Oil and Gas Development in the EVGMA

A Comparison of Virginia Legislation and Regulations with Several Other States

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Executive Summary

Renewed interest in extracting gas from shale formations in the Taylorsville Basin, which is within the Eastern Virginia Groundwater Management Area, has prompted the Commonwealth of Virginia to analyze its existing regulations. Shale Exploration and Production Corporation has secured over 80,000 acres in land leases to attempt to extract some of the trillion cubic feet of gas within the formation. The Virginia Department of Environmental Quality and Department of Mines, Minerals and Energy are collaborating to review the environmental impacts of permitting for oil and gas drilling in this area.

Approximately one dozen exploratory wells were drilled in the Taylorsville Basin from 1917 to 1992, but these were all plugged due to the absence of commercially viable flows of gas. Technological advances in oil and gas development, including hydraulic fracturing and the accompanying horizontal drilling, could potentially result in commercially viable flows of gas from the formation.

This report, on behalf of Mr. Joe Nash and the Thomas Jefferson Program in Public Policy at the College of William & Mary:

- Examines Virginia's existing laws and regulations that may apply to hydraulic fracturing in the Eastern Virginia Groundwater Management Area
- Compares these laws and regulations to those of California, Colorado, Illinois, and Pennsylvania
- Provides a legislative proposal for Virginia to attain a regulatory framework that emulates what we have identified as best practices

To identify the model of best practices, we determined several criteria by which to compare the states to one another. We selected requirements for disclosure, waste management, drilling, casing, cementing, air emissions, reclamation, and oversight and inspection. The five states in our analysis were ranked from one to five, from least to most stringent. Our analysis indicated Colorado and Illinois as the states with the most stringent laws and regulations with respect to our criteria.

Our proposal, detailed in the body of the report, calls for Virginia to regulate various aspects to ensure oversight, as well as public and environmental health and safety.

II. Introduction

A company based in Dallas, Texas has secured over 80,000 acres of leased land for exploratory drilling in the Taylorsville Basin region of the Eastern Virginia Groundwater Management Area. Before this drilling begins, the Virginia Department of Environmental Quality and Department of Mines, Minerals, and Energy, the two departments primarily in charge of oil and gas regulations, are coordinating to review environmental impacts of permits for oil and gas drilling. We analyze how Virginia's existing laws and regulations may apply to hydraulic fracturing in the Taylorsville Basin shale, and compare those regulations to other states. Our team has researched a variety of states and regulations to identify the best model of practices, and have developed a legislative outline that will serve as recommendations for Virginia.

Projections suggest hydraulic fracturing will account for over 75 percent of gas development in the future, making it crucial that a proper regulatory framework is in place in Virginia.[1] Virginia should take steps to ensure that hydraulic fracturing can be done in the eastern half of the state without damage to its numerous financial resources and water-dependent activities.

This report describes the methodology employed in our research, gives a primer on the history and process of hydraulic fracturing, and analyzes oil and gas development regulations from many states.

[1] API, Hydraulic Fracturing Primer, http://www.api.org/~/media/files/oil-and-natural-gas/hydraulic-fracturing-primer/hydraulic-fracturing-primer-2014-highres.pdf

III. Methodology

We compared four states in addition to Virginia in terms of regulation and policy: California, Colorado, Illinois, and Pennsylvania. We selected Pennsylvania, Illinois, and Colorado because of how their regulatory frameworks were implemented--through legislation. Colorado is also included because, like Virginia, hydraulic fracturing is overseen by state agencies. Our comparison focuses on state regulations; due to the federal environmental regulations that were enacted in 2005, the states were delegated responsibility for hydraulic fracturing regulations.

The four comparison states have existing laws regulating hydraulic fracturing that provide oversight through state administrative agencies. The states differ in how comprehensive of an approach is given to these regulations. While the four states provide oversight in some capacity, some states provide oversight in a more fragmented approach. In particular, regulations related to hydraulic fracturing in California are governed by more than four offices. Our regulatory comparison focused on the environmental factors related to hydraulic fracturing and not related property issues.

Next, we identify what criteria were necessary to formulate a best model of practices for regulations. We consulted several federal reports, namely from the Government Accountability Office (GAO) and the Environmental Protection Agency (EPA). We also verified our selections and were advised on additions through key conversations with policy analysts, state employees, and experts in the subject. We chose several broad categories by which we identified our best model: well placement,

chemical disclosure, site reclamation, well plugging, waste management, air emissions, drilling, and oversight and inspection.

Per a discussion with a policy analyst at the National Conference of State Legislatures (NCSL), an organization that conducts policy analysis and research and advises state legislatures, the regulatory review for the five comparison states and recommendations for Virginia follow recent legislative trends. As named in a recent presentation given by NCSL public health and environmental concerns related to hydraulic fracturing include water pollution and air quality[2]. Concerns related to water pollution are water contamination from leaks and spills, water withdrawals, and managing wastewater[3]. Air quality concerns are related to ethane emissions and are noted in the review of state regulations for criteria, or common, air pollutants and hazardous air pollutants[4].

The legislative proposal for Virginia includes regulatory recommendations related to water and air pollution to ensure public safety and address health related concerns. By addressing legislative trends in the proposed legislation, it is hoped that the proposed regulatory scheme for state will be at pace with current practices and address environmental and health concerns related to the hydraulic fracturing process.

In order to identify the "best" model of practices, which we interpret to mean the most stringent, we established a ranking system for each state for every criteria we

[2] Hartman, Kristy. "Hydraulic Fracturing: States take Action." National Conference of State Legislatures. 22 July 2014.
[3] See id.
[4] See id.

identified. In our system, states were ranked from one through five based on the stringency of the regulation for the respective criteria. Generally, each state is assigned a ranking, although there are cases in which states are ranked with the same value. States ranking at a five are considered the most stringent, meaning most detailed or with environmental impacts most closely considered. States at the lower end of the ranking system have more broad regulations for the criteria, or none at all.

In our analysis, we considered overall environmental impacts and water quality to be the most important factor in ranking the states according to our criteria. While there are some concerns on the implementation of some states' regulations, such as Illinois, where hydraulic fracturing is regulated but non-occurring, our research focuses on the framework of the regulations.

Though we have identified one single state as having the most stringent regulations overall, our proposals for Virginia are tailored to the needs of the EVGMA. In some cases, the most stringent practices for the criteria we identified were not suitable for the Commonwealth.

IV. History and Process of Hydraulic Fracturing in Virginia

Hydraulic fracturing usage dates back to the early 20th century. This would be the method of extraction for gas in the Taylorsville Basin. The process is currently used in Virginia in the southwestern portion of the state in over 6,000 coalbed methane wells and over 2,000 wells producing from shale, sandstone, and limestone formations. The coalbed methane wells are produced using a foam frac, which involves using water, chemicals, nitrogen. About a dozen exploratory wells were drilled in the eastern portion in the early 20th century but were all plugged due to the absence of commercial quantities of hydrocarbons.[5]

The first commercial use of hydraulic fracturing was in Kansas or Oklahoma (this is disputed) in the 1940s and soon became a widely used technology in the completion of gas wells, especially those involved in what is known as unconventional production. Unconventional production refers to production from tight shale reservoirs, unlike conventional production, which typically occurs in reservoirs of porous sandstone.[6]

Hydraulic fracturing involves the use of pressurized liquids and/or gases such as nitrogen to stimulate or fracture rock formations to release gas or oil. Sand is often pumped in with the fluids to help prop the fractures open so that more gas or oil can be extracted from the formations. The type, composition, and volume of fluids used depend largely on regional geologic structure, as well as the pressure and geologic characteristics of the formation and well target.

[5] VA Department of Mines Minerals and Energy, Hydraulic Fracturing
http://www.dmme.virginia.gov/dgo/HydraulicFracturing.shtml
[6] FracFocus, A Historic Perspective
https://fracfocus.org/hydraulic-fracturing-how-it-works/history-hydraulic-fracturing

Especially in shale reservoirs, hydraulic fracturing is combined with horizontal drilling. The well is drilled vertically to a depth slightly above the target reservoir, and then directed horizontally and continued for several thousand feet within the reservoir. This technique exposes a longer section of the wellbore to the target formation than that of a strictly vertical well. Steel casing is then run to the bottom of the hole and secured in place with cement or packers. Perforations are then created in the casing. Fluid or gases are then pumped through the perforations under high pressure to generate small fractures in the shale reservoir. These fractures create the necessary conditions for the gas to flow into the wellbore at an economic flow rate. The internal pressure of the rock formation causes fluid to return to the surface through the wellbore. The fluid is known as "flowback" or "produced water" and may contain the injected chemicals and hydrocarbons. The flowback is typically stores on site in tanks before treatment, disposal, or recycling, while the natural gas that flows to the surface of the well is piped to market.[7]

A dry frac has been developed that uses no water, and only nitrogen, and is recommended for use in brittle shale formations that are in water-sensitive areas. This may be applicable to Virginia and its use of hydraulic fracturing in the Taylorsville Basin area within the Potomac Aquifer. Any hydraulic fracturing that takes place in the Taylorsville Basin area will likely involve drilling wells through aquifers, so it is of utmost importance to ensure that any fracking that takes place in the Taylorsville Basin is done safely.

