way in which land is used by adding requirements such as review by a planning commission or a public hearing.⁷⁹

2. Overview of regulatory action

The degree to which a local government is able to exert control over drilling activities varies from state to state. For example, Pennsylvania's Oil and Gas Act of 1984 expressly preempts municipal oversight to the extent that it regulates aspects of oil and gas drilling that are already regulated at the state level. North Carolina's constitution similarly preempts municipal ordinances that overlap with state law.⁸⁰ Several mechanisms address impacts on local communities and landowners.

- Setback requirements: The minimum distance allowed between a well and municipal water supply intakes and reservoirs, private water wells, private property lines, protected lands, floodplains, and other valuable land uses depends on the state's expectations about the extent of drilling impact.⁸¹ The Pennsylvania Governor's Marcellus Shale Advisory Commission, the Secretary of Pennsylvania's Department of Environmental Protection, New York's Department of Environmental Conservation, and the Delaware River Basin Commission have all recommended extending setback requirements for shale gas activities in their respective states.^{82-83,84-85}
- Operating requirements: Louisiana's Office of Conservation has established regulations for the production of gas from urban areas of the Haynesville shale formation, including: (a) a mandate to manage the site to minimize standing water, weeds, trash, dust, vibration, and odors; (b) a prohibition on construction activities at night; and (c) noise restrictions.⁸⁶ Ohio's Department of Natural Resources can set enforceable noise standards.⁸⁷ Although the standards are not tailored to the needs of each particular municipality, this policy allows the state to require operators to adopt less noisy technology. New York's revised draft SGEIS addresses the impact of truck traffic on local roads by requiring operators to develop local transportation plans to "reduce the impacts from truck traffic to local road systems to the maximum extent feasible."⁸⁸

- Bans on hydraulic fracturing within municipalities: Some municipalities in Pennsylvania, New York, and West Virginia ban hydraulic fracturing within and around their borders. A state court recently overturned one such ban, in Morgantown, West Virginia.⁸⁹ The judge held that a municipality did not have the authority to pre-empt the Department of Environmental Protection's regulation of drilling. Whether such bans will prevail in court under various state constitutions is unclear.

C. Impacts from Wastewater Storage, Treatment, and Disposal

The normal operation of shale gas production facilities can pose significant risks to water quality. Three key aspects of the production process contribute to these risks: wastewater storage, treatment, and disposal; drill cuttings and mud storage, treatment, and disposal; and well casing and cementing. This section provides a discussion of risks and existing policy responses associated with wastewater storage, treatment, and disposal.

Two primary sources of wastewater are associated with hydraulic fracturing: flow-back fluid and produced water.

- *Flow back fluid* is fracturing fluid that returns to the surface. An estimated 10%–40% of injected water flows back to the surface in the days and weeks following hydraulic fracturing.⁹⁰ The components of flow-back fluid vary depending on the additives in the original fluid and the quality of the original water in the shale formation, which is typically composed of a brine solution with high concentrations of salts, metals, radionuclides, oils, greases, and volatile and semi-volatile organic compounds.⁹¹
- *Produced water* (also known as brine, saltwater, and formation water) exists within the shale formation and is brought to the surface during the gas extraction process. The makeup of produced water is a function of the location of the field and the type of geologic formation. It may contain oil and grease, inorganic and organic compounds introduced as chemical additives to drilling fluid, and naturally occurring radioactive material.⁹² It typically has very high levels of total dissolved solids (TDS or salts) that are difficult and expensive to remove.⁹³ As noted above, North Carolina's shale rock formations formed from organic matter associated with a freshwater environment rather than a marine environment.⁹⁴ Hence, the makeup of produced water in North Carolina, including the level of TDS, is unknown.

Federal hazardous waste storage, transportation, and disposal requirements do not apply to wastewater produced through shale gas extraction, and regulatory decisions regarding wastewater treatment and disposal are therefore left to the states.⁹⁵ Regulators in states that allow hydraulic fracturing are responsible for disposing of significant amounts of waste and may have limited disposal options.⁹⁶ Current technology offers no single best practice.

