Executive Summary

Background

In Session Law 2011-276, the North Carolina General Assembly directed the North Carolina Department of Environment and Natural Resources (DENR), the Department of Commerce (Commerce), and the Department of Justice, in conjunction with the nonprofit Rural Advancement Foundation International (RAFI), to study the issue of oil and gas exploration in the state and specifically the use of directional and horizontal drilling and hydraulic fracturing for natural gas production.

DENR researched oil and gas resources present in the Triassic Basins (Section 1 of this report), methods of exploration and extraction of oil and gas (Section 2), potential impacts on infrastructure, including roads, pipelines and water and wastewater services (Section 3), potential environmental and health impacts (Section 4), potential social impacts (Section 6), and potential oversight and administrative issues associated with an oil and gas regulatory program (Section 7).

S.L. 2011-276 directed the Department of Commerce, in consultation with DENR, to gather information on potential economic impacts of natural gas exploration and development (Section 5 of this report). Department of Commerce prepared Sections 5.A through 5.F of the report that discuss job creation and other projected economic impacts of natural gas drilling. DENR prepared Sections 5.G though 5.N that address the different financial tools (such as bonding requirements and severance taxes) used by oil and gas producing states to assure funding for reclamation of drilling sites, cover regulatory costs and offset public infrastructure costs.

The law directed the Consumer Protection Division of the Department of Justice to study consumer protection and legal issues relevant to oil and gas exploration in the state, including matters of contract and property law, mineral leases and landowner rights. The Consumer Protection Division was directed to consult with RAFI on the consumer protection issues. The Department of Justice did not provide this section to DENR, and it is therefore not included in this report; the Department of Justice will release the consumer protection section separately.

Study Limitations

As requested by the General Assembly, this report analyzes the potential environmental, health, economic, social and consumer protection impacts that an oil and gas extraction industry may have in North Carolina. The analysis is constrained by the limited information available at this time. We do not have detailed or comprehensive information on the extent and richness of the shale gas resource in North Carolina. For purposes of this report we have been forced to extrapolate from data gathered from only two wells in the Sanford sub-basin; those well values have been averaged to project an estimate of the natural gas resource potentially available in that sub-basin. Since there are only two data points and the two wells have significantly different values, it is not clear how well the average value represents the resource throughout the Sanford sub-basin. This report generally uses the Sanford sub-basin as the basic unit for analysis of all impacts because the available data came from that sub-basin.

The Sanford sub-basin represents only a fraction of the total Triassic basin formations in the state – approximately 59,000 acres out of a total of 785,000 acres.

These limitations carry over into the assessment of both potential economic and environmental impacts. DENR projected the number of wells and total gas production *for the Sanford sub-basin,* using the limited data derived from averaging the values of two wells. Those projections are used throughout the report as the basis for assessing economic and environmental impacts.

Many impacts of natural gas extraction will vary based on local characteristics, such as water resources and even the weather. For example, the depth and quality of groundwater resources in the Triassic basins of North Carolina appear to be very different from conditions in the Marcellus shale formations in Pennsylvania. North Carolina does not seem to have as great a separation between potential drinking water resources and the gas-producing zone; understanding the geology and groundwater hydrology of North Carolina's shale formations will be critical to ensuring protection of drinkable groundwater. In terms of infrastructure impacts, weather can be an important factor. A local government official in Pennsylvania told DENR staff that when the natural gas industry first came to Pennsylvania from the South, oil and gas operators were surprised at how the harshness of the winters magnified the road damage caused by heavy oil and gas trucks.

There are some aspects of oil and natural gas extraction for which data is extremely limited even at a national level; the limited time available to prepare this report prevented us from taking into account additional research that is currently underway. This includes EPA's research on potential groundwater impacts in Pavillion, Wyo., and Dimock, Pa., and EPA's study of hydraulic fracturing and its potential impact on drinking water resources. EPA's first report of results related to drinking water is expected in 2012; the final report is not expected until 2014.