[7] EPA, Hydraulic Fracturing http://www2.epa.gov/hydraulicfracturing/process-hydraulic-fracturing

V. Eastern Virginia Groundwater Management Area and Geology

A. EVGMA

The Groundwater Management Act of 1992 allows Virginia to manage a program regulating the withdrawals of groundwater in areas designated as Groundwater Management areas (GWMAs).[8] Virginia established the GWMAs to assure the continued resource viability into the future as well as comprehensive resource management. The statute established criteria for these GWMAs:

(1) groundwater levels in the area are declining or are expected to decline excessively

(2) two or more groundwater users within the area are interfering with each other

(3) available groundwater supply has been or may be overdrawn, and

(4) groundwater has been or may become polluted

Currently, there are two designated GWMAs, the Eastern Virginia Groundwater Management Area comprising all area east of I-95 and the Eastern Shore Groundwater Management Area. The former is the focus of our study. Under the current regulations, any individual or entity located within a declared GWMA must obtain a permit to withdraw 300,000 gallons or more of groundwater in any one month. These permits are valid for a maximum of 10 years.

There is already groundwater over usage concerns for the EVGMA even before considering hydraulic fracturing in the region as a source of water use. Groundwater levels are declining and are expected to decline further. Presently, groundwater users

[8] Virginia Department of Environmental Quality, Groundwater Withdrawal Permitting Program

withdraw 90 million gallons a day. At current withdrawal rates, it may take 30 to 50 years for supply to fall below demand. Additionally in January 2014, the EVGMA expanded into 10 additional counties and portions of 6 others (several of these expanded counties overlapping with portions of the Taylorsville basin such as Caroline and King George Counties).[9]

B. Geological Characteristics of Taylorsville Basin

The Taylorsville basin, located in Virginia and Maryland, is one of the largest of the Triassic-Jurassic rift basins in eastern North America formed approximately 227 million years ago. By definition, a basin is any area that collects sediment. The East Coast basins were filled with a variety of sediments including boulder beds, coarse-grained fluvial to deltaic sandstones, red siltstones, mudstones, gray and black shales, and coal.[10] These rift basins, or aborted rifts were created by large-scale continental extensions when the supercontinent Pangaea began to break apart. Since they are aborted rifts, they are tectonically inactive and therefore are no longer collecting sediments.

The basin is approximately 4 kilometres thick of sedimentary rock. Most of the basin is buried beneath Coastal Plain deposits[11], but a small portion is exposed close to

[9] Springston, Rex. "State getting tougher on some groundwater withdrawals." Richmond Times-Dispatch. 18 June 2013.
[10] U.S. Geological Survey, U.S. Department of the Interior. "Assessment of Undiscovered Oil and Gas Resources of the East Coast Mesozoic Basins of the Piedmont, Blue Ridge Thrust Belt, Atlantic Coastal Plain, and New England Provinces, 2011."
[11] LeTourneau, Peter M., Olsen, Paul E., and Kent, Dennis V. "Stratigraphic Architecture and Paleomagnetic Reversal Stratigraphy of the Late Triassic Taylorsville Basin, Virginia and Maryland".

Ashland, Virginia. The discovery of this basin beneath the Coastal Plain deposits in eastern Virginia and parts of Maryland was a result of deep drilling and geophysical surveys. Taylorsville basin was the focus of oil and gas exploration in the mid to late 1980s and early 1990s however it was not technologically viable.

In 2011, the US Geological Survey made an assessment of undiscovered oil and gas resources of the East Coast basins, which included Taylorsville basin in its study. The assessment is based on geological and geochemical characteristics of individual total petroleum systems that were recognized in the basins[12]. Petroleum source rock includes the characteristics of source rock richness, thermal maturation, timing of petroleum generation and migration. Taylorsville was assessed to have approximately 1 trillion cubic feet of gas, which amounts to approximately 37 million barrels of natural gas liquids[13]. In comparison, the Marcellus shale is estimated to have over 400 trillion cubic feet of gas.

C. Existing Regulations

Under current Virginia regulations, anyone who wishes to get a permit for a well in the Virginia Tidewater region must submit an application to the Virginia Department of Environmental Quality (DEQ). This agency will then perform an Environmental Impact Analysis within 90 days. The DEQ does not have any direct authority to regulate oil and gas development but it can regulate the water withdrawal from the EVGMA,

[12] U.S. Geological Survey, U.S. Department of the Interior. "Assessment of Undiscovered Oil and Gas Resources of the East Coast Mesozoic Basins of the Piedmont, Blue Ridge Thrust Belt, Atlantic Coastal Plain, and New England Provinces, 2011."
[13] See id.

which may be used. The state of Virginia also implements a State Water Control Plan, regulations enacted after a drought in 2002.

VI. Regulation of Hydraulic Fracturing throughout the US

The criteria by which we ranked each of the states are, as listed in the table below: chemical disclosure, siting and site preparation, reclamation, well plugging, waste management, air emissions, drilling, casing, cementing, and oversight and inspections. The proceeding sections detail the laws and regulations of each state pertaining to each criteria, and provide a summary of the rankings.

Overview

	Virginia*	Pennsylvania	Illinois	Colorado	California
Chemical disclosure	1	3	4	5	2
Siting and site preparation	2	3	10	8	6
Site reclamation	3	4	3	5	1
Well plugging	4	4	9	9	9
Waste management	11	16	25	28	17
Managing air emissions	4	4	6	8	10
Drilling, casing, and cementing	10	8	25	20	12
Oversight and Inspection Requirements	6	14	16	18	6
TOTAL	**41**	**56**	**98**	**101**	**63**

Chemical Disclosure

Chemical disclosure is one of the most prominent current legislative trends in hydraulic fracturing regulations. All of the states in our analysis require some form of chemical disclosure. In Colorado, companies and vendors of chemicals involved in the hydraulic fracturing process are required to disclose all information to operators. Operators are then required to disclose all information to the FracFocus website, or directly to the Colorado Oil and Gas Conservation Commision. Typical characteristics among the states in our analysis for chemical disclosure ensure trade secret protections for companies. Only Colorado, Ohio, and Pennsylvania provide processes by which the public can challenge trade secret protections. We also found that several states allow for medical professionals, upon request, to obtain information about the chemicals included in the hydraulic fracturing process following an incident. We ranked Colorado as the most stringent for these reasons.

Chemical Disclosure					
	Virginia*	California	Pennsylvania	Illinois	Colorado
Requirements to disclose information on fracturing fluids	1	2	3	4	5

Virginia

Virginia currently does not require the disclosure of all chemicals involved in oil and gas development, but is working to "require greater disclosure of chemicals used in stimulating oil and gas wells"[14].

[14] *Supra* note 1

Pennsylvania

On February 14, 2012, Governor Tom Corbett approved H.B. 1950, which requires the disclosure of all chemicals and concentrations used in the hydraulic fracturing within 60 days after fracturing. Unconventional well operators must complete a chemical disclosure registry form for publication on FracFocus.org in addition to the reporting required to be submitted to the Department of Environmental Protection. Chemical Abstract Service (CAS) numbers are required only for chemicals that are considered dangerous and producers must disclose chemicals on Material Safety Data Sheets. Trade secrets are protected, but the operators must disclose the chemical family of withheld chemicals when a trade secret claim is made.[15]

Colorado

On December 13, 2011, the Colorado Oil and Gas Conservation Commission issued Order 1R-114, which requires the disclosure of the product names, concentrations, chemicals used, and the Chemical Abstract Service (CAS) numbers. These CAS numbers are uniquely assigned by the American Chemical Society and unambiguously identify the composition of each chemical, which is essential in ensuring full disclosure.[16] The rule does not require companies to report on how hydraulic fracturing chemicals are combined in the extractive process. Companies must disclose the chemicals used in hydraulic fracturing to the Chemical Disclosure Registry (FracFocus.org) within sixty days of completing hydraulic fracturing activity. Trade

[15] Pennsylvania House Bill 1950, General Assembly http://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?syear=2011&body=H&type=B&BN=1950
[16] NRDC, State Hydraulic Fracturing Disclosure Rules and Enforcement, http://www.nrdc.org/energy/files/Fracking-Disclosure-IB.pdf

secrets will remain protected by federal and state laws, but regulators and health care professionals may request confidential information about hydraulic fracturing chemicals, and a company must file an affidavit that its confidential information meets the legal definition of a trade secret.

