The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide I

Marcellus Shale Natural Gas: From the Ground to the Customer

League of Women Voters of Indiana County
2008-2009 Marcellus Shale Study Committee

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Marcellus Shale natural gas, one of more than twenty natural gas shale deposits in the United States, is the largest on-shore natural gas reserve in the world. It lies a mile or more down under two-thirds of Pennsylvania, waiting to be extracted to supply our country's natural gas needs for up to an estimated eighty years. The extraction depends upon horizontal drilling and hydraulic fracturing, technology refined for extracting natural gas from Texas's Barnett Shale. Once extracted the natural gas must be prepared for and delivered to the customer.

About 380 million years ago during the Middle Devonian period the African continent shoved against the North American continent and created an anticline or fold that is today known as the Appalachian Mountains. Under intense pressure rotting vegetation became trapped in the sediment that became Marcellus Shale, a rock so dense that the gas was trapped within it.

The Marcellus Shale basin extends from western New York to West Virginia and eastern Ohio to eastern Pennsylvania. It lies under forty of Pennsylvania's 67 counties (See Appendix I). It ranges in depth from 4,000 to 8,000 feet under the surface, and varies from 50 to 200 feet in thickness. The formation is estimated to contain 250 trillion to 500 trillion cubic feet of natural gas. Geologists have long known that natural gas is trapped inside Marcellus Shale, but until recently the technology for releasing the natural gas in commercial quantities was unavailable.

Maps of the Marcellus Shale formation can be viewed at:

http://geology.com/articles/marcellus-leases-royalties.shtml
or
http://www.marcellusshales.com/marcellusshalemap.html

Drilling For Marcellus Shale Natural Gas

Before drilling a Marcellus Shale natural gas well, the drilling company needs to know who owns the gas rights. In Pennsylvania, rights to the subsurface minerals can be separated from the surface rights through deeding. Because subsurface rights to minerals may be held by the current owner or have been sold by others in the past, it is imperative that drilling companies find out who owns these rights. To find the rightful owner, drilling companies use agencies that specialize in title searches to determine with whom to negotiate a lease. Usually a representative of the drilling company contacts the owner to lease the rights. Under Pennsylvania law, the owners of gas rights are paid at least a 12.5% royalty, although they may negotiate a higher royalty and a bonus. Owners who hold both surface and gas rights may also negotiate a lease for the land that the drilling company uses. At this point people who own the surface and the natural gas rights can negotiate how the surface will be treated. This includes siting access roads, specifying whether on-site water will be used or the water will be trucked in, and what kind of reclamation will be done. In Pennsylvania surface owners cannot stop lease holders from obtaining their oil, coal, or natural gas.

Once seismic testing is done to ascertain the depth of the Marcellus Shale and the drilling rights are secured, the drilling company applies for a permit from the state. The Pennsylvania Department of Environmental Protection (DEP) requires drillers to name both the source of the water needed to drill the well and the site where the wastewater or flowback will be treated. Because of the depth of a Marcellus Shale well, two to ten million gallons of fresh water are needed. During drilling, the water is used both to cool the drill bit, creating a clay slurry, and to

remove the rock cuttings. The used water or sludge is stored at the well site in lined pits until it can be hauled away.

Drillers drill both vertical and horizontal wells to access the natural gas. The vertical bores are like conventional natural gas wells that go straight down. Horizontal wells are part of the new technology that is used to retrieve the natural gas in the Marcellus Shale. Both types of wells are drilled using multiple layers of steel and concrete casings to avoid contaminating the ground water aquifers. The casings also serve to keep the natural gas flowing upward toward the wellhead.

At a depth determined by geoscientists, the drillers start the horizontal drilling. A 600 foot arc is drilled to change the pipe from vertical to horizontal. Horizontal drilling can extend out more than 5000 feet (Ground Water Protection Council & ALL Consulting, April ,2009; [there are 5280 feet in a mile]). Once the horizontal pipe is in place, the well is hydraulically fractured.

Hydraulic Fracturing

Once the drilling is finished, the drilling rig is broken down and moved. The support equipment such as pipe racks and tool sheds are also removed. Then the well is ready to be "fraced." The "fracing" company brings in its equipment- including generators, trailers with the computer equipment to monitor the fracing,and possibly hundreds of truckloads of water. To frac a Marcellus Shale gas well, millions of gallons of fresh water are hauled in or withdrawn from a local source, above or below the surface, and chemicals and sand are added to the water. The chemicals are used to make the natural gas flow more efficiently up to the well head. They include a lubricant to reduce pipe friction, biocides to eliminate pipe fouling, a scale inhibitor to break down mineral deposits inside the pipe, oxygen scavengers to reduce rust-causing oxygen in the wellbore, and acids to clean the perforations in the horizontal pipe through which the gas enters. Sand is added to the fracture fluid as a proppant to keep the fractures in the shale open so the gas can escape from the rock. DEP requires fracing companies to list the chemicals they use on the permit, although not the proportions which are considered proprietary knowledge.