1. Experiences in other states

The options for wastewater disposal include injection into underground disposal wells, partial treatment at publicly owned treatment works (POTWs) followed by discharge into nearby surface water, land application, commercial wastewater treatment, and reuse in future hydraulic fracturing operations.⁹⁷

a. Underground injection

Underground injection (also known as deep well injection) is the most common disposal strategy for flow-back fluid.⁹⁸ The Argonne National Laboratory estimates that operators inject 98% of all U.S. produced water from oil and gas drilling into Class II disposal wells regulated by the EPA Underground Injection Control Program.⁹⁹ Although underground injection is considered a safe disposal method, it is not without risk. For example, the high pressure used to inject wastewater into disposal wells has been known to induce earthquakes in Ohio, New York, Texas, and most recently Arkansas.¹⁰⁰ The risk that human activities will cause earthquakes is dependent on the natural frequency and magnitude of seismic

events in a given area, although human activities can significantly increase the number of earthquakes that occur.¹⁰¹

Underground injection of wastewater is currently illegal in North Carolina.¹⁰² Even if the ban were lifted, the state may not possess suitable geologic storage formations. An EPA assessment of industrial waste injection sites nationwide classified western North Carolina as unfavorable under all conditions and coastal North Carolina as unsuitable under most conditions.¹⁰³ Therefore, if the state did lift the ban on underground injection, other disposal methods for wastewater produced through shale extraction may be necessary.

b. Treatment at publicly or privately owned treatment facilities

In states with limited capacity for underground injection, such as Pennsylvania, operators must use alternative disposal methods. Pennsylvania allowed operators to send wastewater to publicly owned treatment works until the spring of 2011, when the state stopped the practice due to water quality concerns. Most POTWs cannot remove the high concentrations of TDS from wastewater.¹⁰⁴ High TDS discharges to surface water can impair water quality and kill aquatic life.¹⁰⁵ When treated for drinking water, high TDS can also create byproducts that are harmful to human health.¹⁰⁶

A number of existing and developing technologies can treat TDS in wastewater, but none is without limitations. For example, desalinization through reverse osmosis can remove high quality water from a brine concentrate that must then be disposed of. This process is energy intensive, however, and is generally considered economically infeasible for treating flow-back fluid with high TDS.¹⁰⁷ Another treatment method is distillation and crystallization, but current systems can only accept up to 300 cubic meters of fluid per day, whereas a typical hydraulic fracturing operation can produce 3,000 cubic meters or more of flow-back fluid per day.¹⁰⁸ In addition to POTWs, some states utilize privately-owned treatment facilities. Pennsylvania, for example, has several existing brine treatment plants that treat wastewater from the oil and gas industry before discharging it to surface waters.¹⁰⁹ These plants have been unable to meet rising demand, and 25 new treatment facilities have been proposed.¹¹⁰

The U.S. EPA recently announced plans to develop regulations under the Clean Water Act to create a pretreatment standard for wastewater that is sent to POTWs. The EPA plans to propose this rule in 2014 as part of a larger rulemaking for shale gas extraction.¹¹¹

c. Land application

A recent peer-reviewed publication by the U.S. Forest Service found that land application of wastewater from oil and gas drilling operations can have negative environmental effects. The study focused on the land application of 303,000 L of flow-back fluid on 0.20 hectares of forest in West Virginia and found that within days hundreds of trees had lost their foliage.¹¹² Two years later, 56% of trees in the area were dead and sodium and chlorides in the soil increased fifty-fold.¹¹³ The experimental land application was authorized by the Forest Service and required that the company spread fracturing fluid over a smaller area than is typical.¹¹⁴ An industry trade group responded that it would have used an area three to five times larger than the one allowed in the state forest and would have expected no negative effect on the local environment.¹¹⁵

d. Reuse of wastewater

Some experts consider reusing wastewater as fracturing fluid in other wells a best practice to reduce the volume of wastewater and need for freshwater.¹¹⁶ However, some additives commonly used in fracturing fluid can interact with the TDS wastewater, reducing their effectiveness.¹¹⁷ TDS interactions with the shale formation itself may also reduce gas production from the well.¹¹⁸ The development of fracturing fluids that are salt-tolerant would facilitate expansion of reuse.¹¹⁹ Wastewater recycling does not eliminate disposal concerns, because companies must remove some elements, including barium, strontium, and radioactive elements, from wastewater before reuse.¹²⁰

