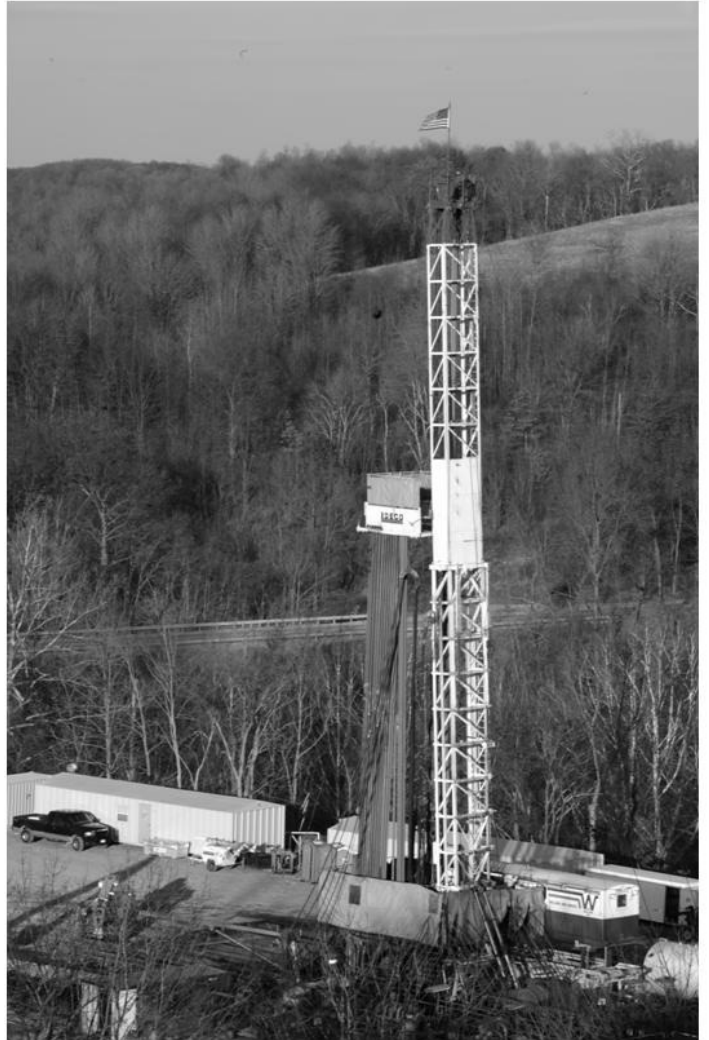


Visual Assessment Manual



marcellus citizen stewardship project
an outreach, assessment and monitoring initiative

The Marcellus Citizen Stewardship Project is an initiative of the

**Mountain Watershed Association
Home of the Youghiogheny RIVERKEEPER®**

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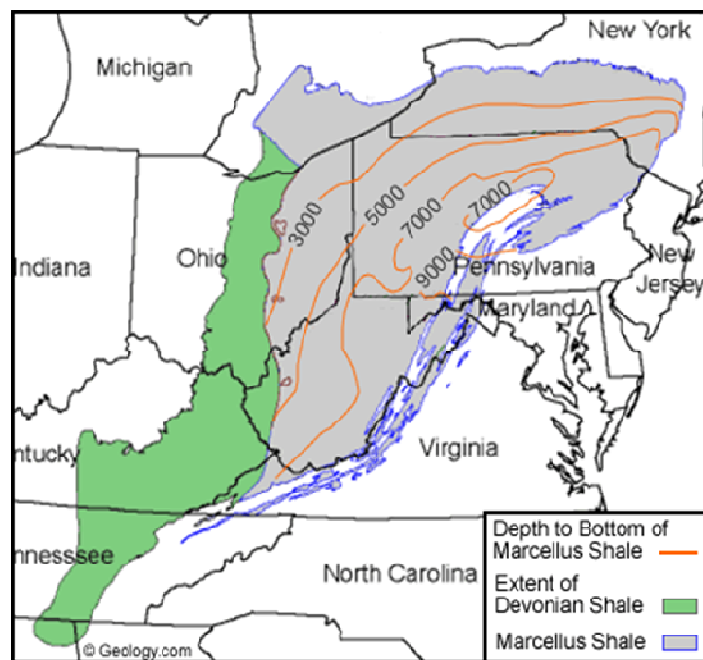
Chapter 1

The Marcellus Shale Extraction Process

What is Marcellus Shale?

The Marcellus Shale forms the bottom or basal part of a thick sequence of Devonian age, sedimentary rocks in the Appalachian Basin. This sediment was deposited by an ancient river delta, the remains of which now form the Catskill Mountains in New York¹. The basin floor subsided under the weight of the sediment, resulting in a wedge-shaped deposit (fig. 1) that is thicker in the east and thins to the west. The eastern, thicker part of the sediment wedge is composed of sandstone, siltstone, and shale (Potter and others, 1980), whereas the thinner sediments to the west consist of finer-grained, organic-rich black shale, interblended with organic-lean gray shale. The Marcellus Shale was deposited as an organic-rich mud across the Appalachian Basin before the influx of the majority of the younger Devonian sediments, and was buried beneath them.²

Figure 2



De Wit, Wallace, et al. (1993) Principal Oil and Gas Plays in the Appalachian Basin (Province 131). U.S. Geological Survey Bulletin 1839-1, p.37.

Where is it?

This formation underlies much of the Mid-Atlantic and Northeastern regions of the United States, including portions of New York, Pennsylvania, Ohio, Maryland, West Virginia and Virginia. The Marcellus Shale is a rock formation found at a depth of 5,000 to 8,000 feet.

How big is it?

The Marcellus Shale layer consists of little more than approximately 90,000 square miles (300 x 300 miles).³

What does the Marcellus Shale offer?

It is believed to hold trillions of cubic feet of natural gas which have remained largely untapped to date due to the expense associated with extracting it. Recent advances in drilling technologies, including hydraulic fracturing, have made the Marcellus shale layer more accessible. This combined with the proximity of the shale layer to eastern energy markets has resulted in new interest in the formation.

Natural gas, as we use it, is almost entirely methane. Natural gas as we find it underground, however, can come associated with a variety of other compounds and gases, as well as oil and water, which must be removed. Natural gas transported through pipelines must meet purity specifications to be allowed in, so most natural gas processing occurs near the well

- Natural Gas
- Propane
- Butane
- Other byproducts

How much is there?

Estimates vary, but many geologists believe the Marcellus Shale formation could contain between 168 trillion to 516 trillion cubic feet of natural gas, though it is not currently known how much of this gas is recoverable.⁴ Some geologists believe that the gas stored in the Marcellus Shale formation could meet the energy needs of the entire United States for over twenty years.⁵ The annual average for natural gas usage in the United States is 23 tcf.⁶ If the infrastructure and use of natural gas increases we could see this annual average increase considerably. Currently at 516 tcf, (which some industry representatives say is low for recoverable gas) divided by 23 tcf annually then the expectation is that we will obtain about 23 years of natural gas usage.

Well site determination

The exact placement of the drill site depends on many factors, including the nature of the potential formation to be drilled, the characteristics of the subsurface geology, and the depth and size of the target deposit.

Seismic testing

The exploration for natural gas typically begins with geologists examining the surface structure of the earth, and determining areas where it is geologically likely that petroleum or gas deposits might exist. By surveying and mapping the surface and sub-surface characteristics of a certain area, the geologist can extrapolate which areas are most likely to contain a petroleum or natural gas reservoir. Surveying and mapping is done using outcroppings of rocks on the surface or in valleys and gorges, to the geologic information attained from the rock cuttings and samples obtained from the digging of irrigation ditches, water wells, and other oil and gas wells.

The biggest breakthrough in petroleum and natural gas exploration came through the use of basic seismology. Seismology refers to the study of how energy, in the form of seismic waves, moves through the Earth's crust and interacts differently with various types of underground formations. The basic concept of seismology is quite simple. As the Earth's crust is composed of different layers, each with its own properties, energy (in the form of seismic waves) traveling underground interacts differently with each of these layers. These seismic waves, emitted from a source, will travel through the earth, but also be reflected back towards the source by the different underground layers. It is this reflection that allows for the use of seismology in discovering the properties of underground geology.

Geophysicists are able to artificially create vibrations on the surface and record how these vibrations are reflected back to the surface. In practice, using seismology for exploring onshore areas involves artificially creating seismic waves, the reflection of which are then picked up by sensitive pieces of equipment called 'geophones', imbedded in the ground. The data picked up by these geophones are then transmitted to a seismic recording truck, which records the data for further interpretation by geophysicists and petroleum reservoir engineers. The source of seismic waves creates vibrations, which reflect off of the different layers of the earth, to be picked up by geophones on the surface, and relayed to a seismic recording truck to be interpreted and logged.

Recently, due to environmental concerns and improved technology, it is often no longer necessary to use explosive charges to generate the needed seismic waves. Instead, most seismic crews use non-explosive seismic technology to generate the required data. This non-explosive technology usually consists of a large heavy wheeled or tracked vehicle carrying special equipment designed to create a large impact or series of vibrations. These impacts or vibrations create seismic waves similar to those created by dynamite. There is a large piston in the middle which is used to create vibrations on the surface of the earth, sending seismic waves that are used to generate useful data.

Other Means of Geological Testing

Exploratory Wells

The best way to gain a full understanding of subsurface geology and the potential for natural gas deposits to exist in a given area is to drill an exploratory well. This consists of actually digging into the earth's crust to allow geologists to study the composition of the underground rock layers in detail. In addition to looking for natural gas and petroleum deposits by drilling an exploratory well, geologists also examine the drill cuttings and fluids to gain a better understanding of the geologic features of the area. Logging, explained below, is another tool used in developed as well as exploratory wells. Drilling an exploratory well is an expensive, time consuming effort. Therefore, exploratory wells are only drilled in areas where other data has indicated a high probability of petroleum formations.

Logging

Logging refers to performing tests during or after the drilling process to allow geologists and drill operators to monitor the progress of the well drilling and to gain a clearer picture of subsurface formations. There are many different types of logging, in fact; over 100 different logging tests can be performed, but essentially they consist of a variety of tests that illuminate the true composition and characteristics of the different layers of rock that the well passes through. Logging is also essential during the drilling process. Monitoring logs can ensure that the correct drilling equipment is used and that drilling is not continued if unfavorable conditions develop.

It is beyond the scope of this manual to get into detail concerning the various types of logging tests that can be performed. Various types of tests include standard, electric, acoustic, radioactivity, density, induction, caliper, directional and nuclear logging, to name but a few. Two of the most prolific and often performed tests include standard logging and electric logging.

Standard logging consists of examining and recording the physical aspects of a well. For example, the drill cuttings (rock that is displaced by the drilling of the well) are all examined and recorded, allowing geologists to physically examine the subsurface rock. Also, core samples are taken, which consists of lifting a sample of underground rock intact to the surface, allowing the various layers of rock, and their thickness, to be examined. These cuttings and cores are often examined using powerful microscopes, which can magnify the rock up to 2000 times. This allows the geologist to examine the porosity and fluid content of the subsurface rock, and to gain a better understanding of the earth in which the well is being drilled.

Electric logging consists of lowering a device used to measure the electric resistance of the rock layers in the 'down hole' portion of the well. This is done by running an electric current through the rock formation and measuring the resistance that it encounters along its way. This gives geologists an idea of the fluid content and characteristics. A newer version of electric logging, called induction electric logging, provides much the same types of readings but is more easily performed and provides data that is more easily interpreted.⁷

Selection of the Drill Site

The exact placement of the drill site depends on a variety of factors, including the nature of the potential formation to be drilled, the characteristics of the subsurface geology, and the depth and size of the target deposit. After the geophysical team identifies the optimal location for a well, it is necessary for the drilling company to ensure that they complete all the necessary steps to ensure that they can legally drill in that area. This usually involves securing permits for the drilling operations, establishment of a legal arrangement to allow the natural gas company to extract and sell the resources under a given area of land, and a design for gathering lines that will connect the well to the pipeline. There are a variety of potential owners of the land and mineral rights of a given area.

Well Site Preparation

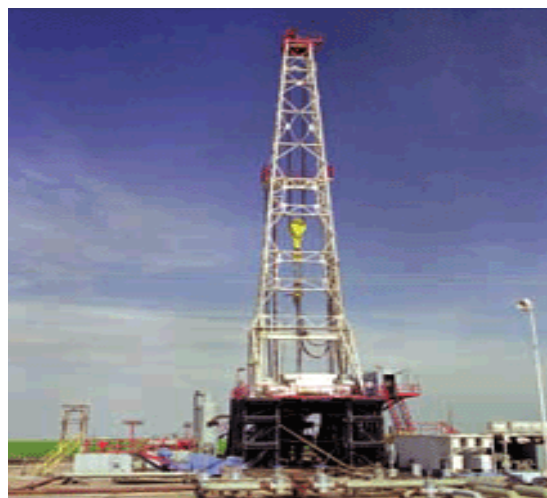
A level land platform is necessary for the drilling and well completion operations. Often times in Southwestern and other areas of Pennsylvania, New York and West Virginia the terrain is sloped and hilly and it is necessary for heavy construction equipment to be brought to the proposed well site to excavate and level the terrain to achieve a 2-5 acre level platform for operations continue.

The leveling or site construction process may include the removal of trees. How these trees are disposed of is usually determined by the company unless a lease is negotiated for the sale or disposal of this lumber.

Access roadways are needed to access the drilling platform. These roadways are frequently gravel, in order to handle large trucks and promote drainage of storm water runoff. Paved roadways involved in transport to and from the drill site, will often be reconstructed to handle larger and higher volumes of truck traffic in and out of the drill site during development. Many gas companies will work with municipalities to re-mediate or reconstruct roadways damaged during the well development and completion process.

Frequently when hydraulic fracturing is employed large open air impoundments are constructed. A permit is obtained from the Department of Environmental Protection to construct these impoundments which can be used to store drilling mud/sludge from the vertical and horizontal well bore and for storing fresh water and flow back water during the vertical and horizontal drilling process. Frequently a large hole is dug that can be the size of 2 or 3 football fields or larger. The earth removed from these impoundments is placed next to them to form a hill. This earth will later be used to fill in the impoundment in order to re-mediate the land. The liners of these impoundments are to be disposed according to permit. These impoundments are frequently surrounded by a wire or plastic fence.

Deep Gas Drilling



Vertical well drilling

Until recently, nearly all gas wells drilled in the eastern United States have been drilled vertically, meaning that the well is drilled straight down until the desired gas formation has been penetrated, and then the formation is fractured in the area immediately surrounding the vertical well bore in order to increase the flow of gas to the surface.

Because of the 'tightness' of the Marcellus shale, drilling vertically into this formation is not economically feasible. A different set of rigging is put in place for horizontal well drilling

Horizontal drilling

Horizontal wells can be drilled up to 5000 ft from a vertical well.

There can be 6-10 wells from one well pad. However, each horizontal well has a separate vertical well. Vertical wells must be at least 15 ft apart.

In horizontal drilling, a well is drilled straight down until the desired gas formation has been penetrated; at which point the drill rods are then turned horizontally in order to drill perpendicularly from the original vertical well bore. Horizontal drilling can provide greater access to a gas formation with a much smaller footprint, as multiple horizontal wells can be drilled from a one drilling pad. Each horizontal well can access gas trapped beneath 200-400 surface acres; it is possible to drill up to 5000 feet horizontally from the original vertical well bore.⁸

Circulating System

The final component of rotary drilling consists of the circulating system. There are a number of main objectives of this system, including cooling and lubricating the drill bit, controlling well pressure, removing debris and cuttings, and coating the walls of the well with a mud type-cake. The circulating system consists of drilling fluid, which is circulated down through the well hole throughout the drilling process. Typically, liquid drilling fluids are used. The most common liquid drilling fluid, known as 'mud', may contain clay, chemicals, weighting materials, water, oil, or gases. 'Air drilling' is the practice of using gasses as the drilling fluid, rather than a liquid. Gases used include natural gas, air, or engine exhaust. Air drilling can significantly cut down on drilling time, as well as drilling fluid costs

The circulating system consists of a starting point, the mud pit, where the drilling fluid ingredients are stored. Mixing takes place at the mud mixing hopper, from which the fluid is forced through pumps up to the swivel and down all the way through the drill pipe, emerging through the drill bit itself. From there, the drilling fluid circulates through the bit, picking up debris and drill cuttings, to be circulated back up the well, traveling between the drill string and

the walls of the well (also called the 'annular space'). Once reaching the surface, the drilling fluid is filtered to recover the reusable fluid.

In addition to the fluid itself regulating down hole pressures encountered while drilling, a device known as the 'blowout preventer' is situated on the well casing below the deck of the rig. A blowout can occur when uncontrolled underground oil or gas pressure exerts more upward pressure than the drilling fluid itself can offset. The blowout preventer can consist of hydraulically powered devices that can seal off the well quickly and completely, preventing any potential for a well blowout should extreme down hole pressures be encountered. Pressure release systems are also installed to relieve the great pressure that can be experienced in a blowout situation.

Mud is, with varying degree, toxic.

Mud is difficult and expensive to dispose of in an environmentally-friendly manner.

Well Completion⁹

Once a natural gas or oil well is drilled, and it has been verified that commercially viable quantities of natural gas are present for extraction, the well must be 'completed' to allow for the flow of petroleum or natural gas out of the formation and up to the surface. This process includes strengthening the well hole with casing, evaluating the pressure and temperature of the formation, and then installing the proper equipment to ensure an efficient flow of natural gas out of the well.

There are three main types of conventional natural gas wells.

Oil Wells - Since oil is commonly associated with natural gas deposits, a certain amount of natural gas may be obtained from wells that were drilled primarily for oil production. These are known as oil wells. In some cases, this "associated" natural gas is used to help in the production of oil, by providing pressure in the formation for the oils extraction. The associated natural gas may also exist in large enough quantities to allow its extraction along with the oil.

Natural gas wells - are wells drilled specifically for natural gas, and contain little or no oil.

Condensate wells - contain natural gas, as well as a liquid condensate. This condensate is a liquid hydrocarbon mixture that is often separated from the natural gas either at the wellhead, or during the processing of the natural gas. Depending on the type of well that is being drilled, completion may differ slightly. It is important to remember that natural gas, being lighter than air, will naturally rise to the surface of a well. Because of this, in many natural gas and condensate wells, lifting equipment and well treatment are not necessary.

Completing a well consists of a number of steps; installing the well casing, completing the well, installing the wellhead, and installing lifting equipment or treating the formation should that be required.

Well Casing¹⁰

Cased Completion

Cased completions are more the norm. The installation (setting) of relatively thin-walled casing in the well bore allows most possible production problems to be avoided. The casing process consists of hanging the casing in the hole, cementing it in place, isolating the producing horizon with some combination of cement plugs and tools called packers, perforating the casing and any cement opposite the desired producing interval and, perhaps, installing a production liner. Aspects of each of these are discussed below.

Well casing consists of thin-walled tubing, usually constructed of steel, that is used to line the drilled hole. The casing supports the wall of the well, checks the caving tendencies of unconsolidated formations, prevents unwanted exchange of fluids between the various penetrated formations, excludes the inflow of fluids and fines from all but the target producing intervals, and provides the mounting base for surface well control equipment. Normally, the casing is $\frac{3}{4}$ inch or more smaller in diameter than the drilled hole.

Cementing

Cased wells are nearly always cemented (i.e., cement is pumped down through the well into the annular space between the casing and the hole wall). The cement serves to mechanically stabilize the casing string within the hole and seals off water flows from the adjacent formations

It is often the failure to properly case a well that results in contaminated fresh water aquifers and subsequent private drinking water well contamination.