California

California has regulations proposed and is currently operating under interim emergency regulations published by California's Division of Oil, Gas, and Geothermal Resources (DOGGR) to implement California Senate Bill 4, legislation designed to bring additional regulation and oversight to oil and gas operations involving hydraulic fracturing. Senate Bill 4 requires the adoption of finalized rules by Jan. 1, 2015, and the DOGGR anticipates the rulemaking process will take 1 year to complete. The new senate bill will require oil and gas well operators to disclose to DOGGR the identity and quantity of every chemical used in hydraulic fracturing and acidizing fluids. These proposed regulations have been hailed as the most "stringent" in the US, but until the implementation can be observed, this is difficult to confirm. Suppliers must disclose all chemical constituents to DOGGR even if a trade secret is claimed. If the trade secret claim is invalid or invalidated, DOGGR must release the information to the public. A company claiming trade secret status may prevent this disclosure only if, within 60 days, the operator files a lawsuit claiming trade secret status and the reviewing court agrees, determines the relevant information qualifies as a trade secret under California law, and issues a court order preventing DOGGR from making the disclosure.[17]

[17] California Senate Bill 4, http://leginfo.ca.gov/pub/13-14/bill/sen/sb_0001-0050/sb_4_bill_20130920_chaptered.htm

Illinois

On June 17, 2013, Governor Pat Quinn approved SB 1715, which requires hydraulic fracturing operators submit a chemical disclosure report to the Illinois Department of Natural Resources identifying each chemical and proppant anticipated to be used. Information required to be disclosed includes the type and volume of the base fluid utilized; the trade name, vendor, description, and Material Safety Data Sheet (MSDS) of each additive; and the name, Chemical Abstracts Service (CAS) number, and anticipated concentration of each chemical added to the base fluid. This information must be submitted during the permit application process or at latest 21 days before the hydraulic fracturing operation begins. During operation, the chemical contents are allowed to be altered, as long as the Illinois Department of Natural Resources is notified within 24 hours. Trade secrets are protected except when disclosure is required to health professions.

Well Placement

For well placement, regulations related to site identification and testing prior to drilling and whether states require setbacks from water sources are evaluated. The first category for identification of water wells includes noting the site where drilling is to occur and whether water source testing has been mandated. Water source testing is a method to prevent and test for water contamination. This is important to ensure public health and safety. Illinois has the most extensive requirements and requires testing before and after wells are constructed and site identification. Colorado and California also require identification and testing. Virginia has a surface owner testing option and requires site identification only for coal and methane drillers.

Regulations related to whether states require setbacks from waters sources concerns whether states note that wells must be a determined distance from water sources. Illinois and Colorado also include prescribed regulations related to residential areas or places of worship (Illinois) and around urban areas and outdoor activity spaces (Colorado). The other three states California, Pennsylvania and Virginia also require setbacks from water sources, but are not as detailed or as extensive as Illinois and Colorado. In contrast to the other four states, Pennsylvania does not require setbacks from water sources.

	Virginia*	Pennsylvania	Illinois	Colorado	California
Requirements related to site identification and water source testing prior to production well drilling	1	2	5	4	3
Required setbacks from water sources	2	1	5	4	3
TOTALS	**3**	**3**	**10**	**8**	**6**

Virginia

Recommendations for Virginia include that the state mandate water source testing for hydraulic fracturing and mandate further setbacks from water sources if feasible. The state currently requires that coal and methane drillers submit site information for approval. Virginia regulations also state that water source testing is a surface owner option. Although, the state does have setback requirements, which concern Class II injection wells, and would be applicable to hydraulic fracturing.

Virginia also mandates that drilling not occur within 200 feet from an inhabited building unless pre-approval is received from the Director. Virginia also has mandated setback requirements of 400 feet from public supply reservoirs and 100 feet difference from water supply wells or springs. Recommendations include that Virginia consider increasing setback distances for water supply sources, such as wells, springs, and surface water. On average, Illinois and Colorado prescribe setback requirements of 500 feet from water sources.

Pennsylvania

Pennsylvania does not currently require water source testing before drilling, but the state does require that oil and gas explorers submit a site identification for the department for approval. The state's regulations advise that they will not approve applications that are within the same area of current orders or within 300 feet of boundary lines. Any exemptions must be approved through a public hearing. Unlike other states, Pennsylvania does not mandate that drilling occur away from a specified groundwater zone. It is likely that the water sources are considered in whether a permit is granted in the site identification process, but this is not explicitly included in state regulations.

California

California is currently undergoing rule-making procedures, but does have requirements that mandate that water source testing occur before and after drilling. California's proposed legislation also includes that before applying for a permit that oil and gas operators identify the proposed location and whether the proposed location is within a gas field-specific or regional monitoring program. In California, setbacks are considered land use issues and are delegated to city and county authorities to regulate.

Colorado

Colorado has extensive regulations related to site identification and water source testing. The state mandates that water source testing be performed before and after

drilling commences. Colorado is also unique in that it has specific requirements related to urban mitigation, which mandates buffer zones and setbacks from high occupancy buildings and outdoor activity areas. As mentioned earlier, Colorado along with Illinois also have the greatest setback requirements. With its specific requirements related to urban mitigation, Colorado has also included urban and commercial interests that are unique to city spaces.

Illinois

Illinois' current regulations require water source testing before and after drilling occurs along with site identification. Like Colorado, Illinois also has extensive environmental regulations related to hydraulic fracturing. The state mandates that various prescribed distances that drilling must occur from water sources, which will be discussed in more detail in the "Drilling, casing, and cementing" section.

Site Reclamation

For analyzing reclamation, we looked at requirements for backfilling, regrading, recontouring, and alleviating compaction of soil. We found Colorado's regulations ideal for Virginia to follow.

Site Reclamation					
	California	Virginia*	Pennsylvania	Illinois	Colorado
Requirements for backfilling, regrading, recontouring, and alleviating compaction of soil	1	2	4	3	5

Virginia

Virginia currently requires a stabilization plan for site restoration once a well is plugged, as well as a vegetative cover to be maintained for at least two years. The Commonwealth also regulates the process by which operatregulationsors can request a variation from the established reclamation standards, which, if approved, become part of the operation plan that is to be submitted before drilling begins.[18]

Pennsylvania

Pennsylvania's regulations for site reclamation are broad in that they simply require "restoration" of land that has been disturbed by oil and gas operations. The state mandates that within nine months of well completion, the site must be restored, pits

[18] 4VAC25-150-260, http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+4VAC25-150-260

must be removed or filled, and any production equipment must be removed. The state also stipulates that the timeframe of nine months may be extended to a maximum of two years if a submitted plan is approved.[19]

California

California's regulations for site reclamation are also broad in description. The state only specifically requires restoration of a water well site to as nearly as possible the subsurface conditions that existed before the well was constructed. [20]

Colorado

Colorado requires that areas be restored to their original condition or their final land use. Reclamation in Colorado also focuses on controlling dust and minimizing erosion, and this could be of great use for Virginia's future regulations.

In Colorado, areas disturbed by by drilling and subsequent operations no longer needed for production will be restored to their original condition or their final land use as designated by the surface owner and shall be maintained to control dust and minimize erosion. Reclamation must occur no later than three months on crop land or six months on non-crop land after operations cease unless otherwise approved by the state. Stabilization on well sites focuses especially on minimizing erosion.