2. Overview of regulatory action

Oil- and gas-producing states often set standards for the wastewater storage facilities and disposal methods that operators can use.¹²¹ A few states have revised these standards for hydraulic fracturing sites in response to heightened wastewater concerns.

- Wastewater storage: Colorado revised its oil and gas rules, including: (a) individual permitting requirements for pits storing produced water; (b) lining specifications for pits storing certain harmful materials; and (c) new response and reporting procedures for spills and releases.¹²² New York's Department of Environmental Conservation's proposed regulations ban open containment of wastewater stored on site, and require all flow-back fluid to be contained in watertight tanks within a secondary containment area.¹²³ STRONGER also has a set of recommendations for state regulation of wastewater storage.¹²⁴
- Treatment at publicly or privately owned treatment facilities: Pennsylvania recently issued regulations to address TDS in wastewater.¹²⁵ The regulations allow already-approved TDS discharges to continue but require that new and expanding TDS discharges meet average monthly flow standards.¹²⁶ Ohio similarly does not authorize POTWs to receive hydraulic fracturing wastewater with high TDS concentrations and requires approval to receive wastewater with lower TDS.¹²⁷ West Virginia regulators proposed a maximum in-stream standard for TDS, as opposed to regulating point sources, but the standard has not gained support from the legislature.¹²⁸
- Land application: Louisiana and Pennsylvania prohibit land application of all drilling wastewater.^{129,130} Arkansas allows land application of produced water, but flow-back fluids, which contain chemical additives used during hydraulic fracturing, are not eligible for land application under the permit program.¹³¹
- Wastewater reuse: Pennsylvania now requires operators to develop and submit a source reduction strategy to maximize recycling of wastewater. Operators must also report the volume of wastewater recycled from each well.¹³²

In addition, some states have recognized the need for a water supply and disposal registry to track wastewater. Pennsylvania's Secretary of the Department of Environmental Protection proposed a tracking system for hydraulic fracturing wastewater that would create a manifest system for wells that produce over a minimum volume of wastewater, similar to the tracking of hazardous waste under the federal Resource Conservation and Recovery Act (RCRA), which does not apply to waste from oil and gas activities.^{133,134} Colorado requires well operators to maintain a record of the volume of transported wastewater, the pickup date, and the identity of the transporter.¹³⁵

D. Impacts on Air Quality

Activities related to shale gas drilling and production are a source of air pollutants, including nitrous oxides (NO_x) and volatile organic compounds (VOCs) (both precursors to ground-level ozone), hazardous air pollutants (HAPs), and greenhouse gases (GHGs).¹³⁶ Most of these emissions occur during the "flow-back period" following the hydraulic fracturing process, when chemical-laden water flows out of the well.¹³⁷ Other sources of air pollutants include truck traffic and idling, drilling equipment, natural gas compression, and pressure regulation inside the well. Wells are another potential source of air pollution, because operators sometimes vent them to control pressure.

Air pollutants from natural gas wells may contribute to poor air quality and interfere with localities' ability to meet National Ambient Air Quality Standards (NAAQS) as required by the federal Clean Air Act. Ground-level ozone pollution, in particular, is a concern around shale gas plays.¹³⁸ North Carolina's potential shale gas development areas are located upwind of the Triangle 8-hour ozone nonattainment area, which includes the northeast corner of Chatham County. If shale gas extraction occurs in North Carolina, the potential impact on ground-level pollution will be among the important considerations for

regulators, including whether shale gas production could expand the existing non-attainment zone or create new non-attainment zones in the state.¹³⁹

