7-2014

Hydraulic Fracturing 101 Resource Guide

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Hydraulic Fracturing 101 Resource Guide

Developed July 2014 by the Alliance for Aquatic Resource Monitoring
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Alliance for Aquatic Resource Monitoring
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Terms to Know

- Annulus: An annulus is the space between the casing and the wall of the borehole, the tubing and casing, or two strings of casing ("Glossary of Oil and Gas Terms").
- Blowout Preventers (BOPs): Operators can use this series of valves to close an active oil or natural gas well. Blowout preventers may be used to regain control of the wellbore if oil or natural gas is forced into the wellbore by underground pressure (Pennsylvania Environmental Quality 5).
- Borehole (or wellbore): A borehole, or wellbore, is a hole drilled for the extraction of natural resources such as shale gas, oil, or water (Pennsylvania Environmental Quality 5).
- Brine: Brine is a saltwater and chemical mix that can mix with fracturing fluid underground and come to the surface in produced water, where it must be treated as contaminated wastewater. Brine often contains strontium, barium, naturally occurring radioactive substances, and metals ("Glossary of Terms Shale Oil").
- Casing: Casing is the steel pipe inserted in the well to keep fluids such as shale gas and fracturing fluid in the well (Pennsylvania Environmental Quality 5).
- Cementing: Cement is pumped down between the casing and the wellbore wall to hold it in place and prevent gas from leaking (Pennsylvania Environmental Quality 5).
- Christmas Tree: The Christmas tree, which refers to the various fittings and valves placed on top of the casing, controls the rate of natural gas production from the well ("Glossary of Oil and Gas Terms").
- Closed Loop Wastewater Management Systems: This generally refers to drillers operating with a water cycle that is never exposed to the open air, unlike containment ponds and reserve pits. Forced in part by policies that increased the costs of wastewater disposal, closed loop systems typically incorporate wastewater recycling (Closed-Loop 4).
- Conventional Gas Well: A conventional gas well is drilled into a conventional formation. Conventional formations vary in age and are found both above and below the Elk Sandstone formation. In Pennsylvania, most conventional gas wells still require hydraulic fracturing to produce a significant amount of natural gas, but on average the process requires a much lower volume of fluids than the volume used for hydraulic fracturing in unconventional gas formations ("Act 13").
- Cuttings (or drill cuttings): Cuttings are the rock debris created by the drill as it cuts into the rock. Cuttings are brought to the surface with the mud ("Glossary of Oil and Gas Terms").
- Environmental Assessment: An assessment of the possible positive or negative impacts that a proposed project may have on the environment (Pipeline Transportation 1).
- Environmental Impact Statement: A document required by the National Environmental Policy Act (NEPA) for actions that will significantly affect the quality of the environment. It describes the environmental effects of a proposed action, and it usually
also lists one or more alternative actions that may be chosen instead of the action described in the EIS (*Pipeline Transportation* 1).

- **Flowback Water**: Flowback water is the fracturing fluid that flows to the surface of the well immediately after the fracturing process is completed (“Hydraulic Fracturing Water”).

- **Gas Migration**: Gas migration is the process in which gas escapes from shale rock, a pipeline, or a gas well and moves through the bedrock and soil. It typically occurs along fractures in bedrock and through permeable soils and ground water aquifers. Within a well, gas migration occurs from the wellbore due to deteriorated or poorly constructed wells (*Pennsylvania Environmental Quality* 5).

- **Impact Fee**: An impact fee allows local governments to charge a fee to offset the impact of natural gas producers. The impact fee in PA created by Act 13 gives revenue to counties, especially those with natural gas production, more than the state (PA PUC).

- **Kickoff Point**: The kickoff point is the start of the well’s arc as the drill changes direction (Rountree and Estrada).

- **“Man Camps”**: “Man camps” are dormitory-style housing and training facilities built by gas companies for workers (Dobb).

- **Methane**: Methane is a colorless, odorless, and flammable gas that is the main component of natural gas (*Pipeline Transportation* 2).

- **Mud**: Mud is a mixture of base substance and additives that lubricates the drill bit and counteracts pressure of the shale formation that is naturally occurring (“Glossary of Oil and Gas Terms”).

- **Pennsylvania Department of Conservation and Natural Resources**: PA DCNR is the state agency that issues permits and enacts leasing policy for drilling on state-owned lands. DCNR does not regulate wells (“Glossary of Terms Shale Oil”).