During fracing, millions of gallons of the frac fluid are pumped into the well under great pressure to break up the shale at predetermined intervals along the horizontal pipe. Between 30% and 70% of the frac fluid returns to the surface as "flowback". Flowback contains any matter that is dissolved in the frac water, including salt from the ancient sea bed. What is dissolved depends on the locale. The briny flowback may contain radioactive material (Shultz, 1999, p. 792) and other compounds such as arsenic, depending upon what is naturally in the rock. The flowback is held in plastic lined pits at the well site until it is trucked to a DEP-approved treatment plant.

Moving The Natural Gas To The Customer

Existing pipelines are inadequate to handle distribution of a gas resource as large as the Marcellus Shale. Distribution will require new facilities, new processing and transporting equipment, and new pipelines--partly because much of the gas will be sent outside of Pennsylvania. All of these matters will affect Pennsylvanians.

Once natural gas comes to the surface, it is "wet," which means that it is not only methane but also other gases and water. Propane, for example, can be removed at the well head

and trucked away. Or the propane, along with the other hydrocarbon products, can be sent through underground gathering lines to a cryogenic processing plant. Cryogenic processing "sorts" the water and gas using a super-cooling process that liquefies the gases at different temperatures, separating the raw gas into ethane, butane, propane, and methane.

Marcellus Shale natural gas is about 85% methane, the type that is used residentially. Surface right owners can use gas extracted directly from conventional wells to heat their homes. But this is not possible with Marcellus Shale natural gas because it burns at too high a temperature and pressure to be safely used residentially.

Leaving the processing plant, the natural gas may be sent into main pipelines. In Pennsylvania there are currently not enough pipelines to move the anticipated millions of cubic feet per day of Marcellus Shale gas to existing northeastern and Atlantic seaboard markets. With permits from DEP, pipeline companies may build along an existing public right-of-way but need the surface owners' permission to build pipelines on private property. The mainline pipelines are of wide diameter, 42 to 48 inches, and as many as five or six may lie side by side. Many pipelines are "looped"--that is, fitted with connectors between the pipes lying side by side underground. Looping allows technicians monitoring the pipes via computer to isolate pipe sections. The technicians can stop the flow by section, which allows the natural gas to be stored or "line-packed" so the gas will be available during times of peak usage (Arthur, J.D. Langhus,B., & Alleman, D., 2008).

Between the processing plant and the market area, or "city gate," compressor units move the gas along under pressure. A large compressor station in a rural area may have as many as ten to sixteen units, either of a centrifugal (turbine) or reciprocating (piston) type. These have overall horsepower ratings of 50,000 to 80,000 horsepower and are usually driven by natural gas. In urban areas, to reduce noise pollution, the compressors may be powered by electricity. Distance between compressor stations varies from 40 to 100 miles. At the "city gate" where the natural gas approaches its market, the pressure is reduced from 200 to 500 pounds per square inch (psi) to about 2 psi. Along main pipelines, safety cutoff meters are installed to stop the flow of natural gas when a drop in pressure or leak is noted.

Because the demand for natural gas is not steady, storage is also needed. Salt mines, depleted gas and oil wells, and geologic formations can be used. Pennsylvania's geology does not favor storing natural gas in rock formations. If pipelines are not at capacity, the gas may be stored in a pipeline. Natural gas can also be stored above ground in tanks as compressed, liquefied natural gas or LNG. This is the most expensive way to store natural gas but also the quickest way to retrieve it during peak usage.

If there is too much natural gas in storage, the well may be "capped," keeping the natural gas in the well. To cap a well is to block the pipe between fifty to a hundred feet below the well head. Then a second block is placed closer to the surface. At the surface the valves are closed. Otherwise the natural gas proceeds through gathering lines

After a well is fraced, the hydraulic fracturing company and its many trucks leave. The trailers used for on-site offices and the portable toilets are moved on to the next job. The last of the frac fluid is pumped from the plastic lined pit to be taken to an approved wastewater disposal treatment plant. A bulldozer then pushes the plastic sides toward the middle of the pit and covers the plastic with dirt. After the topsoil is spread back over the ground, seed and straw are spread. All that shows of the four- to six-acre drilling site is the gas field "Christmas tree," consisting of pipes and valves about four feet high. There may also be condensate tanks to capture water in the gas and solar-powered measuring equipment that sends data to monitor production from a

remote site. Once the area is reclaimed, the four-to-six acre well site is reduced to the size of a two-car garage.

When the well is exhausted, the site is abandoned. The "Christmas trees, monitoring devices, and any tanks are removed. Fresh cement is poured down the well and flows between the casing and the earth. It also flows into any tubular piping elements and solidifies. The bore is then capped at the wellhead and the surface is cemented over.

Site reclamation after the completion of drilling and extraction is addressed in Study Guide II, Environmental Impact.

Resources and References for Study Guide I

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Land, water, and air are affected by the Marcellus Shale natural gas extraction process. However, the level of impact on all three vital resources can be alleviated by responsible decision-making of companies, governments, and individuals. All Pennsylvanians can be part of promoting responsible decisions through advocating for carefully written leases, enforceable state and federal regulations, and on-going monitoring.