To our knowledge, no comprehensive studies are currently available on the long-term impacts to health from hydraulic fracturing for natural gas, and DENR is not qualified to conduct such a study. DENR recognizes that questions remain about health impacts. The EPA drinking water study may provide additional insight on health effects.

Key Findings

North Carolina's potential shale gas resource

Most of the N.C. Geological Survey's information on potential shale gas resources in the state comes from the Sanford sub-basin of the Deep River geologic basin — a 150-mile-long area that runs from Granville County southwestward across Durham, Orange, Wake, Chatham, Lee, Moore, Montgomery, Richmond, Anson and Union counties into South Carolina.

The Deep River Basin is one of several similar geologic formations in North Carolina that cover approximately 785,000 acres.

The available organic geochemical and seismic data has caused NCGS to focus on an area of more than 59,000 acres in the Sanford sub-basin as the most promising location for organic-rich shale and coals from which natural gas can be extracted.

The shale formation in this area can be found at depths generally ranging between 2,100 and 6,000 feet below the surface. This particular shale formation has a maximum thickness of 800 feet and an average thickness that ranges from 180 to 540 feet.

Hydraulic Fracturing

Natural gas extraction by hydraulic fracturing involves drilling a well vertically and then horizontally into the shale formation. The natural gas production company perforates the well and then pumps fracturing fluid into the well under pressure to fracture the shale.

Fracturing fluids may be composed primarily of water and a proppant (such as sand) to keep the fractures open. Water and sand represent between 98 percent and 99.5 percent of the fracturing fluid. The fluid also includes chemical additives used to condition the water. Additives may be used to thicken or thin the fluid, prevent corrosion of the well casing, kill bacteria or for other purposes.

The exact makeup of fracturing fluid varies from company to company and may also be adjusted based on conditions at the individual well site. Several hundred chemical compounds have been identified by the industry as chemicals that have been used in fracturing fluid. Any single fracturing fluid generally contains between 6 and 12 chemical additives.

Some chemicals that have been used in fracturing fluids, such as diesel fuel, have raised concern because of potential health impacts. EPA has discouraged use of diesel fuel in hydraulic fracturing.

Environmental Impacts

Water Supply: Hydraulic fracturing requires between 3 and 5 million gallons of water per well. To put this in perspective, a number of small cities in North Carolina withdraw 5 million gallons per day to serve their water system customers.

Based on some informed assumptions about the number of wells that could potentially be located in the Sanford sub-basin and the pace of well development, there appear to be adequate surface water supplies to meet the needs of the industry.

The timing of water withdrawals will need to be managed, however, to avoid injury to other water users and the environment. Under existing state law, water withdrawals do not require a state permit except in the Central Coastal Plain Capacity Use Area where a permitting program exists to manage withdrawals from two depleted aquifers. The Capacity Use Area permitting program does not overlap with any part of the shale formation. As a result, the state currently has no ability to ensure that groundwater or surface water withdrawals for natural gas development will be appropriately managed to avoid stream impacts and conflicts with other water users. A 3 million gallon withdrawal made over a three-day period (which is technically possible for the industry) has a much greater potential impact than a 3 million gallon withdrawal made over the course of three weeks. In the absence of permit conditions to prevent rapid withdrawals, streams could run dry and other water users may be harmed.

Water Quality: In the Sanford sub-basin, there appears to be much less separation between groundwater used for drinking water and the gas-producing layer than in other gas-producing states. Water supply wells of up to 1,000 feet deep have been found in North Carolina's Triassic

Basins and the depth to which freshwater extends is unknown. Some of the shale that might be tapped for natural gas in the Triassic Basins of North Carolina lies at depths of 3,000 feet or less. (By contrast, the Pennsylvania shale gas resource lies at depths of roughly 10,000 feet or more and the deepest water supply wells are generally no more than 600 feet deep.)

At least two recent studies have found higher levels of methane in groundwater near natural gas wells that had been hydraulically fractured. In Pavillion, Wyo., EPA found methane of thermogenic origin and organic chemicals consistent with those used in hydraulic fracturing fluids in both monitoring wells and water supply wells. Conditions in Pavillion are not necessarily representative of most shale plays, however; the hydraulic fracturing that occurred in Pavillion involved injection of hydraulic fracturing fluids directly into the same formation tapped by water supply wells.