- **Pennsylvania Department of Environmental Protection**: PA DEP is the state agency with permitting and primary regulatory authority over the natural gas industry (“Glossary of Terms Shale Oil”).

- **Plugging**: Plugging describes the process in which cement and other materials are used to seal the well permanently (“Glossary of Oil and Gas Terms”).

- **Pooling vs. Forced Pooling**: Pooling allows drilling corporations to combine adjacent areas of leased land into one unit, in which they can produce gas or oil with the least amount of wells. Forced pooling basically gives an oil and gas corporation eminent domain in certain circumstances by enabling it to do pooling, even if it does not own rights to all the property in the unit (Legere).

- **Produced Water**: Produced water is a mixture of fracturing fluid and natural formation water, containing minerals and salts, that flows through the wellhead along with the natural gas (“Hydraulic Fracturing Water”).

- **Royalties**: Royalties refers to the money paid by exploration and production companies to the mineral rights owners of a producing well. Pennsylvania state law requires this rate be
no less than 12% of the market price per 1,000 cubic feet of gas on the day that gas comes out of the ground (“Glossary of Terms Shale Oil”).
- Scoping: Scoping identifies the issues that are likely to be of most importance during the Environmental Impact Statement or Environmental Assessment and eliminates those that are of little concern (Pipeline Transportation 2).
- Severance Tax: A severance tax is a tax imposed on the extraction of a non-renewable resource, which compensates for the impacts on a community that are created by production. If implemented in PA, revenue from a severance tax would benefit the state (Nat’l Assoc. Royalty 1).
- Shale: Shale is a sedimentary rock that is fine grained and may contain natural gas or oil (“Glossary of Terms”).
- Shale Gas: Shale gas is natural gas trapped within shale formations (“What is Shale”).
- Susquehanna River Basin Commission: The SRBC governs water withdrawals within the Susquehanna River Basin, which includes many counties with hydraulic fracturing in PA. It has no oversight of discharges (“Glossary of Terms Shale Oil”).
- Unconventional Gas Well: An unconventional gas well is drilled into an unconventional formation, which is characterized as a geologic shale formation below the base of the Elk Sandstone or its geologically equivalent formation. Natural gas production in unconventional formations generally requires hydraulic fracturing, either in a vertical or horizontal well (“Act 13”).
- United States Environmental Protection Agency: The EPA is a federal agency that regulates industrial impacts on the environment (“What is Shale”).
- Wellbore: See “Borehole” definition

**Process of Hydraulic Fracturing**

*Establishment and Preparation for the Drilling Site*

To establish the site of each well pad, an area of four to six acres is leveled. This area is used for the well pad, storage of drilling waste, generators, vehicles, and other necessary equipment (Rountree and Estrada). Before a site is established though, various steps are taken to prepare for a hydraulic fracturing site. The initial steps to the preparation process are depicted below.

- The Penn State Marcellus Center for Outreach and Research describes the equipment used before, during, and after the process of hydraulic fracturing in slides 8-21 of a presentation available at the following link: [http://ecosystems.psu.edu/presenter/4-h-water/GasFieldGuide/](http://ecosystems.psu.edu/presenter/4-h-water/GasFieldGuide/)
**Machine:** Boring Machine

**Purpose:** Collects 3D seismic information to determine optimal sites for drilling. (Brittingham et.al.)


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**Machine:** Seismic or “thumper” trucks

**Purpose:** Collects 2D seismic information to determine optimal sites for drilling. (Brittingham et.al.)

Drilling Process
First, the well is drilled vertically, approximately 6,000 feet deep, through various geological layers, such as limestone, siltstone mixed with shale, sandstone, and coal, to access the shale formation. The Marcellus shale formation is 4,000 to 8,500 feet (1,200 to 2,590 meters) below the surface (Rountree and Estrada). A mud solution is pumped under pressure through the drilling pipe and the drill head to cool and lubricate the drill (Hydraulic Fracturing Shale).

Once the well reaches its intended depth in the shale layer, the drill turns horizontally. The kickoff point is the start of the well’s arc as the drill changes direction. The horizontal distance of the well amounts to approximately 3,000 to 5,000 feet (Rountree and Estrada). The vertical and horizontal lengths of unconventional wells vary, and depend largely on the characteristics of the shale formation. After drilling, both the rock cuttings created by the drilling and mud solution are sucked out of the well and the drill is removed (Hydraulic Fracturing Shale). In total, the process of drilling a new unconventional well requires approximately 100,000 gallons of water to cool the drill and bring rock cuttings out of the well (Brittingham et al.).