Installing well casing is an important part of the drilling and completion process. Well casing consists of a series of metal tubes installed in the freshly drilled hole. Casing serves to strengthen the sides of the well hole, ensure that no oil or natural gas seeps out of the well hole as it is brought to the surface, and to keep other fluids or gases from seeping into the formation through the well. A good deal of planning is necessary to ensure that the proper casing for each well is installed. Types of casing used depend on the subsurface characteristics of the well, including the diameter of the well (which is dependent on the size of the drill bit used) and the pressures and temperatures experienced throughout the well. In most wells, the diameter of the well hole decreases the deeper it is drilled, leading to a type of conical shape that must be taken into account when installing casing.

There are five different types of well casing. They include:

1. Conductor Casing

Conductor casing is installed first, usually prior to the arrival of the drilling rig. The hole for conductor casing is often drilled with a small auger drill, mounted on the back of a truck. Conductor casing, which is usually no more than 20 to 50 feet long, is installed to prevent the

top of the well from caving in and to help in the process of circulating the drilling fluid up from the bottom of the well. Onshore, this casing is usually 16 to 20 inches in diameter while offshore casing usually measures 30 to 42 inches. The conductor casing is cemented into place before drilling begins.

2. Surface Casing

Surface casing is the next type of casing to be installed. It can be anywhere from a few hundred to 2,000 feet long, and is smaller in diameter than the conductor casing. When installed, the surface casing fits inside the top of the conductor casing. The primary purpose of surface casing is to protect fresh water deposits near the surface of the well from being contaminated by leaking hydrocarbons or salt water from deeper underground. It also serves as a conduit for drilling mud returning to the surface, and helps protect the drill hole from being damaged during drilling. Surface casing, like conductor casing, is also cemented into place. Regulations often dictate the thickness of the cement to be used, to ensure that there is little possibility of freshwater contamination.

3. Intermediate Casing

Intermediate casing is usually the longest section of casing found in a well. The primary purpose of intermediate casing is to minimize the hazards that come along with subsurface formations that may affect the well. These include abnormal underground pressure zones, underground shales, and formations that might otherwise contaminated the well, such as underground salt-water deposits. In many instances, even though there may be no evidence of an unusual underground formation, intermediate casing is run as insurance against the possibility of such a formation affecting the well. These intermediate casing areas may also be cemented into place for added protection

4. Liner String

Liner strings are sometimes used instead of intermediate casing. Liner strings are commonly run from the bottom of another type of casing to the open well area. However, liner strings are usually just attached to the previous casing with 'hangers', instead of being cemented into place. This type of casing is thus less permanent than intermediate casing.

5. Production Casing

Production casing, alternatively called the 'oil string' or 'long string', is installed last and is the deepest section of casing in a well. This is the casing that provides a conduit from the surface of the well to the petroleum producing formation. The size of the production casing depends on a number of considerations, including the lifting equipment to be used, the number of completions required, and the possibility of deepening the well at a later time. For example, if it is expected that the well will be deepened at a later date, then the production casing must be wide enough to allow the passage of a drill bit later on. Well casing is a very important part of

the completed well. In addition to strengthening the well hole, it also provides a conduit to allow hydrocarbons to be extracted without intermingling with other fluids and formations found underground. It is also instrumental in preventing blowouts, allowing the formation to be 'sealed' from the top should dangerous pressure levels be reached. See below for more information on blowout prevention planning. Once the casing has been set, and in most cases cemented into place, proper lifting equipment is installed to bring the hydrocarbons from the formation to the surface. Once the casing is installed, tubing is inserted inside the casing, from the opening well at the top, to the formation at the bottom. The hydrocarbons that are extracted run up this tubing to the surface. This tubing may also be attached to pumping systems for more efficient extraction, should that be necessary.

Blowouts and Blowout Contingency Plans (BCP)¹¹

Probability of a blowout might be small, but consequences can be catastrophic, so additional "problem solving" BCPs and BTFs are being implemented. There are two BCP types, general and specific. General plans are strategy manuals without specific well or site information that outline how a particular operator will respond to blowouts. They are used as a training guide or workbook for developing specific plans. Specific plans use strategy from general plans for particular areas and blowout scenarios, and go through the complete intervention process on paper.

Effective BCPs should include the following:

- Emergency BTF management-Organization and job descriptions; mobilization priorities; Initial procedures and instructions; Pre-qualification of critical equipment, personnel, contractors and suppliers; data acquisition needs for site survey and files; Safety, documentation and audits; emergency classifications, risks and consequences
- General intervention strategies- Relief well or surface control
- Blowout scenarios-Define and classify critical wells and structures based on subjective risk assessment by local management and advisors.
- Specific intervention strategy- Identify relief well and surface needs for hypothetical blowouts on critical structures and exploration wells.
- Logistics and support-Detail and source equipment, material and services requirements based on scenarios and local capabilities.
- Drilling and completion procedure audits-Review and critique well plans and risks, summarizing possible corrective measures, anticipated geology and reservoir conditions. If possible, drilling rigs to be used are reviewed and well control equipment is listed.
- Blowout prevention-Well control inspections of ongoing drilling operations, listing results and recommended corrective action.
- Appendix-Include items useful if a blowout occurs (wind rose, current data, surface topography maps, local water sources, etc.).

Response plans must include directives for activating intervention BTF, and mobilizing or designating a project manager. Blowout intervention projects pose special problems unique to

hazardous operations. Any number of blowout scenarios and unforeseen challenges can occur. BCPs are a pre-crisis planning process to gather, based on existing experience, available input on assumptions and strategy to reduce uncertainty. A systematic planning strategy must be adopted to evaluate risks.

The first priority and single most important factor to assure successful blowout intervention is to quickly organize a focused team and manage the right mix of operational and technical professionals. Most problems can be attributed to misconceptions, and lack of communication, leadership and experience, rather than technical factors.

Types of Well Completion

Once a natural gas or oil well is drilled, and it has been verified that commercially viable quantities of natural gas are present for extraction, the well must be 'completed' to allow for the flow of petroleum or natural gas out of the formation and up to the surface. This process includes strengthening the well hole with casing, evaluating the pressure and temperature of the formation, and then installing the proper equipment to ensure an efficient flow of natural gas out of the well.

There are two main types of conventional natural gas wells: natural gas wells and natural gas condensate wells. In addition, there are oil wells that contain “associated” natural gas. In an oil well with associated gas, the natural gas is often used to add pressure to the well and enhance the extraction of the well. Sometimes associated natural gas exists in large enough quantities to allow its extraction along with the oil. Natural gas specific wells are wells drilled exclusively for natural gas, and contain little or no oil. Shale-gas drilling is an example of wells being drilled for their natural gas resources.

Condensate wells are wells that contain natural gas, as well as a liquid condensate. This condensate is a liquid hydrocarbon mixture that is often separated from the natural gas either at the wellhead, or during the processing of the natural gas. It is important to remember that natural gas, being lighter than air, will naturally rise to the surface of a well. Because of this, in many natural gas and condensate wells, lifting equipment and well treatment are not necessary.

Well completion commonly refers to the process of finishing a well so that it is ready to produce oil or natural gas. In essence, completion consists of deciding on the characteristics of the intake portion of the well in the targeted hydrocarbon formation. There are a number of types of completions, including:

Open Hole Completion

Open hole completions are the most basic type and are only used in very competent formations, which are unlikely to cave in. An open hole completion consists of simply running the casing directly down into the formation, leaving the end of the piping open, without any

other protective filter. Very often, this type of completion is used on formations that have been treated with hydraulic or acid fracturing.

Conventional Perforated Completion

Conventional perforated completions consist of production casing being run through the formation. The sides of this casing are perforated, with tiny holes along the sides facing the formation, which allows for the flow of hydrocarbons into the well hole, but still provides a suitable amount of support and protection for the well hole. The process of actually perforating the casing involves the use of specialized equipment designed to make tiny holes through the casing, cementing, and any other barrier between the formation and the open well. In the past, 'bullet perforators' were used, which were essentially small guns lowered into the well. The guns, when fired from the surface, sent off small bullets that penetrated the casing and cement. Today, 'jet perforating' is preferred. This consists of small, electrically ignited charges, lowered into the well. When ignited, these charges poke tiny holes through to the formation, in the same manner as bullet perforating.

Sand Exclusion Completion

Sand exclusion completions are designed for production in an area that contains a large amount of loose sand. These completions are designed to allow for the flow of natural gas and oil into the well, but at the same time prevent sand from entering the well. Sand inside the well hole can cause many complications, including erosion of casing and other equipment. The most common method of keeping sand out of the well hole are screening, or filtering systems. This includes analyzing the sand experienced in the formation and installing a screen or filter to keep sand particles out. This filter may either be a type of screen hung inside the casing, or adding a layer of specially sized gravel outside the casing to filter out the sand. Both of these types of sand barriers can be used in open hole and perforated completions.

Permanent Completion

Permanent completions are those in which the completion, and wellhead, are assembled and installed only once. Installing the casing, cementing, perforating, and other completion work is done with small diameter tools to ensure the permanent nature of the completion. Completing a well in this manner can lead to significant cost savings compared to other types.

Multiple Zone Completion

Multiple zone completion is the practice of completing a well such that hydrocarbons from two or more formations may be produced simultaneously, without mixing with each other. For example, a well may be drilled that passes through a number of formations on its way deeper underground, or alternately, it may be efficient in a horizontal well to add multiple completions to drain the formation most effectively. Although it is common to separate multiple completions so that the fluids from the different formations do not intermingle, the complexity of achieving complete separation is often a barrier. In some instances, the different formations being drilled are close enough in nature to allow fluids to intermingle in the well hole. When it is necessary to separate different completions, hard rubber 'packing' instruments are used to maintain separation.

Drain hole Completion

Drain hole completions are a form of horizontal or slant drilling. This type of completion consists of drilling out horizontally into the formation from a vertical well, essentially providing a 'drain' for the hydrocarbons to run down into the well. In certain formations, drilling a drain hole completion may allow for more efficient and balanced extraction of the targeted hydrocarbons. These completions are more commonly associated with oil wells than with natural gas wells.

The use of any type of completion depends on the characteristics and location of the hydrocarbon formation to be mined.

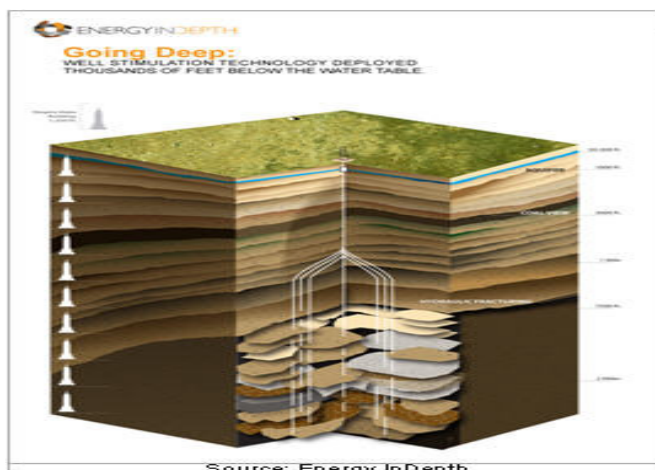
Well Treatment

Fracturing¹²

Hydraulic fracturing, often referred to simply as fracking, is the process through which typically 3 to 4 million gallons of water, mixed with sand and fractional amounts of chemical additives, are pumped into the wellhead at high pressure, creating cracks in the rock beds.

Each Marcellus shale well can be fractured up to 10 times, and each instance of fracturing uses between three and five million gallons of water. Drillers are required throughout Pennsylvania to file water withdrawal plans and obtain a permit for water withdrawal. In the eastern portions of the state water withdrawal plans and permits are under the jurisdiction of the Susquehanna or Delaware River Basin Commissions and in the Western area of the state the PA Department of Environmental Protection are responsible for overseeing water withdrawal plans and issuing permits. While some new technologies have allowed the industry to begin re-using some of this wastewater to fracture additional wells, concerns about concentrated levels of contaminants overshadow this practice.

Hydraulic fracturing (fracking) is the method used to make hard shale rock more porous, thus allowing natural gas to flow through the shale to the well bore.



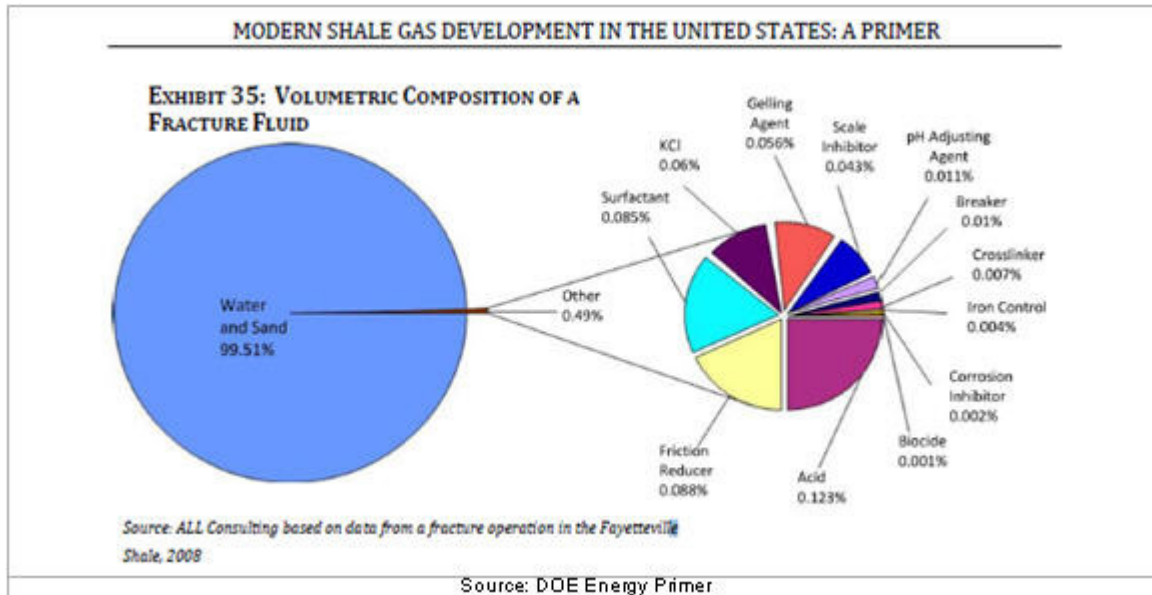
First, producers drill into the earth several thousand feet until they reach the natural gas reservoir. Next, steel casings are inserted to a depth of 1,000 to 3,000 feet, and the space between the casing and the drilled hole is filled with cement to stabilize the well and prevent any leakage. After the cement has set, this process is repeated, using a series of successively smaller casings until the reservoir is reached, usually a distance of 6,000 to 10,000 feet. There are numerous state and federal regulations that govern the casing and cementing process

What is in the fracturing fluid?¹³

Once the drilling and casing is complete, typically 3 to 4 million gallons of water, mixed with sand and fractional amounts of chemical additives, are pumped into the wellhead at high pressure, creating cracks in the rock beds.¹⁴ The hydraulic fracturing mixture is 95 percent water, 4.5 percent sand and 0.5 percent chemical additives formulated to promote gelling and cleaning according to the Ground Water Protection Council and U.S Department of Energy. A list of chemicals used in fracturing is found in the Appendix.

Fracturing fluid formulas vary slightly among production sites in accordance with the unique requirements of each site’s geology.

The initial fracturing stage may use hydrochloric acid to clean up the wellbore damage done during drilling and cementing



Currently, hydraulic fracturing fluids are exempted from federal Safe Drinking Water Act (SDWA) oversight. However operators comply with a range of federal chemical record keeping and reporting requirements, including the Occupation Safety and Health Administration (OSHA) Hazard Communication Standard. In addition, operators must also comply with individual state laws and regulations regarding hydraulic fracturing and also must provide local emergency personnel with chemical information. Industry representatives contend that the composition of fracturing fluids is proprietary information and that fracturing fluids are physically separated

from the water table by cement and steel casings, thousands of feet, and tons of impermeable rock. They say the practice is strictly regulated by the states and it has been reviewed and declared safe by the Environmental Protection Agency (EPA), as well as other environmental oversight groups. (The EPA is continuing research into the topic and its next report is scheduled to be completed in 2012.)

Industry says shale producers already comply with federal and state disclosure requirements that require regulators, first responders and medical personnel to have access to information concerning the chemical composition of fracturing fluids at all well sites, so that they can appropriately protect and safeguard human health and the environment. A number of states publicly publish fracturing ingredients online, including New York and Pennsylvania.

The natural gas industry contends that hydraulic fracturing is properly regulated under state laws. Of the 27 states that provide 99.9 percent of all natural gas exploration activities nationwide, all 27 have permitting requirements in place that govern the siting, drilling, completion and operation of wells, including hydraulic fracturing.

Shale producers point out that at no point do fracturing fluids come into contact with drinking water reservoirs. In fact, hydraulic fracturing takes place thousands of feet below the water table and thus are isolated from drinking water by thousands of feet and millions of tons of impermeable rock. The gas industry also notes that more than one million wells have been fractured without drinking water contamination. Should a surface spill or incident occur, state regulators have testified that they have sufficient authority to prosecute the offending parties so that incidents do not occur in the future.

Producers, regulators, citizens and environmentalists all are in agreement that any irresponsible actors should be prosecuted. Enforcement of the existing state laws not only protects the groundwater, it provides reassurance to the community and shale producers that shale wells are being properly managed and are sustainable. Hydraulic fracturing is vital to shale gas production and regulatory uncertainty regarding the process could prevent the full-scale development of the U.S. shale gas resource base. And without hydraulic fracturing, it is neither economical nor technically feasible to extract natural gas from shale at this time.

There are many avenues for transporting fresh water to the well site. Often fresh water is withdrawn from the permitted source and trucked to the well site and then drained into an impoundment. Fresh water can also arrive in closed tanks or by over land pipelines from a water source.

Impoundments to hold water or fluids for fracturing can be as large as an acre and hold thousands of gallons of water.

Water Use¹⁵

Drilling a typical deep shale gas well requires between 65,000 and 600,000 gallons of water.

Water is also used in hydraulic fracturing, where a mixture of water and sand is injected into the deep shale at a high pressure to create small cracks in the rock and allows gas to freely flow to the surface. Hydraulically fracturing a typical horizontal deep shale gas well requires an average of 4.5 million gallons per well.

In the Marcellus Shale area of the Appalachian Basin, power generation accounts for more than 70% of the water consumption, while agriculture accounts for approximately one tenth of one percent (0.10%). Water used in Chesapeake deep shale gas differs most notably from all other uses because it is temporary, occurring only once during the drilling and completion phases of each well. Use of this water does not represent a long-term commitment of the resource which are typically years, decades or even longer for other water users..

Processing Natural Gas¹⁶

Natural gas, as it is used by consumers, is much different from the natural gas that is brought from underground up to the wellhead. Although the processing of natural gas is in many respects less complicated than the processing and refining of crude oil, it is equally as necessary before its use by end users.

The natural gas used by consumers is composed almost entirely of methane. However, natural gas found at the wellhead, although still composed primarily of methane, is by no means as pure. Raw natural gas comes from three types of wells: oil wells, gas wells, and condensate wells. Natural gas that comes from oil wells is typically termed 'associated gas'. This gas can exist separate from oil in the formation (free gas), or dissolved in the crude oil (dissolved gas). Natural gas from gas and condensate wells, in which there is little or no crude oil, is termed 'nonassociated gas'. Gas wells typically produce raw natural gas by itself, while condensate wells produce free natural gas along with a semi-liquid hydrocarbon condensate. Whatever the source of the natural gas, once separated from crude oil (if present) it commonly exists in mixtures with other hydrocarbons; principally ethane, propane, butane, and pentanes. In addition, raw natural gas contains water vapor, hydrogen sulfide (H₂S), carbon dioxide, helium, nitrogen, and other compounds.