A study in Pennsylvania found that water supply wells close to active exploration and production wells in the Marcellus shale have higher levels of dissolved methane than wells farther away. The study did not find constituents of hydraulic fracturing fluids in any of the water supply wells that were sampled. The study did find methane in water supply wells. The methane had an isotopic signature indicating that it originated from deep, thermogenic sources consistent with a Marcellus shale source, rather than from shallow biogenic sources. The lack of pre-drilling groundwater samples make it difficult to definitively link the methane to drilling practices.

Water quality problems have been associated with oil and gas operations generally; the problems can result from a number of production activities other than hydraulic fracturing. A Groundwater Protection Council study found that most Texas groundwater contamination incidents related to oil and gas activity reviewed were traced to either the production phase of well operations or involved waste management and disposal.

Oil and gas exploration and production can disturb large areas of land to develop access roads, well pads, impoundments and other infrastructure. These activities have impacts very similar to the stormwater impacts of any large development project: sedimentation and erosion, water pollution, increased peak discharges, increased frequency and severity of flooding, and other stormwater concerns. Unlike other construction projects, oil and gas exploration and production activities are exempt from federal Clean Water Act stormwater requirements.

Air Quality: Federal Clean Air Act standards have only been adopted for natural gas processing facilities. In 2011, EPA developed draft standards for air emissions from natural gas exploration and production activities. As proposed, the rules would affect gas wellheads, centrifugal compressors, reciprocating compressors, pneumatic controllers, storage vessels and sweetening units. Until the proposed rules go into effect, no federal new source performance standards or hazardous air pollution standards apply to emissions from these natural gas exploration and production activities. EPA finalized the rules on April 17, 2012, but industry is not required to implement all of the provisions of the rules until 2015.

A recent New York Environmental Impact Statement estimated that statewide NOx emissions could be increased by 3.7 percent from hydraulic fracturing operations and as much as 10.4 percent in the upstate New York area where the Marcellus Shale is located. These increases in

NOx emissions raise concerns for the impact on ozone concentrations and the state's ability to attain and maintain compliance with the federal ozone standard.

The state air toxics program requires a source of state-regulated toxic air pollutants to demonstrate compliance with the ambient air levels at the property boundary. Shale gas production often occurs under a lease of property that may be owned and in some cases occupied by another person. If natural gas production occurs on a residential property or farm, the property owner or occupant may be exposed to unhealthy concentrations of toxic pollutants.

Earthquakes: Hydraulic fracturing fluid under pressure cracks the surrounding rock; these cracks generate vibrations while breaking that can be picked up by sensitive geophones.

Data from other states suggests that the process of hydraulic fracturing causes microseismic events that do not pose a threat to the environment or human health or safety. An Oklahoma Geologic Survey study of an earthquake complaint near a hydraulic fracturing operation found that seismographs had recorded as many as 50 very small events on the day of the complaint. Most of the earthquakes occurred within a 24-hour period after the hydraulic fracturing operations had ceased and were so minor (between 1 and 2.4 on the Richter scale) that they could not be felt.

Most reports of significantly increased earthquake activity have occurred in regions where disposal wells are operated and related to underground injection of waste rather than hydraulic fracturing. Only a small fraction of injection wells have caused significant seismic activity. Limiting injection volumes, decreasing pressure and distributing the waste between more disposal wells have been shown to reduce and even eliminate induced seismicity, while reusing and recycling of wastewater can reduce the need for other waste management options.

Wastewater and Solid Waste: Between 9 and 35 percent of the fluid pumped into a well for hydraulic fracturing returns to the surface as "flowback" shortly after fracturing. During the remainder of the productive life of the well, a much smaller volume of wastewater is generated more or less continuously as the well produces gas; this wastewater is produced water.

In many states, flowback or produced water from a drilling operation can be disposed of by underground injection. N.C. General Statute 143-214.2(b) prohibits the use of wells for waste disposal.