Fracturing Process
Next, steel casing is inserted the length of the well, and cement is pumped in to surround the outside of the casing. A perforating pipe gun containing explosive charges is inserted into the casing, and is detonated by an electrical charge sent through the well by a wire (Chesapeake Energy; Hydraulic Fracturing Shale; Rountree and Estrada). The resulting explosion creates holes in the shale through the casing and cement. The perforating gun is removed from the well.
and fracturing fluid is pumped into the well under high pressure at a rate of about 4,200 gallons (15,900 liters) per minute. The fracturing fluid enters the holes and creates many fractures throughout the shale, allowing natural gas to flow into the steel casing (Hydraulic Fracturing Shale; Rountree and Estrada). During extraction of the natural gas, anywhere from 10-100% of the fracturing fluid flows immediately to the surface with the natural gas (referred to as flowback water) where it is separated and disposed of. The remainder of the fluid stays underground (Chameides).

Fracturing Fluid
Fracturing fluid is prepared aboveground at the drilling site. Water from a water storage impoundment is mixed with sand, proppant, and chemicals that assist in the fracturing process (NY State Dept. of Environmental Conservation 5-53, 5-54). Approximately 4.4 million gallons of fresh water are used per well in the fracturing process in the Susquehanna River Basin (figure 1). Water comprises about 90.2% of the fracturing fluid mixture. Proppant, which is usually sand, comprises about 9.1% of the mixture, and chemicals comprise about 0.7% of the mixture. The types of chemicals used in fracturing fluid fall under thirteen types of additives, including acid, breaker, bactericide/biocide/antibacterial agent, buffer/pH adjusting agent, clay stabilizer/control/KCl, corrosion inhibitor (including oxygen scavengers), crosslinker, friction reducer, gelling agent, iron control, scale inhibitor, solvent, and surfactant. Acids, friction reducers, and surfactants tend to be some of the most prominent chemicals used by weight (NY State Dept. of Environmental Conservation 5-53, 5-54).

- The NY Dept. of Environmental Conservation created an SGEIS, which is an excellent source on chemicals used in fracturing fluid. View the document here: www.dec.ny.gov/energy/75370.html
Figure 1.

Multi-Stage Fracturing
A single unconventional well may be fractured multiple times. The average well has eight to twelve stages of fracturing spaced fifty to eighty feet apart (Chesapeake Energy). In multi-stage hydraulic fracturing, the perforating gun moves in reverse down the well to start each new stage of fracturing (Hydraulic Fracturing Shale). Plugs are placed before each fractured area to contain natural gas and fracturing fluid in its respective area (Chesapeake Energy). After all the fracturing stages are completed, the plugs are drilled out and extraction of natural gas from the well can begin (Hydraulic Fracturing Shale).
Post-Fracturing Process
After the fracturing process has been completed, a blowout preventer, commonly referred to as a Christmas tree, is left on the wellhead. The equipment used in the drilling and fracturing processes are removed. The Christmas tree allows gas to flow from the well through a pipeline to production lines, has a valve to shut off the gas, and has another valve to control pressure inside the well. Meanwhile, a dehydrator separates liquid from natural gas (Brittingham et al.).

Management and Disposal of Waste
Fluid from unconventional well sites can be disposed of in deep injection wells, known as class II underground injection wells (“Underground Injection”). The Safe Drinking Water Act regulates deep injection wells through the Underground Injection Control program. The U.S. Environmental Protection Agency (EPA) administers the UIC program, unless a state has been given authority to do so. State governments have authority over the UIC program in MD, OH, and WV in the Marcellus Shale region, while the EPA administers it in PA, VA, and NY (Hansen). Although there are over 1,800 deep injection wells in PA, only seven of them are active (“Classes and Numbers;” “Deep Injection”). Meanwhile, three deep injection wells in PA
have permits, but are currently inactive. The EPA temporarily shut down operations at a deep injection well in Clearfield County. Local officials are appealing the other two inactive wells, located in Clearfield and Elk counties. Much of the fluid waste from unconventional well sites in Pennsylvania is transported to deep injection wells in Ohio (“Deep Injection”).

- For information on the regulation of class II wells and the different types of class II wells (enhanced recovery wells and disposal wells), read pgs. 18-22 of GAO-12-874, a report by the U.S. Government Accountability Office, here:

Some of the liquid waste from the fracturing process is mixed with fracturing fluid for use at other unconventional wells sites. The liquid waste may or may not be treated before reuse.
In the Susquehanna River Basin, the average fracturing fluid mixture includes approximately 15% reused fluid from previously fractured wells (figure 1).