LAND

Extracting natural gas from Marcellus Shale impacts Pennsylvania's farmland and forests where drilling is taking place (the wellhead). Related activity involving the transportation of heavy equipment impacts municipal roadways. These issues, as well as land reclamation, are addressed in this section.

Impact at the Well Site

The horizontal drilling techniques used in Marcellus Shale natural gas extraction use less land surface than would be needed to access the same reservoir of natural gas through vertical drilling alone. Vertical drilling on a square mile of ground would require sixteen separate well pads. Horizontal wells thus reduce the number of access roads, well pads, pipelines, and production facilities needed. A site measuring four to six acres during initial drilling is reduced to the size of a two car garage once drilling and fracing is completed. Although a "pine-tree" array of underground pipes remains below the surface, the well head, a separator, and water tanks are all that remain above ground.

Landowners may or may not also own the mineral rights under their land. Landowners who also own the mineral rights can negotiate the location of access roads and to minimize the impact of drilling on their property. Owners of mineral rights only have the right to recover the mineral. Landowners have the right to protection from "unreasonable encroachment or damage" (PA Department of Environmental Protection (DEP) Fact Sheet). According to DEP, owners of surface rights only should seek legal advice and negotiate with drilling companies for location of access roads and drilling equipment and a reasonable price for damages, crop loss, etc.

Impact on Farmland

When heavy drilling and fracing equipment travels over farmland, soil compaction occurs. There are two types of soil compaction. First, topsoil compaction is caused by tire pressure, and this can severely reduce plant production in the short term. Second, subsoil compaction is caused by axle loads which reduce productivity for decades and cannot be alleviated over time by any natural means (Grafton County Conservation District, n.d.). It results in decreased soil percolation and increased soil run off. This, in turn, leads to less growth of vegetation and more soil erosion. One might compare topsoil compaction to a bicycle rider or car riding at a uniform speed across the a well-drained lawn and subsoil compaction to a fully loaded cement mixer driving across a lawn immediately after a heavy rainfall. The first creates tread marks while the second creates ruts that will not be alleviated by time alone.

Best practices in the industry can prevent compaction. Companies can move the topsoil and stock pile it to one side of the site. Stone is then added to the subsurface to stabilize it before

heavy equipment is moved across the land. Once the well is completed, the topsoil is returned and crops can be grown. There are examples in which monitoring equipment and tanks are moved away from the actual crop-growing areas so all that remains in the open field is a well-marked wellhead.

Impact of Well Sites on Forestlands

To drill in forests, a large number of trees may need to be cut to build graveled access roads. Native shrubs and wild flowers may also be killed. Disturbing the soil gives non-native plants (i.e. garlic mustard, stilt grass, autumn olive, Japanese knotweed, and multi-flora roses) the opportunity to out compete native species.

Forest ecosystems are complex. Internal, dense regions are habitats for some plants and animals while edge or transition regions serve as habitats for others. When roads are built and land cleared for drilling, these open spaces become highways for birds and animals that do not typically go into dense forests. Ornithologists have noticed declines in woodland birds, such as scarlet tanagers, thrushes, and warblers, as their nests are overtaken by cowbirds, a species that thrives in open and edge areas. Birds such as the forest dwelling hawks, that require large, undisturbed woods, may decline or go elsewhere. Typical edge animals, like skunks and opossums, travel access roads into forests and feed on chicks and eggs that would not typically be in their reach. Culverts and ditches can also disrupt travel patterns of amphibians such as spotted salamanders. Clearing land also changes the forest canopy and floor that may alter the growth rates of trees. Light patterns affect plant habitats that in turn impact the diversity of animals ranging from mammals to insects.

Forest owners can stipulate where access roads are placed or require a drilling company to use old lumbering roads. If trees need to be cut, they can be compensated for the lumber. Federal and state regulations and local ordinances may stipulate added protection for endangered species, wet lands, and unique habitats. It is important for natural gas rights owners and landowners to contact foresters, conservancies, and lawyers who specialize in Marcellus Shale natural gas extraction for advice regarding minimizing negative impacts on forest land.

Site Reclamation

Responsible drilling companies can nearly restore the surface land to its pre-drilling state. However, a good lease must consider future development problems and specify how the land will be reclaimed. If topsoil has been scraped from the surface and banked, provisions can be made for its redistribution. Other provisions can be made to establish a new forest cover and to plant specific grasses and shrubs as needed. Soil tests should be done to determine if contamination has occurred or even added nutrients such as lime or fertilizers are needed. Landowners need to educate themselves about terminology. For example, there is a difference between land restored to its pre-drilling state or to an environmentally equivalent state and/or relocating a stream or changing the location of a wetland. Because of the many complexities involved, a lawyer is essential for reviewing a lease.