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as 'pipeline quality' dry natural gas. Major transportation pipelines usually impose restrictions on the make-up of the natural gas that is allowed into the pipeline. That means that before the natural gas can be transported it must be purified. While the ethane, propane, butane, and pentanes must be removed from natural gas, this does not mean that they are all 'waste products'.

In fact, associated hydrocarbons, known as 'natural gas liquids' (NGLs) can be very valuable by-products of natural gas processing. NGLs include ethane, propane, butane, iso-butane, and natural gasoline. These NGLs are sold separately and have a variety of different uses; including enhancing oil recovery in oil wells, providing raw materials for oil refineries or petrochemical plants, and as sources of energy.

While some of the needed processing can be accomplished at or near the wellhead (field processing), the complete processing of natural gas takes place at a processing plant, usually located in a natural gas producing region. The extracted natural gas is transported to these processing plants through a network of gathering pipelines, which are small-diameter, low pressure pipes. A complex gathering system can consist of thousands of miles of pipes, interconnecting the processing plant to upwards of 100 wells in the area. According to the American Gas Association's Gas Facts 2000, there was an estimated 36,100 miles of gathering system pipelines in the U.S. in 1999.

In addition to processing done at the wellhead and at centralized processing plants, some final processing is also sometimes accomplished at 'straddle extraction plants'. These plants are located on major pipeline systems. Although the natural gas that arrives at these straddle extraction plants is already of pipeline quality, in certain instances there still exist small quantities of NGLs, which are extracted at the straddle plants.

The actual practice of processing natural gas to pipeline dry gas quality levels can be quite complex, but usually involves four main processes to remove the various impurities:

In addition to the four processes above, heaters and scrubbers are installed, usually at or near the wellhead. The scrubbers serve primarily to remove sand and other large-particle impurities. The heaters ensure that the temperature of the gas does not drop too low. With natural gas that contains even low quantities of water, natural gas hydrates have a tendency to form when temperatures drop. These hydrates are solid or semi-solid compounds, resembling ice like crystals. Should these hydrates accumulate, they can impede the passage of natural gas through valves and gathering systems. To reduce the occurrence of hydrates, small natural gas-fired heating units are typically installed along the gathering pipe wherever it is likely that hydrates may form.

Capping and Well Development



A Wellhead

Source: NETL - DOE

The Wellhead

The wellhead consists of the pieces of equipment mounted at the opening of the well to manage the extraction of hydrocarbons from the underground formation. It prevents leaking of oil or natural gas out of the well, and also prevents blowouts caused by high pressure. Formations that are under high pressure typically require wellheads that can withstand a great deal of upward pressure from the escaping gases and liquids. These wellheads must be able to withstand pressures of up to 20,000 pounds per square inch (psi). The wellhead consists of three components: the casing head, the tubing head, and the 'christmas tree.'



The 'Christmas Tree'

Source: NGSA

The casing head consists of heavy fittings that provide a seal between the casing and the surface. The casing head also serves to support the entire length of casing that is run all the way down the well. This piece of equipment typically contains a gripping mechanism that ensures a tight seal between the head and the casing itself.

The tubing head is much like the casing head. It provides a seal between the tubing, which is run inside the casing, and the surface. Like the casing head, the tubing head is designed to support the entire length of the casing, as well as provide connections at the surface, which allow the flow of fluids out of the well to be controlled.

The 'christmas tree' is the piece of equipment that fits on top of the casing and tubing heads, and contains tubes and valves that control the flow of hydrocarbons and other fluids out of the well. It commonly contains many branches and is shaped somewhat like a tree, thus its name, 'christmas tree.' The christmas tree is the most visible part of a producing well, and allows for the surface monitoring and regulation of the production of hydrocarbons from a producing well. A typical Christmas tree is about six feet tall.

Oil and Condensate Removal

In order to process and transport associated dissolved natural gas, it must be separated from the oil in which it is dissolved. This separation of natural gas from oil is most often done using equipment installed at or near the wellhead. The actual process used to separate oil from

natural gas, as well as the equipment that is used, can vary widely. Although dry pipeline quality natural gas is virtually identical across different geographic areas, raw natural gas from different regions may have different compositions and separation requirements. In many instances, natural gas is dissolved in oil underground primarily due to the pressure that the formation is under. When this natural gas and oil is produced, it is possible that it will separate on its own, simply due to decreased pressure; much like opening a can of soda pop allows the release of dissolved carbon dioxide. In these cases, separation of oil and gas is relatively easy, and the two hydrocarbons are sent separate ways for further processing.

The most basic type of separator is known as a conventional separator. It consists of a simple closed tank, where the force of gravity serves to separate the heavier liquids like oil, and the lighter gases, like natural gas. In certain instances, however, specialized equipment is necessary to separate oil and natural gas. An example of this type of equipment is the Low-Temperature Separator (LTX). This is most often used for wells producing high pressure gas along with light crude oil or condensate. These separators use pressure differentials to cool the wet natural gas and separate the oil and condensate. Wet gas enters the separator, being cooled slightly by a heat exchanger. The gas then travels through a high pressure liquid 'knockout', which serves to remove any liquids into a low-temperature separator. The gas then flows into this low-temperature separator through a choke mechanism, which expands the gas as it enters the separator. This rapid expansion of the gas allows for the lowering of the temperature in the separator. After liquid removal, the dry gas then travels back through the heat exchanger and is warmed by the incoming wet gas. By varying the pressure of the gas in various sections of the separator, it is possible to vary the temperature, which causes the oil and some water to be condensed out of the wet gas stream. This basic pressure-temperature relationship can work in reverse as well, to extract gas from a liquid oil stream.

Water Removal

In addition to separating oil and some condensate from the wet gas stream, it is necessary to remove most of the associated water. Most of the liquid, free water associated with extracted natural gas is removed by simple separation methods at or near the wellhead. However, the removal of the water vapor that exists in solution in natural gas requires a more complex treatment. This treatment consists of 'dehydrating' the natural gas, which usually involves one of two processes: either absorption, or adsorption.

Absorption occurs when the water vapor is taken out by a dehydrating agent. Adsorption occurs when the water vapor is condensed and collected on the surface.

Glycol Dehydration

An example of absorption dehydration is known as Glycol Dehydration. In this process, a liquid desiccant dehydrator serves to absorb water vapor from the gas stream. Glycol, the principal agent in this process, has a chemical affinity for water. This means that, when in contact with a stream of natural gas that contains water, glycol will serve to 'steal' the water out of the gas stream. Essentially, glycol dehydration involves using a glycol solution, usually either diethylene glycol (DEG) or triethylene glycol (TEG), which is brought into contact with the wet gas stream in what is called the 'contactor'. The glycol solution will absorb water from the wet gas. Once

absorbed, the glycol particles become heavier and sink to the bottom of the contactor where they are removed. The natural gas, having been stripped of most of its water content, is then transported out of the dehydrator. The glycol solution, bearing all of the water stripped from the natural gas, is put through a specialized boiler designed to vaporize only the water out of the solution. While water has a boiling point of 212 degrees Fahrenheit, glycol does not boil until 400 degrees Fahrenheit. This boiling point differential makes it relatively easy to remove water from the glycol solution, allowing it be reused in the dehydration process.

A new innovation in this process has been the addition of flash tank separator-condensers. As well as absorbing water from the wet gas stream, the glycol solution occasionally carries with it small amounts of methane and other compounds found in the wet gas. In the past, this methane was simply vented out of the boiler. In addition to losing a portion of the natural gas that was extracted, this venting contributes to air pollution and the greenhouse effect. In order to decrease the amount of methane and other compounds that are lost, flash tank separator-condensers work to remove these compounds before the glycol solution reaches the boiler. Essentially, a flash tank separator consists of a device that reduces the pressure of the glycol solution stream, allowing the methane and other hydrocarbons to vaporize ('flash'). The glycol solution then travels to the boiler, which may also be fitted with air or water cooled condensers, which serve to capture any remaining organic compounds that may remain in the glycol solution. In practice, according to the Department of Energy's Office of Fossil Energy, these systems have been shown to recover 90 to 99 percent of methane that would otherwise be flared into the atmosphere.

Solid-Desiccant Dehydration

Another form of natural gas dehydration is solid-desiccant dehydration is the primary form of dehydrating natural gas using adsorption, and usually consists of two or more adsorption towers, which are filled with a solid desiccant. Typical desiccants include activated alumina or a granular silica gel material. Wet natural gas is passed through these towers, from top to bottom. As the wet gas passes around the particles of desiccant material, water is retained on the surface of these desiccant particles. Passing through the entire desiccant bed, almost all of the water is adsorbed onto the desiccant material, leaving the dry gas to exit the bottom of the tower.

Solid-desiccant dehydrators are typically more effective than glycol dehydrators, and are usually installed as a type of straddle system along natural gas pipelines. These types of dehydration systems are best suited for large volumes of gas under very high pressure, and are thus usually located on a pipeline downstream of a compressor station. Two or more towers are required due to the fact that after a certain period of use, the desiccant in a particular tower becomes saturated with water. To 'regenerate' the desiccant, a high-temperature heater is used to heat gas to a very high temperature. Passing this heated gas through a saturated desiccant bed vaporizes the water in the desiccant tower, leaving it dry and allowing for further natural gas dehydration.

Separation of Natural Gas Liquids

Natural gas coming directly from a well contains many natural gas liquids that are commonly removed. In most instances, natural gas liquids (NGLs) have a higher value as separate products, and it is thus economical to remove them from the gas stream. The removal of natural gas liquids usually takes place in a relatively centralized processing plant, and uses techniques similar to those used to dehydrate natural gas.

There are two basic steps to the treatment of natural gas liquids in the natural gas stream. First, the liquids must be extracted from the natural gas. Second, these natural gas liquids must be separated themselves, down to their base components.

NGL Extraction

There are two principle techniques for removing NGLs from the natural gas stream: the absorption method and the cryogenic expander process. According to the Gas Processors Association, these two processes account for around 90 percent of total natural gas liquids production.

The Absorption Method

The absorption method of NGL extraction is very similar to using absorption for dehydration. The main difference is that, in NGL absorption, an absorbing oil is used as opposed to glycol. This absorbing oil has an 'affinity' for NGLs in much the same manner as glycol has an affinity for water. Before the oil has picked up any NGLs, it is termed 'lean' absorption oil. As the natural gas is passed through an absorption tower, it is brought into contact with the absorption oil which soaks up a high proportion of the NGLs. The 'rich' absorption oil, now containing NGLs, exits the absorption tower through the bottom. It is now a mixture of absorption oil, propane, butanes, pentanes, and other heavier hydrocarbons. The rich oil is fed into lean oil stills, where the mixture is heated to a temperature above the boiling point of the NGLs, but below that of the oil. This process allows for the recovery of around 75 percent of butanes, and 85 - 90 percent of pentanes and heavier molecules from the natural gas stream. The basic absorption process above can be modified to improve its effectiveness, or to target the extraction of specific NGLs. In the refrigerated oil absorption method, where the lean oil is cooled through refrigeration, propane recovery can be upwards of 90 percent, and around 40 percent of ethane can be extracted from the natural gas stream. Extraction of the other, heavier NGLs can be close to 100 percent using this process.

The Cryogenic Expansion Process

Cryogenic processes are also used to extract NGLs from natural gas. While absorption methods can extract almost all of the heavier NGLs, the lighter hydrocarbons, such as ethane, are often more difficult to recover from the natural gas stream. In certain instances, it is economic to simply leave the lighter NGLs in the natural gas stream. However, if it is economic to extract ethane and other lighter hydrocarbons, cryogenic processes are required for high recovery rates. Essentially, cryogenic processes consist of dropping the temperature of the gas stream to around -120 degrees Fahrenheit.

There are a number of different ways of chilling the gas to these temperatures, but one of the

most effective is known as the turbo expander process. In this process, external refrigerants are used to cool the natural gas stream. Then, an expansion turbine is used to rapidly expand the chilled gases, which causes the temperature to drop significantly. This rapid temperature drop condenses ethane and other hydrocarbons in the gas stream, while maintaining methane in gaseous form. This process allows for the recovery of about 90 to 95 percent of the ethane originally in the gas stream. In addition, the expansion turbine is able to convert some of the energy released when the natural gas stream is expanded into recompressing the gaseous methane effluent, thus saving energy costs associated with extracting ethane. The extraction of NGLs from the natural gas stream produces both cleaner, purer natural gas, as well as the valuable hydrocarbons that are the NGLs themselves.

Natural Gas Liquid Fractionation

Once NGLs have been removed from the natural gas stream, they must be broken down into their base components to be useful. That is, the mixed stream of different NGLs must be separated out. The process used to accomplish this task is called fractionation. Fractionation works based on the different boiling points of the different hydrocarbons in the NGL stream. Essentially, fractionation occurs in stages consisting of the boiling off of hydrocarbons one by one. The name of a particular fractionator gives an idea as to its purpose, as it is conventionally named for the hydrocarbon that is boiled off. The entire fractionation process is broken down into steps, starting with the removal of the lighter NGLs from the stream. The particular fractionators are used in the following order:

- **Deethanizer** - this step separates the ethane from the NGL stream.
- **Depropanizer** - the next step separates the propane.
- **Debutanizer** - this step boils off the butanes, leaving the pentanes and heavier hydrocarbons in the NGL stream.
- **Butane Splitter or Deisobutanizer** - this step separates the iso and normal butanes.

By proceeding from the lightest hydrocarbons to the heaviest, it is possible to separate the different NGLs reasonably easily.

Sulfur and Carbon Dioxide Removal

In addition to water, oil, and NGL removal, one of the most important parts of gas processing involves the removal of sulfur and carbon dioxide. Natural gas from some wells contains significant amounts of sulfur and carbon dioxide. This natural gas, because of the rotten smell provided by its sulfur content, is commonly called 'sour gas'. Sour gas is undesirable because the sulfur compounds it contains can be extremely harmful, even lethal, to breathe. Sour gas can also be extremely corrosive. In addition, the sulfur that exists in the natural gas stream can be extracted and marketed on its own. In fact, according to the USGS, U.S. sulfur production from gas processing plants accounts for about 15 percent of the total U.S. production of sulfur. For information on the production of sulfur in the United States, visit the USGS [here](#).

Sulfur exists in natural gas as hydrogen sulfide (H₂S), and the gas is usually considered sour if the hydrogen sulfide content exceeds 5.7 milligrams of H₂S per cubic meter of natural gas. The process for removing hydrogen sulfide from sour gas is commonly referred to as 'sweetening' the gas.

The primary process for sweetening sour natural gas is quite similar to the processes of glycol dehydration and NGL absorption. In this case, however, amine solutions are used to remove the hydrogen sulfide. This process is known simply as the 'amine process', or alternatively as the Girdler process, and is used in 95 percent of U.S. gas sweetening operations. The sour gas is run through a tower, which contains the amine solution. This solution has an affinity for sulfur, and absorbs it much like glycol absorbing water. There are two principle amine solutions used, monoethanolamine (MEA) and diethanolamine (DEA). Either of these compounds, in liquid form, will absorb sulfur compounds from natural gas as it passes through. The effluent gas is virtually free of sulfur compounds, and thus loses its sour gas status. Like the process for NGL extraction and glycol dehydration, the amine solution used can be regenerated (that is, the absorbed sulfur is removed), allowing it to be reused to treat more sour gas.

Although most sour gas sweetening involves the amine absorption process, it is also possible to use solid desiccants like iron sponges to remove the sulfide and carbon dioxide.

Sulfur can be sold and used if reduced to its elemental form. Elemental sulfur is a bright yellow powder like material, and can often be seen in large piles near gas treatment plants, as is shown. In order to recover elemental sulfur from the gas processing plant, the sulfur containing discharge from a gas sweetening process must be further treated. The process used to recover sulfur is known as the Claus process, and involves using thermal and catalytic reactions to extract the elemental sulfur from the hydrogen sulfide solution.

Transport System

There are three major types of pipelines along the transportation route: the gathering system, the interstate pipeline system, and the distribution system. The gathering system consists of low pressure, small diameter pipelines that transport raw natural gas from the wellhead to the processing plant. Should natural gas from a particular well have high sulfur and carbon dioxide contents (sour gas), a specialized sour gas gathering pipe must be installed. Sour gas is corrosive, thus its transportation from the wellhead to the sweetening plant must be done carefully.

Pipelines can be characterized as interstate or intrastate. Interstate pipelines are similar to in the interstate highway system: they carry natural gas across state boundaries, in some cases clear across the country. Intrastate pipelines, on the other hand, transport natural gas within a particular state.

Pipeline Components

Interstate pipelines consist of a number of components that ensure the efficiency and reliability

of a system that delivers such an important energy source year-round, twenty four hours a day, and includes a number of different components.

Transmission Pipes

Transmission pipes can measure anywhere from 6 to 48 inches in diameter, depending on their function. Certain component pipe sections can even consist of small diameter pipe, as small as 0.5 inches in diameter. However, this small diameter pipe is usually used only in gathering and distribution systems. Mainline transmission pipes, the principle pipeline in a given system, are usually between 16 and 48 inches in diameter. Lateral pipelines, which deliver natural gas to or from the mainline, are typically between 6 and 16 inches in diameter. Most major interstate pipelines are between 24 and 36 inches in diameter. The actual pipeline itself, commonly called 'line pipe', consists of a strong carbon steel material, engineered to meet standards set by the American Petroleum Institute (API). In contrast, some distribution pipe is made of highly advanced plastic, because of the need for flexibility, versatility and the ease of replacement. Transmission pipelines are produced in steel mills, which are sometimes specialized to produce only pipeline. There are two different production techniques, one for small diameter pipes and one for large diameter pipes. For large diameter pipes, from 20 to 42 inches in diameter, the pipes are produced from sheets of metal which are folded into a tube shape, with the ends welded together to form a pipe section. Small diameter pipe, on the other hand, can be produced seamlessly. This involves heating a metal bar to very high temperatures, then punching a hole through the middle of the bar to produce a hollow tube. In either case, the pipe is tested before being shipped from the steel mill, to ensure that it can meet the pressure and strength standards for transporting natural gas.

Line pipe is also covered with a specialized coating to ensure that it does not corrode once placed in the ground. The purpose of the coating is to protect the pipe from moisture, which causes corrosion and rusting. There are a number of different coating techniques. In the past, pipelines were coated with specialized coal tar enamel. Today, pipes are often protected with what is known as a fusion bond epoxy, which gives the pipe a noticeable light blue color. In addition, cathodic protection is often used; which is a technique of running an electric current through the pipe to ward off corrosion and rusting.

Compressor Stations

As mentioned, natural gas is highly pressurized as it travels through an interstate pipeline. To ensure that the natural gas flowing through any one pipeline remains pressurized, compression of this natural gas is required periodically along the pipe. This is accomplished by compressor stations, usually placed at 40 to 100 mile intervals along the pipeline. The natural gas enters the compressor station, where it is compressed by either a turbine, motor, or engine.



A Compressor Station

Source: Duke Energy Gas Transmission Canada

Turbine compressors gain their energy by using up a small proportion of the natural gas that they compress. The turbine itself serves to operate a centrifugal compressor, which contains a type of fan that compresses and pumps the natural gas through the pipeline. Some compressor stations are operated by using an electric motor to turn the same type of centrifugal compressor. This type of compression does not require the use of any of the natural gas from the pipe, however it does require a reliable source of electricity nearby. Reciprocating natural gas engines are also used to power some compressor stations. These engines resemble a very large automobile engine, and are powered by natural gas from the pipeline. The combustion of the natural gas powers pistons on the outside of the engine, which serves to compress the natural gas.

In addition to compressing natural gas, compressor stations also usually contain some type of liquid separator, much like the ones used to dehydrate natural gas during its processing. Usually, these separators consist of scrubbers and filters that capture any liquids or other unwanted particles from the natural gas in the pipeline. Although natural gas in pipelines is considered 'dry' gas, it is not uncommon for a certain amount of water and hydrocarbons to condense out of the gas stream while in transit. The liquid separators at compressor stations ensure that the natural gas in the pipeline is as pure as possible, and usually filter the gas prior to compression.