It is not clear that injection wells would be a feasible option for managing produced waters from a gas well in the Triassic Basins of North Carolina. The areas with potential for natural gas development have not been sufficiently characterized to determine whether the formations would be suitable for disposal of shale gas production wastewater. The sedimentary rocks of these basins generally have very low permeability, and natural fractures are responsible for nearly all of the permeability and groundwater movement in these basins. Disposal by injection into fractured rock presents difficulty in predicting the fate and transport of the injected wastewaters. These conditions suggest that Triassic Basins in North Carolina generally do not have suitable hydrogeologic conditions for disposal by injection.

Some wastewater streams can go to a municipal wastewater treatment plant. These waste streams can be difficult to treat in a conventional wastewater treatment plant, however, and it would be advisable to require pretreatment.

A number of states allow land-application of produced water from hydraulic fracturing. The acceptability of wastewater for that purpose may depend on its quality at the time of land application since high levels of salts and chlorides can be a problem.

Chesapeake Energy is currently recycling and reusing 95 percent of the flowback water that returns to the surface (only a small percentage of the volume of water used in hydraulic fracturing) by a filtering process.

EPA has exempted "drilling fluids, produced waters, and other wastes associated with the exploration, development or production of crude oil, natural gas or geothermal energy" from regulation under the Resource Conservation and Recovery Act (RCRA) -- the federal statute that regulates hazardous waste.

Since some exploration and production wastes may have the characteristics of hazardous wastes, but are not regulated under RCRA, oil and gas-producing states have generally developed specific standards for handling exploration and production wastes. North Carolina does not have standards that specifically address disposal of or transportation of exploration and production waste.

Since North Carolina statutes and rules have not been written to address these particular types of wastes, existing state rules would allow disposal of all RCRA-exempt exploration and production wastes (other than oils and liquid hydrocarbons) in a municipal solid waste (MSW) landfill. Although North Carolina has strong standards for design and construction of both industrial and MSW landfills, those standards were not developed for disposal of hazardous waste.

Economic Analysis

The economic impact analysis focuses on the statewide economic impact of gas drilling activities in the Sanford sub-basin. (The Sanford sub-basin is approximately 59,000 acres of the 785,000 acres of the Triassic Basins in North Carolina.) The analysis does not take site preparation, leasing of land, hydraulic fracturing or extraction, production or transmission of gas into consideration.

Review of studies from other parts of the country show that a large infusion of economic activity from shale gas drilling will increase the incomes of some individuals and communities and will add jobs. Without reliable expenditure inputs for North Carolina, however, it remains uncertain how much wealth, income or benefits from long-term employment would accrue to Lee, Chatham and surrounding counties.

For its analysis, the Department of Commerce used the IMPLAN modeling tool. IMPLAN allows researchers to develop local level input-output models to estimate the economic impacts associated with marginal changes in the economy, such as "shocks" of new production or output.

The model estimates that 36 percent of drilling investments will be spent locally with North Carolina vendors. Since North Carolina does not presently have a developed fossil fuel extraction industry, there will likely be substantial economic "leakages" as dollars are spent outside the North Carolina economy. For example, drilling requires specialized equipment that is not available from in-state companies.

The IMPLAN model estimates drilling activities in the Sanford sub-basin would sustain an average of 387 jobs per annum over the seven-year time period studied:

- In the peak well year, drilling activities are estimated to sustain 858 jobs over a one-year period.
- In Year 1, the year with the lowest level of drilling expenditures, the IMPLAN model estimates that 59 jobs will be either created or partially supported by these expenditures.

At the completion of all drilling activities in the state, it is estimated the economy will have increased output by $453 million. Output represents the level of all economic activity from production and is typically larger than value added impacts, which measure the direct change in North Carolina's gross domestic product (GDP). Anticipated drilling activities are estimated to positively affect the state's GDP by $292 million by year 2019.

It is not likely that North Carolina's shale play will be developed in the near-term. IHS Global Insight, in a December 2011 study for the American Natural Gas Alliance, reported that six prominent plays are expected to account for more than 90 percent of U.S. shale capacity by 2035. North Carolina was not on this list and, at this time, does not appear on U.S. Geological Survey maps of North American shale plays.