Impact on Municipalities

Municipalities need to plan for the long term effects of the Marcellus Shale natural gas drilling equipment on roads. Prior to and during the four to six weeks that the well is being

drilled, heavy trucks carrying drilling equipment and tankers carrying water to and from the site use state highways and township roads. Heavy trucks cause potholes and break pavement, especially along the edges. Heavy trucks on gravel roads raise enough dust to change air quality. Municipalities can work with drilling companies to minimize long-term effects and to address traffic congestion, road damage, and dust. The current road bonding is $12,500 per mile. This is less than the cost of repairing a damaged mile. According to an industry source, responsible companies can restore roads to their pre-drilling state, and some companies may even leave the roads better than they were before the drilling (Range Resources, 2009). However, without clear regulation and enforcement, each company operates differently.

WATER

Soeder and Kappel (2009) cite three areas of concern regarding water in relation to Marcellus Shale natural gas extraction: its management for all users in a single watershed; contamination of the surface water due to erosion and ground cover removal during site preparation and drilling; and treatment and safe disposal of the produced water.

Watershed management is important to protect water quality and ensure adequate water resources to meet the needs of watershed stakeholders including residential, commercial and industrial users as well as plants and animals dependent on water.

The Marcellus Shale natural gas formation lies under all of six Pennsylvania's watersheds. The Ohio, Susquehanna and Delaware watersheds cover most of the state. The Erie, Genesee and Potomac watersheds each occupy a smaller area.

> *The Ohio basin forms a corridor from the southwestern corner of Pennsylvania to its north central border. This area is drained by the Allegheny and Monongahela Rivers that meet in Pittsburgh to form the Ohio River. The Susquehanna basin covers large parts of New York, Pennsylvania and Maryland before emptying into the Chesapeake Bay. The Delaware basin covers the eastern end of Pennsylvania as well as parts of New Jersey and Delaware and empties into the Delaware Bay. The Erie basin which includes parts of Michigan, Indiana, Ohio, Pennsylvania and New York, covers most of Erie County and is part of the Great Lakes system. The Genesee originates in Potter County in north central Pennsylvania and flows through New York before draining into Lake Ontario. The Potomic drains parts of the District of Columbia, Maryland, Virginia, West Virginia and Pennsylvania and empties into the Chesapeake Bay. A map of these watersheds can be viewed at* http://www.earthethics.com/pennsylvania.htm.

Both surface and ground water are used in the drilling and fracing operations to extract natural gas from the Marcellus Shale formation. According to the 2008 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (April 2009), there is enough ground water in Pennsylvania to cover the state to a depth of eight feet. Pennsylvania's fresh water surface holdings include 86,000 miles of streams and rivers, 161,445 acres of lakes, 403,924 acres of wetlands, and 63 miles of Lake Erie shoreline.

During drilling, water is used to cool the drill bit and to create a slurry that carries the rock cuttings up to the surface. Water is also used for the hydraulic fracturing of the dense, black shale that contains the natural gas. Approximately 30 percent to 70 percent of the frac water returns to the surface. The slurry and the frac water are stored in plastic lined pits until it is hauled away for wastewater treatment. Under Pennsylvania law these pits must have at least two feet of freeboard. Freeboard is the space between the surface of the water and the top of the pit. Freeboard prevents the pit from filling with rain water and spilling its contents over the edge into the soil or a stream. Together, drilling and fracing use between two and ten million gallons of water for each well on an as-needed basis. Such quantities are essential because the wells are so deep, ranging from over 5000 feet vertically and up to 5000 feet horizontally.

The PA Department of Environmental Protection is responsible for reviewing and issuing drilling permit and monitoring drilling operations. In addition to DEP, the impacts of drilling on water quality are monitored by the Pennsylvania Fish and Boat Commission, the Susquehanna River Basin Commission (SRBC), the Delaware River Basin Commission (DRBC), and the U.S. Fish and Wildlife Service.

Three Concerns about Water

Water Management

Water for drilling and hydraulic fracturing of Marcellus Shale wells frequently comes from surface water bodies such as rivers and lakes. However, it can also come from ground water, private water sources, municipal water, and recycled frac water.

While the water volumes needed to drill and stimulate shale gas wells are large, they generally represent a small percentage of total water resource use in a basin. Calculations indicate that water use will range from less than 0.1 percent to 0.8 percent by basin (Satterfield, et al., 2008; Arthur, Bohm, Coughlin. & Layne, 2008). To put things in perspective, an electric generating plant in the Susquehanna River basin uses nearly 150 million gallons of water a day. By comparison, the estimated amount needed for Marcellus Shale well drilling in an area might reach eight million gallons a day. However, this amount of water is used "on demand" during the relatively short, four to six week period needed for site preparation and drilling. Unlike water used to cool a generating plant, the water used in drilling is "consumed." This is because the water is contaminated and has to be hauled away and treated, not simply diverted, used and returned to its source.

Most of the Marcellus Shale natural gas lies in basins of moderate to high levels of annual precipitation. But, even in areas of high precipitation, because of the needs of growing populations, other industrial water demands, and seasonal variation in precipitation, it can be difficult to meet the as-needed demands of Marcellus Shale natural gas extraction. If there is low stream flow at the time water is required, this could negatively affect fish and other aquatic life, fishing, recreational activities, municipal water supplies, and industries such as power plants.