[19] Pennsylvania General Assembly, Section 3216 Title 58 - Oil and Gas http://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/58/00.032.016.000..HTM
[20] California Water Well Standards http://www.water.ca.gov/groundwater/well_info_and_other/california_well_standards/wws/wws_combined_sec20-22.html

Illinois

The Illinois Administrative Code details that all excavations and pits must be filled and leveled to original grade within six months after the last well on a lease has been plugged. The Code also stipulates that at the conclusion of drilling, all drill cuttings shall be buried in pits or land spread with the permission of the surface owner and that all pits used in drilling shall be filled and restored to support farm machinery. Illinois also requires that all drilling debris be removed from the site.[21] The recently passed Hydraulic Fracturing Regulatory Act (HFRA) requires any lands used by the operator in high volume operations (operations requiring 80,000 gallons per stage or 300,000 gallons total of hydraulic fracturing fluid and proppant) be restored, as approximately as possible, to that of the condition of the land before any drilling activities took place. The state provides several examples of adequate restoration activities, which include but are not limited to, repair of tile lines, repair of fences and barriers, mitigation of soil compaction and rutting, application of fertilizer or lime to restore the fertility of disturbed soil, and repair of soil conservation practices such as terraces and grassed waterways.[22]

[21] Illinois Administrative Code, Title 62, Part 240
http://www.dnr.illinois.gov/adrules/documents/62-240.pdf
[22] Illinois Hydraulic Fracturing Regulatory Act,
http://ilga.gov/legislation/publicacts/98/PDF/098-0022.pdf

Well Plugging

We broke well plugging regulations into two categories. The first looked at requirements for notification, plugging plan or method, witnessing and reporting of well plugging. The second criterion we analyzed looks at programs to plug wells that are not properly plugged and have been abandoned. Of the five states, Colorado and Illinois had the best regulations. California was noted for having particularly strong regulations related to well plugging programs and life of well bonds.

Well Plugging					
	*Virginia	Pennsylvania	Illinois	Colorado	California
Requirements for notification, plugging plan or method, witnessing, and reporting	2	3	5	4	4
Programs to plug wells that are not properly plugged and have been abandoned	2	1	4	5	5
TOTALS	**4**	**4**	**9**	**9**	**9**

Illinois

Illinois's regulations regarding well plugging discusses and defines the type of cement, cement quality and other materials that will be used in the well plugging process, whether they are cased and uncased wells. It also discusses the two methods (circulation method and dump bailer method) of plugging which it determines are

acceptable methods. The permittee of the wells is responsible for plugging wells. Illinois requires that uncased production wells should be plugged within 30 days after drilling has ceased. If the regulating department determines there is contamination or a public safety hazard, the permittee must plug the well within 24 hours of department notification. There is an additional process for abandoned or inactive production wells. The current procedure for plugging requires notification to plug at least 24 hours prior. Interestingly, regulations describe methane monitoring during the plugging process. Within 6 months, the plugged well site is expected to be restored to as close to pre-drilling status as possible. Finally, the permittee must complete and file a plugging report immediately after plugging is complete. In the case that a permittee fails to properly plug a well, the state has a well plugging fund (afforded through the bonds permittees pay) which will properly plug the well. The cost of plugging it by the state will then be charged to the permittees or the well owners.

Virginia

In the case of Virginia, the regulations stipulate that a permittee inform the department division at least 48 hours before any activity. Additionally, plugging operations cannot commence until a detailed plugging plan is submitted and approved by the director. In contrast to the Illinois regulations, Virginia permittees have up to 90 days to submit an affidavit concerning the well plugging completion to the division director. Virginia also possesses a Gas and Oil Plugging Restoration Fund, which the permittee operators pay into. While Virginia possesses a restoration fund program, the

bonds and fees were substantially lower than in Colorado and Illinois. Its score was illustrative of that fact.

Pennsylvania

Pennsylvania also has notification and witnessing requirements; however, they only apply to coal areas. The exclusion of oil and gas operations partially explains our lower score for them compared to the other states. Their regulations include reporting requirements as well but the coal restriction continues to apply, which is part of the reason we ranked them lower than in the cases of Illinois and Colorado in this category. Pennsylvania allows for the request approval of alternative methods or materials used in the drilling or plugging process as long as the operator describes the alternative in reasonable detail, which should include discussion of completing the well plugging goal and inclusion of a drawing. Pennsylvania has a bonds system, though the bond amount per well is incredibly low and it is not specifically stated that such bonds will go to funds to complete improper plugging.

Colorado

For Colorado, the well operators must notify and obtain prior approval of the plugging method as well as the full description of the proposed abandonment operations. In addition, these operators must provide notice of the date and time of the plugging along with a report of the plugging submitted to the agency. Within 30 days after abandonment is completed, a Well Abandonment Report must be filed with the Director. The report includes such information as pressure test results, downhole logs, in addition to plugging verification reports detailing all procedures. The Plugging

Verification Report for each person setting the plugs must be submitted as well. The reporting scheme that Colorado implements allows the reports made by these operators to conform to what was originally proposed and approved by the agency Director. As with the other states discussed, Colorado possesses a fund of very similar weight to that of Illinois.

California

Following the trends from above, California requires written approval of the Supervisor before plugging and abandonment operations may commence. Plugging and abandonment operations further require witnessing. The witnessing requirement is fulfilled if the plugging is witnessed and approved by a Division employee. The regulations also include the methods and materials that are and are not permissible in the plugging operations. Interestingly California had the most rigid bond program for well plugging. The Supervisor establishes a life-of-well bond amount to cover the cost to properly plug and abandon a well, including site restoration, well condition and the cost to finance a spill. The Supervisor may not go below minimum bond coverage. Their regulations also allow for annual review of the bonds, which can be increased if necessary.

Waste Management

Waste management included several different categories. The first criterion we focused on related to pit lining requirements. This criterion discusses the quality of the liner, the capacity of the pit liner and how it will be installed and constructed as a few examples. We also looked at hazardous waste disposal; however many states had little to no specific regulations for the hazardous waste disposal in the oil and gas process. We also looked at underground injection requirements, which overlap with existing federal Environmental Protection Agency (EPA) requirements for these types of wells. Fourth, we looked at prohibitions and restrictions for direct discharge to surface water. The last two characteristics were regulations for solid waste disposal and included requirements for the disposal of discharge to publicly-owned treatment works or centralized waste treatment facilities.

	*Virginia	Pennsylvania	Illinois	Colorado	California
Pit lining requirements	2	3	5	5	1
Hazardous waste disposal	1	1	3	5	3
Underground injection requirements	3	3	4	5	4
Direct discharge to surface water	1	3	5	4	4
Requirements for discharge to publicly-owned treatment works or centralized waste treatment facilities	2	3	4	5	2
Solid waste disposal	2	3	4	4	3
TOTALS	**11**	**16**	**25**	**28**	**17**

Illinois

Illinois's regulations only allow pits for temporary storage of unexpected hydraulic fracturing flowback. The liner material must have a minimum thickness of 24 mils[23] with high puncture and tear strength, making it impervious to deterioration. The pit lining system must be designed to have a capacity of at least 110% of the flowback anticipated to be recovered. The included details about the foundation quality and the length of the liner for the pit. Their latest hydraulic fracturing regulations also included specifications for the construction, installation, and maintenance of the lined pits. Illinois requires the waste disposal of all wastes related to the hydraulic fracturing process. The Act expects drilling fluids & wastes to be stored in tanks or pits. Most wastes that are nonhazardous must be completely removed from the well site, transported and disposed of at an Illinois Environmental Protection Agency special waste facility, landfill or waste treatment facility. On-site disposal of non-organic wastes is prohibited. Illinois regulations further prohibit direct discharge to surface water. Finally there are very thorough requirements for underground injection wells.

Colorado

Similar to Illinois, Colorado has very thorough regulations for waste management. Colorado requires that liners be impervious to deterioration with a minimum thickness of 24 mils. Prior to installation of a liner, the well operator must inform the regulation department 48 hours in advance. They have additional higher pit lining requirements for E&P waste management facilities with a minimum thickness of

[23] A unit of length equal to one thousandth of an inch.

60 mils liner. Their regulations also specify the foundation for the liner and standards for maintaining the liner. Colorado regulations discuss the use of waste disposal facilities regulated by the Colorado Department of Public Health and Environment. Hazardous material must be stored, treated and handled in designated containers and be labeled in accordance with the US Department of Transportation's Hazardous Materials Regulations. Colorado's solid waste disposal requirements include the storage, treatment, utilization, and processing or final disposal of these wastes.

Pennsylvania

Pennsylvania requires that wastes be disposed at an approved waste disposal facility. The regulations further specify that the operator submit to the Department the types and volumes of waste produced and the address of the waste disposal facility and hauler used to dispose the waste. Pennsylvania does allow pits to be used. The synthetic liner must be designed, constructed and maintained to be of a sufficient strength. The liner must be thicker than the regulations under Colorado and Illinois, with a minimum thickness of 30 mils. Pennsylvania has regulations for solid waste, discussed under its Solid Waste Management Act. Pennsylvania also requires that discharge water must be spread over an undisturbed, vegetated area capable of absorption but also in a manner to prevent direct discharge to surface waters. Finally Pennsylvania discusses underground injection requirements which must be submitted to the EPA.