Low natural gas prices also make activity in North Carolina unlikely in the near-term. The Energy Information Administration's preliminary 2012 *Annual Energy Outlook* assumes that with increased production, average annual wellhead prices for natural gas will remain below $5 per thousand cubic feet (2010 dollars) through 2023. Low prices make it less likely that the industry will move from areas already in production to a new and unproven area.

Bonding: North Carolina Session Law 2011-276 revised the amount of the bond required for an oil and gas-drilling permit to $5,000 plus $1 per linear foot. Under North Carolina's law, the bond only covers proper closure and abandonment of the well. The bond does not cover the costs of restoring the surface of the site to pre-existing conditions or remediation of any contamination caused by the drilling operation.

States vary significantly in the amount of bond required per well, but typically the uses of those bonds extend beyond well closure and often cover site reclamation.

As one measure of the adequacy of bond requirements for wells on public lands, the General Accounting Office (GAO) looked at the cost to the Bureau of Land Management of reclaiming orphan wells. Over a 21-year period, BLM spent about $3.8 million to reclaim 295 orphaned wells, or an average of about $12,900 per well. The GAO report states that "the amount spent per reclamation project varied greatly, from a high of $582,829 for a single well in Wyoming in fiscal year 2008 to a low of $300 for 3 wells in Wyoming in fiscal year 1994." The BLM also

estimated the costs of wells it has yet to reclaim at approximately $1.7 million for 102 orphaned wells, an average of roughly $16,700 per well.

Severance Taxes: North Carolina's Oil and Gas Conservation Act currently sets the state's severance tax for natural gas at 5/100 of a cent – $.0005 per 1,000 cubic feet of gas. The revenues can only be used to pay the costs of administering the law.

North Carolina has one of the lowest severance taxes in the nation. With the exception of those states that do not assess any severance tax, North Carolina's tax rate was the lowest of all states for which severance taxes were identified as part of this study. Maryland, New York and Pennsylvania do not assess severance taxes on the production of natural gas, however, Pennsylvania recently enacted a law imposing an "impact fee" on natural gas production, and New York assesses a "property type production tax" on the amount of natural gas produced.

Community, Infrastructure and Social Impacts

In Pennsylvania, road impacts have been a major problem for municipalities in the Marcellus shale region. Gas development significantly increases truck traffic on roads that often were not designed for such heavy use. For many of Pennsylvania's small towns, road maintenance and repair accounts for the largest part of the town budget.

New York's EIS estimated 1,148 one-way heavy-duty truck trips and 831 one-way light-duty truck trips per well during the construction phase of gas development. For early well pad development, this is a total of 2,296 round-trip heavy-duty truck trips and 1,662 round-trip light-duty truck trips per well for all truck traffic needs; these figures assume that all water is transported by truck rather than by pipeline.

In some states, natural gas production companies have entered into road maintenance agreements with local government – committing to return the roads to good condition.

Pennsylvania recently enacted a local option impact assessment to provide additional revenue to counties and towns affected by drilling activity.

Significant increases in truck traffic can lead to an increase in accidents and increased demand for traffic control. Both place additional demand on police and other emergency services. Given the volume and nature of the liquids being transported, accident response can be both more complex and more time-consuming than a typical one- or two-car accident.

Spills of hazardous chemicals require labor- and time-intensive responses from law enforcement and environmental agencies. In regions unaccustomed to oil and gas activity, the specialized nature of the response required for spills, explosions or fires related to the industry might necessitate new equipment, training and staff. This can place a special strain on rural areas still served by volunteer fire and rescue services.

As drilling activity has increased in certain parts of the United States, rural areas and small towns have, in some cases, been overwhelmed by the demand for worker housing. The impact of gas production on housing costs and availability likely depends on three key factors: 1) the speed and scale of industry growth in a given community; 2) the existing housing capacity of a

community before drilling begins; and 3) the industry's need to import workers skilled in gas production activities.