Metering Stations

In addition to compressing natural gas to reduce its volume and push it through the pipe, metering stations are placed periodically along interstate natural gas pipelines. These stations allow pipeline companies to monitor the natural gas in their pipes. Essentially, these metering stations measure the flow of gas along the pipeline, and allow pipeline companies to 'track' natural gas as it flows along the pipeline. These metering stations employ specialized meters to measure the natural gas as it flows through the pipeline, without impeding its movement.



A Ground Valve

Source: Duke Energy Gas Transmission Canada

Interstate pipelines include a great number of valves along their entire length. These valves work like gateways; they are usually open and allow natural gas to flow freely, or they can be used to stop gas flow along a certain section of pipe. There are many reasons why a pipeline may need to restrict gas flow in certain areas. For example, if a section of pipe requires replacement or maintenance, valves on either end of that section of pipe can be closed to allow engineers and work crews safe access. These large valves can be placed every 5 to 20 miles along the pipeline, and are subject to regulation by safety codes.

Control Stations and SCADA Systems¹⁷

Natural gas pipeline companies have customers on both ends of the pipeline - the producers and processors that input gas into the pipeline, and the consumers and local gas utilities that take gas out of the pipeline. In order to manage the natural gas that enters the pipeline, and to ensure that all customers receive timely delivery of their portion of this gas, sophisticated control systems are required to monitor the gas as it travels through all sections of what could be a very lengthy pipeline network. To accomplish this task of monitoring and controlling the natural gas that is traveling through the pipeline, centralized gas control stations collect, assimilate, and manage data received from monitoring and compressor stations all along the pipe.

Chapter 2

Regulations and Leasing

Regulations

Permitting

There are a number of different conditions related to obtaining a permit that applicants must meet before they can begin to operate a well.

1. They must provide notice to all interested parties in the area, including; a copy of the plat (drawing of the proposed construction) for the well site to the surface landowner who has leased the mineral rights to the applicant as well as a copy to surface landowners and water purveyors whose water supplies are within 1,000 feet of the proposed well location.¹⁸
2. Surface landowners and users of water supplies within 1,000 feet of the proposed location shall be made aware of their available rights in protecting their water supply and the advisability of taking their own "pre-drilling or pre-alteration survey".¹⁹ This survey measures the water quality before drilling occurs, so that any contamination or harm that may result from drilling can be properly attributed to its source.

Surface landowners also have the right to object to the proposed location of the well for a number of different reasons.²⁰

1. One restriction is that a well may not be located within 200 feet horizontally of an existing building or water well without written consent or a granted variance.²¹
2. There are grounds for objection if the well site is within 100 feet measured horizontally from a stream, spring or body of water as identified on the most current 7½ minute topographic quadrangle map and the operator does not have a waiver.
3. The well site must also not be within 100 feet of any wetland greater than one acre in size and the operator does not have a waiver.²²

An objection may be filed if any of the provided information in the application is in anyway untrue. Objections and requests for a conference must be filed within 15 days of receipt of the site plat.

Marcellus deep well drilling requires the use of vast amounts of water at numerous stages of development.

1. Well operators must file Water Management Plans that identify the water sources for all water withdrawals over 10,000 gallons of water per day, including average quantity and the maximum withdrawal rate.²³
2. If this withdrawal is located in the Delaware or Susquehanna River Basin, those commissions must also approve the withdrawal plan.
3. Any potential impacts on water quality, groundwater, wetlands or wildlife must be noted in the plan.

Regulatory Changes

Any regulatory changes that are proposed by the Pennsylvania Department of Environmental Protection under the Oil and Gas Act (and other statutes as well) must be noticed to the public in the Pennsylvania Bulletin.²⁴ These regulations can include:

1. Standards for Well Casing or plans for controlling erosion and sedimentation around well sites.²⁵
2. The publication of these regulations is a crucial time for public participation in the regulatory process; the DEP must consider all comments in reaching their final published standard, so public input is quite powerful.
3. Additionally, the DEP maintains a database of permitted entities through eFacts and eNotice, which provides a searchable map and email notification of permitting details.²⁶ This allows the public to locate permitted sites within their counties and region and to be notified of forthcoming permits through the email notification feature.

Right To Know Laws

Pennsylvania's Sunshine and Right to Know laws provide additional means of maintaining access to government activities. The Sunshine Act ensures that the public has access to government meetings. Section 704 of the Sunshine Act requires that:

1. "Official action and deliberations by a quorum of the members of an agency shall take place at a meeting open to the public," subject to a few exceptions.²⁷
2. In addition, the Right to Know Law can be used to provide information contained in certain public records. Information about Marcellus Shale activity can include: legislative records about laws that pertain to:
 - a. Shale gas
 - b. Financial records of corporations involved in the Marcellus Shale industry
 - c. The compliance history of a particular energy company.

Oil and Gas Act

Natural gas operations and extraction are governed primarily by the Oil and Gas Act, preempting all "local ordinances and enactments purporting to regulate oil and gas well operations", except those enacted pursuant to the Municipal Planning Code (MPC) and Flood Plain Management Act.²⁸ What this means is that the only authority municipalities have to affect oil and gas extraction under this Act is merely incidental to the authority derived through the MPC to perform traditional zoning tasks. Residents of local municipalities should check the relevant legislative code in their local government for standards that apply to Marcellus activity and for opportunities to ensure that those standards are met. Many municipalities are scrambling to match the rush of natural gas development with some form of local regulation, so there is wide opportunity for participation ranging from testifying at public hearings to correspondence with government officials.

There is a section of the Oil and Gas Act dedicated to the protection of water supplies.²⁹ It requires that well operators that affect a public or private water supply by either pollution or diminution of water quantity, the well operators must restore or replace the affected supply with an alternate source of water adequate in quantity or quality for the purposes served by the supply. It provides the following opportunities for those whose water supplies are affected to become involved:

1. Any landowner or water purveyor suffering pollution or diminution of a water supply as a result of the drilling, alteration or operation of an oil or gas well may so notify the department and request that an investigation be conducted. Without notification, the Department does not have to do anything. Within ten days of such notification, the Department shall investigate any such claim. Within 45 days following notification, the Department shall make a determination. If the department finds that the pollution or diminution was caused by the drilling, alteration or operation activities or if it presumes the well operator responsible for pollution pursuant to section 601.208(c), then it shall issue such orders to the well operator as are necessary to assure that water supplies are restored or replaced. The Department may require the temporary replacement of a water supply where it is determined that the pollution or diminution may be of limited duration.³⁰
2. There is a sentence in §601.208(b) of the Oil and Gas Act about the presumption of a well operator's responsibility. If the affected water supply is within 1,000 feet of the oil or gas well and the pollution occurred within six months after the completion or drilling or alteration of the well, then the Department will presume that the well operator is responsible for the impact on the water supply. There are ways that an operator can combat this presumption of fault, including a claim that the pollution was preexisting of from another source and that the water supply is not in fact within 1000 feet of the well.³¹

As we previously discussed, proving that a well operator caused the pollution or diminution of a water supply is tremendously difficult. Ideally the person whose water supply has been affected will already have the results of a "baseline test," known in the law as a "predrilling or prealteration survey." In order to be successful in a claim against a well operator for pollution or diminution to a water supply, the affected landowner or water purveyor must:

1. Contact an "independent certified laboratory" to test their supply.³²
2. The independent certified laboratory must follow sample collection, preservation, handling and chain of custody procedures that are established in the Pennsylvania Code.³³
3. If the well operator wishes to defend against a contamination claim, they will likely conduct their own tests as well, which affected landowners must not refuse at the risk of losing a claim of pollution or diminution.
4. Once the DEP investigates the results of the surveyed water supply, it may issue an order requiring an at-fault actor to repair or replace the affected water supply and additional penalties as it sees fit.³⁴

There are traditional civil claims and remedies that affected citizens can pursue that can be just as effective in protecting their interests against natural gas extraction. One such remedy is a nuisance claim, which is the "substantial, unreasonable interference with another individual's use or enjoyment of property to which he has a right or possession." This will arise most often in the context of natural gas extraction invasions like dust emissions or noise. Nuisance claims can be difficult to succeed on for several reasons.

1. Courts will often consider the fact that an activity is permitted by the government as a defense, albeit not an absolute one.
 - a. This means that the fact that DEP has allowed the activity to proceed may disrupt a nuisance claim, so long as the permit is not being violated.
2. The harm to a landowner must be "significant," the proof of which often involves tangible impacts on the claimant's health and lifestyle.
3. These cases can be very expensive to pursue, often requiring multiple tests of air or water quality in order to tie down the problem to its source.

When a well has completed its production cycle and reached its economic limit, it is required to be plugged and abandoned.³⁵

All disturbed areas, particularly impoundments or containment pits, well pads and access roads, must be reclaimed back to the conditions required by law.³⁶

Specifically, within nine months after completion of drilling of any well, the owner or operator must restore the well site, remove or fill all pits used to contain produced fluids or industrial wastes and remove all drilling supplies and equipment not needed for production.

If the surface landowner permits it in writing, drilling supplies and equipment not needed for production may be stored on the well site.

Within nine months after plugging a well, the owner or operator also must remove all production or storage facilities, supplies and equipment and restore the well site. There are deadline extensions available for well operators with a showing of inclement weather or lack of resources available to complete the restoration.

If a surface landowner or lessor discovers an abandoned well on their property, they should notify the DEP within 60 days so it can be classified as an "orphan" well.³⁷ This classification allows the DEP to take action resulting in the well being plugged.

If, after abandonment and plugging, a landowner discovers that his land has been contaminated by the previous drilling operation, there may be an available claim under the Hazardous Sites Cleanup Act (HSCA).

The HSCA provides that a "person who has experienced or is threatened with personal injury or property damage as a result of a release of a hazardous substance may file a civil action against any person to prevent or abate a violation of this act or of any order, regulation, standard or approval issued under this act."³⁸

Aside from having to prove that injury or damage, or the threat of injury or damage, a claimant would also have to prove that the contaminating substance at issue is a "hazardous substance"

as defined under the act.³⁹ In addition, there is a powerful provision presuming that any party responsible for a release of hazardous materials is responsible for all damage that results within 2,500 feet of the perimeter of the release area, rebuttable only with clear and convincing evidence.

Zoning

Zoning is “the legislative division of a region, especially a municipality, into separate districts with different regulations within the districts for land use, building size, and the like.”⁴⁰

Typically, zoning ordinances separate various land uses because of potential incompatibilities with noise, odors, traffic, etc. For example, business uses are typically separated from residential uses to keep neighborhoods livable and business districts concentrated into one location.

Each municipal entity in Pennsylvania –township, borough, county, city, etc. – has the authority to enact and enforce a zoning code. By law, these ordinances must be designed “[t]o promote, protect and facilitate . . . the public health, safety, morals, and the general welfare.”⁴¹ Given that zoning can affect such a broad range of community concerns, zoning ordinance can be very powerful and include absolute limitations on legal uses of land.

With respect to Marcellus Shale, most municipalities appear to have the authority to place restrictions on drilling locations through zoning. This is generally understood to stem from the basic authority to separate land uses for the betterment of a municipality. Two cases decided by the Pennsylvania Supreme Court in 2009⁴² and another preliminary decision by the Commonwealth Court in 2010⁴³ support municipal authority to place traditional zoning restrictions on Marcellus Shale activities. These traditional powers include “preserving the character of residential neighborhoods, as well as each zoning district, and encouraging beneficial and compatible land uses.”⁴⁴ However, these cases make it very clear that zoning ordinances cannot act as a “comprehensive regulatory scheme relative to oil and gas development within the municipality.” In other words, municipalities cannot dictate how drilling operators act but they can place restrictions on their location, how the site is managed, and how some negative effects are minimized.

Cautions for Citizen Surveillance

If a citizen takes up the responsibility of surveying Marcellus shale natural gas extraction in their community, it is important that they follow some important guidelines for effective and legal observation.

1. First and foremost, if an eminent threat to human health or property is ever observed, 911 must be immediately dialed and the appropriate authorities must be alerted. This may include the PA DEP, EPA and the local organization sponsoring the surveillance operations.
2. It is important that observers remain on public property and not on private land. Trespass only requires intent to be on the land in question, not knowledge that the land belonged to another, so always be aware of posted signs and notices.

3. If confronted while observing activity, treat the other party with respect, as you wish to be treated.
4. You should identify yourself and why you are there confidently yet non-confrontationally.

Sites often contain permit information on a sign near their entrance. It is important to note the name of the operator and permit number for good record-keeping and subsequent cross-reference with detailed permit provisions. It is important that permits may allow some activities that are troubling, such as water withdrawals, while other activities that may look normal are outside the terms of the permit. Because of the variability of allowable activity from permit to permit, it is important to note all activities that occur on a site on the standardized reporting form that the sponsor organization can provide.

Leasing

The energy companies need to either lease the minerals from a landowner or be the landowner to drill for gas in the Marcellus Shale. The first step the energy companies will do is research the ownership of gas rights where they have an interest in exploring for natural gas. Then a land agent will contact the landowner either by mail or in person with a contract already drafted and ready to sign. The land agent will work hard to get a signed lease that deviates as little as possible from the first lease.

Laws and Regulations

There is no law or regulation that enables any Pennsylvania agency to tell landowners in advance whether his or her property overlies Marcellus Shale gas. Landowners who are interested can contact the Bureau of Topographic and Geologic Survey, which can provide a list of qualified hydrocarbon consultants. The contract law states that if an individual chooses to sell their land to an energy company, then the laws for real property sales transactions would apply and if an individual chooses to lease their mineral rights, contract law will apply for the most part.

Issues at stake in leasing mineral rights

There are numerous issues to consider when signing a lease. There are the two main ones.

1. The lesser will receive a percentage of the production, which is called a royalty. The state law requires that the minimum royalty to be offered is 12.5% but the lesser is free to negotiate for a higher royalty. The law is not clear as to whether an energy company can deduct their "post-production cost" (production cost are the expenses of getting gas to the point it exits the ground, and are the expenditures from when gas exits the ground until it is sold) from the royalty payment.
2. Environmental and property protection are the other main issue when leasing mineral rights. Lessors who are concerned with the effects of drilling on their real property, water resources, air quality, and other environmental resources can negotiate for those protections. Typically these negotiated provisions are called "addenda" and energy

companies often have prepared addenda that would offer protections involving noise levels and impacts on water sources, crops, and livestock.

- a. Of particular importance is ensuring that the contract contains provisions about the protection of water supplies.
- b. Landowners can ask that energy companies perform a pre-drilling or pre-alternation survey of the water supplies. If the energy company refuses, landowners should obtain such a survey in order to facilitate any future claims against energy companies for damage to their water supply.

The landsman will present you with a lease ready to sign that is the standard for the company. Never sign a standard lease because there are many aspects of drilling, well pad development, well capping and productions and well tending that need to be negotiated. Negotiations can take up to a year to be finalized.

Five Pillars to Consider before Signing a Lease

- I. First take your time in negotiations. A quick or impulsive decision on your part, instead of careful deliberation, only helps the landsman and the lessee. Never agree to anything you have not fully considered.
- II. Second virtually everything in a proposed lease is negotiable. Often, when a landsman come to your home to express interest in leasing your land, they will give you a document they refer to as a “a standard lease.” Just because your neighbor decided to sign what the landsman gave them, does not meant that you should.
- III. Third each tract, each lessor’s needs and each lease are unique. One size does not fit all and there is no such thing as a standard lease. Ask yourself why the gas producer wants each paragraph in its draft lease. What does it do and why should that particular gas producer’s form lease be used?
- IV. Fourth do not accept anything a landsman tells you as true. Determine the identity of the lessee. Who does the landsman work for? Does he work for a gas driller/producer or someone trying to put together numerous leases to sell to another party? Try to be certain the lessee is a gas driller/producer that has the financial capability of undertaking and conducting the operations contemplated.
- V. Fifth speak with your neighbors. Talk to your neighbors about the idea of combining properties into one “pooled” lease, in order to enhance your potential for a fair and competitive lease. Whether combining on a lease with your neighbor or leasing your own property, the more information you have about the potential driller’s operation the better off you will be in making a good lease decision.

When considering signing a lease for Marcellus gas activity it is best to contact a lawyer who specializes in that field to help you get the best lease possible.

Chapter 3

Permits and Laws

Permits

General Permits

Erosion, Sediment and Storm Water Control Plan/Erosion, Sediment Control General Permit (ESCGP-1)

An ESCGP-1 must identify the exact coordinates, area and type of project proposed. Each step of construction and disturbance must be identified and planned for with proposed dates and phases. The Best Management Practices utilized to minimize disturbance must also be noted and detailed for regulatory review.

Application for Dam Permit for a Centralized Dam Impoundment for Marcellus Shale Gas Well.

All impoundment pits or dams must meet the requirements of PA Code Chapter 78.56-.63 and the *Design, Construction and Maintenance Standards for Dam Embankments Associated with Impoundments for Oil and Gas Wells*. For dams, the maximum depth and storage volume must be noted, along with the drainage area. Any watercourses or flood plains that may be impacted must be noted as well. The potential impacts of a dam failure must be noted and filed; as must a site restoration plan. It is important to note that if a pit is proposed to store fresh water no permit is required, unless the pit is located on a wetlands, watercourse or floodway of a watercourse.

Water Permits

Water Management Plan

A Water Management Plan must be completed that identifies the water source utilized for the hydraulic fracturing for wells within a region of the state for each drilling company. The plan must identify the watershed and water basin that the source belongs to, along with the anticipated maximum 30-day average daily quantity of withdrawal in gallons per day and the maximum rate of withdrawal in gallons per day. If the total water withdrawn by the operator exceeds 10,000 gallons per day in any 30-day period from the same watershed, an Act 220 registration must be filed. This registration notes the source, location and amount of withdrawal with specifics on how the amount withdrawn will be measured and what safeguards are in place to insure compliance with passby flow requirements. A withdrawal impacts and low flow analysis must also be completed by well operators. Finally, depending on the location of the source, the withdrawal may be subject to approval from a River Basin Commission.

Air Permits

Air Quality Regulations for Natural Gas Exploration and Production in Pennsylvania

Natural gas exploration and production results in significant air pollution emissions. Sources of these emissions include compressor engines, condensate tanks, dehydrators, venting and flaring operations, process heaters, leaking pipes, and vehicle exhaust. Air pollution sources throughout most of Pennsylvania are regulated by the Pennsylvania Department of Environmental Protection (DEP) Bureau of Air Quality. Allegheny and Philadelphia County each operate their own air programs separate from DEP. While air permitting procedures in Allegheny and Philadelphia County are generally similar to those described here, there are important differences. Be sure to always reference the policies and procedures these counties employ.

Generally, air pollution sources must obtain an air permit from the Bureau of Air Quality prior to constructing or installing an air pollution source, but not in all cases. This section will address air permitting concerns unique to natural gas extraction operations.

Determining if a Permit is Necessary

DEP does not require a permit for sources that the Department determines are “of minor significance.”⁴⁵ This makes permitting natural gas extraction operations difficult because it often includes many small sources at different sites. DEP might conclude that each individual piece of equipment listed above is of minor significance even though the combined emissions from these sources can create substantial air quality problems.

The following bullet point address DEP’s requirements for a “source of minor significance” and will aid in determining if a well operator violated the law by failing to obtain a required air permit.

Permit Analysis

DEP must include all appropriate related pollution-emitting activities and equipment in its permitting analysis. One simple rule is that the more activities and equipment that are considered part of a single source, the more likely the source will not be considered “of minor significance” and will be required to apply for an air permit. Combining multiple pollutant-emitting activities for consideration as a single source for air permitting purposes is referred to as aggregation. **Aggregation is particularly important in the context of natural gas development because these projects are often made up of many small sources.** Therefore, it is vital to ensure that DEP included and accounted for all related air pollution-emitting activities and equipment in its permitting analysis.