The U.S. EPA recently issued draft federal air regulations tailored to hydraulic fracturing. The draft rule includes new source performance standards (NSPS) for VOCs and sulfur dioxide as well as a more stringent air toxic standard for benzene.¹⁴⁰ The NSPS for VOCs would create pollution reduction standards for well completions, compressors, pneumatic devices, condensate storage tanks, and natural gas processing plants. The EPA plans to release the final rule in February 2012.¹⁴¹

1. Experiences in other states

In 2008, Sublette County, Wyoming, became an ozone non-attainment area, a classification that the Department of Environmental Quality attributes to shale gas production and meteorological conditions favorable to ozone formation.¹⁴² Similarly, emissions from Colorado's oil and gas operations exceed motor vehicle emissions for the entire state.¹⁴³

2. Overview of regulatory action

In the absence of federal standards, a few states have responded to deteriorating air quality around natural gas plays by revising their state implementation plans under the Clean Air Act and applying standards beyond the current federal minimums.¹⁴⁴ Some states are also tightening regulations on specific sources of emissions such as pneumatic devices, natural gas dehydration units, condensate, and well completions.

- Apply more stringent emissions limits: Wyoming now requires ozone offsets whenever the state issues a permit for new or modified sources in Sublette County, regardless of whether the source is a “major source” under the federal Clean Air Act (the Clean Air Act requires offsets for major sources of criteria pollutants in non-attainment areas).¹⁴⁵ The state adopted this practice to maintain and improve air quality in all districts.¹⁴⁶
- Regulate emissions from pneumatic devices: The oil and gas industry frequently uses pneumatic devices to manage liquid level controllers, pressure regulators, and valve controllers.¹⁴⁷ These devices are typically powered by natural gas and are designed to vent (“bleed”) large amounts of methane as part of normal operations.¹⁴⁸ Colorado addresses pneumatic devices through its NO_x and VOC regulations.¹⁴⁹ Wyoming also regulates pneumatic devices through its VOC and HAP programs.¹⁵⁰
- Efficiency standards for natural gas dehydration units: Natural gas dehydration units remove saturated water from natural gas prior to transmission. Wyoming and Colorado both impose efficiency requirements on these units.¹⁵¹
- Efficiency standards for condensate: Some natural gas wells produce condensate as a byproduct of the gas. Condensate is composed of hydrocarbons and aromatic hydrocarbons that are in a gaseous state in the reservoir and that become liquid as a result of the gas production process. Tanks used to store condensate may be sources of VOC emissions.¹⁵² Colorado and Wyoming both impose control efficiency standards on such tanks.¹⁵³
- Well completion: The well completion process also releases VOCs, HAPs, and methane when gases and liquids are brought to the surface. Operators can adopt special completion methods, referred to as “green completions” or “green flow-back methods,” to reduce the emissions volume.¹⁵⁴ Colorado requires the use of green completions where technically feasible, and Wyoming addresses this issue by including best management practices (BMPs) in its permitting process.¹⁵⁵

The U.S. EPA also administers a voluntary partnership called the Natural Gas STAR Program, which recommends technologies and best practices to reduce methane emissions from natural gas operations.¹⁵⁶ Many of the state requirements discussed above are reflected in the EPA recommendations, and the EPA goes beyond these primarily technology-based requirements to recommend proper use of technology to

further reduce air quality impacts. The EPA estimates the payback period for recommended technologies and practices in increased production from recovered natural gas and clearly demonstrates that a range of cost-effective strategies exist to reduce the air quality impacts of natural gas drilling. Although the Natural Gas STAR program focuses on the climate change impacts of methane in the atmosphere, its strategies for reducing methane emissions also reduce VOCs and HAPs emissions.¹⁵⁷

V. ADDRESSING SPILLS AND OTHER ACCIDENTS

Accidents and equipment failures can cause leaks, spills, and environmental contamination even under effective regulatory programs. Although accidents can occur at any stage of the process, they commonly occur during drilling and fracturing or when wastes are improperly managed.¹⁵⁸ Some states are beginning to respond—with technical standards for drilling procedures, requirements for spill prevention and cleanup plans, and financial responsibility for damages—to the risks most commonly associated with shale gas production.