California

California's regulations did not discuss pit-lining requirements. This may be because California does not allow for permanent disposal of waste in pits. California also

includes requirements for underground injection projects. Its regulations require that the operators provide their waste disposal methods and inform the department of any changes. Interestingly, California's regulations have requirements for discharges into the ocean conforming to the appropriate Regional Water Quality Control Board.

Virginia

Finally Virginia's existing regulations for waste management show some interesting criteria. Virginia requires that pits only be temporary with a properly installed liner of at least 10 mil thickness. This was the lowest of all the states that had pit lining requirements. Further Virginia only requires that the pits are of sufficient size to contain fluids. There was no discussion of impermeability. Solid waste must be collected and disposed of properly in a facility permitted to accept that type of waste. Virginia' regulations include a section Class II injection wells, in addition to meeting the requirements imposed by the EPA under their Underground Injection Control Program. There is not a prohibition of discharge into surface water though there is discussion of fluid not being applied closer than 50 feet of wetlands and watercourses or 100 feet closer than water supply wells or springs.

Air Emissions

Although, most of the environmental regulations related to hydraulic fracturing have been delegated to the states by the federal government, the federal Clean Air Act is responsible for regulating air pollution produced from industries, including oil and gas exploration. The EPA is currently conducting a national study related to air pollutants emitted by hydraulic fracturing and analyzing criteria and hazardous air pollutants effects from hydraulic fracturing. The section related to managing air emissions has been divided into two categories and states are ranked based on whether they regulate criteria or hazardous air pollutants.

Criteria air pollutants are the common air pollutants, carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. In particular, criteria air pollutants are often related to the hydraulic fracturing process. Hazardous air pollutants, or toxic air pollutants or air toxics, have been defined by the EPA, and are pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental or ecological effects.Because air emissions are regulated by the Clean Air Act, some states have opted not to regulate air emissions further. All of the states included in our analysis have opted to adopt criteria air emissions regulations. Although, only Colorado and California have adopted air emissions regulations related to hazardous air pollutants.

	Virginia*	Pennsylvania	Illinois	Colorado	California
Requirements for criteria pollutants	3	2	3	4	5
Requirements for hazardous air pollutants	1	2	3	4	5
TOTALS	**4**	**4**	**6**	**8**	**10**

Pennsylvania

Per the Department of Environmental Protection (DEP) website, Pennsylvania is actively involved in the notice and comment rule-making period for current EPA proposed air emissions regulations. In 2013, the state also amended its air emissions regulation to include unconventional oil and gas wells[24]. The DEP also provides technical guidance documents on its website to advise oil and gas explorers. Per technical guidance document number 275-2101-003, explorers are exempt from the permitting process if they have an air pollution control plan that is stricter than federal guidelines[25]. Per technical guidance document number 270-0810-006, stationary sources are currently reviewed on a case by case basis by the department for permit eligibility[26]. State agency policies related to stationary sources and exemptions were developed under a formal notice and comment period. Pennsylvania reviews well sites on a case by case basis before granting air permits[27].

[24] "Bureau of Air Quality." Pennsylvania Department of Environmental Protection. 2014. Web. 30 November 2014. <http://www.portal.state.pa.us/portal/server.pt/community/bureau_of_air_quality/14528>
[25] See id.
[26] See id.
[27] See id.

Virginia

In contrast to Colorado and California, Virginia only regulates criteria air pollutants through the state's DEQ Air Control Board. As a note, Virginia's Department of Environmental Quality website notifies citizens that hazardous air pollutants are also regulated under the federal Clean Air Act and was likely included to reflect the state's stance[28]. Virginia has regulations related criteria air emissions. Under the state's Department of Environmental Quality's Air Control Board a permit has to applied for if criteria emissions are emitted. This regulation pertains to any point of source that emits criteria air emission.

Illinois

Illinois has a permitting program, which is overseen by its Bureau of Air Permits. Many of the pollutants which can be produced through hydraulic fracturing are covered by this permit program, which notes that if drilling equipment produces noted pollutants, such as sulfur dioxide, nitrogen oxides, carbon dioxide, lead, hazardous air pollutants, particulate matter, or greenhouse gasses, then a permit has to be granted before any action.

Colorado

Colorado also has extensive regulations related to the hydraulic fracturing process and air pollution in general. The state also has a permitting and registration air program for criteria and hazardous air pollutants.

[28] "Air Toxics." Virginia Department of Environmental Quality. No publication date. Web. 30 November 2014. <http://www.deq.virginia.gov/Programs/Air/PermittingCompliance/Permitting/AirToxics.aspx>

California

In California, the legislative bill SB. 4 delegates air emissions regulatory oversight to the state Air Emissions Control Board and local air districts. Similar to Colorado, California regulations include hazardous and criteria air pollutants.

Drilling, Casing, and Cementing

Casing and cementing requirements largely concern the process and oversight that is involved before drilling commences. This section ranks states based on whether they have regulations related to submitting cementing and casing plans, prescribed placement of surface casing relative to groundwater zones, prescribed cementation techniques for surface casing, requirements for waiting periods and/or integrity tests, and blowback preventer equipment (BPE) requirements. Cement waiting periods and integrity tests are important for establishing quality well construction so that the wells can withstand pressure related to drilling.

The states differ on whether they require cement waiting periods and integrity testings. As will be described below, some states only require either a cement waiting period or an integrity test. Pennsylvania, Colorado and Illinois mandate both. For the purpose of ranking, states that require integrity testing are rated higher than states that solely require a cement waiting period. For this section, Illinois and Colorado are rated higher because they have more extensive legislation. While Colorado and Virginia have specified cement waiting periods, they do not require integrity tests. California does require integrity testing, which is thought to be more beneficial in terms of public safety. Pennsylvania has more thorough requirements related to record-keeping, but California is rated higher because the state requires more extensive testing of parts and casing before drilling occurs.

Each of the five states mandate use for blowout preventer equipment use. Illinois and Colorado were rated the highest for having the most stringent regulations due to

stringency and specificity, including level of detail. In this instance, Pennsylvania's regulation was rated the least stringent due its broad regulatory language. Recommendations for Virginia include more detailed regulations, including instructional guides for BPE, required testing and records, and inspection oversight to ensure greater compliance and public safety.

Because Virginia includes more detailed regulations related to cementation techniques and prescribed placement for casing, as far as drilling, casing, and cementing, recommendations for the state are based on BPE requirements and integrity tests. Virginia was rated lower in comparison to the other states due to less extensive regulations related to cement/casing plans. Since the state requires prior approval from a Director and a public hearing before operations can proceed, this process is considered adequate especially in consideration that the state has more detailed regulations related to casing and cementing requirements.

	Virginia*	Pennsylvania	Illinois	Colorado	California
Requirements relating to cementing/casing plans	1	3	5	4	2
Prescribed placement of surface casing relative to groundwater zones	3	1	5	4	2
Prescribed cementation techniques for surface casing	3	1	5	4	2
Requirement for cement waiting period and/or integrity tests	1	2	5	4	3
Requirements for blowout preventer use	2	1	5	4	3
TOTALS	**10**	**8**	**25**	**20**	**12**

Virginia

Virginia requires that a public hearing be given before a drilling permit is granted. The state also mandates that cementing techniques be approved by a DOGGR Division Director and where casing string should be place. Although, Virginia's cementing regulations are not as extensive overall in comparison to other states, public hearing requirements and department approval ensure public safety and environmental quality concerns are addressed.

In terms of cement waiting period and integrity testing, Virginia has general regulations in place for geothermal drilling, which include a cement waiting period of 24 hours or until comprehensive strength equals 500 per square inch (psi) before drilling.

Virginia regulations state that wells shall be equipped to withstand formation pressure during drilling and servicing. Hydraulic fracturing can exceed pressures of 9,000 pounds psi[29]. Virginia's regulations 4VAC25-150-320 (B)(1) which notes that BPE is required when expected pressures of 1,000 or greater are expected would be applicable to hydraulic fracturing.

Pennsylvania

Like Virginia, Pennsylvania requires that a public hearing be given before a drilling permit is granted. Pennsylvania also describes cementing techniques and that cement should be able to withstand 500 bpi pressure. Pennsylvania's regulations do not mention the prescribed placement of surface casing but do note that wells should be thoroughly insulated from groundwater zones.

Although, Pennsylvania prescribes a waiting period of no less than eight hours, the state also has has a mechanical integrity assessment test. The Mechanical Integrity Assessment (MIA), which is a regulatory process, where operating oil and gas wells are inspected, assessed, and their well integrity data is recorded quarterly. This quarterly inspection is required by regulation under 25 Pa. Code § 78.88, Mechanical Integrity of Operating Wells. Section § 79.12(b) states that "Blowout equipment shall be in good working condition at all times and sufficient to prevent waste." Regulation also defines blowout equipment as "a heavy casinghead control fitted with special gates or rams

[29] Lallanilla, Marc. "What is Fracking?" Live Science. 17 July 2013. Web. 30 November 2014. <http://www.livescience.com/34464-what-is-fracking.html>

which can be closed around the drill pipe, or which completely closes the top of the casing."