In Pennsylvania, data of production and waste is self-reported by the oil and gas industry to the PADEP. The PADEP releases this information from unconventional well sites to the public biannually (PA DEP Oil). Types of waste created by unconventional well sites include basic sediment, drill cuttings, flowback fracturing sand, flowback water, produced water, servicing fluid, and spent lubricant (Kelso). The waste is treated differently depending on whether it is classified as liquid, solid, or hazardous waste (table 1).

| Table 1: Potential Waste Management and Disposal Options

<table>
<thead>
<tr>
<th></th>
<th>Liquid waste</th>
<th>Solid waste</th>
<th>Hazardous waste</th>
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</thead>
<tbody>
<tr>
<td>Primary types of waste</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Produced water</td>
<td>Drill cuttings</td>
<td>Unused hydraulic fracturing chemicals being discarded</td>
</tr>
<tr>
<td></td>
<td>Drilling mud</td>
<td>Trash</td>
<td>Certain other chemical and oily wastes</td>
</tr>
<tr>
<td>Options for temporary storage</td>
<td>Tanks or pits</td>
<td>Tanks or pits</td>
<td>Tanks</td>
</tr>
<tr>
<td>Options for reuse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recycle for use in future hydraulic fracturing</td>
<td>Roadspraying of drill cuttings</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Irrigation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Roadspraying (used for dust or ice suppression)</td>
<td></td>
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<tr>
<td></td>
<td>Reuse of drilling mud</td>
<td></td>
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<tr>
<td>Options for permanent disposal</td>
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<tr>
<td></td>
<td>Underground injection well</td>
<td>Solid waste landfill</td>
<td>Hazardous waste disposal facility</td>
</tr>
<tr>
<td></td>
<td>Discharge to surface water</td>
<td>Bury drill cuttings on or near well pad</td>
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<tr>
<td></td>
<td>Commercial treatment facilities</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Publicly-owned treatment works</td>
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</tbody>
</table>

Table 1. Methods for Management and Disposal of Waste from Hydraulic Fracturing (U.S. GAO 14).

a. Note: These methods are used in the United States as of 2012. Some of the outlined methods, such as disposal through publicly owned treatment works, are not used in PA at this time.

The oil and gas industry in Pennsylvania is increasingly using closed storage tanks for temporary storage of liquid waste on-site. Liquid waste may also be stored in open pits known as impoundment ponds. These ponds started meeting stricter requirements in 2012 in PA (Drouin).

- FracTracker created an interactive map of locations receiving various types of waste from unconventional natural gas well sites in PA. View the map here: http://www.fractracker.org/2014/03/pa-production-waste/

- Self-reported information from the oil and gas industry on waste from well sites is provided by PA DEP here: https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/Welcome/Welcome.aspx
Pennsylvania’s regulations on the management and disposal of waste are outlined in a frequently asked questions page by the PA DEP under the section, “Containment for unconventional wells.” This page includes information on the requirements for impoundment ponds in Pennsylvania. View the information here: [http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/1127392](http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/1127392)

**Sources for Further Information**

- This animated video from SMT Learning describes the drilling process, fracturing process, and multi-stage fracturing: [http://www.youtube.com/watch?v=IB3FOJpy7s](http://www.youtube.com/watch?v=IB3FOJpy7s)
- This animated industry video from Chesapeake Energy provides a strong description of the fracturing process and multi-stage fracturing: [http://www.youtube.com/watch?v=qjP-K1Va11k](http://www.youtube.com/watch?v=qjP-K1Va11k)

**Federal Policy and Regulation of Hydraulic Fracturing**

*Exemptions from Major Federal Environmental Laws for the Oil and Gas Industry*

Hydraulic fracturing has at least partial exemptions from the following federal environmental laws:

- **Clean Air Act (CAA)**
- **Clean Water Act (CWA)**
- **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)**
- **National Environmental Policy Act (NEPA)**
- **Resource Conservation and Recovery Act (RCRA)**
- **Safe Drinking Water Act (SDWA)**
Toxic Release Inventory of the Emergency Planning and Community Right-to-Know Act (EPCRA)


- A succinct description on each of the above laws and the exemptions that the oil and gas industry has from them, entitled “Loopholes for Polluters: The oil and gas industry’s exemptions to major environmental laws”, is provided by EarthWorks at the following link:
  http://www.shalegas.energy.gov/resources/060211_earthworks_fs_oilgasexemptions.pdf

- A more detailed description on the above laws, excluding NEPA, is available on pgs. 17-44 of a U.S. GAO report at the following link:

Energy Policy Act of 2005

In 2001, George W. Bush appointed the National Energy Policy Development Group to develop a revised federal energy policy, which would be proposed to Congress (Hines 1). This group was headed by Vice President Dick Cheney, and included other prominent political leaders such as Secretary of State Colin Powell and the administrator of the U.S. Environmental Protection Agency, Christine Whitman (National Energy 1). The group submitted its report to the president in May 2001 (National Energy 1).