A. Drilling

Accidents and equipment failures during drilling can lead to dangerous releases of natural gas, extremely salty water or “brine,” and toxic substances. These failures can occur when operators encounter unexpected pockets of pressurized gas before reaching the target formation, or when higher-than-anticipated pressures occur during the fracturing, flow-back, or production phase. Either scenario can cause the release of gas as well as naturally occurring brine and any chemicals injected during drilling. Improper well casing and cementing can also create underground conduits where fracturing fluid, hydrocarbons, brine, and other substances can leak into the surrounding environment.¹⁵⁹

1. Experiences in other states

New York regulators studying the hydraulic fracturing industry found that three accidents occurred at a single shale gas well pad in Dimock Township, Pennsylvania, due to equipment failures when pressure ratings were exceeded.¹⁶⁰ In Lawrence Township, Pennsylvania, another operator lost control of a wellbore during post-fracturing activities and released natural gas, flow-back fluid, and brine. In this case, insufficient blowout prevention equipment and the absence of certified well-control personnel on site contributed to the accident.¹⁶¹ More recently, another blowout of a shale gas well in Pennsylvania sent fracturing fluid and natural gas 75 feet into the air over the course of approximately 16 hours.¹⁶²

The Groundwater Protection Council, a national association of state groundwater and underground-injection-control agencies, recommends that operators use an appropriate cement evaluation tool when a well is hydraulically fractured near an underground source of drinking water and that regulators approve the results prior to fracturing.¹⁶³ STRONGER also suggests that regulators identify and address potential conduits of fluid migration and management during the permitting process.¹⁶⁴ The U.S. Department of Energy’s SEAB Shale Gas Subcommittee recommends that regulators and industry adopt best practices in well development and construction, including casing, cementing, and pressure management.¹⁶⁵

2. Overview of regulatory action

States with a long history of oil and gas production have safety requirements to minimize drilling accidents.¹⁶⁶ However, with the proliferation of horizontal drilling and hydraulic fracturing in shale gas extraction, many states are now revising their requirements to address the increased risks associated with the high pressures encountered during the fracturing process.¹⁶⁷

- Blowout prevention: Colorado’s recently revised rule for oil and gas drilling requires operators to: (a) install blowout preventer equipment on any well expected to flow; (b) inspect the equipment daily; (c) check that it has a sufficient rating to meet anticipated pressure; and (d) ensure that rig operators have proper training.¹⁶⁸ The New York Department of Environmental Conservation’s proposed regulations require pressure testing of blowout prevention equipment,

the use of at least two mechanical barriers, and the use of specialized equipment designed to enter the wellbore when pressure is anticipated. Additionally, New York would require the on-site presence of a certified well control specialist to address the risk of releases due to equipment failure under pressure.¹⁶⁹

- Well casing and cementing: Most states with oil and gas production have minimum standards for well casing and cementing,¹⁷⁰ but some states are revising regulations to address the high pressures associated with hydraulic fracturing. Oklahoma recently adopted new casing and cementing standards that require operators to install casing at increased depths to protect the water table, to complete surface casing prior to drilling past a certain depth, and to alert regulators at least 24 hours before casing and cementing to allow an inspector to observe.¹⁷¹ Colorado also revised its casing requirements to prevent migration of oil, gas, and other contaminants and to mandate pressure tests prior to operation.¹⁷²
- Underground injection control: The federal Safe Drinking Water Act (SDWA) regulates underground injection of fluids through the Underground Injection Control (UIC) program.¹⁷³ However, the Energy Policy Act of 2005 excluded the practice of hydraulic fracturing from the SDWA.¹⁷⁴ Attempts to reverse the exclusion have been unsuccessful.¹⁷⁵ Nevertheless, states could choose to regulate hydraulic fracturing through the UIC program.