There are potential actions that could alleviate competing water use demands. The Ground Water Protection Council and ALL Consulting (2009) suggest, a study to identify water supplies available to drilling and fracing companies that do not compromise the needs of the rest of the community. Another idea is to capture and store river water when it is seasonally available. In August 2009, the U.S. Department of Energy funded nine projects nationwide to study how to find alternative sources to the fresh water currently used (Kelly, August 25, 2009).

In the Barnett Shale area of Texas, drilling companies formed a consortium to coordinate drilling needs with available water supplies. On-site recycling of frac water has been tried but found to be very expensive.

Although ground water extraction is not regulated in Pennsylvania, a drilling company that uses ground water must have a water management plan as part of the permit process. In Pennsylvania, when water surface or ground withdrawals exceed 10,000 gallons per day for a thirty-day period, the Pennsylvania Department of Environmental Protection (DEP) requires the water user to register its usage under the authority of Act 220 of 2002, the Water Resources-Planning Act. The implementing regulations of Pennsylvania Code Chapter 110 must also be followed.

Both the Susquehanna River Basin Commission (SRBC) and the Delaware River Basin Commission (DRBC) regulate water withdrawals within their watersheds. They require drilling companies to obtain permits. In the Ohio River basin, that drains approximately one-third of Pennsylvania, the Ohio River Sanitary Commission regulates water quality but not withdrawals. By using SRBC guidelines, DEP currently reviews water management plans associated with Marcellus Shale natural gas extraction in the Ohio River and the Genesee River basins.

Water Contamination

Water quality can be compromised at several stages of Marcellus Shale natural gas extraction. Gaining access to the proposed well site involves building access roads for the heavy equipment to transport the drilling rig, pipe, and water. Both transporting material to the site and site preparation can cause erosion and subsequent silting. Drilling through aquifers can contaminate water supplies. Approximately 15,000 gallons of chemicals are added to the fresh water for fracing (Soeder &Kappel, 2009). This water/chemical mix can leak onto the ground. The drilling slurry also contains cuttings of the native rock, which in the case of Pennsylvania's Marcellus Shale, includes uranium (Shultz, 1999, p. 792). The flowback that comes to the surface at the drill site is fracing fluid – complete with dissolved minerals and added chemicals.

To avoid contaminating drinking water aquifers, drillers use cement casings to surround the drilling pipe**.** The first**,** a 24" conductor casing, goes thirty to sixty feet down to the drinking water aquifer. Starting again at the surface, a twenty inch casing is extended 200 to 500 feet through the coal bearing seams, preventing leakage into the aquifer. A third casing, 13-3/8", is cemented from the surface down to 1,000 feet, passing through shallow sandstones and shales containing natural gas and brine. If necessary, a 9-5/8" cement casing is extended down to seal off more shallow oil, natural gas, or brine. The final casing, 5-1/2", is cemented to 500 feet above the Marcellus Shale (Range Resources, n.d., 56-57). In Pennsylvania, two percent of conventional natural gas wells drilled have resulted in contamination.

> *If a water supply is suspected to be contaminated it is the responsibility of the user to report the problem to the Department of Environmental Protection (DEP) for investigation within six months of the completed drilling. If found at fault, the drilling company is responsible for providing water to the user for an indefinite period of time. In Pennsylvania the burden is put on landowners to show damage to water supplies by drilling. Therefore it is important for landowners to require drillers to have their water tested by a certified laboratory before drilling begins. Legislation has been introduced in the PA General*

Assembly to lengthen to two years the period to report problems after completion of drilling.

The frac fluid or flowback removed from the well after hydrofracing, contains chemicals used by the company to facilitate gas recovery from the shale and subsequent gas flow in the pipe. The chemicals used may include oils, gels, acids, alcohols, and various man-made organic chemicals. Because fluids injected into wells are specifically excluded from the 2005 Safe Drinking Water Act, states must provide regulations. In Pennsylvania, as of October 2008, all hydraulic fracturing companies must list the chemicals they use for fracing on their drilling permits. However, the proportions of each chemical used are considered proprietary information. The flowback is also site specific and some may contain diverse contaminants such as low levels of radioactive radon released from the underground rock formation. This flowback also contains hydrocarbons, heavy metals, and very high levels of total dissolved solids (TDS). TDS can include calcium, potassium, sodium, chloride, and carbonate. Because of its geology, Marcellus shale flowback tends to include more TDS than the flowback from other shale gas wells (Kelly, August 25, 2009). Before disposal, it is necessary to treat drilling wastewater appropriately.

Another important issue is the connection between water quantity and water quality. For example, taking water for drilling and fracing from a small stream rather than a large lake or river places a relatively increased burden on plant and wildlife within its limited ecosystem. Further, if fracing fluid is released into a small stream, the chemicals will not be diluted sufficiently to avoid damaging fragile ecosystems and harming aquatic life.