- The report, entitled Reliable, Affordable, and Environmentally Sound Energy for America’s Future, can be found at the following link:

The National Energy Policy Development Group’s report received criticism for a couple major reasons. The Bush administration kept the details of many of the group’s meetings secret. Cheney’s work in the private sector before his public service as Vice President also created controversy. He worked as Chief Executive Officer of Halliburton Corporation, which developed the modern hydraulic fracturing process in the 1940s and was looking to begin hydraulic fracturing in Marcellus Shale (Hines 1).

- An article entitled “Papers Detail Industry’s Role in Cheney’s Energy Report” by reporters Abramowitz and Mufson in 2007 from the Washington Post’s investigative series on the NEPDG can be found at the following link:

Other Key Federal Legislation Governing Hydraulic Fracturing

- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- Toxic Substances Control Act (TSCA)
• The role of FIFRA and TSCA in governing hydraulic fracturing is summarized by Tip of the Mitt Watershed Council at the following link:

The FRAC Act
The Fracturing Responsibility and Awareness of Chemicals Act, or FRAC Act, has been introduced to Congress in 2009, 2011, and 2013. The bill died in 2009 and 2011, and the most recent version is being reviewed by both the House Committee on Energy & Commerce: Environment & the Economy and the Senate Committee on Environment and Public Works. If enacted, the FRAC Act would, among other changes, repeal the hydraulic fracturing exemption under the Safe Drinking Water Act (SDWA) and mandate the disclosure of chemicals used in each hydraulic fracturing site (“S. 1135”)

• A complete synthesis of the FRAC Act in the Senate that is sponsored by Robert Casey Jr. (S. 1135), the full text of the bill, and an updated tracker of actions taken on the bill are provided by Congress here: http://beta.congress.gov/bill/113th-congress/senate-bill/1135

• A complete synthesis of the FRAC Act in the House of Representatives that is sponsored by Diana DeGette (H.R. 1921), the full text of the bill, and an updated tracker of actions taken on the bill are provided by Congress here: http://beta.congress.gov/bill/113th-congress/house-bill/1921

Sources for Further Information

• The U.S. Government Accountability Office published a detailed report in 2012, GAO-12-874, on federal and state regulations on hydraulic fracturing. The report includes information on the various exemptions that the oil and gas industry has from federal legislation, as well as information on several of Pennsylvania’s policies on the industry in comparison to other states. View the full report here: http://www.gao.gov/assets/650/647782.pdf

Pennsylvania Policy and Regulation of Hydraulic Fracturing

Pennsylvania Oil and Gas Act
The Pennsylvania Oil and Gas Act, or Act 223 of Title 58 (Oil and Gas) of the Pennsylvania Consolidated Statutes, passed in 1984 and took effect in 1985. It is one of the primary laws regulating natural gas extraction in PA. Before the passage of Act 13 in 2012, the Oil and Gas Act was not updated for unconventional wells. It is administered by the PA DEP Oil and Gas Management Program and established a permitting process, well registration, bonding requirements, technical standards (for casing, waste disposal, cementing, and plugging), and a complaint process for surface landowners. The law devoted all fines and fees to plugging oil and
gas wells that were abandoned and superseded some municipal ordinance regulation of oil and
gas operations (Pifer).

- The Penn State Dickinson School of Law provides a complete summary of the law, “The
  Pennsylvania Oil and Gas Act: A Summary of the Statutory Provisions,” here:
  http://law.psu.edu/_file/aglaw/SummaryOfPennsylvaniaOilAndGasAct.pdf

**Act 13 of Pennsylvania’s Oil and Gas Act**

Act 13 of 2012 of Pennsylvania’s Oil and Gas Act, commonly referred to as Act 13, amended
Title 58 (Oil and Gas) of the Pennsylvania Consolidated Statutes (PA PUC 1). The impact fee
created under Act 13 is explained in the next section.