B. Drill Cuttings and Mud

Drilling mud (or “drilling fluid”) is a substance used to control subsurface pressures, lubricate the drill bit, stabilize the wellbore, and carry cuttings to the surface.¹⁷⁶ It can be water based, oil based, or synthetic oil based.¹⁷⁷ Water-based muds are relatively benign and can be disposed of on site. However, operators often favor oil-based muds for horizontal drilling, which is common in shale gas extraction.¹⁷⁸ Oil-based muds contain diesel, mineral oil, or synthetic alternatives that can contaminate the local environment.¹⁷⁹ Generally, operators either bury cuttings on site, send them to a commercial disposal facility, or remove drill mud and sell the cuttings for road spreading, as fill material, to cover landfills, or as an aggregate or filler in concrete, brick, or block manufacturing.¹⁸⁰

Horizontal wells generally produce 40% more cuttings than vertical gas wells, creating more waste to store, transport, treat, and dispose of safely.¹⁸¹ If handled improperly, heavy metals and other components of drill mud and cuttings can leach into groundwater or have adverse impacts on soil.¹⁸² Drill cuttings can also contain materials that lead to acid rock drainage (highly acidic water laden with heavy metals, such as pyrite).¹⁸³

The components of drill cuttings that would be brought to the surface if shale gas extraction takes place in North Carolina are unknown. Data collection prior to the establishment of a regulatory program could help inform the levels of protection needed for handling and disposal of these cuttings.

1. Experiences in other states

At a storage site for shale drill cuttings in Clearfield County, Pennsylvania, a pit liner tore and allowed leachate into the groundwater. The leachate contaminated a nearby spring, where tests found levels of barium four times above those considered safe for drinking water.¹⁸⁴

2. Overview of regulatory action

Drilling muds and other wastes associated with the exploration, development, or production of crude oil or natural gas are exempt from federal regulation under the federal Resource Conservation and Recovery Act, which sets standards for the storage, transportation, treatment, and disposal of hazardous wastes.¹⁸⁵ States with oil and gas drilling typically regulate the types of pits and tanks that operators can use to store drill cuttings and mud as well as the options for disposal or reuse.

In response to increased volumes of drill mud and cuttings, some states are revisiting their regulations related to this waste stream. West Virginia Governor Earl Ray Tomblin recently called for emergency

regulations, including a requirement that operators dispose of drill cuttings and mud off site in an approved facility or on site in an approved manner.¹⁸⁶ The New York DEC's proposed regulations require oil-based muds to be managed in closed-loop tank systems and disposed of off site. The proposed regulations would also require plans to mitigate acid rock drainage by, for example, adding carbonate such as limestone to drill cuttings to neutralize any acid that can leach into water along with heavy metals.¹⁸⁷

Although the EPA does not regulate hazardous waste that results from the exploration or production of natural gas, it has issued a list of suggested management practices for drill cuttings and mud.¹⁸⁸

C. Spill Response Planning and Liability

Drilling carries the risk of widespread damage to natural resources and, with it, the question of who is responsible if damage occurs. At the federal level, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes cleanup standards and liability for hazardous waste contamination.¹⁸⁹ However, CERCLA expressly excludes petroleum and natural gas.¹⁹⁰ As a result, state regulators face the task of assigning financial and cleanup responsibility.

1. Experiences in other states

State agencies have the authority to levy fines on operators for violations of permitting requirements or regulations as a means of mitigating the cost when accidents occur. On May 17, 2011, the Pennsylvania Department of Environmental Protection fined Chesapeake Energy \$1,088,000 for violations related to natural gas drilling activities.¹⁹¹ In August 2004, Colorado's Oil and Gas Conservation Commission (COGCC) fined Encana Oil and Gas \$371,200 for violations of well-cementing requirements that resulted in water contamination.¹⁹² In addition to retroactive actions, many states have, or are beginning to develop, a more proactive approach to spill response and liability.