California

California also has prescribed techniques for well cementation in oil and gas production and is developing its regulations towards hydraulic fracturing drilling. California's regulations do not mention the prescribed placement of surface casing but do not that wells should be thoroughly insulated from groundwater zones. California also has prescribed techniques for well cementation in oil and gas production and is developing its regulations towards hydraulic fracturing drilling. As mentioned previously, the state delegates much of its water management to local and county agencies.

The state does not require a cement waiting period, but mandates that the well bore's mechanical integrity should be tested and that all cemented casing strings and all tubing strings utilized in the well stimulation treatment operations shall be pressure tested prior to well stimulation treatment. Although, California is currently undergoing rulemaking for hydraulic fracturing procedures, it does have the framework in place for BPEs in oil and gas exploration.

Colorado

Colorado possesses intensive regulations related to the cementation process. Colorado has a casing program for groundwater management and requires that a report

and permit be granted before drilling. Colorado has extensive cementation techniques that drillers must comply with including receiving prior approval from the Director before cementing, daily summary reports, cement verification reports. The state also prescribes a casing cementing period of at least eight hours along with production and intermediate casing pressure testing and mechanical integrity testing.

Section 604c describe BPE requirements and differentiate between rigs with and without kellys. For rigs without kellys, at least one operator on the site must receive Mineral Management certification or Director approved training for blowout prevention. While drilling occurs, pressure testing of casing string and components of the BPE equipment are to be recorded and documents retained by the department for one year.

Illinois

Illinois has have extensive cementation techniques that drillers must comply with. Illinois is very thorough in their regulations and even outlines the cementing the process and includes instructional schematic drawings within their regulations. The state also prescribes a cement waiting period of 48 hours and integrity testing.

Illinois has the most extensive and detailed regulations related to BPEs. Like Colorado, Illinois also mandates that drillers provide records, but Illinois mandates that they be kept onsite. Illinois also notes that any equipment or parts that need to be repaired should be replaced before drilling can commence. To further ensure compliance, Illinois requires that drillers notify the department before drilling so that an

inspector can be onsite when pressure testing occurs. Like Colorado, Illinois also noted that a designated representative should be onsite during installation, testing and use and that the representative undergo well control certification from an accredited program.

The state also describes the process for installing BPEs, including pipe fittings, valves, and unions. Pressure testing is also mandated before and after drilling and is to be in accordance with industry standards as defined in Sections 1 - 70(e) of the Act. To further ensure safety, a remote blowout preventer actuator is also required to be within 50 feet from the wellhead.

Oversight and Inspection

We also analyzed some aspects of oversight and inspection for the selected states and Virginia. We found Colorado to be the strongest, overall, in the development of stringent laws and regulations ensuring compliance with respect to public environmental health and safety. Most states have at least broad requirements for reports at each step of the drilling process. Spill reporting refers to fracturing fluid spills, which, in our research, could have adverse effects on public and environmental health and safety. A study by the Energy Institute at the University of Texas at Austin found that although there were no direct correlations between hydraulic fracturing and groundwater contamination, surface spills due to poor casing and cementing techniques were harmful to the environment.[30] Few states have implemented any oversight or inspection mechanisms to track spillage of fracturing fluid and chemicals. The states vary greatly with respect to well and site inspections--stringency ranges from vague inspection requirements to a complete list of all the inspections needed throughout the lifetime of a well and its site.

Requirements for baseline water sampling vary among the states in our analysis, from complete lack of requirements to mandating sampling at several points during the lifetime of a well.

[30] Bryan Walsh "Shale Gas: It's Not the Fracking That Might Be the Problem. It's Everything Else" http://science.time.com/2012/02/17/shale-gas-its-not-the-fracking-that-might-be-the-problem-its-everything-else/

Oversight and Inspection Requirements					
	California	Virginia*	Pennsylvania	Illinois	Colorado
Notification reports at each step of drilling process	1	2	3	4	5
Baseline sampling for water quality	2	1	3	4	5
Spill reporting	1	2	3	5	4
Well inspections	2	1	5	3	4
TOTAL	**6**	**6**	**14**	**16**	**18**

Virginia

In terms of inspection and oversight, the Commonwealth mainly relies on permittees to inspect and ensure the continued maintenance of equipment (tanks, casings, pipes, etc.) and make annual reports. These reports are to be filed with the Director of the Department of Mines, Minerals, and Energy.

Furthermore, the Director appoints the Gas and Oil Inspector. The Inspector is responsible for any delegated authorities from the Director and the administering of all of Virginia's Oil & Gas legislation. They also maintain records, including the reports filed by the permittees of wells/drilling sites. The permittee also keeps a driller's log and digital forms which update the Division when nearing the completion of drilling. When it comes to plugging, the Director is also the ultimate authority, approving permit changes that allow the wells to be plugged. The Virginia Oil & Gas Act and the Regulations put forward in Title 4-150 do not specify any specific authority figures that oversee and inspect the plugging, other than the Director who must approve all actions undertaken by the permittee.

This is also the case with waste management. It is implied that applications must abide by certain rules and procedures when seeking a permit. Enforcement is mainly instituted by follow-ups from the Gas and Oil Inspector and the Director while receiving reports from the Site allocations/prepping require the assistance/certification of licensed engineers and surveyors. These certifications and the daily-updated driller's log are all overseen by the office of the Director.

With respect to notification reports, each oil and gas permittee must notify the Division of Gas and oil within the Department of Mines, Mineral and Energy at least 48 hours prior to commencing any ground-disturbing activity. Drilling reports after a well reaches total depth are required within 90 days. The next report required by the Commonwealth is a well plugging report, followed by a completion report within 90 days after the well is completed.[31] Virginia only requires one drilling report after a well reaches total depth. Requiring multiple drilling reports can help ensure compliance.

Virginia has regulations for oil and gas that may apply to hydraulic fracturing in the Taylorsville Basin. These include requirements for reporting on and off site spills. These requirements detail that operators must provide details of the incident to the state within 24 hours.

Pennsylvania

Pennsylvania only requires a drilling report after a well has been completed. The state also requires restoration and production reports for each well throughout its lifetime. Pennsylvania does not require baseline water sampling, but gives companies

[31] Virginia Gas and Oil Regulations, http://www.dmme.virginia.gov/DGO/pdf/DGORegs.pdf

the option of utilizing sampling as a protection for liability purposes. The Pennsylvania Oil and Gas Act includes a provision that an oil and gas well operator is presumed to be responsible for pollution of a water supply if it occurs within six months of drilling and is within 1,000 feet of the well. One of the defenses against this presumption is a pre-drilling survey that documents baseline water quality. Proposed changes to the regulations will require results of such testing to be provided to the landowner and to DEP. In order to rebut the presumption of liability, where the operator is responsible for pollution of water, the well operator must provide adequate defense.

For well inspections, we determined that Pennsylvania has the most stringent set of regulations. This is because the state requires at least 16 inspections of wells throughout its operation. These are a combination of routine and unannounced inspections of drilling sites and wells.

Colorado

Colorado requires a series of reports to be completed throughout the drilling process, and it for this reason that we have ranked the state as the most stringent. The state's laws and regulations carefully stipulate a list of reports required, including preliminary drilling and post-drilling reports. This diverges from most other states in that other states typically only require one drilling report once a well reaches total depth.

Colorado was the first state in the nation to mandate baseline water sampling for water quality by oil and gas companies. The requirements detail that operators sample nearby domestic water wells (or other waterways, if they are the only sources of water

available) before and after drilling activities. This is crucial because of the possibility of natural contamination of groundwater. This serves as an insurance against allegations of contamination of water by oil and gas operations by requiring that water be sampled and undergo a set of rigorous laboratory analyses prior to drilling.[32]

Colorado requires the reporting of any spills and releases of exploration and production fluids, but does not specifically mandate the reporting of fracturing fluid spills to the state. It is possible that future rules could be promulgated to include fracturing fluid.

Colorado also has a team of 15 field inspectors assigned to different geographical areas, and two environmental inspection specialists who focus on reclamation issues. Nearly all inspections are unannounced, and all inspectors have a variety of equipment including laptops, GPS devices, pressure gauges, range finders and cameras. The state conducts inspects during and after drilling, construction, and production to verify that all project work performed by the operator complies with regulations and permits.