Wastewater Treatment

Although the technology of drilling directional boreholes and the use of sophisticated hydraulic fracturing processes to extract natural gas have improved over the past few decades, the knowledge of how this extraction might affect water resources has not kept pace.

The fluid from drilling has a high salt content and contains minerals from the rocks penetrated by the drill. The brine is pumped into streams at a rate prescribed by DEP for dilution. Evaporation in open tanks, frequently used in arid areas such as Texas, is not a viable method in Pennsylvania because there is too much rainfall. The rock cuttings are taken to landfills.

The second type of wastewater is frac water. To produce gas from shale, companies break apart the rock more than a mile underground with millions of gallons of water, chemicals, and sand. The purpose of the sand, or proppant, is to prop open the fractures in the shale, thus freeing the trapped natural gas. The added chemicals keep the inside of the pipe clean so the gas will flow efficiently upward. Harper (2008) reports that it appears a "slickwater" frac works best in the Marcellus Shale. To create the slickwater, a fluid with a gel-like viscosity, fracing companies use an acid to smooth the cement, a biocide to destroy growth, and gels to reduce friction. There are also chemicals added to control scaling in the pipe and oxygen scavengers to reduce the oxygen in the pipe that leads to rust.

Between 30 percent and 70 percent of the fracing water returns to the surface and brings with it hydrocarbons (gases other than methane), heavy metals, naturally occurring radioactive materials, and high levels of total dissolved solids (TDS). The TDS are the salts, calcium, potassium, sodium, chloride, and carbonate, organic material from the shale formation. Frac water is trucked to one of eight wastewater treatment plants in Pennsylvania currently capable of

treating the flowback. At the wastewater treatment plant, the heavy metals and salts are precipitated out of the water. While some may be sold, others go to landfills as dry waste.

In Texas, frac flowback is injected into depleted gas wells. This method appears to be questionable in Pennsylvania because of its unique geology. The rock formations in the Appalachian range contain a permeable limestone and shale with naturally occurring fractures. Contaminated frac water could migrate into drinking water aquifers. As is the case with drilling wastewater, evaporation in open tanks or pits is not an option for frac fluid because of Pennsylvania's relatively high rainfall levels.

Recognizing the lack of research into natural gas extraction wastewater disposal, the U.S. Department of Energy recently awarded contracts to the University of Pittsburgh and eight other institutions to develop techniques for decontaminating and reusing flowback (Kelly, August 25, 2009). More companies are seeking permits to build plants capable of handling this waste, but it takes more than a year to bring a facility into operation. Municipal sewage plants have not been designed to handle the TDS that are part of the wastewater. However, if required upgrades are installed, DEP may grant such facilities permits to process flowback. To obtain the necessary DEP permit requires expensive upgrades that most municipal plants cannot afford to make. The attempts to recycle frac on-site have thus far been too expensive to be commercially viable.

AIR QUALITY

Because natural gas is the cleanest of all fossil fuels, its air quality benefits are often lauded. For example, when used for generating electricity, it emits approximately half the carbon dioxide of coal and 30 percent less than fuel oil. Its combustion byproducts are mostly carbon dioxide and water vapor. Consequently, it is considered to be central to energy plans focused on the reduction of greenhouse gases (Ground Water Protection Council & ALL Consulting, 2009) and as a stopgap measure when weather conditions and storage capacity make wind and sun unavailable. However, natural gas production is not without consequences. Its extraction from Marcellus Shale impacts air quality and releases greenhouse gases into the atmosphere.

Air pollution has been studied and measured during Texas Barnett Shale gas extraction (Armendariz 2008) and in shale operations in the Western U.S. (Russell & Pollack, 2005). As a result, Colorado changed its air quality regulations in December 2006, to reduce oil and gas production emissions (Earthworks, n.d.). According to Armendariz, in Texas, "by 2009, emissions of smog forming compounds (Nitrogen Oxides [NOx] and Volatile Organic Compounds [VOCs]) from the engine and tank point sources will be approximately 260 tons per day. The combined emissions from the engines, tanks and the fugitive and intermittent sources will be approximately 624 tons per day, greater than the estimated emissions of many other source categories in North Central Texas, including the major airports or on-road motor vehicles." However, there is some debate in this area. Ireland (2009) of the Barnett Shale Energy Council (an industry educational group) refutes these numbers, stating that ozone levels historically have gone down in the area as the number of wells has increased. Ireland disagrees with Armendariz's VOC predictions from condensate tanks. He believes the Texas Commission on Environmental Quality is more concerned with NOx emissions in the area. Ireland further states that NOx sources, which include both oil and gas industry as well as residential natural gas emissions, compose only nine percent of the NOx totals.

Regardless of the nature and quantity of air pollution created through natural gas extraction, it is important to examine the sources, composition, potential solutions, and monitoring of air quality issues.

Sources of Air Pollution during Drilling and Production

Potential sources of air emissions vary depending on the phase of the drilling operation. In the early phases, emissions may come from drilling rigs and fracing engines that are typically fueled by diesel or gasoline. In addition air pollution comes from the hundreds of truckloads of water carried to the drilling site and hundreds more haul wastewater away. The number of truckloads needed will vary by site depending upon the amount of water needed, the wastewater generated, the location of the water source, and the distance from the wastewater treatment facility. Evaporation of chemicals from the pit water may occur, and, during well completion, venting and flaring may add to these temporary emission sources.