EPA has recently clarified the approach that permitting authorities like DEP should take when determining what pollutant emitting activities should be aggregated. Aggregation determinations must be made on a case-by-case basis considering the following factors:

1. Whether the activities are under the control of the same person (or person under common control)
2. Whether the activities are located on one or more contiguous or adjacent properties
3. Whether the activities belong to the same industrial grouping.

[The information above is provided from a memo from Gina McCarthy, EPA Assistant Administrator, to EPA Regional Administrators, Withdrawal of Source Determinations for Oil and Gas Industries (Sept. 22, 2009), available at: <http://www.epa.gov/Region7/air/nsr/nsrmemos/oilgaswithdrawal.pdf>. Natural gas exploration, drilling, production, and processing operations all belong to the Standard Industrial Classification System (SIC) industrial group 13: Oil And Gas Extraction, see: http://www.osha.gov/pls/imis/sic_manual.display?id=8&tab=group.]

If the DEP fails to consider these factors, citizens can take action by providing the DEP with information demonstrating the proximity, common ownership, or operational interdependency of the natural gas projects at issue. Examples of relevant information include:

1. Evidence a natural gas operator has an economic stake in another nearby natural gas operation,
2. Gas or condensate extracted at a wellhead is transported for additional processing to another nearby site,
3. Multiple well sites are connected to a single compressor station.

DEP maintains an Air Permit Exemption List of sources that are presumed to be exempt sources of minor significance

DEP maintains a list of classes of sources that are generally considered of minor significance that are exempt from air permit requirements. Many of these classes include very specific criteria that must be met in order to be entitled to an exemption. The current exemption for natural gas exploration and production is quite expansive, covering natural gas operations from drilling, to extraction, to processing, and to eventual well plugging and site restoration.⁴⁶

However, these exemptions do not cover every aspect of the process. For example, gas compressor station engines of 100 HP or greater are not exempt. A source that is not described on the air permit exemption list may still be eligible for a permit exemption by submitting an exemption request, called a "request for determination" to PADEP. If PADEP determines that the source described in the request for determination is of minor significance no permit is required.

Exempt sources are still required to meet a number of air pollution control requirements. For example, exempt sources:

1. Shall not emit offensive odors perceptible beyond the boundary of the property where the source is located.⁴⁷
2. Shall not create a public nuisance⁴⁸
3. Shall not create air pollution that threatens “public health, safety or welfare or which is or may be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life or property;”⁴⁹
4. Must be maintained and operated “in a manner consistent with good operating and maintenance practices; and in accordance with practices based on the manufacturer’s specifications to the extent such practices have a material impact on the source’s emissions;”⁵⁰
5. Must meet particulate matter, sulfur dioxide, and opacity emission limits for any stationary fuel burning equipment⁵¹
6. Must maintain adequate records to demonstrate no permitting thresholds are exceeded⁵²
7. Must ensure storage tank pressure relief valves are in good working order and do not open at an unnecessarily low pressure⁵³ and
8. Must comply with any applicable air emissions regulations under the federal Clean Air Act’s New Source Performance Standards (NSPS) and National Emissions Standards for Hazardous Air Pollutants (NESHAP).⁵⁴

Finally, it is important to note that DEP is in the process of modifying its oil and natural gas exemption criteria to narrow the scope of the exemptions.⁵⁵ DEP expects that the revised exemption criteria will become effective sometime in Fall 2010. After these criteria take effect, new natural gas operations and modifications of existing operations must comply with the new, tougher exemption criteria. The proposed new exemption language is included in Appendix B.

Operations exempted by DEP might be subject to Federal Clean Air Act requirements such as NNSR or PSD program or required to obtain a title V operating permit

Even if the natural gas extraction operation falls within the list of exempted sources, the permit exemption will not apply if the natural gas project is subject to the federal Clean Air Act’s Nonattainment New Source Review (NNSR), Prevention of Significant Deterioration (PSD), or title V permit programs.⁵⁶ The present section focuses on the factors that make a source subject to PSD, NNSR, or title V requirements and thus ineligible for an air permit exemption. NNSR, PSD, and title V applicability is determined based on how much pollution a source is capable of emitting (i.e. “potential emissions”). Permit applications are a good source of data on potential emissions. Of course, a natural gas project claiming to be exempt from air permitting requirements is unlikely to submit a permit application; in this case the potential emissions calculations from a permit application for similar equipment at a larger, nonexempt natural gas project can be used to estimate the potential emissions for the source of interest.

PSD Source Applicability:

Most natural gas sources will be subject to PSD requirements if they have the potential to produce at least 250 tons per year (TPY) of any single pollutant. For sulfur recovery plants, the threshold is 100 TPY. The pollutants most likely to exceed this threshold for natural gas projects are nitrogen oxides (NOx) and volatile organic compounds (VOCs).

NNSR Source Applicability:

A natural gas source is likely to be subject to NNSR requirement if it:

- has the potential to emit at least 50 TPY of VOCs;
- has the potential to emit at least 100 TPY of NOx; or
- is located in Bucks, Chester, Delaware, Montgomery or Philadelphia Counties and has the potential to emit at least 25 TPY of VOCs or NOx.

Title V Permit Applicability:

A source must obtain a title V operating permit if it has the potential to emit:

- 100 TPY or more of any single air pollutant;
- 50 TPY or more of VOCs;
- 25 TPY or more of VOCs or NOx and is located in Bucks, Chester, Delaware, or Montgomery counties;
- 10 TPY or more of a single hazardous air pollutant (HAP)⁵⁷ or
- 25 TPY or more of any combination of HAPs.

Citizens can take action by informing DEP of any operations that might be exceeding any of these limits.

Non-Exempt Air Permit Requirements

Drilling operations not exempt from DEP's air permit requirements must obtain either a general permit or obtain a plan approval prior to beginning construction or installation followed by an operating permit when the source commences normal operations. These permitting activities are announced to the public in the *Pennsylvania Bulletin*.⁵⁸ These announcements are also sometimes published in the legal notice section of local newspapers.

General Permits Related to Air Quality

These permits are standardized documents intended to streamline the permitting process for types of sources that are similar in nature. DEP has identified 18 types of air pollution sources that are eligible for general permits. Natural gas projects seeking a general permit are most likely to apply for GP-5 – Natural Gas Production Facilities,⁵⁹ or GP-9 – Diesel or No.2 Fuel-Fired Internal Combustion Engines.⁶⁰

Other important information about general permits:

- Sources subject to PSD or NNSR requirements cannot apply for general permits
- General permits serve as both installation and operating permits
- General permits must be renewed every 5 years
- DEP does not provide a public comment period prior to issuing a general permit. Public notice is provided only after DEP has reached a decision to issue or deny a permit. Individuals who disagree with a general permit decision must appeal to the Pennsylvania Environmental Hearing Board. For more information on the appeals process,

Plan Approvals / Installation Permits

Natural gas projects that are not eligible for a general permit must obtain an installation permit (a/k/a “Plan Approval”) prior to commencing construction of a proposed source.

The operator of a proposed air pollution source must submit an application to the DEP to obtain a plan approval. The application is a public record. Citizens can obtain valuable information from reviewing a plan approval application. These applications must demonstrate that:

1. The source will have the ability to monitor, record, and report its air emissions;
2. The source will comply with all applicable air pollution regulations;
3. The source’s pollution emissions will be sufficiently low to satisfy the DEP’s “best available technology” standard;
4. The applicant has notified the county and municipality where the source would be located of their intention to construct the source; and
5. Finally, the applicant must submit a compliance review form documenting any violations of air pollution regulations that have occurred at any of the applicant’s Pennsylvania facilities in the past 5 years. If any of the applicant’s facilities are currently in violation, the existing violation must be resolved before the DEP will issue a plan approval.

If the proposed source exceeds the Prevention of Significant Deterioration (PSD) threshold discussed above, it must also satisfy the PSD requirements. PSD is a permitting program that applies to large sources located in an area that meets the EPA’s health-based air pollution standards. Before constructing or modifying such a source, the applicant must demonstrate the source will not cause the area to exceed air quality standards and that air emissions will be minimized and controlled sufficiently to meet the “best available control technology” (BACT) standard. This standard is generally stricter than the state-only best available technology (BAT) standard.⁶¹

If the proposed source exceeds the Nonattainment New Source Review (NNSR) threshold discussed above, it must also satisfy the NNSR requirements. NNSR is a permitting program that applies to large sources located in an area that fails to meet the EPA’s health-based air pollution standards. Before constructing or modifying such a source, the applicant must secure

pollution reductions from existing sources in the area sufficient to offset the air emissions the new or modified source will produce; further, the applicant must demonstrate that air emissions will be minimized and controlled sufficiently to meet the “lowest achievable emission rate” (LAER) standard. The LAER standard is even stricter than the BACT standard.⁶²

After reviewing the application the DEP will create a draft permit. This permit should list or reference all air pollution limitations and standards contained in state or federal law that are applicable to the equipment, as well as any other permit “terms and conditions the Department deems necessary to assure the proper operation of the source.”⁶³ When the draft permit is complete, the DEP will publish a public notice in the *Pennsylvania Bulletin* and the applicant must publish the notice in the legal notices section of a local newspaper. Once the notice is published, the public has 30 days to review the permit and submit written comments to the DEP. The public notice will also include instructions for citizens to request a public hearing where oral testimony can be provided. Individuals who disagree with the DEP’s ultimate permit decision can file an appeal to the Pennsylvania Environmental Hearing Board. For more information on the appeals process,

If construction or installation of the project described in the permit does not commence within 18 months of the DEP issuing a plan approval, or if there is an 18 month lapse in construction, the source must request and justify a permit extension or submit a new plan approval.⁶⁴

Operating Permits

Once a facility has commenced normal operations it will be required to obtain an operating permit if it was required to obtain a plan approval or its emissions exceed the Title V or state-only operating permit threshold mentioned above. If a source must obtain a Title V permit, the source does not have to obtain a state-only operating permit as well.

State only operating permits

DEP requires sources whose actual emissions meet or exceed any of the pollutant emissions thresholds listed below to obtain state-only operating permits prior to commencing normal operations:

- 20 TPY of carbon monoxide,
- 10 TPY of nitrogen oxides,
- 8 TPY of sulfur oxides,
- 3 TPY of particulate matter 10 microns or smaller (PM10),
- 8 TPY of volatile organic compounds,
- 1 TPY of any single hazardous air pollutant,
- 2.5 TPY of a combination of hazardous air pollutants.

Other important information about operating permits:

- State only operating permits must be renewed every five years.

- When DEP creates a draft operating permit, the department will publish a public notice in the Pennsylvania Bulletin and the applicant must publish the notice in the legal notices section of a local newspaper. Once the notice is published, the public has 30 days to review the draft permit and submit written comments to DEP. The public notice will also include instructions for citizens to request a public hearing where oral testimony can be provided. Individuals who disagree with DEP's ultimate permit decision can file an appeal to the Pennsylvania Environmental Hearing Board. For more information on the appeals process, see

Title V Operating Permits

Title V operating permits are required by the Federal Clean Air Act. Title V requirements apply to large sources of emissions that have commenced normal operations. Sources whose potential emissions meet or exceed any of the pollutant emissions thresholds obtain a title V permit.

Title V permits combine all air pollution control requirements applicable to a pollution emitting facility into a single, comprehensive document; further, the Title V program establishes monitoring and reporting procedures a source must meet in order to demonstrate compliance with the Title V permit requirements.⁶⁵

When the DEP creates a draft Title V operating permit, the department will publish a public notice in the Pennsylvania Bulletin and the applicant must publish the notice in the legal notices section of a local newspaper. Once the notice is published, the public will have 30 days to review the draft permit and submit written comments to the PADEP. The public notice will also include instructions for citizens to request a public hearing where oral testimony can be provided.

Title V permits also must be approved by the EPA. From the time the DEP submits a proposed permit to the EPA, The EPA has 45 days to review it. If the EPA rejects the permit, the DEP must either deny the permit or revise the permit and resubmit it to the EPA. If the EPA does not reject the permit within the 45-day period, the permit becomes final. Citizens who submit comments on the permit have 60 days from the time the EPA's 45 day review period ends to petition the EPA to reconsider and reject the permit. If the EPA refuses to reject the permit despite a citizen petition, citizens who submitted comments can challenge the EPA's decision in federal court or appeal the DEP's decision before the Pennsylvania Environmental Hearing Board. For more information on the appeals process,

Laws

Oil and Gas Act

Pennsylvania passed the Oil and Gas Act in 1984. The Oil and Gas Act requires that all new wells be permitted by the state prior to being drilled, and also requires that all existing wells be registered. The Oil and Gas Act 223 generally sets forth the permitting, drilling, operating, casing, plugging, reporting, financial responsibility, registration, restoration, and gas storage

requirements, among others for all gas wells that are overseen by the DEP Oil and Gas program. Coal and Gas Resource Law Act 214 for non conventional gas wells that penetrate the workable coal seam. There is also the Oil and Gas Conservation law, Act 359 for conservation wells, which govern wells drill to a depth of at least 3,800 feet. The extra depth and high pressures encountered in these wells require special requirements for well casings, well spacing, waste preventions and pooling are necessary. Marcellus gas wells would have to follow the Act 350 regulations. The Oil and Gas owner and the operator also must apply for coverage under the Erosion and Sediment Control General Permit-1 (ESCGP-1), and must prepare an Erosion and Sedimentation Control Plan which must be posted at the well site for the duration of operations.

Pennsylvania Oil and Gas Act Regulates well drilling, including well construction.

Marcellus gas wells are an unconventional gas well and parts of the process are new to the existing law and regulations. The following are some of the regulations that apply to Marcellus wells.

- Well placement - A 100 foot buffer from any stream, spring, or body of water identified on a topography map and a 200 foot buffer from buildings or water supplies unless the landowner gives consent to construct closer.
- Well restorations - Each well operator must restore the land area within nine months of well completion.
- Protections of Water - There are many casing requirements to prevent the pollution of ground water and the disposal of brine water and other produced water must follow the
- Pennsylvania Clean Streams Law. Any well operator that affects a public or private water supply must restore or provide a water supply to it's original quality and quantity.
- If the gas well was within 1,000 feet of the well the well operator is responsible for determining the reason for contamination while anything over 1000 feet is the burden of the land owner to determine reason for contamination.
- Well Reporting - The well operator must report their production to the DEP annually and they must also report other logs and data to the DEP within five years of well completion.

Pennsylvania Clean Streams Law

The Pennsylvania Clean Streams Law provides the DEP with basic legal authority to prevent and abate water pollution within Pennsylvania. This law also allows for enforcement and penalties of polluting Pennsylvania's waters. In article III of the clean streams law deals with industrial waste and it requires persons or municipalities to obtain a permit to discharge industrial waste into the waters of the commonwealth. The clean streams law defines industrial wastes as follows: "any liquid, gaseous, radioactive, solid or other substance, not sewage, resulting from any manufacturing or industry, or from any establishment, as herein defined, and mine drainage, refuse, silt, coal mine solids, rock, debris, dirt and clay from coal mines, coal collieries, breakers or other coal processing operations." Marcellus waste water is considered industrial waste and requires a permit to be discharged into the waters of the commonwealth. Article I

Chapter 94 Municipal Waste load Management regulates the amount of industrial waste that municipal treatment facilities can accept. Article I Chapter 102 requires Marcellus well operators to obtain an erosion and sediment control plan if the earth disturbance will be greater than 5 acres or the well site may affect a High Quality or Exceptional Value stream. This permit will regulate well locations to have the least amount of earth disturbance and have a best management practice. According to the erosion and sediment control plan pits and impoundments that store flowback, produced water must be 20 inches above the groundwater table.

Chapter 4

Marcellus Shale Air Impacts & Air Quality in Southwestern Pennsylvania

History

As Southwestern Pennsylvania moved into the 20th century, the negative health effects of polluted air were recognized but not well understood. The aesthetic impact of sooty air was obvious, but aesthetics competed with the smoke = prosperity and jobs attitude. However as coal fueled industrial activity and home heating increased, rail and barge traffic intensified and cities grew, the soot and poor air quality gained increasing attention. In southwest Pennsylvania, Pittsburgh had already been given the moniker of the “Smoky City”. In 1948 in Donora, a small river valley town near Pittsburgh, a deadly air temperature inversion lasting 5 days, trapped emissions from a zinc smelter, steel mill and other pollution sources in a cool layer of air below warmer air. The polluted, stagnant air enveloped and sickened about half of the area’s residents and resulted in twenty deaths.

The Donora Air Pollution Tragedy helped galvanize new air cleanup efforts, and bolstered those efforts already underway, such as the *Commission for the Elimination of Smoke* formed in 1941 in Pittsburgh. On the federal level, the Air Pollution Control Act of 1955 became law and provided funds for federal research into air pollution. In 1957, the Allegheny County Health Department (ACHD) was formed and the Air Quality Program for the city of Pittsburgh and Allegheny County were consolidated at ACHD to regulate air pollution. In 1962, Rachel Carson’s book, *Silent Spring* was published arguing against the pervasive and indiscriminant use of pesticides. The book was widely read and became a strong motivating factor in creating public concern about environmental damage and the implications for human health. The Federal Environmental Protection Agency was established in 1970.

The Clean Air Act Amendments (CAA) of 1970 authorized creation of comprehensive federal and state regulations to limit emissions from both stationary (industrial) sources and mobile sources. Significant CAA amendments were added in 1977 and 1990.

Air Pollutants

Criteria Air Pollutants

There are six broadly distributed air pollutants considered harmful to health and environment. The CAA requires control of these pollutants by setting National Ambient (outdoor, in the environment) Air Quality Standards (NAAQS). The regulated pollutants are sulfur dioxide, nitrogen dioxide, carbon monoxide, particulates (particles of both size 2.5 and 10 micrometers), ozone and lead. Each pollutant has a primary standard which may include several time dependent standards set at limits sufficient to protect public health including sensitive populations such as children and asthmatics. Separately, secondary standard limits may apply to some criteria pollutants where the pollutant can affect public welfare such as protection of

visibility, damage to animals, crops, vegetation or buildings.
(see NAAQS at- <http://www.epa.gov/air/criteria.html>).

Hazardous Air Pollutants (HAPs)

The Clean Air Act in 1970 and 1977 required the EPA to regulate emissions of a list of hazardous air pollutants that could reasonably be expected to cause death or serious illness. Initially, EPA was to set these standards based on health considerations but for many of these substances no safe level can be identified. The CAA Amendments of 1990 established a new approach to setting National Emissions Standards for Hazardous Air Pollutants, known as *Maximum Achievable Control Technology* (MACT). The standards now cover 187 hazardous air pollutants. These standards moved away from the risk-based approach of the 1970 law to primarily a "technology-based" approach-meaning that the standards are based on considerations of the level of emission reduction technologically feasible rather than determinations of a level of reduction resulting in healthy air. MACT requirements are specific to individual industry sectors. See <http://www.epa.gov/ttn/atw/eparules.html>

Monitoring: The Criteria Air Pollutants

State and local air pollution control agencies are required to create and maintain an ambient air-monitoring network for the criteria pollutants. Individual monitor locations are determined based on federal monitor sighting requirements. (State and local air monitoring networks may also have additional monitors) It is on the basis of these monitors that areas are determined to meet or fail to meet the National Ambient Air Quality (NAAQS) standards. For each criteria pollutant, areas that meet the standard are said to be in "attainment". Those that don't are said to be in "non-attainment" of that standard. If in non-attainment, EPA requires state or local air pollution control agencies to create an "implementation plan" containing sufficient quantifiable, enforceable pollution reduction measures to bring the area into attainment.