2. Overview of regulatory action

- Spill response or contingency plans: States often require operators to submit spill response or contingency plans at some stage of the permitting process to ensure that the operator is ready to respond if an incident occurs.¹⁹³ Some states are using them as a tool to address new risks from shale gas production. For example, Pennsylvania requires that operators submit preparedness, prevention, and contingency (PPC) plans before drilling and operating oil and gas wells or brine disposal wells and before road spreading of oil and gas waste.¹⁹⁴ In one instance, regulators ordered Cabot Oil and Gas Corporation to shut down operations following three separate spills that occurred in less than one week, and they mandated that the company conduct an engineering study to update its PPC plan before resuming operations.¹⁹⁵
- Bonding requirements: States that allow natural gas drilling typically demand bonds, paid at the time of permitting, from well operators to cover the cost of cleanup in case the well is not plugged or the site is not properly reclaimed.¹⁹⁶ Bonding requirements typically vary by the depth of a well. Pennsylvania and the Delaware River Basin Commission are considering raising bond requirements for wells that are hydraulically fractured.¹⁹⁷
- Strict liability: Plaintiffs have recently brought suit in Arkansas, Louisiana, and Pennsylvania alleging that various aspects of hydraulic fracturing constitute an "ultrahazardous activity" to which strict liability (i.e., liability regardless of whether the defendant is negligent) should apply.¹⁹⁸ Some states, such as Texas, have determined that the storage of produced fluid for underground injection does not constitute an ultrahazardous activity.¹⁹⁹ Other states, such as New York, are currently considering application of strict liability to natural gas drilling.²⁰⁰
- Anti-indemnity acts: Several states, including Louisiana, New Mexico, Texas, and Wyoming, passed nearly identical oilfield anti-indemnity acts to limit the ability of well operators to protect themselves against liability when their negligence is the sole cause of harm.²⁰¹ These laws ensure

that contractors do not sign agreements that leave them without legal recourse if injured by the negligence of the company operating the well on which they work.

- Presumptive liability: As noted above, states such as Michigan, Pennsylvania, and West Virginia have established presumptions of liability when water contamination occurs within a specified distance of an oil or gas well. Holding drilling companies responsible for nearby contamination if they cannot prove otherwise can create an incentive for them to invest in pre-testing and to protect landowners when drilling damages water supplies.

North Carolina's Session Law 2011-276, which became law in June 2011, includes several provisions that affect how liability will be managed if shale gas drilling is allowed in North Carolina.²⁰² Section 113-378 sets a bond requirement of \$5,000 plus \$1 per linear foot of the well. The shale formations in Lee County are estimated at a depth of 2,400 to 3,800 feet, meaning bonds would range from \$7,400 to \$8,800 plus an additional \$1 for each foot drilled laterally. Section 113-421 requires oil and gas developers to compensate landowners for harm to their water supply or damage to their property due to the operators' activity.

CONCLUSION

Because North Carolina has no active oil and gas production and no existing regulatory framework for this industry, it has a unique opportunity to build a program from the ground up. State oil and gas regulatory programs have not kept pace with the rapid expansion of shale gas extraction, and the issues that other states have encountered while bringing their policy up to date can provide valuable insight for North Carolina. Specifically, as North Carolina lawmakers consider whether and under what conditions to allow shale gas extraction, they can learn from the policy decisions that other states have made regarding collecting baseline information, funding regulatory programs, and addressing water and air quality issues, water supply, impacts on municipalities, and liability concerns. Although these experiences can help inform the policymaking process, industry practices and regulatory approaches are rapidly evolving, and regional variation in the geology of shale deposits is high. North Carolina's elected officials and regulators will need to evaluate these experiences as well as recommendations of stakeholder groups carefully as they evaluate their policy options.

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²⁰⁰ New York Comptroller Thomas P. DiNapoli recently announced that he will propose an industry-supported fund to remediate contamination and recover damages caused by accidents related to natural gas drilling. DiNapoli's plan would impose a surcharge on drilling permits to establish a Natural Gas Damage Recovery Fund, empower the DEC to order immediate cleanup or take over sites for cleanup, require natural gas operators to post surety bonds to cover any difference between Fund resources and cleanup costs, and apply strict liability to natural gas drilling.

²⁰¹ Redfearn, R. (2005, August 22). Oilfield anti-indemnity acts and their impact on insurance coverage: a comparative analysis. *Insurance Journal*.

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