Once drilling and fracing are completed, production begins and permanent emission sources are established. These include compressor engines as well as venting and/or leaking condensate tanks. Fluids brought to the surface can include a mixture of natural gas, other gases, water, and hydrocarbon liquids. The greater the amount of water and hydrocarbon liquids, the "wetter" the gas. Wet gas must go through a dehydration process that separates the gases from the water and hydrocarbons. This process results in a "condensate." Condensate liquid is stored in tanks, then collected by truck, and transported to refineries for incorporation into liquid fuels. During this process, hydrocarbons can be released into the atmosphere from the condensate tanks.

Fugitive and intermittent sources of emissions from equipment and transmission sites also occur during this phase. Unintended leaks from drilling equipment components can result from wear, rust, corrosion, improper installation, lack of maintenance, and over-pressurization of the gases or liquids in the piping. Armendariz states these leaks are "not uncommon." By design, small quantities of natural gas are leaked from pneumatic valves used during normal operation of wells, processing plants, and pipelines. Approximately 250,000 pneumatic valves are used during production and are the "single largest source of methane emissions, venting nearly 50 billion cubic feet annually" (United States Department of Energy, n.d.).

Composition of Air Emissions

Armendariz and the Ground Water Protection Council, 2009 agree that the following air emissions are typically found during shale natural gas drilling and production.

- *Methane* (CH_4), the principal component of natural gas, is a known greenhouse gas. It may be released as fugitives from the processing equipment and especially from pneumatic devices.
- *Nitrogen Oxides* (NOx) result when fossil fuel is burned to provide power to machinery, compressor engines, and trucks and also during flaring. It is a precursor to ozone formation.
- *Volatile Organic Compounds* (VOCs), carbon containing substances that readily evaporate into the air.

- *Benzene, toluene, ethyl benzene, and xylenes* (BTEX), toxic compounds emitted in low quantities.
- *Carbon Monoxide,* which occurs during flaring and from incomplete combustion of carbon-based fuels used in engines.
- *Sulfur Dioxide* (SO_2) which may form when fossil fuels containing sulfur are burned. It contributes to acid rain and is regulated by the US Environmental Protection Agency (EPA) and contributes to acid rain.
- *Particulate Matter* resulting from dust or soil entering the air during construction from traffic on and off roads and from diesel exhaust of vehicles and engines.
- *Ozone,* which occurs when VOCs and NOx combine with sunlight to form ground level ozone.
- *Hydrogen sulfide* (H_2S), which exists naturally in some oil and gas formations. It may be released when gas is vented, leaked, or incompletely burned during flaring. It is toxic and smells of rotten eggs. Thus far, little has been found in Marcellus Shale.

Proposed Solutions

Armendariz (2008) and the United States Department of Energy Fact Sheet 2 (n.d.) offer the following suggestions to reduce air emissions:

- Use new, low bleed pneumatic devices that, according to the EPA, reduce methane emissions nearly 90%.
- Install flash tank separators (vapor recovery units) on condensate tanks. These may recover 90-99% of methane that would otherwise be flared or vented.
- Use infrared cameras in the field to visually identify fugitive hydrocarbon leaks.
- Use portable equipment to process and direct the produced natural gas into tanks or pipelines rather than venting or flaring the gas. This process recovers about 53% of the gas for sale instead of having it lost in the atmosphere or combusted.
- Replace internal combustion engines with electric motors for compression power as appropriate.
- Develop and implement aggressive inspection and maintenance procedures.

Monitoring Air Quality in Pennsylvania and the Marcellus Shale Formation

Ground-level ozone is a problem in PA. Ground-level ozone is the main component of urban smog and is formed by a chemical reaction between volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight. The U.S. Clean Air Act regulates man made emissions of VOCs and NOx as "ozone" precursors," and set standards for ground level ozone trusting that reduction of VOCs and NOx will result in lower ground level ozone.

Twenty-nine counties in Pennsylvania exceed the 2008 Eight-Hour Ozone National Ambient Air Quality Standard (PADEP, 2009). Of these 29 counties 17 (Dauphin, Perry, Lebanon, Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland, Indiana, Greene, Erie, Mercer, Lycoming, Carbon, Monroe) lie within the Marcellus Shale geological formation (See Appendix II). Also, there are 29 primarily rural counties in the Marcellus Shale Play (Huntington, Bedford, Fulton, Juniata, Mifflin, Somerset, Crawford, Elk, McKean,

Venango, Warren, Clarion, Jefferson, Forest, Clinton, Columbia, Montour, Union, Snyder, Northumberland, Bradford, Cameron, Potter, Sullivan, Wyoming, Pike, Schuylkill, Susquehanna, Wayne) which are assumed to meet the Eight Hour Ozone Standard even though they have no air quality monitors. The EPA sets the criteria for air quality monitor placement and is in the process of changing rural monitoring procedures.