- Act 13 can be read in its entirety at the following link:
  http://www.legis.state.pa.us/WU01/LI/LI/US/HTM/2012/0/0013..HTM

- The PA Department of Environmental Protection (PA DEP) outlined some major aspects
  of Act 13 in “Act 13 Frequently Asked Questions” at the following link:
  http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/11273
  92

- PennFuture created an easy-to-read, detailed guide to Act 13. Information on corporate
  liability in the event of pollution of a drinking water supply is available on pg. 12. View
  the guide at the following link:

**Impact Fee**

In Pennsylvania, an impact fee was created under Act 13. Natural gas corporations are charged a
fee for each unconventional well that is actively drilling for natural gas, referred to as a spud well
(“Act 13”). Sixty percent of the proceeds from the fee are distributed to counties and towns with
unconventional wells. Fifteen percent of the proceeds are distributed to all counties in the state,
including those without natural gas production, for certain environmental initiatives. The
remaining proceeds are distributed throughout PA for infrastructure and environmental projects
Meanwhile, Pennsylvania remains the only major natural gas-producing state to not have a
severance tax (“Oil and Gas Law”).

- A detailed outline of the impact fee, “Act 13 of 2012 – The Unconventional Gas Well
  Impact Fee: Frequently asked questions,” was created by the PA Public Utility
  Commission at the following link:
  http://www.puc.state.pa.us/NaturalGas/pdf/MarcellusShale/12_Act13_FAQs.pdf

- The PA Public Utility Commission synthesized information on the impact fee revenue
  with graphs at the following link: https://www.act13-
  reporting.puc.pa.gov/Modules/PublicReporting/Overview.aspx
Supreme Court of Pennsylvania Decision on Act 13

In a 4-2 decision in December 2012, the Supreme Court of Pennsylvania struck down parts of Act 13 of the state’s Oil and Gas Act (“Oil and Gas Law”). Some of the major parts of the decision include:

- The oil and gas industry is no longer required to place unconventional gas wells a minimum of 300 feet, or to place the edge of the disturbance created by well pads a minimum of 100 feet, from streams or wetlands at least one acre in size (figure 2). However, Act 13 had included a loophole that allowed corporations to circumvent this minimum distance. There are currently no setbacks from streams and wetlands required for the industry (Cusick, “Did Pennsylvania’s”).

  - Read an explanation of the loophole that was in Act 13 and the reasoning behind the court’s decision on setbacks in “Did Pennsylvania’s Highest Court Unravel Environmental Protections for Oil and Gas?” by Marie Cusick at: http://stateimpact.npr.org/pennsylvania/2014/01/10/did-pennsylvanias-highest-court-unravel-environmental-protections-for-oil-and-gas/

![Figure 2. Minimum Setbacks for Unconventional Gas Production from Streams and Wetlands that were Created by Act 13 and Struck Down by the Supreme Court of PA (Cusick, “Did Pennsylvania’s”).](image)

- The court struck down a part of Act 13 that limited the ability of local governments to regulate and zone hydraulic fracturing (“Oil and Gas Law”). Many municipalities throughout PA established zoning regulations on the oil and gas industry following the court’s decision. The following link shows municipalities with Zoning Codes for Natural Gas Drilling and Gas Wells in Pennsylvania as of February 2014 (Colaneri and Thomas).
The court sent some questions regarding Act 13 back to the lower Commonwealth Court, such as whether the act can stand without the parts of the law that PA’s supreme court ruled unconstitutional. Most of the provisions of Act 13 remained intact (“Oil and Gas Law”).

- Read a synthesis of the major issues of Act 13 that were reviewed by the Commonwealth Court in “What’s Still at Stake in the Act 13 Court Battle?” by Marie Cusick at the following link: http://stateimpact.npr.org/pennsylvania/2014/03/14/whats-still-at-stake-in-the-act-13-court-battle/


- The Commonwealth Court made rulings in July 2013 on parts of Act 13 that were sent back to the court following the Supreme Court of PA’s decision.

**Clean and Green Act**
The Clean and Green Act, formally known as the Pennsylvania Farmland and Forest Land Assessment Act of 1974, is a PA program that gives enrolled landowners preferential tax assessment based on the production value of farmland and forestland rather than on the land’s market value. If land is removed from agricultural production, a five years’ difference in the taxes with interest is due. Bradford, Tioga, and two other counties originally required back payments for the entire property if ineligible construction, including gas facilities, occurred on any part. Depending on the wording of leases, landowners may be responsible for thousands of dollars of rollback taxes with interest if a drill pad is constructed on their property. Those charges can be particularly difficult while the pad is constructed and before or without any royalties from production. PA courts have resolved that back taxes must only be paid on the area of land moved out of agricultural production (“Chapter 137b” § 137b.23).