California

California is currently in the rulemaking process, but aims to include mandates for reporting at all steps of the drilling process for operators. As of now, there are no requirements for notification of the commencement of drilling activities. For this reason, we ranked California as the least stringent for general reporting. Though the state is in the process of regulating reporting throughout the hydraulic fracturing process, it is impossible to gauge the effectiveness of those regulations when a

[32] Colorado Groundwater baseline sampling and monitoring, http://cogcc.state.co.us/RR_HF2012/Groundwater/FinalRules/FinalGWA_318Ae4_01092013.pdf

commencement report is not required.

California's interim regulations throughout the rulemaking process require well operators to submit a groundwater monitoring plan as part of their well stimulation treatment notices. Additionally, operators must provide water monitoring information to landowners located both within 1,500 feet of the well and those within 500 feet from the horizontal projection of all subsurface portions of the well to the surface.

The draft regulations for hydraulic fracturing in California under Senate Bill 4 contain requirements for notification, response, and cleanup of fracturing fluid spills. Additionally, once a spill occurs, operators must disclose to the state details of the incident, including types and volumes of fluids released, cause of spill, and a remediation plan to cleanup the spill.

California's draft regulations also require periodic inspections to ensure that the information provided on well treatments are accurately reported, including that production estimates are consistent. Casing pressure tests are also subject to inspection--a DOGGR inspector is required to be present at these, as well as mechanical integrity tests.

Illinois

Illinois specifically regulates reporting, response, and cleanup of fracturing fluid spills, and is one of the few states in the nation to do so. Any release of hydraulic fracturing fluid, additive, flowback, or produced water is required to be reported to the state, cleaned up, and remediated. In excess of five barrels, a spill must also be reported to the Illinois Emergency Management Agency (IEMA).

Illinois requires baseline water sampling before hydraulic fracturing can begin. Currently, the radius for required baseline testing is 1500 feet from oil and gas wells. Illinois requires an independent third party under the supervision of a professional engineer or professional geologist to collect baseline water samples and an independent testing lab to analyze them. Section 1-80 of the Illinois Hydraulic Fracturing Regulatory Act requires each applicant for a high volume horizontal hydraulic fracturing permit shall provide the department with a work plan to ensure accurate and complete sampling and testing. A work plan must include

1) information identifying all water sources within the required range of testing
2) sampling plan and protocol
3) the name and contact info of an independent 3rd party to conduct sampling to establish a baseline
4) name of the lab that is conducting analysis
5) proof of access and the right to test within the area for testing
6) identification of contingency measures, including provision for alternative drinking water supplies.

After baseline tests, all applicable water sources must be sampled and tested in the same manner 6, 18, and 30 months after the high volume horizontal fracturing operations have been completed.

For spill reporting, we identified Illinois as having the most stringent set of regulations. In Illinois, any release of fracturing fluid or flowback in excess of one barrel is to be reported to the state. Illinois also regulates the cleanup and remediation in

response to spills. Most states have little to no oversight in this category, making Illinois unique.

Other States

While the states, such as California, Colorado, Illinois, and Pennsylvania have elected to implement hydraulic fracturing, some states and municipalities have decided to ban hydraulic fracturing or moratoriums on drilling. At this time, New York is the only state to have banned hydraulic fracturing upon further research[33]. Counties, within California, Texas, Hawaii Island, and New Mexico[34]. Frequently cited reasons for banning hydraulic fracturing are related to health concerns[35]. In particular, many municipalities cite concerns over drinking water contamination. As reflected by the current study being conducted by the EPA at the request of the U.S. Congress, health risks related to hydraulic fracturing are still being reviewed and determined[36].

The proposed legislative model focuses on providing environmental and health protection through protecting groundwater sources from contamination, disclosure of chemicals involved in the hydraulic fracturing process, and well-defined safety procedures. This is done through more extensive setbacks from water sources and well-defined blowout prevention requirements to ensure compliance and safety for drillers but also to reduce the potential for soil contamination.

[33] "Keep Tapwater Safe." Global Bans on Fracking. <http://keeptapwatersafe.org/global-bans-on-fracking/>
[34] See id.
[35] See id.
[36] U.S. Environmental Protection Agency. "EPA's Study of Hydraulic Fracturing for Oil and Gas and Its Potential Impact on Drinking Water Resources. 21 November 2014. Web. 10 December 2014. <http://www2.epa.gov/hfstudy>

VII. Proposals for Virginia

Chemical Disclosure

As one of the leading legislative trends in oil and gas development, requiring complete chemical disclosure may help improve the trust of the public. Virginia could do this by emulating Colorado's regulations and mandating that vendors and operators disclose complete information about all chemicals involved in the fracturing process to the state and to FracFocus.

Well Placement

Virginia currently mandates that coal and methane explorers submit site identification for approval before drilling. We recommend that these regulations also be extended to hydraulic fracturing. Virginia currently does not mandate that oil and gas explorers conduct water source testing before drilling, but instead notes that it is to be an option for surface owners. In the interest of public safety and water source protection, we recommend that Virginia mandate water source testing before and after wells are constructed.

Issues related to commerce and transportation are not included in our methodology. Broadly, Virginia may want to consider regulations related to urban mitigation as reflected in Colorado's regulations for prescribed setbacks from water sources. Taylorsville Basin is within a rural area. Due to commercial interests and state residents that could be affected by hydraulic fracturing, Virginia may also want to consider urban mitigation planning for hydraulic fracturing. This concern is related to

water contamination, waste contamination and transportation, and material and part transportation issues that could affect citizens throughout the state.

Site Reclamation

Our analysis indicates Colorado's regulations as the most sensible for Virginia to follow. Given the characteristics of the EVGMA, and the erosional nature of the groundwater system, it would be in Commonwealth's interest to do all possible to minimize erosion and sedimentation.

One caveat to adopting regulations similar to those of Colorado is in the economic feasibility of the regulation. Under the basic economic principle of diminishing marginal returns, the cost of restoring a site to 99.5 percent of its original condition and restoring the extra .5 percent to 100 percent of its original condition may be equal; meaning, it may be the most cost-effective approach to require restoration to 99 percent or another threshold as determined by an economic impact analysis. The state could mandate that this economic assessment be included in the operations plan or environmental impact analysis.

Well Plugging

We recommend that Virginia implement well plugging regulations that include a well plugging witnessing requirement, either by a department employee or signed affidavits of those who participated in the well plugging process and their roles, as well as a stronger reporting requirement. Presently, a well operator has up to 90 days to report the plugging of a well. We would recommend a swifter turnaround though

immediately after well closure as seen in Illinois may be too stringent. Additionally, we recommend that Virginia increase its financial insurance and protection of aquifers by increasing the bond per well and/or blanket bond payments.

Waste Management

We would recommend that Virginia increase its synthetic pit lining requirements from 10 mils thickness to at least 24 mils thickness. The liners should be rated impervious to deterioration, with pit liner construction, installation and maintenance, to best practices of the industry standard. On-site disposal of wastes that are nonhazardous or inorganic wastes should be prohibited. Consequently, these materials should be removed from the well site, transported and disposed of to an approved waste treatment facility. Any hazardous material must be stored, treated and handled in designated containers and labeled according to . We recommend that Virginia prohibit the direct discharge into or near surface water.

Air Emissions

We do not suggest further regulations for Virginia concerning criteria and hazardous air pollutants. Virginia currently has the framework in place to provide oversight related to criteria air pollutants. As the DEQ's website also notes, the state is committed to regulating hazardous air pollutants under the federal Clean Air Act.

Drilling, Casing and Cementing

Our recommendations for this section, focus on more extensive requirements related to integrity testing and blowout preventer equipments. Suggestions include mandated integrity testing throughout the process with interim inspections by officials and required record-keeping by operators. It is also recommended that Virginia consider mandated training for an on-site representative (like Illinois and Colorado) to prevent blowout prevention and more detailed requirements related to BPE to ensure industry compliance and public safety.

Oversight and Inspection

We propose that Virginia take steps to ensure complete compliance with any oil and gas development regulations. This includes requiring preliminary drilling and post-drilling reports. Some states only require that operators complete drilling reports once a well reaches its total depth, but requiring more reports can help form a complete record and ensure oversight. Additionally, Virginia should adopt Pennsylvania's model of sixteen exactly identified inspections of a well site. We propose that Virginia conduct these inspections entirely unannounced, which diverts from Pennsylvania's combination of routine and unannounced inspections. Results from inspections, to build public trust and hold oil and gas companies accountable, should be made publicly available on the DMME and DEQ websites.