Property owners who control the mineral rights to economically recoverable gas resources under their land may see substantial increases in property values. Analysis claimed that the taxable value of oil and gas properties in Texas' Barnett shale region increased from $341 million to $5.9 billion, a 1,730 percent increase, from 2000-2005. Other studies of property values have generally shown much more modest increases.

Increased value can be attributed to two financial benefits to property owners: bonuses upon signing an oil and gas lease agreement and royalty payments. Lease agreements can range anywhere from $5 per acre to $20,000 per acre. On properties where lease agreements have not been signed, potential buyers may factor an expected bonus payment into the value of the property. Mineral owners receive royalties on income from gas production, typically earning 12.5 percent to 20 percent of the gas revenue generated at their wellhead.

Regulatory Program

The fact that oil and gas production activities are exempt from a number of federal environmental statutes that otherwise apply to industrial activities places a special burden on oil and gas-producing states to create adequate state regulatory programs.

Storage and disposal of oil and gas wastes have been exempted from federal hazardous waste regulation, specifically to allow states to develop tailored programs for management of those wastes. Congress has also deferred to the states to regulate stormwater runoff from drilling sites, exempting those sites from Clean Water Act permitting requirements for construction stormwater and industrial stormwater discharges.

States that have a long history of oil and gas production typically have very detailed regulations for well siting, well construction, wastewater disposal, storage and disposal of solid wastes, and water use. Since North Carolina does not have an active oil and gas industry, the state does not have standards appropriate for the special nature of these activities and the waste products generated in the process.

Guidelines for state oil and gas regulatory programs developed by the State Review of Oil and Natural Gas Environmental Regulations (STRONGER) recommend:

- Standards for casing and cementing sufficient to handle highly pressurized injection of fluids into a well for purposes of fracturing bedrock and extracting gas.
- Rules requiring the driller to identify potential conduits for fluid migration; address management of the extent of fracturing; and identify actions to be taken in response to operational or mechanical problems.
- Standards for dikes, pits and tanks, including contingency planning and spill risk management procedures.
- Waste characterization, including testing of fracturing fluids. Waste should be tracked to ensure appropriate disposal.

- Prior notification of fracturing activity.
- Assessment of water use for hydraulic fracturing in terms of volume in light of water supply, competing water uses and the environmental impacts of withdrawing water for fracturing. Use of alternative water sources and recycling of water should be encouraged.

Recommendations for siting standards, such as setbacks from streams, wetlands and floodplains, can be found in the New York Department of Environmental Control EIS and in recent legislation enacted in Pennsylvania.

In the last three years, a number of states have moved to require disclosure of the chemicals used in hydraulic fracturing fluids to state regulatory and emergency response agencies. Several states have also required disclosure to the public with appropriate safeguards for proprietary information.

Oil and gas producing states have also found it necessary to address the issue of local authority to regulate natural gas production activities. Several states that have comprehensive state oil and gas regulatory programs continue to allow local governments to exercise some degree of planning and zoning authority with respect to production activities.

Conclusions and Recommendations

After reviewing other studies and experiences in oil and gas-producing states, DENR has concluded that information available to date suggests that production of natural gas by means of hydraulic fracturing can be done safely as long as the right protections are in place. Production of natural gas by means of hydraulic fracturing can only be done safely in North Carolina if the state adopts adequate safeguards in the form of regulatory standards specifically adapted to conditions in the state and invests sufficient resources in compliance and enforcement. Development of appropriate standards will require additional information on North Carolina's geology and hydrogeology to identify conditions under which hydraulic fracturing can be done without putting the state's water resources at risk. The ban on hydraulic fracturing and horizontal drilling should remain in effect until both standards and a strong compliance and enforcement program are in place. Both of these are needed before issuing permits for hydraulic fracturing in North Carolina's shale formations. A number of states have experienced problems associated with natural gas exploration and development because the appropriate measures were not in place from the beginning – forcing both the state and the industry to react after damage had already been done.