• View the Clean and Green Act here: [http://www.pacode.com/secure/data/007/chapter137b/chap137btoc.html](http://www.pacode.com/secure/data/007/chapter137b/chap137btoc.html)

**Policies Concerning Eminent Domain**
In Pennsylvania, the oil and gas industry has eminent domain in certain circumstances for transportation or storage purposes. The industry cannot exercise eminent domain for storage purposes unless the original recoverable gas or oil reserves have been depleted by a minimum of 80% and the condemnor has the right to store gas underlying a minimum of 75% of the proposed storage area (Pifer).

**Hydraulic Fracturing in State Parks and Forests**
In May 2014, Governor Corbett issued an executive order that overturned a moratorium in PA on new leasing of land in public parks and forests to the oil and gas industry (Cusick, “Corbett Lifts”).


**Other Major Pennsylvania Legislation on Hydraulic Fracturing**
Other key statutes to the Pennsylvania Oil and Gas Act include:

- Act 214 – Coal and Gas Resource Coordination Law
Act 214 – Pennsylvania Law Governing Natural Gas Exploration

- View Act 214 at the following link:

Act 359 – Oil and Gas Conservation Law

- This law was passed in 1961 and pertains to pooling in the state (Legere). It covers wells that penetrate layer of underground rock known as the Onondaga Horizon. Since the Onondaga Horizon is deeper than the Marcellus Shale, hydraulic fracturing in the Marcellus is not covered under this law (Pifer). However, the law does apply to hydraulic fracturing in the Utica Shale. The PA Department of Environmental Protection reviews applications for forced pooling through the Oil and Gas Conservation Law (Legere).

- View Act 359 at the following link:
  http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/LawsRegsGuidelines/Act359uc.pdf

Act 394 – Clean Streams Law

- View Act 394 at the following link:
  http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/LawsRegsGuidelines/CleanStreamsLawUpdate.doc

Sources for Further Information

- A presentation from Penn State’s Dickinson School of Law describes the various Pennsylvania laws governing natural gas exploration:

- A succinct description on the legislative process in PA is provided by the House of Representatives of Pennsylvania here:
  http://www.pacapitol.com/Resources/PDF/Making-Law-In-PA.pdf

- The Marcellus Shale Coalition created a diagram outlining the various processes related to hydraulic fracturing that are regulated in Pennsylvania and what agencies regulate them, which is available here: http://marcelluscoalition.org/wp-content/uploads/2011/10/PA_Regulations.pdf

Science of Shale Gas

Geology

The Marcellus Shale, formally known as the Marcellus Formation, is hydraulically fractured for natural gas in the Northeastern United States. Marcellus is black shale, which means it has a carbon content over one percent. It is also clastic, or made up of pre-existing rock fragments, and mostly consists of silicon dioxide (Curtis). The thickness of the Marcellus Shale extends to over 350 feet, while its base ranges from approximately 2,000 to 9,000 feet deep (figure 4; figure 5).
Natural gas is either classified as dry or wet. Wet natural gas can contain natural gas liquids such as pentane, butane, propane, and ethane, which are separated from methane following extraction. Dry natural gas is more thermally mature than wet natural gas, and is predominately comprised of methane. Currently, wet natural gas is considered more valuable than dry natural gas due to the value of natural gas liquids. Wet natural gas is found in western PA (figure 5).

Figure 4. Thickness of the Marcellus Shale (“Maps and Graphics”).
Reports on the total amount of natural gas available in the Marcellus Shale have varied. For information on the differences in the reports, read “How Much Natural Gas Can the Marcellus Shale Produce?” by Pennsylvania State University’s MCOR, here: http://extension.psu.edu/natural-resources/natural-gas/news/2012/05/how-much-natural-gas-can-the-marcellus-shale-produce

The Utica Shale is calcareous, black, and organic-rich shale in eastern North America, located thousands of feet deeper than the Marcellus Shale (King). The thickness of the Utica Shale extends to over 500 feet, while the depth of its base ranges from approximately 2,000 to 14,000 feet (figure 6; figure 7). As of 2014, natural gas production from the Utica is very low in Pennsylvania, since the process is more expensive than in the Marcellus Shale (PA DCNR). By area, the Utica and the Marcellus are the largest shale plays within the United States (figure 8).