- See Pennsylvania Department of Environmental Protection:
http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/docs/2010_NetworkDescription_for_EPA.pdf for 2010 locations of ambient air monitors and the parameters monitored at each site
- See:http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/docs/PA_Air_Monitoring_Network_Plan_for_2011.pdf for proposed 2011 locations of ambient air monitors and the parameters monitored at each site.
(Allegheny County has its own air program & additional air monitors in Allegheny County are not shown at these sites).

Air Quality Index

The Air Quality Index (AQI) provides a daily measure of air quality for many areas of the country. The AQI is color-coded to correlate pollution concentrations to the likelihood and severity of suffering negative health effects when exposed to air pollution at these levels. For instance, green means the air quality is good; orange means the air is unhealthy for sensitive groups, such as individuals with asthma; and red means the air is unhealthy for everyone. EPA calculates the Air Quality Index, AQI, for five major air pollutants regulated by the Clean Air Act:

ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide.

- You can follow the AQI levels of criteria air pollutants in your area and in the country in real time at: <http://www.airnow.gov/>
- Similar information for southwestern Pennsylvania is recorded on DEP's website <http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/psipitt.htm>

Pennsylvania has state regulations to control the natural gas industry. *See Air Regulations Section.

Air Emissions from Natural Gas Operations

The process of natural gas drilling, extraction, and delivery may result in significant air pollution emissions. Below is a general discussion of air pollutants associated with natural gas extraction and sources of those emissions in the oil and gas development process.

Natural Gas

*Natural gas is released during venting operations or where there are leaks in equipment during oil and gas development. **

Natural gas is a combustible mixture of hydrocarbons. It may form from deeply buried organic matter under the pressure of many strata of sediment and rock combined with heat deep in the earth. Under such conditions, carbon bonds can be broken in the organic molecules forming methane, which is the main component of natural gas. This process creates thermogenic methane and is the process that forms most of the Marcellus Shale methane.

Near the surface, microorganisms that thrive in oxygen-deprived environments such as landfills may chemically decompose organic matter, creating methane as a byproduct. This is referred to as biogenic methane.

Levels: Constituents⁶⁶: Methane is the most prevalent constituent of raw natural gas making up 70%-90% of its volume. Methane is the gas usually used in home heating. Other gases include ethane, propane and butane in levels from 0% to 20%. These gases are also valuable and usually separated from the methane and sold. Some gases that may be present in small quantities include carbon dioxide 0%-8%, Oxygen 0%-0.2%, nitrogen 0%-5%, hydrogen sulfide 0%-5% and A, He, Ne, Xe (trace of rare gases).

Health & Environmental Concerns: OSHA encourages well site monitoring for hydrogen sulfide (H₂S), (see H₂S below). Although, natural gas can sometimes occur naturally near the earth's surface, natural gas can also migrate into aquifers, wells and buildings and create hazardous conditions if not properly contained at the gas well. Natural gas is highly combustible. Report any signs of bubbling gas in streams or wells to DEP.

Methane (CH₄)

Methane gas may escape to the atmosphere during gas production, processing, storage, and distribution.

The primary component of natural gas, methane, is colorless and odorless. Methane may leak from wellheads, equipment and extensive pipelines. Prior to sale, an odorant is added, usually mercaptan, which is the odor typically, noticed at a gas stove fire ring that has failed to ignite.

Levels: Methane can be explosive at a concentration of 5% to 15%.⁶⁷ These two numbers are known as the lower explosive limit (LEL) and the upper explosive limit (UEL) respectively.

Health & Environmental Concerns: Methane is not itself a toxicant but may be an asphyxiant if it rises to sufficient levels. Methane is a greenhouse gas having a global warming potential at least 20 times more potent than carbon dioxide averaged over a 100-year period and even more potent over a shorter period. Beginning in 2011, petroleum and natural gas facilities that emit more than 25,000 metric tons of carbon dioxide equivalent a year will be required by the EPA to monitor and report all greenhouse gas emissions. Petroleum and natural gas sources will begin data collection in January 1, 2011. The first annual reports are due to EPA March 31, 2012. This includes tracking carbon dioxide emissions.

Carbon monoxide (CO):

*Carbon monoxide is emitted from flares, compressors, vehicles, and other machinery at natural gas production sites.**

CO is a colorless, odorless, tasteless flammable gas. It is produced by incomplete combustion of carbon-based fuels.

Levels: The U.S. National Ambient Air Quality Standards for carbon monoxide are 9 ppm (parts per million) averaged over 8 hours, and 35 ppm average for 1 hour.** Average levels in a home without a gas stove vary from .5 to 5 ppm.⁶⁸ The highest levels of CO outdoors typically occur during the colder months when inversion conditions are more frequent. Inversions occur when a stable air mass with cooler air is underneath a warmer layer of air above. This configuration allows for less air layer mixing and may concentrate ground level air pollutants in the lower layer.

Health & Environmental Concerns: CO reduces the body's ability to carry oxygen. Headache and dizziness are symptoms of lower levels of exposure. Symptoms of carbon monoxide poisoning include headache, nausea, vomiting, dizziness, fatigue and a feeling of weakness. At very high levels death can occur in minutes. Every home should have a carbon monoxide detector. Outdoors, CO contributes to the formation of ozone.

Hydrogen Sulfide: (H₂S)

Hydrogen Sulfide may be released during venting, incomplete combustion of flared gas or fugitive emissions from equipment-(emissions not caught by a capture system) if present in the

*gas stream.**

Hydrogen sulfide gas occurs in some natural gas formations. It is a colorless, highly flammable and explosive gas. It has a rotten egg odor at low concentrations. Oil or natural gas is referred to as “sour” if it contains high concentrations of hydrogen sulfide. Hydrogen sulfide is slightly heavier than air and can collect in enclosed or low-lying areas.

Levels: The ambient one-hour and 24-hour Pennsylvania H₂S ambient air standards are 100 ppb (parts per billion) and 5 ppb respectively. Typical environmental concentrations of hydrogen sulfide are (.11ppb–.33 ppb). The concentration at which 50% of humans can identify the characteristic odor of H₂S is 5 ppb. The ability to perceive an odor varies widely among individuals. Olfactory fatigue with loss of ability to detect H₂S odor can set in at chronic low-level exposure and very quickly at higher levels (about 300 ppm). Respirators are recommended above 10 ppm. Inability to detect the H₂S odor can make this compound particularly dangerous.

Health & Environment Concerns: Inflammation and irritation of the eyes, cough, headache and neurologic symptoms can occur at chronic low airborne concentration.⁶⁹ H₂S can be rapidly lethal, causing collapse, if inhaled at very high concentrations.

Nitrogen Oxide (NO_x)

*Nitrogen Oxides are formed during flaring operations, from vehicles and when fuel is burned to power generators or compressors**

Nitrogen oxides are a product of fossil fuel combustion. The sum of nitric oxide (NO) and nitrogen dioxide (NO₂) are typically called nitrogen oxides or NO_x (there are other compounds in the nitrogen oxide family). EPA measures NO₂ to approximate concentrations for the entire category of nitrogen oxides.

Levels: The primary federal ambient one-hour standard for NO₂ is 100 parts per billion (ppb) and the primary annual standard is 53 ppb. **

Health & Environment Concerns: Short-term NO₂ exposures, ranging from 30 minutes to 24 hours, is associated with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma.⁷⁰

NO_x contributes to, acid rain, particle pollution and ground level ozone formation through atmospheric reactions.

Ground level ozone (O₃) is a criteria pollutant with new federal regulatory ambient air limits (.075 ppm averaged over 8 hours). The 1997 standard of .08 ppm remains in effect until EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard. **

Ground level Ozone is formed particularly in heat and sunlight when volatile organic compounds react with nitrogen oxides in a complex photochemical reaction. Natural gas extraction process are therefore contributing to the formations of ozone through precursor emissions. Because heat and sunlight are needed, ground level ozone is usually formed in higher levels in the warmer months. Ozone may travel for considerable distances so that rural as well as urban areas may have unhealthy ozone levels.

Increased ozone levels are associated with respiratory symptoms such as wheezing, chest pain, coughing and an increased risk of asthma attack. Repeated exposure may permanently damage lung tissue. Sensitive individuals should avoid exercising when outdoor ozone levels are high. Ozone can interfere with some plants ability to produce and store food-creating susceptibility to disease. It can reduce forest growth and crop yields.

Particulate Matter: (PM₁₀, PM_{2.5})

Particulate Matter at oil and gas sites typically result from diesel engine exhaust, vehicles, venting and flaring operations, and dehydrators. Soil particles mixing in the air during well pad construction and road dust from truck traffic on access roads may be another significant source.

*

Particulate Matter is composed of small solid or liquid airborne particles. The larger of these particles is referred to as PM₁₀ (particles less than or equal to 10 micrometers in diameter). The smaller particles are referred to as PM_{2.5} (particles less than or equal to 2.5 micrometers in diameter). The very small PM_{2.5} particles are able to penetrate more deeply into the respiratory system and pose serious health problems. Diesel emissions for example have a large component of PM 2.5 particles and even smaller “ultra fine particles.”

Levels: The primary ambient PM₁₀- 24 hour standard is 150µg/m³. ** The primary ambient 24-hour PM 2.5 particulate standard is 35 µg/m³, and the annual PM 2.5 particulate standard is 15.0 µg/m³. **

Health & Environment Concerns: Health effects associated with inhalation of these particles include respiratory problems, aggravated asthma, development of chronic bronchitis, nonfatal heart attacks and premature death in people with heart and lung disease, lung cancer. “Each 10-µg/m³ elevation in fine particulate air pollution was associated with approximately a 4%, 6%, and 8% increased risk of all-cause, cardiopulmonary, and lung cancer mortality respectively.”⁷¹ Particles in the air also contribute to regional haze.

Volatile Organic Compounds: (VOC)

Volatile Organic Compounds may be emitted by venting at dehydrators, condensate tanks, fugitive emissions, venting and flaring of gas during stimulation, evaporation from containment pits, diesel and natural gas engine exhaust.

Volatile Organic Compounds consist primarily of photochemically reactive hydrocarbons with high vapor pressure and low-to-medium water solubility.

Levels: VOCs include many different chemicals. There are no federal ambient VOC air standards. Some VOCs pose health risks at very low concentrations. Benzene, for example, is a highly dangerous VOC that is a known carcinogen that can cause leukemia.

Health & Environment Concerns: Exposure may be by respiration, ingestion or absorption through the skin. The Environmental Working Group (EWG) recently did a study indicating benzene is a component of some hydro fracture fluids.⁷² VOCs at the well site may be derived from man made application but some VOCs at the well site may be mobilized from the shale formation itself.

“In general, long-term exposure to low concentrations of Volatile Organic Compounds in water or air, at or above regulatory standards—such as Maximum Contaminant Levels (the maximum permissible contaminant level set by EPA) in water, may result in liver or kidney effects.”⁷³ VOCs also contribute to the atmospheric formation of ozone.

Sulfur Dioxide: (SO₂)

*Sulfur Dioxide emissions may result from flaring of natural gas and combustion of fossil fuels containing sulfur.**

SO₂ is a colorless, nonflammable gas at room temperature with a pungent odor.

Levels: EPA has set a new national primary ambient one-hour SO₂ health standard at 75 ppb. The 24-hour ambient primary standard of 0.14 ppm and the annual primary standard of 0.03 ppm are revoked but remain in effect until August 23, 2011. Currently EPA notes, the annual ambient average SO₂ concentrations range from approximately 1 – 6 parts per billion.

Health & Environment Concerns: Short-term exposure is associated with respiratory problems such as wheezing, chest tightness and shortness of breath. SO₂ can aggravate asthma. SO₂ contributes to formation of atmospheric particle pollution as well as acid rain. (In many cases, improved gas field air emission prevention or capture techniques are available. The additional natural gas recovered as a result means many of these control measures pay for themselves, often in less than a year.)

Scope of Some Emissions Associated with Natural Gas Recovery

1. In the 5-counties in the Dallas Fort Worth metropolitan area annual NO_x and VOC emissions from the oil and gas sector exceed emissions from all motor vehicles.⁷⁴
2. “According to the EPA [Inventory of U.S. Greenhouse Gases and Sinks: 1990-2007](#), dated April 2009, oil and gas systems are the second largest human-made source of methane emissions and account for 23 percent of methane emissions in the United States or 2 percent of the total greenhouse gas emissions in the United States.”⁷⁵

*Information for the emission sources at the oil and gas extraction site for the pollutants

discussed above in section *Air Emissions in Natural Gas Operations* are taken from *Earthworks: Air Contaminants*, available at <http://www.earthworksaction.org/aircontaminants.cfm> and *Oil and Gas Air Pollution* available at <http://www.earthworksaction.org/oilgasairpollution.cfm> and *Oil and Gas Pollution* available at <http://www.earthworksaction.org/pubs/Oilandgaspollution.pdf>

**The numerical values cited for air quality standards have additional requirements such as averaging periods, allowable exclusions and appropriate monitors. See details at <http://www.epa.gov/air/criteria.html>. Note at this website that there are also secondary standards set to protect against decreased visibility, damage to animals, crops, vegetation and damage to buildings for many of the above air pollutants.

Truck Emissions From Natural Gas Drilling/Production

Another part of the air pollution problem from Marcellus Shale drilling comes from diesel trucks used in the operations. Diesel emissions contain numerous carcinogens. “Carbon soot particles from diesel engines adsorb onto their surfaces other metals and toxic substances produced by diesel engines such as cancer-causing aldehydes (like formaldehyde) and PAH (polycyclic aromatic hydrocarbons.)”⁷⁶ These diesel particles are extremely small and may pass through nasal filtration into the lungs and bloodstream. “Consistently, lung cancer risk is elevated among workers in occupations where diesel engines have been used.”⁷⁷ Higher risks of asthma, heart attack, stroke, and premature death are all linked to diesel exhaust. Diesel engines also emit carbon monoxide, and oxides of nitrogen—a precursor to ground-level ozone, another serious air pollutant.

While new regulations on diesel engines, effective in 2007, have begun to clean up diesel fleets, older engines are still dirty—and may have a lifespan of thirty years or more. Each well is different, but a safe assumption is that about 1,000 truck trips are needed per well, most of which will occur during the multi-week period of drilling, hydraulic fracturing, and completion of the well. The majority of these trips come from trucking water in and taking flow-back water out. Clustering drilling activity can lessen the number or length of trips needed, as well as water management practices that involve water recycling and a centralized water impoundment site, but diesel pollution from trucks will be a serious issue for our region to deal with, as we struggle to climb out of federal non-attainment for ozone and small particulate matter (PM2.5).

Radon-Radioactivity in Natural Gas Recovery

“The Marcellus Shale is considered to be a highly radioactive shale”⁷⁸ This is a feature helpful in characterizing the location and thickness of the shale as the naturally occurring radioactive materials (NORM) will allow the shale layer and location to be detected.⁷⁹ The radioactivity generally arises from small amounts of thorium and uranium along with decay elements of radium as well as radioactive potassium elements. The Environmental Protection Agency (EPA) notes that NORM is referred to as “Technologically-Enhanced, Naturally-Occurring Radioactive

Material (TENORM) when activities such as uranium mining, or sewage sludge treatment, concentrate or expose radioactive materials that occur naturally in ores, soils, water, or other natural materials.”

During drilling, Marcellus shale cuttings, usually with elevated radioactivity will be carried to the surface in the drilling mud. Later the hydro fracturing process will bring flow-back water to the surface. The flow backwater from Marcellus drilling is made up largely of returning, hydro-fracture water and stimulation chemicals, significant levels of total dissolved solids (TDS), hydrocarbons, heavy metals and dissolved TENORM from the Marcellus shale. After a few weeks the volume of flow backwater is reduced. Water that continues to come to the surface is referred to as produced water consisting generally of a briny liquid with very high TDS levels and TENORM. EPA notes (<http://www.andrewkaram.com/andy/pdf/TENORM.pdf>) that produced water from oil and gas production ranges in radiation levels from a low of .1pCi/l to a high 9000 pCi/l. As a comparison, soils of the United States have radiation levels producing a low of .2 pCi/gram to a high of 4.2 pCi/gram. Radon gas, a daughter product of radium 226 may also be produced in the natural gas recovery process. Typically, the returning water to the surface will be recycled, held in tanks or in lined impoundment pits or taken to permitted treatment facilities.

Exposure levels increase if the TENORM concentrates. This can happen in several ways. Temperature and pressure changes may cause radium in produced water to co precipitate with barium sulfate to form a scale in surface equipment and tubes.⁸⁰ “Radon decay elements occur as a film on the inner surface of inlet lines, treating units, pumps, and valves principally associated with propylene, ethane, and propane processing streams”.⁸¹ TENORM components may settle to the bottom of impoundment pits along with other constituents to concentrate as a sludge. TENORM from produced water can concentrate in the filtration systems at treatment facilities or in specialized treatment equipment. The employees that work in the natural gas recovery operation areas are usually the most highly exposed to the TENORM. Natural gas equipment and pipes should be cleaned of any TENORM before being recycled or reused. Pennsylvania disposal of very low-level radioactive shale cuttings is permitted as land application with criteria or buried at the bottom of the pits after liquid removal and with criteria.⁸² Disposal also is available at appropriate landfills. Testing in Pennsylvania for unacceptable high radioactivity typically occurs as transport vehicles pass through landfill entrances. Recently the Chemung County Landfill in New York has had its proposed expansion challenged by the surrounding community. One of the main community arguments against the expansions is the radioactivity and safety issue surrounding the landfills ongoing acceptance of Marcellus Shale drill cuttings.

Federal laws don't directly address naturally occurring radioactivity and waste generated during natural gas exploration, and production is generally exempt from federal laws dictating handling of natural gas production waste, leaving the burden on the states.

Radon is a colorless, odorless and tasteless gas that seeps through soil and may enter wells or buildings. It is common in Pennsylvania shale and granite soils that contain traces of uranium

with decay elements. Affected household water is more likely if water is drawn from underground aquifers than if water is withdrawn from river systems. Water filters should be changed frequently. Pennsylvania does not regulate radon levels but encourages all home residents to test for radon gas. Research to clarify immediate and long-term health impacts from radon and other radioactivity materials related to Marcellus natural gas recovery and disposal is needed. See the PA Bureau of Radiation Protection web site for additional information on home radon testing.⁸³ Radon gas is clearly linked with lung cancer.

Radium can also cause cancer. Exposure can be through inhalation, ingestion, or physical exposure. The National Primary Drinking Water Standard for combined radium Maximum Allowable Contaminant level is 5pCi/L (picocuries per liter). The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows for an adequate margin of safety for combined radium is zero. "Dr. Peter Davies, a Professor of Biology at Cornell University and a licensed handler of low-level radioactive material, states that, "It is imperative that drilling wastes not be disposed of, by either on-site burial or land spreading, in areas that are located close to residences or public facilities, or where they can contaminate water supplies. Radioactive wastes must be taken to an appropriate facility that is designed to handle radioactive waste."⁸⁴

Chapter 5

Marcellus Shale Water Impacts

Regulations

Preparation - Erosion and Sediment and Storm Water Control Plan

Well operators must apply for coverage under the Erosion and Sediment Control General Permit-1 (ESCGP-1), and must prepare an Erosion and Sedimentation Control Plan.

The Erosion and Sedimentation Control Plan dictates the flow of storm water from the well site during the construction of the well pad. This plan has to be filed with DEP and is required to be posted at the well site for the duration of operations. Once posted at the well site, this plan should be available for public viewing, and by looking over the plan it may be possible to determine if violations of the plan exist for example, missing hay bales or a tear in the silt fences.

Drilling

In order to drill a well in Pennsylvania, drilling companies are required to obtain a Well Permit from DEP's Bureau of Oil and Gas Management. These permits are often brief, generally no more than 10 pages, and describe the proposed location, bonding and land ownership information for a well. DEP has 45 days to review a well permit, and occasionally special conditions will be placed on the operations. These conditions will be available as part of the well permit. Per the 1984 Oil and Gas Act, there is no public participation component in the permitting process so it is not possible to request a public hearing or file public comments on the permit application.