DENR has identified a number of immediate recommendations for management of natural gas exploration and development activities. A complete oil and gas permitting program will require more detailed standards than it is possible to provide in this report and those standards should be based on conditions in North Carolina. Conditions in the Triassic Basins of North Carolina are not identical to those found in Pennsylvania or other gas-producing states. For example, a better understanding of the depth of usable groundwater in the Triassic Basin will be necessary to set well construction standards that will adequately protect drinking water resources.

Based on the research and analysis in this report, the Department of Environment and Natural Resources, in consultation with the Department of Commerce, developed the following recommendations for the General Assembly. These recommendations have been revised based on public comment. It should be noted that these recommendations do not take into account information from the Department of Justice's section on consumer protection, because DENR had not received that section of the report in time for preparation of the recommendations.

A brief description of each recommendation is listed; a more detailed explanation of each recommendation is included in Section 9. The recommendations are organized by subject matter but are not listed in order of priority.

Funding recommendations

1. **Provide funding for any continued work on the development of a North Carolina regulatory program for the natural gas industry.**
2. **Address the distribution of revenues from oil and gas excise taxes and fees to support the oil and gas regulatory program, fund environmental initiatives, and support local governments impacted by the industry.**

Water and air quality recommendations

3. **Collect baseline environmental quality data including groundwater, surface water and air quality information.**
4. **Require oil and gas operators to operate in compliance with a DENR-approved Water and Wastewater Management Plan. The Water Management Plan should limit water withdrawals to 20 percent of the 7Q10 stream flow and prohibit withdrawals during times of drought and periods of low flows.**
5. **Develop a state stormwater regulatory program for oil and gas drilling sites.**

Hydraulic fracturing fluids recommendations

6. **Require full disclosure of all hydraulic fracturing chemicals and constituents to regulatory agencies and to local government emergency response officials prior to drilling. The state should encourage the industry to fully disclose that same information to the public and require public disclosure of hydraulic fracturing chemicals and constituents with the exception of trade secrets already protected under state law.**
7. **Prohibit the use of diesel fuel in hydraulic fracturing fluids**

Waste management standards

8. **Develop specific transportation, storage and disposal standards for management of oil and gas wastes.**

Regulatory program recommendations

9. **Develop a modern oil and gas regulatory program, taking into consideration the processes involved in hydraulic fracturing and horizontal drilling technologies, and long-term prevention of physical or economic waste in developing oil and gas resources.**
10. **Enhance existing oil and gas well construction standards to address the additional pressures of horizontal drilling and hydraulic fracturing.**
11. **Develop setback requirements and identify areas (such as floodplains) where oil and gas exploration and production activities should be prohibited.**
12. **Close the gaps in regulatory authority over the siting, construction and operation of gathering pipelines**
13. **Identify a source of funding for repair of roads damaged by truck traffic and heavy equipment.**

Permitting recommendations

14. **Keep the environmental permitting program for oil and gas activities in DENR where it will benefit from the expertise of state geological staff and the ability to coordinate air, land and water permitting.**
15. **Develop a coordinated permitting process.**

Data management recommendations

16. **Improve data management capabilities and develop an e-permitting program that is easily accessible by the public**

Emergency response recommendations

17. **Ensure that state agencies, local first responders and industry are prepared to respond to a well blowout, chemical spill or other emergency.**

Local government authority recommendations

18. **Clarify the extent of local government regulatory authority over oil and gas exploration and production activities.**

Address liability

19. **Address the natural gas industry's liability for environmental contamination caused by exploration and development, particularly for groundwater contamination.**

Public participation

20. Provide additional opportunities for the public to participate in development of detailed standards to govern gas exploration and development.

Additional research recommendations

21. Complete additional research on impacts to local governments and local infrastructure.

22. Complete additional research on potential economic impacts.

23. Complete additional research on closed-loop systems and the potential for prohibiting open wastewater pits.

24. Complete additional research on the ability of the air toxics program to protect landowners who lease their land for natural gas extraction and production activities.

25. Complete additional research on air emissions from hydraulic fracturing operations.

26. Complete additional research on the shale gas resource.

27. Complete additional research on groundwater resources in the Triassic Basins.