Figure 6. Thickness of the Utica Shale (“Maps and Graphics”).

Figure 7. Depth of the Utica Shale (“Maps and Graphics”).
Figure 7. Depth of the Utica Shale ("Maps and Graphics").

Figure 8. Shale Plays and Basins in the Contiguous United States as of 2011 (Lower 48 States).

Sources for Further Information

- The Penn State Marcellus Center for Outreach and Research (MCOR), provides informational maps, including an animated map of unconventional wells drilled in PA from 2004 to 2013, and other excellent resources on the science of shale gas, here: http://www.marcellus.psu.edu/

- For volunteer shale gas monitoring resources in response to water quality concerns, view the Alliance for Aquatic Resource Monitoring’s (ALLARM) toolkit here: http://allarmwater.org

- The Energy Data Exchange (EDX), a DOE database, provides science-focused databases with geophysical data related to shale gas, such as formation depth maps, Class II injection well databases, and well location map, here: https://edx.netl.doe.gov/group/unconventional-resources
The U.S. Energy Information Administration (EIA) released a new report in 2013 on the amount of natural gas available in the world, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*, which is available here: 
http://www.eia.gov/analysis/studies/worldshalegas/

**Recommended Sources for Further Information on Various Topics**

**Leasing Land to the Oil and Gas Industry**

- For information on leasing land to the oil and gas industry, read *A Landowner’s Guide to Leasing Land in Pennsylvania* by Penn State Extension, which is available here: 
  http://pubs.cas.psu.edu/FreePubs/pdfs/ua448.pdf

**Mapping Resources**

- An open-source GIS platform, started by Harvard University, can be used as a central database and can be used locally to identify the location of vulnerable populations, health reports, observations, monitoring data, etc. The map, which provides the GPS coordinates for thousands of active unconventional wells, is available here: 
  http://worldmap.harvard.edu/maps/FrackMap
- Numerous maps related to hydraulic fracturing in the United States are provided by FracTracker here: http://www.fractracker.org/

**Occupational Hazards**

- The U.S. Department of Labor outlines the various potential hazards for workers in the oil and gas industry here: https://www.osha.gov/SLTC/etools/oilandgas/index.html
- The Center for Disease Control and Prevention provides information on the occupational hazards associated with exposure to sand, which also creates risks to public health, used in fracturing fluid at the following link: http://blogs.cdc.gov/niosh-science-blog/2012/05/23/silica-fracking/

**Resources for In-Depth Research on Hydraulic Fracturing**

- StateImpact Pennsylvania publishes numerous articles on political, economic, and environmental concerns of hydraulic fracturing in PA. Access the website, which is an excellent tool for staying updated on current events on the issue, here: 
  http://stateimpact.npr.org/pennsylvania/
- The New York Times published various articles on the risks connected to hydraulic fracturing. The NY Times also provides an archive of oil and gas leases and research that it conducted on toxic waste, wastewater recycling, mortgages and gas leases, and the study scope associated with hydraulic fracturing. Access these resources here:
Pennsylvania State University provides numerous resources related to hydraulic fracturing, which can be accessed through Penn State Extension here: [http://extension.psu.edu/natural-resources/natural-gas](http://extension.psu.edu/natural-resources/natural-gas) and Marcellus Center for Outreach and Research (MCOR) here: [http://www.marcellus.psu.edu](http://www.marcellus.psu.edu)

Carnegie Mellon University and the PA State Association of Boroughs created a research guide for information on hydraulic fracturing in the Marcellus and Utica shales, which is available here: [http://rpstrauss.pairserver.com/marcellusshale/sourcesbycategory.html](http://rpstrauss.pairserver.com/marcellusshale/sourcesbycategory.html)

**Societal Concerns**


**Water Quality Concerns**

- A comprehensive and well-organized guide to drinking water and groundwater testing, as well as resources to find a lab, collect samples, and interpret data, compiled by the Colorado Water and Energy Research Center (CWERC), are available here: [http://cwerc.colorado.edu](http://cwerc.colorado.edu)

- Information on hydraulic fracturing and drinking water, waste water, water use, and water management, compiled by Penn State Extension, is available here: [http://extension.psu.edu/natural-resources/water/marcellus-shale](http://extension.psu.edu/natural-resources/water/marcellus-shale)
Works Cited


Picture References

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