Water Withdrawal

In the Ohio River basin, there is no river basin commission such as in the Delaware and Susquehanna River watersheds in Pennsylvania. The Delaware and Susquehanna River Basin Commissions have regulatory authority over water withdrawals in their jurisdictions. Since there is no such entity in the Ohio River watershed (which includes much of western Pennsylvania), DEP requires drilling companies in the Ohio River watershed to adhere to the water withdraw provisions in the Water Resources Planning Act 220, enacted in 2002.

Water Resources Planning Act 220

The Water Resources Planning Act requires well operators to submit a Water Management Plan if they will be withdrawing more than 10,000 gallons of water per day (gpd) for the purpose of drilling a well. A withdrawal impact narrative must be attached to the water management plan.

The withdrawal impact narrative will describe the methods used to avoid or minimize impact to the stream of withdrawal and answer nine questions about the stream of withdrawal.

The Water Resources Planning Act also requires companies withdrawing water to monitor the amount of water withdrawn and the flow of the stream/river from which withdrawals are

occurring. The company is also required to notify the county and municipality of where they are withdrawing. A record of withdrawals is to be kept and submitted to the DEP quarterly and DEP is to be notified of new withdrawal points at least 48 hours in advance. This information is planned to be public record in the near future.

While many drilling companies adhere to their Water Management Plan, some illegal withdraws are occurring especially in rural areas where it may be necessary to drive a significant distance to obtain water. By reviewing the Water Management Plan, it is possible to determine where the water for fracking is to be obtained.

Discharge

On August 21, 2010 the PA DEP enacted new regulations on the discharge levels of TDS. Gas waste water discharged has to be less than 500mg/L of TDS. This new regulation was designed to protect the streams and rivers and also encourage the drilling industry to reuse the water.

Marcellus wastewater is considered residual waste and the wastewater should be taken to a water treatment facility before discharge into rivers and streams. Reports of illegal dumping of Marcellus shale flowback water being illegally discharged into surface waters (lakes, streams and rivers) are becoming more and more common, and the public is encouraged to be alert for this activity.

Potential Impacts

Site Preparation

During the site preparation there is the possibility of erosion and sedimentation from the construction of access roads, pipelines and the well pad. This erosion and sedimentation can impact streams and rivers, and is problematic especially in areas where surface water provides source water for drinking. Drilling companies are required to construct siltation fencing, ditched near access roads, and detentions basins to control the flow of storm water from a drilling site. If you notice increases sedimentation or murky waters in streams near a drill site there could an issue with erosion and sedimentation and you should follow the instructions in Chapter 6.

Drilling

Horizontal drilling requires the use of drilling muds in order to reach the depth desired.

Disposal of drilling muds is a concern. According to DEP, the drilling muds are not allowed to be land-applied because of the potential for contamination of groundwater, and therefore they must be taken to an appropriate disposal center. If you see the disposal of drilling muds anywhere contact the DEP.

Hydrofracking

The hydrofracking process has the greatest potential for contamination of ground and surface waters. The process can require up to 5 million gallons of water to frack a well and anywhere from 20% to 70% of that water can flowback and needs to be disposed of.

Water Withdrawals

The hydrofracking process requires anywhere from one to five million gallons of water each time a well is 'fracked.' Each well can be fracked up to 10 times, and each well pad can hold multiple wells, essentially meaning that over the life of the wells on one pad's water use could exceed 100 million gallons. This water must be withdrawn from nearby streams, lakes, or purchased from public water supply companies. The withdraw of such large amounts of water from surface waters, particularly small streams, could potentially dewater these streams in drought periods.

Water Treatment

A portion of the millions of gallons of water used in the hydrofracking process returns to the surface as flowback or produced water. This water contains hydrocarbons, salts, dissolved solids, and other constituents. The first flow-back water has a salt content of only between 1,500 and 2,000 parts per million, but the longer the water remains in the Marcellus Shale, the saltier it becomes. By the end of the first week, the salt content can reach 45,000 parts per million. Seawater averages between 10,000 and 35,000 parts per million. The high salt content makes the water highly corrosive to metals and harmful to land, vegetation, and other living organisms. The biggest difficulty in treating Marcellus waste water is the high levels of TDS in the water.

TDS is the acronym for total dissolved solids. Total dissolved solids are the amount of mobile ions including minerals, salts, and metals dissolved in a given volume of water. TDS in the water is secondary regulation for drinking water. The EPA states the the maximum TDS level for drinking water is 500mg/L but some drinking water has levels as high as 1,000mg/L.

Currently in this area flowback water is being taken publicly owned water treatment (POWT) facilities, specialized treatment facilities in New Stanton and Fairmont, or being reused by the companies. These POWT can remove some of the contaminates from the water but cannot adequately treat the high level of salinity in the water. Our region has already experienced the results of this practice when it was found in the summer of 2009 that levels of total dissolved solids (TDS) in the Monongahela River were seriously elevated. Given that the Monongahela River provides the source water for over 300,000 people's drinking water in this region, the threat of a major public health emergency was very real. POWT facilities are suppose to accept 1% of total intake as Marcellus waste water. The DEP is trying to get the industry to take their waste water to specialized treatment facilities or to reuse the water. This could result in more unauthorized dumping in streams to cut cost of treatment from the industry.

Chapter 6

Marcellus Shale Public Health Impacts

There have been reports of environmental impacts from activity related to Marcellus shale gas exploration and development. There are also potential public health and safety implications in the communities being impacted by Marcellus shale activity. A listing of the possible environmental and public health impacts related to Marcellus activities is listed below.

Possible Environmental and Public Health Impacts

Seismic Testing

It is important to note that if testing is occurring or known to occur it is important to check for possible damage to foundations, bridges, retaining walls, towers, and other infrastructure. Note that homeowners' insurance does not usually cover damage resulting from seismic testing related to industry operations.

Radon

Radon activity already occurs in homes located over the Marcellus Shale. Higher levels of radon exist because of the enriched amount of uranium in the shale. Uranium decays to radium, which decays into radon gas. Radon gas has a short half life of a couple of days. Therefore, radium must be close to the surface to allow for decay into radon gas that can then move through the soil entering empty pockets such as a basement as a harmful gas. The question is whether disturbing this shale layer will increase the amount of radon in the homes above the shale layer. If Marcellus shale drilling is going to occur it may be helpful to test radon levels in basements in the area. Then test again after fracturing operations have been performed over a period of time. Report any increased levels that are found.

Open Impoundments

Open Impoundments which are typically the large man made pits lined with thick reinforced plastic sheeting to store fresh water used for fracturing, as well as capturing the flow back water from the well. These pools can be foul smelling and emit toxic volatile organic chemicals (VOCs). These impoundments are not currently permitted for air monitoring of any kind, especially for VOCs. Tears or burning of the liner have enabled toxic fluid to leak into the ground contaminating surface and ground water to various degrees. These impoundments are regulated to have what is called 2 foot board, meaning there should be at least two feet of clearance from the top of the impoundment to the top of the fluid. The purpose of this is to allow for the addition of rain water without the impoundment overflowing into the surrounding environment. The contaminants, in sufficient quantities could pose a risk for to health including cancer, breathing difficulties, intestinal or stomach disorders, burning of nose and throat if there is exposure through ingestion or breathing of the contaminants. Surveillance should be performed to assure that this 2 foot level is maintained. Fencing is another issue connected with these impoundments. Currently regulations do not dictate the type of fencing. Frequently it is only plastic fencing or individual wire fencing. Fencing is necessary to avoid unwanted

animals, or humans from entering the impoundment. If you see animals entering the impoundments and drinking the water this should be noted and reported to the project contact.

Water Use

Water used for drilling a single well can be from 1 to 6 million gallons and is frequently obtained from nearby lakes, rivers, streams or ponds according to permitted water withdrawal plans. These water withdrawals are plans included in the planning process but are not monitored. The water is carried to the drilling site either by approximately 200 trucks or by temporary pipelines coming from the impoundment over land. The withdrawal of large volumes of water can impair flow in waterways which can affect fish, other aquatic life, water treatment facilities, and recreational activities. Also care should be taken to note the difference between trucks withdrawing water from streams and trucks depositing waste water. Trucks are currently not permitted to dump waste water into creeks, streams, rivers, ponds, and lakes. If you see this happening you should report this to local authorities such as the police, as well as the PA DEP.

Spills

Spills are not uncommon. Spilled products can include: crude oil, condensate, produced water, and "other" products. The other products included: diesel fuel, glycol, amine, lubricating oil, hydraulic fracturing fluids, drilling muds, other chemicals, and natural gas leaks.⁸⁵ Leaking waste water pipes used in drilling operations have polluted water: killing fish, salamanders, crayfish and aquatic insect life. Drilling mud overflows a well pad and leaks into ground. The PA Land Trust has also obtained data through the Right To Know Act from the PA DEP. This data along with the Center for Healthy Environments and Communities work with the PA DEP, Except for location information, there is a dataset called Pennsylvania Oil and Gas Violations containing violation information from 2007 to the present. The data shows that there were 9,370 violations from 3,661 unique wells. Of that total, there were 2,075 Marcellus Shale violations from 592 wells. This data set can be found <http://www.data.fractracker.org>

Flowback water and produced water

The sites for disposal of these fluids are permitted for only a limited number of gallons per day. There are a number of facilities permitted to accept this waste throughout PA. Currently 14 facilities discharge into the Monongahela watershed. Below is a list of these facilities and the number that represents the total permitted gallons of waste water per day accepted by the facility. The information for permitted waste treatment facilities accepting Marcellus shale waste fluids is on www.data.fractracker.org. The visualization of this dataset is Waste Water Treatment Facilities Accepting Oil and Gas Waste Water:

<http://data.fractracker.org/cbi/snapshot/page?concept=~01bfbd7512998011dfbd812e333ee3799e>

- 1) McKeesport - Monongahela (POTW) **115**
- 2) Clariton Municipal Authority - Peters Creek (POTW) **60**
- 3) Mon Valley Brine (Monongahela River) **200**
- 4) Authority of Borough of Charleroi - Monongahela (POTW) **30**

- 5) Municipal Authority of Belle Vernon - Monongahela (POTW) (2 permits) **10**
- 6) Municipal Authority of Belle Vernon - Monongahela (POTW) **5**
- 7) Borough of California - Monongahela (POTW) **10**
- 8) Brownsville Municipal Authority - Dunlap Creek (POTW) **9**
- 9) Franklin Township Sewer Authority - South Fork Tenmile Creek (POTW) **50**
- 10) Waynesburg Borough - South Fork Tenmile Creek (POTW) **8**
- 11) Shallenberger-Ronco - Monongahela (NPDES permit effective. As of 10/31/09, WQM permit in progress.) **500**
- 12) Shallenberger-Rankin Run (NPDES permit effective on 11/1/2008.) **125**
- 13) Shallenberger Connellsville – Youghiogheny **1,000** (*as of 01/2011, not yet permitted)

The total gallons per day for these plants range between 612,000 and 2,112,000.

One study has demonstrated that important contaminants from Marcellus shale flow back water are total dissolved solids, barium, strontium, and chlorides.⁸⁶ The concentrations of these contaminants in this flow back fluid are:

Total Dissolved Solids (TDS): 161,636 mg/L
 Barium: 2,950 mg/L
 Strontium: 3,280 mg/L
 Chloride: 95,400 mg/L

Doing the math, with the gallons per day permitted for disposal by these 14 plants multiplied by the parts per million (mg/L) of contaminants mentioned here in the flow back fluid converting gallons and parts per million into pounds results in

824,825 lbs. of TDS
15,053 lbs. of barium
16,737 lbs. of strontium
486,812 lbs. of chloride

permitted to be disposed of into the Monongahela river on a daily basis.

We are concerned from a public health perspective that this level of waste disposal combined with pounds of other waste, along with the levels of Acid Mine Drainage flowing into the Monongahela could present a burden to the water treatment facilities as well as aquatic life, especially during low flow times of the year, such as during the month of August.

Fires

Fires have occurred at gas wells and fracking water impoundments. Explosions at private water wells have also been reported.

Gas Migration

Gas migration as a result of gas stored underground or gas that seeps through fissures or holes in pipes and may fill up spaces in the ground such as basements or water wells. Gas migration is common for the areas around western part of Pennsylvania, but there have been no geological

models created to show that disturbances of the shale layer will not affect gas migration nearer to the surface. This is important to note that where drilling is occurring there may be the potential for increased gas migration.

Poor Air Quality

Poor air quality is caused by fugitive gas emissions. The [USGS factsheet 2009–3032](#)⁸⁷ states clearly that the fluid used for fracturing “in close contact with the rock during the course of the stimulation treatment, and when recovered may contain a variety of formation materials, including brines, heavy metals, radio nuclides, and organics that can make wastewater treatment difficult and expensive” to dispose of. These contaminants are the result of the fracturing fluid mixing with the shale layer and absorbing these contaminants from the shale layer. The air in the town of DISH, Texas, which is an area unaffected by other industry, experienced the presence of multiple recognized and suspected human carcinogens as a result of air emissions present on several locations tested. These emissions are sources of hazardous air pollutants as a result of the oil and gas industry. These include: emissions from pumps, compressors, engine exhaust and oil/condensate tanks, pressure relief devices, sampling connections systems, well drilling (hydraulic fracturing), engines, the well head machinery, gas processing and transmissions as well a mobile vehicle transportation emissions.

Large Truck Traffic

Truck traffic in high volume as a result of drill site preparation, drilling, fracturing of the well and removal of product water activities is of concern for public health. During a 3-day enforcement blitz in June 2010, **669 traffic citations** and **818 written warnings** were issued to trucks hauling Marcellus Shale drilling wastewater.⁸⁸ In Harrisburg, May 24, 2010, PennDOT Secretary Allen D. Biehler, P.E. and Pennsylvania State Police Commissioner Frank Pawlowski were reported to say that that in the wake of the drilling, there have been increases in truck traffic, traffic violations, crime, demand for social services, and the number of miles of roads that are in need of repairs.⁸⁹

Roadways

Roads are negatively affected by trucks hauling fresh water to drilling sites, and carrying product water away from the sites. A constant caravan is created of heavy equipment on roads not typically used for this purpose. The damage to road surfaces is sometimes repaired or roads may be replaced by the gas company responsible for the damage. This depends on their interaction with the local municipality.

Roadway Accidents

Accidents can be a result of increased truck traffic, and especially in rural and suburban areas where this traffic is unexpected numerous accidents have occurred. This is mainly caused by truck drivers and residents being unfamiliar with negotiating roadways not designed for large construction vehicles as well as normal residential traffic.

Well Site Incidents

Incidents are not uncommon because this is a dangerous industry. There are a number of

hazards related to this industry because of the highly flammable substances used and extracted in the process. It is not uncommon to have sudden fires or chemical spills. This places a demand on the area's emergency response personnel. Often they are not equipped for very large fires in locations where fire hydrants are not in place. Also, local paramedics and hospitals may not be equipped to handle the types of spills and chemicals from these operations. Typically there are no laws or policy in place requiring the gas industry to subsidize local municipalities for these services.

The Pennsylvania Land Trust Association identified a total of **1435 violations** accrued by Pennsylvania Marcellus Shale drillers between 1/1/2008 and 7/25/2010, using records obtained by the PA Department of Environmental Protection. Of the total violations occurred 483 where violations unlikely to directly endanger the environment and/or the safety of communities.⁹⁰ The report focuses on the remaining **952** violations which were judged as having the most potential for direct impact on the environment. These violations do not include violations incurred by drilling wastewater haulers.

Noise

Noise accompanies drilling and well sites, especially those with multiple wells. The drilling sites require large gas or diesel-powered compressors as well as gas-powered electrical generators. These machines run 24 hours a day, 7 days a week and can create significant noises pollution. Truck traffic also increases noise levels. Completed well sites can contain compressors also which run night and day.

Heightened Criminal Activity

This is mainly due to the mobility of this industry. Therefore, workers in the drilling and well completion industry tend to live outside of PA or the area in which they are drilling. This means that large crews of people may live in hotels or trailers (man camps) for long periods of time in areas where they have no connection. In Harrisburg, May 24, 2010, PennDOT Secretary Allen D. Biehler, P.E. and Pennsylvania State Police Commissioner Frank Pawlowski were reported to say that "More and more, it seems the police reports coming out of the northern tier include arrests because of drug use and trafficking, fights involving rig workers, DUIs, and weapons being brought into the state and not registered properly," said the commissioner. "We've even encountered situations where drilling company employees who have been convicted of a sexual assault in another state come here to work and do not register with our Megan's Law website. Each of these issues is unacceptable and places an even greater burden on our law enforcement and local social programs meant to help those in need."⁹¹ Pawlowski and Biehler both said the state and local governments need additional resources to address the problems that have accompanied the arrival of drilling companies to Pennsylvania.

Heightened Stress

This is reported by numerous individuals and families living near Marcellus shale gas extraction operations. Individuals working or living in communities involved in oil and gas exploration may often experience greater mental health concerns than individuals who live in areas not involved in these industrial activities. Some researchers report that individuals in these regions have a

certain vulnerability to psychological or psychiatric problems.⁹² Furthermore, increasing mental health concerns such as anxiety and depression, have been linked to communities in Wales, India, and the Peruvian Amazon that are involved in oil and gas drilling activities.⁹³ The Center for Healthy Environments and Communities has been conducting research documenting impacts reported by individuals who perceive their lives have been impacted by the Marcellus shale development. These reports also corroborate past research. We have many reports of increased anxiety, depression and stress related to familial, community and interpersonal relationships related to conflicts directly related to the appearance of gas industry operations in the vicinity of their places of residence. These stressors are related to increased noise, truck traffic, fears for safety as well as perceptions of water and air contamination.

Chapter 7

Marcellus Citizen Stewardship Project

The Marcellus Citizen Stewardship Project is a new initiative at the Mountain Watershed Association. This project will provide citizens with tools and knowledge to responsibly monitor Marcellus shale development to aid in community and environmental protection. The purpose of this project is to teach citizens how provide oversight on the incoming development of the Marcellus shale.

This chapter will be your guide to conducting assessment. In the following sections you will learn how to safely assess Marcellus gas activities in your community and how to report your observations. Marcellus monitoring protocols from Dickinson College's Alliance for Aquatic Resource Monitoring (ALLARM)⁹⁴ and Trout Unlimited⁹⁵ were utilized in the production of this chapter.

I. SAFETY

It is very important that you do not put yourself in danger when monitoring in your community. As long as you follow guidelines below you should be able to monitor in your community safely.

1. Do Not Put Yourself in Danger

- a. Do not attempt to wade in flooding streams.
- b. Do not put your fingers, hands or feet in unknown substances.
- c. Be non-confrontational & polite if approached. If a situation escalates (potential violence) get out of the area immediately & make appropriate contacts.
- d. Expect the unexpected & report emergencies immediately.

2. No Trespassing

- a. Be aware of property lines & who owns the property before approaching a site, well, stream, or ground water area.
- b. Do you have the proper permission to be in this area?
- c. Treat others, as you want to be treated; do not damage property (cut gates, damage signs, etc.).

3. Avoid approaching spills, incidences, leaks or areas with poor air quality (foul odors, smell of gas, etc.).

- a. Report spills, incidences, leaks or areas with poor air quality to appropriate authority (911, PADEP, EPA, etc.).