Virginia currently does not conduct any baseline water sampling. This is critical for assessing the complete environmental impacts of hydraulic fracturing on water

quality. Several states at least encourage baseline water sampling to give the drilling companies the option of utilizing sampling as a protection tool for liability purposes. Once again, we identified Colorado as being the best in this category. Colorado was the first in the nation to mandate baseline water sampling both before and after drilling activities.

Virginia does require some reporting at each step of the drilling process, including operations plans and drilling reports, but we feel that Colorado's regulations for reporting are much more suitable to ensure hydraulic fracturing is done safely. Colorado requires both preliminary and final drilling completion reports, whereas Virginia only requires one at the point at which a well reaches its total depth. Requiring more reports throughout the drilling process at specific times can help ensure compliance, and may reduce the risk of operators cutting corners.

VIII. Appendix A: Full Comparison Chart

Ranking of Various Criteria						
		Virginia*	Pennsylvania	Illinois	Colorado	California
	Chemical disclosure					
	Requirements to disclose information on fracturing fluids	1	3	4	5	2
	Siting and site preparation					
	Identifying and testing of water wells prior to drilling of production wells	1	2	5	4	3
	Required setbacks from water sources	2	1	5	4	3
	Site reclamation					
	Requirements for backfilling, regrading, recontouring, and alleviating compaction of soil	2	4	3	5	1
	Well plugging					
	Requirements for notification, plugging plan or method, witnessing, and reporting	2	3	5	4	4
	Programs to plug wells that are not properly plugged and have been abandoned	2	1	4	5	5
	Waste management					
	Pit lining requirements	2	3	5	5	1
	Hazardous waste disposal	1	1	3	5	3
	Underground injection requirements	3	3	4	5	4
	Direct discharge to surface water	1	3	5	4	4
	Requirements for discharge to publicly-owned treatment works or centralized waste treatment facilities	2	3	4	5	2
	Solid waste disposal	2	3	4	4	3

Appendix A: Full Comparison Chart

	Managing air emissions					
	Requirements for criteria pollutants	3	2	3	4	5
	Requirements for hazardous air pollutants	1	2	3	4	5
	Drilling, casing, and cementing					
	Requirements relating to cementing/casing plans	1	3	5	4	2
	Prescribed placement of surface casing relative to groundwater zones	3	1	5	4	2
	Prescribed cementation techniques for surface casing	3	1	5	4	2
	Requirement for cement waiting period and/or integrity tests	1	2	5	4	3
	Blowout preventer requirements	2	1	5	4	3
	Oversight and Inspection Requirements					
	Notification reports at each step of drilling process	2	3	4	5	1
	Baseline sampling for water quality	1	3	4	5	2
	Spill reporting	2	3	5	4	1
	Well inspections	1	5	3	4	2
	TOTALS	41	56	98	101	63

IX. Appendix B: PRS Board of Advisors Reception Poster

The Thomas Jefferson Program in Public Policy at the College of William & Mary

Oil & Gas Development in the EVGMA: A Comparison of Virginia Legislation and Regulations with Several Other States

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XPRT

Project Overview

A company based in Texas has leased over 80,000 acres of land for hydraulic fracturing in the Taylorsville Basin area of Virginia. Our project analyzes existing regulations in Virginia in comparison to several other states to determine a legislative model of best practices. The next step in our project is to evaluate the regulations in Virginia and how they would apply to hydraulic fracturing in the Eastern Virginia Groundwater Management Area (EVGMA).

EVGMA

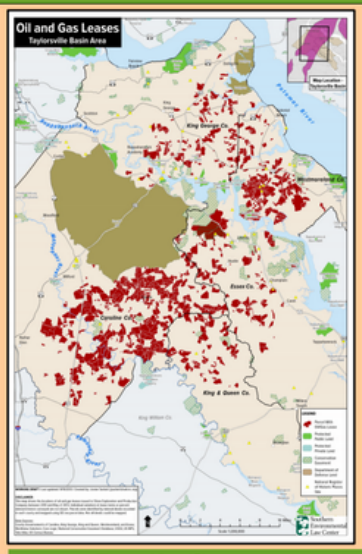
The Ground Water Management Act of 1992 established the Eastern Virginia Groundwater Management Area (EVGMA), an interconnected system of sand based aquifers east of I-95 . The EVGMA overlaps with parts of the Taylorsville basin, which is estimated to have 1 trillion cubic feet of natural gas.

Hydraulic Fracturing

The Department of Mines, Minerals, and Energy (DMME) currently applies existing laws for oil and gas development in Virginia to coal deposits for the extraction of methane in the southwestern portion of the state. Though test wells drilled in the 1980s did not yield commercially viable amounts of gas and oil, advancements in hydraulic fracturing and horizontal drilling have made the Taylorsville Basin an attractive location for new wells.

Federal Requirements

Safe Drinking Water Act	Safeguards to ensure wastewater or fluid injected underground doesn't endanger underground drinking water sources
	Requirements for Class II Underground Injection Control (UIC) wells
Clean Water Act	Regulation of waste management, including the disposal of flowback into surface waters (via the NPDES)
	Forthcoming standards for pretreatment of shale gas wastewater
Clean Air Act	Statutory definitions largely exempt oil and gas exploration and production wells from rules in relation to HAP emissions
	Green completion processes are mandated for all hydraulically fractured wells beginning in 2015
Resource Conservation and Recovery Act	Regulates the generation, transportation, treatment, storage and disposal of hazardous waste
	Certain oil and gas production waste is exempt
Comprehensive Environmental Response, Compensation, and Liability Act	Address the cleanup of releases of hazardous substances, pollutants, and contaminants
	Purely petroleum releases under petroleum exclusion do not apply; Commingled hazardous substances with petroleum would apply
Emergency Planning and Community Right-to-Know Act	Grants access to individuals and communities regarding the release of hazardous materials
	Oil and gas exploration companies are mandated to report releases
Toxic Substances Control Act	Regulating manufacture, processing, use, distribution in commerce, and disposal of chemical substances and mixtures
	Chemical companies are allowed to submit confidentiality claims related to substances
Federal Insecticide, Fungicide, and Rodenticide Act	Mandates that EPA administer pesticide registration requirements and authorizes EPA to regulate the use, sale, and distribution of pesticides
	Some pesticides used in hydraulic fracturing are covered



Executive Summary

Our regulatory comparision includes the states of Pennsylvania, Colorado, California, and Illinois. Our analysis uses these states due to their environmental regulatory models concerning hydraulic fracturing in oil and gas exploration. Relative to what regulatory model would be included for proposed environmental regulations in Virginia, we have analyzed some key criteria categories as a basis for our proposed framework for hydraulic fracturing in Virginia.

State Comparisons

	Virginia*	Pennsylvania	Illinois	Colorado	California
Hydraulic Fracturing					
Requirements to disclose information on fracturing fluids	No	Yes	Yes	Yes	Yes
Siting and Site Preparation					
Identifying and testing of water wells prior to drilling of production wells	Yes*	No	Yes	Yes	Yes
Required setbacks from water sources	Yes	No	Yes	Yes	Yes
Site Reclamation					
Requirements for backfilling, regrading, recontouring, and alleviating compaction of soil	Yes	Yes	Yes	Yes	Yes
Well Plugging					
Requirements for notification, plugging plan or method, witnessing, and reporting	Yes	Yes	Yes	Yes	Yes
Programs to plug wells that are not properly plugged and have been abandoned	Yes	Yes	Yes	Yes	Yes
Waste Management					
Pit lining requirements	Yes	No	Yes	Yes	Yes
Hazardous waste disposal	No	No	Yes	No	Yes
Underground injection requirements	Yes	No	Yes	Yes	Yes
Direct discharge to surface water	No	No	Yes	Yes*	Yes
Requirements for discharge to publicly-owned treatment works or centralized waste treatment facilities	Yes	Yes	Yes	Yes	Yes
Solid waste disposal	Yes	Yes	Yes	Yes	Yes
Managing Air Emissions					
Requirements for criteria pollutants	No	No	No	Yes	Yes
Requirements for hazardous air pollutants	No	No	No	Yes	Yes
Drilling, Casing and Cementing					
Requirements relating to cementing/casing plans	Yes	Yes	Yes	Yes	Yes
Prescribed placement of surface casing relative to groundwater zones	Yes	Yes	Yes	Yes	Yes
Prescribed cementation techniques for surface casing	Yes	Yes	Yes	Yes	Yes
Requirement for cement waiting period and/or integrity tests	No	Yes	Yes	Yes	Yes
Blowout preventer requirements	Yes	Yes	Yes	Yes	Yes

*Virginia's regulations currently only apply to coalbed methane and conventional gas wells