- b. Document spills, incidences, leaks or areas with poor air quality from as safe a distance as possible.
- 4. **Never bring open flames or equipment that can spark near gas wells & equipment.**

II. **REPORTING**

1. **What Do I Report?**

- A. Report Fires (911)
- B. Spills: (911), (PADEP), (EPA)
 - 1. Well equipment: condensate tanks, separators, wellheads, glycol tanks, compressors, etc.
 - 2. Tanker trucks
 - 3. Impoundments: liner tears, flooding, fires, etc.
- C. Poor Air Quality
 - 1. Odors & foul smells (PADEP)
 - 2. Smell of methane or loud, constant hissing sounds (911)
- D. Accidents: (911)
 - 1. Rig collapses
 - 2. Explosions
 - 3. Overturned trucks & tankers
 - 4. Collisions of gas industry equipment & machinery with private citizen's vehicles
- E. Poor Water Quality: (PADEP), (EPA)
 - 1. Cloudy water
 - 2. Sand in water
 - 3. Black or dark water

4. Foul smelling (sulfur or gas smells)
 5. Rashes from water
- F. Fish Kill: (PFBC & PADEP)
- G. Erosion & Sediment Runoff/Complaints
1. Development & Production (PADEP)
 - a. Well Complex
 - b. Production Lines
 - c. Gathering Lines
 - d. Compressor or Meter Stations Connecting Gathering Lines
 - e. Water Pits
 - f. Water Intake Pads
 - g. Water Lines
 - h. Centralized Impoundments
 - i. Intake Structures
 - j. Utility Lines
 - k. Minor Road Crossings
 2. Transmission & Ancillary Facilities (County Conservation District)
 - a. Transmission Lines*
 - b. Compressor or Meter Stations Connecting Transmission Lines
 - c. Equipment Staging Areas
 - d. Temporary Road Crossings*
 - e. Frac/Brine Water Treatment Facilities

- f. Employee Housing Development &/or New Office Buildings
- g. Stand Alone Water Intake Pads
- h. Intake Structures*

**** Some conservation districts are not delegated to review & issue Chapter 105 General Permits (GPs). Call conservation district to find out. If conservation district does not handle GPs, you will be directed to PADEP.***

H. Sickness (911)

- 1. Headaches
- 2. Nausea
- 3. Diarrhea
- 4. Tremors
- 5. Rashes
- 6. Burning eyes or throat
- 7. Heart palpitations

I. Noise Violations (Municipality)

2. How Do I Report?

A. Report Emergencies Immediately to Appropriate Authority

- 1. 911
- 2. PA Department of Environmental Protection (PADEP) - Southwest Office

412.442.4000 – General Number

412.442.4184– Complaint Hotline

(Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington & Westmoreland)

3. PA Fish & Boat Commission (PFBC) – Regional Office Somerset
814.445.8974 – General Number - Covers Southwest Region

4. County Conservation District:

Allegheny	412.241.7645
Armstrong	724.763.3203
Beaver	724.378.1701
Cambria	814.472.2120
Fayette	724.438.4497
Greene	724.852.5278
Indiana	724.463.8547
Somerset	814.445.4652
Washington	724.222.3060
Westmoreland	724.837.5271

5. Environmental Protection Agency (EPA) “EYES ON DRILLING” TIPLINE

1-877-919-4EPA (toll free)

For citizens to report non-emergency, suspicious activity related to oil & natural gas development such as illegal disposal of wastes. Tips may be anonymous.

Reports may also be sent by email to eyesondrilling@epa.gov

- B. Gather Basic Information – Write It Down

1. Primary Information

- a. Location – get as detailed as possible including nearest crossroads
- b. Company Name – some may be subcontractors for larger company - check entrance well sign for name & permit number – in future, Fayette will have 911 address also listed on well sign.

- c. License Plate Number, placards or other identification on truck(s)
 - d. What you saw or smelled & time of day you observed problem
 - e. Take photographs, if safely possible, that include date & time stamp
 - f. Watershed & Stream Name
2. Additional Information
 - a. Stream Conditions (clear, cloudy, muddy, etc.) & Water Quality Information (TDS, pH - if available/accessible)
 - b. Weather Conditions – current (time of complaint) & past 24 hours
 - c. Corroborating Observer(s)
 3. Log & Report Complaint Responses - especially to PADEP or EPA
 - a. Write down name & contact information of complaint respondent
 - b. Write down date you received response & in what format (phone, e-mail, letter or fax)
 - c. Keep hard copies of all correspondence
 - d. Keep all information together in one file
 4. Report All Information to the Fractracker Blog – <http://fractracker.org>
 5. Don't Cry Wolf – Report Only Legitimate Complaints & Violations

You can submit the visual assessment data sheet as your complaint to the DEP. Always follow up a call with a written complaint to ensure follow-up.

If you have any questions as to who you should be submitting the complaint to contact Veronica at 724-455-4200 ext 4#

III. Citizen Assessment

1. Visual Assessment

On a weekly basis you will want to survey your designated site. You will want to record what you see, hear, smell, and feel at that site. Fill out and submit the Visual

Assessment Form every time you visit you site. The Alliance for Aquatic Resource Monitoring (ALLARM) provides the following list of common disturbances to watch for.

A. What Should I Look For?

1. Land Disturbance

Land disturbances are the most reported violations for Marcellus activity. An erosion and sedimentation control plan must be prepared and followed for all well sites, impoundments, and access roads. If these plans are not followed or improperly installed, accelerated erosion can occur and affect the quality of the stream.

2. Spills & Discharges

Spills and discharges can occur from produced wastewater and fracking fluids at a drill site. At well sites fluids are stored in condensate tanks, impoundments, and closed freight carriers and can have accidents such as tears in liners or valves that are left open, which are potential risks of spills. Illegal dumping does occasionally occur. The evidence of this type of pollution disappears quickly and is important to capture and report accordingly.

3. Water Withdrawal

The hydraulic fracking stage of a gas wells requires millions of gallons of water and the water that is being withdrawn from the streams and rivers and must be permitted by PADEP. In the Youghiogheny River Basin there is no oversight on the water withdrawals so there is plenty opportunity for unauthorized water withdrawals.

4. Gas Migration or Leakage

Natural gas can leak or migrate into soils, springs, and waterways from a pipeline break or breach in the gas well casing. This can become dangerous because when natural gas mixes with atmospheric oxygen any spark or flame can ignite the mixture.

5. Air Pollution

There are many diesel engines operating at well sites and the potential for other air pollutants. Look for any visible state emissions and if the smoke or emission is dark in color and extends to a reasonable height than it is not allowed. Steam will dissipate as the plume extends and other emissions will note. Also note the color of the sky and stand with back to the sun if possible. Be aware of any

unusual odors, for example the smell of rotten eggs there could be high levels of sulfur. Be alert to how you feel when you are observing your site and if you notice a pattern of ill feeling record it as some air pollutants do not have any observable indications.

As steward of the environment you are looking for anything that is out of the ordinary. As you continuously visit your site you will become alert to anything that has changed. Any evidence of an incident that is not normal is worth recording. It is better to have a recording of nothing than no recording at all of a harmful incident. Below is a table listing examples of what some of these potentially harmful incidents could look like.

B. Where Should I Monitor?

Any time you are outside, be aware of your surroundings. If you observe an incident, follow the protocol to reporting it. Here are some areas that are at higher risk for incidents:

1. Near Drilling Pads

i. FracTracker

FracTracker is an interactive data platform providing citizens with a common place to learn about and share information on Marcellus shale gas operations. The data platform allows users to make maps of information related to gas extraction activities, as long as an address is attached to it. With this tool, users can pinpoint locations of Marcellus shale wells and view the permit information, as well as locations of treatment plants accepting Marcellus shale waste and permitted water withdrawals. FracTracker can be accessed at data.fractracker.org.

a) By using maps created in FracTracker you can locate where existing and new permits are located in relation to your community. You can also see existing well sites.

b) For help on using FracTracker visit

<http://www.fractracker.org/p/how-fractracker-works.html>

c) A link to a map of drilled and permitted Marcellus wells -

<http://data.fractracker.org/cbi/link/vBMnOQp3OEOYWrIgQfw>

ii. PA DEP

a) PA DEP enotice

1) Signing up for enotice will provide you with daily emails of new permits in your township/county. To sign up for enotice follow the steps below:

i. Go to

<http://www.ahs2.dep.state.pa.us/eNOTICEWeb/>

ii. Click on the create user link

iii. Fill in the fields provided

- iv. A verification email will be sent to your email
- v. Verify your email
- vi. Log into enotice
- vii. Click on DEP Permit Applications
- viii. Click add new program
- ix. Check specific municipality or countywide based on your preference
- x. Select Oil & Gas and click continue to next page
- xi. Pick your county and then municipality and click continue to next page
- xii. Review your selections then click save selections

b) PA DEP E-Facts

- 1) E-facts is place where you can search for already issued permits and also view the inspection reports.

2. The Youghiogheny River & Its Tributaries

Anytime you are in the waterways of the Youghiogheny river basin keep aware for anything out of the ordinary.

3. Near Your Community

Always be aware of anything out of the ordinary and help keep your community safe from possible public health and safety concerns.

C. When Should I Monitor?

There is no wrong time to monitor and simply paying extra attention to your surroundings when you are in the environment for recreation is a great way to start. We recommend checking on the areas of high risk listed above, once a week or more to help you spot when there is something out of the ordinary occurring.

D. How Should I Monitor?

The best thing is to record as much information about what you observe as possible and then take the suggested reporting actions. There is a visual assessment data sheet at the end of the chapter provided. Make copies of it to use in the field and fill them out. If you observe something abnormal refer to the reporting section to see whom the incident should be reported to. If you have any question on how to report the incident or who to report it to, call Veronica at 724-455-4200 Ext 4#. When recording an event, try to fill in each section of the data sheets to the best of your ability. After filling out the data sheet either make a copy and mail it to Veronica or go online to submit the data.

Filling out the Visual Assessment Form Online

- 1) Go to www.mtwatershed.org
- 2) Click on Visual Assessment Tab
- 3) The fields will be the same as the data sheet, so fill in what is recorded on your data sheet.
 - a. The fields with red asterisks are required to move to the next step
- 4) When completed with the fields on first page click next
- 5) Fill in the weather conditions
- 6) Check any disturbances that you observed
 - a. If you checked any disturbances record more information at the box on the bottom
 - b. If you checked any of the disturbances, in most cases you will need to file a complaint to the proper authorities.
- 7) Click next
- 8) If you have pictures or video please add them to the form here
- 9) Click done

The visual assessment data form is found in Appendix C. After completing a visual assessment of a site, please fill out the visual assessment data form and return to Veronica Coptis at the Mountain Watershed Association or fill out online form.

If you have any questions about performing assessment, please contact Veronica Coptis at 724-455-4200 ext 4# or veronica@mtwatershed.com.

APPENDIX A

Chemicals Used for Hydraulic Fracturing in Pennsylvania
Prepared by the PADEP's Bureau of Oil and Gas Management
Compiled from Material Safety Data Sheets Obtained from Industry

1,2,4-Trimethylbenzene	Glycol Ethers (includes 2BE)
1,3,5 Trimethylbenzene	Guar gum
2,2-Dibromo-3-Nitrilopropionamide	Hemicellulase Enzyme
2.2-Dibromo-3-Nitrilopropionamide	Hydrochloric Acid
2-butoxyethanol	Hydrotreated light distillate
2-Ethylhexanol	Hydrotreated Light Dist
2-methyl-4-isothiazolin-3-one	Iron Oxide
5-chloro-2-methyl-4-isothiazotin-3-one	Isopropanol
Acetic Acid	Isopropyl Alcohol
Acetic Anhydride	Kerosine
Acie Pensurf	Magnesium Nitrate
Alcohol Ethoxylated	Mesh Sand (Crystalline Silica)
Alphatic Acid	Methanol
Alphatic Alcohol Polyglycol Ether	Mineral Spirits
Aluminum Oxide	Monoethanolamine
Ammonia Bifluoride	Naphthalene
Ammonia Bisulfite	Nitrioltriacetamide
Ammonium chloride	Oil Mist
Ammonium Salt	Petroleum Distallate Blend
Ammonia Persulfate	Petroleum Distillates
Aromatic Hydrocarbon	Petroleum Naphtha
Aromatic Ketones	Polyethoxylated Alkanol (1)
Boric Acid	Polyethoxylated Alkanol (2)
Boric Oxide	Polyethylene Glycol Mixture
Butan-1-01	Polysaccharide
Citric Acid	Potassium Carbonate
Crystalline Silica: Cristobalite	Potassium Chloride
Crystalline Silica: Quartz	Potassium Hydroxide
Dazomet	Prop-2-yn-1-01
Diatomaceus Earth	Propan-2-01
Diesel (use discontinued)	Propargyl Alcohol
Diethylbenzene	Propylene
Doclecybenzene Sulfonic Acid	Sodium Ash
E B Butyl Cellosolve	Sodium Bicarbonate
Ethane-1,2-diol	Sodium Chloride
Ethoxlated Alcohol	Sodium Hydroxide
Ethoxylated Alcohol	Sucrose
Ethoxylated Octylphenol	Tetramethylammonium Chloride
Ethylbenzene	Titaniaum Oxide
Ethylene Glycol	Toluene
Ethylhexanol	Xylene
Ferrous Sulfate	Heptahydrate
Formaldehyde	
Glutaraldehyde	

Appendix B

Proposed New Air Permit Exemption Conditions for Oil and Gas Operations

[The sources and classes of sources listed in this section were determined to be of minor significance.]

38. Oil and gas exploration and production facilities and operations (include wells and associated equipment and processes), not located at a major source, meeting the following requirements:

i. All engines used at a facility shall not emit combined NO_x emissions of more than 100 lbs/hr, 1000 lbs/day, 2.75 tons per ozone season (period beginning May 1 of each year and ending on September 30 of the same year) and 6.6 tons per year on a 12-month rolling basis.

ii. Sources of uncontrolled VOC emissions shall not emit more than 2.7 tpy. If VOCs contain HAPs emissions, the HAP exemption criteria in Paragraph v of this category must be met.

iii. Temporary flares used at the drilling site shall not operate more than 14 days at each site.

iv. The owner or operator of liquid storage tanks and truck loading facilities shall minimize atmospheric emissions to the maximum degree possible. The measures utilized to minimize emissions shall include carbon canisters on tank vents, use of flares, vapor recovery units or thermal oxidizers on tank vents, the use of pressure relief valves which are maintained in good operating condition and which are set to release at no less than 0.7 psig (4.8 kilopascals) of pressure or 0.3 psig (2.1 kilopascals) of vacuum or the highest possible pressure and vacuum in accordance with state or local fire codes or the National Fire Prevention Association guidelines or other national consensus standards acceptable to the Department. Loading racks equipped with a loading arm with a vapor collection adaptor and pneumatic, hydraulic or other mechanical means to force a vapor-tight seal between the adaptor and the hatch of the tank must also be used to minimize emissions.

v. Sources of uncontrolled HAP emissions of less than 1000 lbs/yr of a single HAP or one tpy of a combination of HAPs that does not include Polychlorobiphenols (PCBs), Chromium, Mercury (Hg), Lead (Pb), Polycyclic Organic Matter (POM), Dioxins and Furans.

vi. The owners and operators of engines not meeting the requirements under (i) – (v) of this source category must submit a request for determination to the Department. If the RFD is not approved by the DEP, an application seeking authorization to use a general permit or plan approval application must be submitted to Department, as appropriate.[25]

Appendix C FORMS

The following forms utilize protocols developed by Dickinson College's Alliance for Aquatic Resource Monitoring (ALLARM) and Trout Unlimited.

marcellus citizen stewardship project
an outreach, assessment and monitoring initiative

Visual Assessment Data Form

Use this form to document your visual assessment activities. Please provide as much information as possible.

Sample Site: _____ **Date:** _____ **Time:** _____
Operator: _____

Location: _____
Latitude: _____ **Longitude:** _____

Observer(s): _____

Current Weather: Clear Cloudy Partly Cloudy Fog/Haze
Rain Drizzle Intermittent Rain Snow

Precipitation Past 48 Hours: None Trace Light Moderate Heavy

Site Description (see, hear, feel or smell): _____

Checklist for Gas Related Earth Disturbances

Receiving Streams

- Evidence of sediment entering stream, pond, wetland, or other body of water
- Sediment plume
- Discolored water
- Increase sediment deposition on the stream bottom

Access Road

- Mud/sediment on road that access road enters
- Mud/sediment entering public road ditch from site
- Access road to site not stabilized with clean gravel

- Access road crosses stream with access road drainage directly emptying into stream
- Access road carrying drainage from site directly to road ditch or stream
- Road banks not stabilized with mulch, seeding, vegetation, etc.

Pad/Storage Pond/Staging Area

- Earth disturbance to edge of water body with no controls to stop or filter
- Clean water entering site from uphill

Pad/Storage Pond/Staging Area - Continued from Previous Page

- Outlets of sediment control structures go directly to water body without filtering/cleaning
- Diversion ditch
- Sediment pond
- Road drainage
- Silt barrier (fence, hay bales, tubes, etc)

Checklist for Spills & Discharges

- Unusual odor in water
- Persistent foam or bubbles in absence of high level of agitation
- Dead fish or other organisms in the water or along the bank
- Discolored water, especially an oily film on the water surface
- Increases bank erosion

Checklist for Water Withdrawal

- Water hoses in or adjacent to stream
- Unusually low flow in the stream not related to drought conditions
- Trucks parked beside streams

Checklist for Gas Migrations or Leakage

- Gas bubbling from pool puddle or stream
- Odor due to mercaptan compounds or other gasses
- Hissing sound near well head

If you checked any of the above, please report it to the appropriate authority & describe in further detail below:

If you checked any of the above please refer to our Visual Assessment Manual (available at www.mtwatershed.com) to report it to the appropriate authority. **If you suspect an emergency, call 911 immediately. Stay at a safe distance until help arrives.**

If you would like to receive feedback about your report, please provide your contact information:

Name: _____
Address: _____
City: _____ State: _____ Zip: _____
Email: _____ Phone: _____

Please submit copies of this data form to Veronica Coptis at veronica@mtwatershed.com or in care of the Mountain Watershed Association, PO Box 408, Melcroft, PA, 15462. This form is also available on our website at www.mtwatershed.com.



ENDNOTES

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- ²² Fayette, 2010 Pa. Commw. LEXIS 397, *29.
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- ²⁷ 65 Pa.C.S.A. § 707.
- ²⁸ 58 P.S. § 601.102, 58 P.S. § 601.602.
- ²⁹ 58 P.S. § 601.208.
- ³⁰ Further details about the contents of the notification to the Department can be found in section 78.51 of Title 25 of the Pennsylvania Code.
- ³¹ 58 P.S. § 601.208(d).
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- ³³ 58 P.S. § 601.208, (If the water testing is refused, the claim will automatically fail).
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- ³⁵ In the Marcellus Shale play, this will not likely happen for most wells for many years. Remember that each well can be fracked many times, extending the economic life of the well considerably.
- ³⁶ 58 P.S. § 601.206, Lease provisions may also require reclamation particulars beyond what is found in the Oil and Gas Act and its associated regulations.
- ³⁷ Section 601.203 of the Oil & Gas Act.
- ³⁸ Section 1115.
- ³⁹ §103 of Hazardous Sites Cleanup Act contains the definition of "hazardous substance", including material "contaminated with a hazardous substance to the degree that its release or threatened release poses a substantial threat to the public health and safety or the environment as determined by the department". Frac water or produced fluid would likely meet this definition.
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- ⁵⁶ PA Department of Environmental Protection, DEP ID: 275-2101-003, Air Quality Permit Exemptions, p. 8, *available at:* <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-80104/275-2101-003.pdf>.
- ⁵⁷ Hazardous Air Pollutants are toxic or carcinogenic compounds regulated by EPA under § 112 of the Clean Air Act. For a list of these compounds, see: <http://www.epa.gov/ttn/atw/orig189.html>. Note, that unlike other air pollutants, the federal Clean Air Act prohibits aggregation of hazardous air pollutant emissions from natural gas exploration and production equipment, 42 U.S.C. § 7412(n)(4).
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