Barbara Hatch, Air Quality Permitting Chief, PA Southwest Region (personal communication) indicated that VOCs are not an issue in dehydrator or compressor engines. And she does not see NOx as a significant problem for any one drilling facility. However, when large numbers of wells are drilled in a geographical area, accumulation of NOx emissions from compressors and dehydrators and the polluting emissions from all of the other sources discussed above may reach a critical level.

The National Park Service (2008) points out that in the Eastern U.S., "on a site-by-site basis, emissions may not be significant but on a regional basis may prove significant." Furthermore, expanded Marcellus Shale development activity may push several new counties into nonattainment, "making rural NOx more of an issue than urban NOx."

When any state is out of compliance with the US EPA Clean Air Standards, the EPA mandates a "state plan" to demonstrate how the state will improve air quality and maintain the good air quality in compliant areas. In PA, the Bureau of Air Quality prepares this plan. They are aware of the increase in natural gas drilling and are tying to determine when, where, and how much drilling is likely to take place. This information is to be incorporated into the "state plan" that could influence drilling/production activity and the placement of air quality monitors (Arleen Shulman, Chief, Air Resources Management Division, Bureau of Air Quality, PA DEP, personal communication).

In summary, air quality is an issue that requires consideration with the increase of natural gas drilling and production in Pennsylvania. Although there is disagreement on the extent of polluting air emissions from shale gas drilling and production, experience in the Western States and Texas suggests the possible need for change in Pennsylvania's air quality plans, air quality monitoring, and coordination/communication between bureaus within the DEP.

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APPENDIX I

PENNSYLVANIA COUNTIES IN THE
MARCELLUS SHALE REGION

Allegheny, Armstrong, Beaver, Bedford, Blair, Bradford, Butler, Cambria, Cameron, Carbon, Centre, Clarion, Clearfield, Clinton, Columbia, Crawford, Dauphin, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Juniata,
Lackawanna, Lawrence, Lebanon, Luzerne, Lycoming, McKean, Mercer, Mifflin, Monroe, Montour, Northumberland, Perry, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Vernango, Warren, Washington, Wayne, Westmoreland, Wyoming

Franklin, Union, and Mifflin have very little land in the play.

Counties not in the region: Adams, Berks, Bucks, Chester, Cumberland, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, York

APPENDIX II

8 Hour Ozone Status of Counties within the Marcellus Shale Formation*

Statistical area	Counties	County Design Value** (in ppb)	Recommended Designation
DEP's Southcentral Region			
Altoona Metropolitan	Blair County	72	Attainment
Harrisburg-Carlisle	Dauphin	79	Nonattainment
	Perry	77	Nonattainment
Lebanon Metropolitan	Lebanon	No monitor	Nonattainment
Huntington Micropolitan	Huntington County	No monitor	Attainment
Remaining in Region	Bedford	No monitor	Attainment
	Fulton	No monitor	Attainment
	Juniata	No monitor	Attainment
	Mifflin	No monitor	Attainment
Chambersburg Micropolitan	Franklin	72	Attainment
DEP's Southwest Region			
Pittsburgh Metropolitan	Allegheny	86	Nonattainment
	Armstrong	80	Nonattainment
	Beaver	78	Nonattainment
	Butler (part of DEP's northwest region)	No monitor	Nonattainment
	Fayette	No monitor	Nonattainment
	Washington	76	Nonattainment
	Westmoreland	76	Nonattainment
New Castle Micropolitan	Lawrence (part of DEP's Northwest region)	71	Attainment
Johnstown Metropolitan	Cambria	70	Attainment
Somerset Micropolitan	Somerset	No monitor	Attainment
Indiana Micropolitan	Indiana	76	Nonattainment
Remaining in Region	Greene	76	Nonattainment
DEP's Northwest Region			
Erie Metropolitan	Erie	78	Nonattainment
Youngstown-Warren-Boardman Metropolitan	Mercer	80	Nonattainment
Meadville Micropolitan	Crawford	No monitor	Attainment
St. Mary's Micropolitan	Elk	No monitor	Attainment

Bradford Micropolitan	McKean	No monitor	Attainment
Oil City Micropolitan	Venango	No monitor	Attainment
Warren Micropolitan	Warren	No monitor	Attainment
Remaining in Region	Clarion	No monitor	Attainment
	Jefferson	No monitor	Attainment
	Forest	No monitor	Attainment
DEP's North Central Region			
State College Metropolitan	Centre	75	Attainment
Williamsport Metropolitan	Lycoming	77	Nonattainment
Lock Haven Micropolitan	Clinton	No monitor	Attainment
Bloomsburg-Berwick Micropolitan	Columbia	No monitor	Attainmment
	Montour	No monitor	Attainment
DuBois Micropolitan	Clearfield	73	Attainment
Lewisburg Micropolitan	Union	No monitor	Attainment
Selinsgrove Micropolitan	Snyder	No monitor	Attainment
Sunbury Micropolitan	Northumberland	No monitor	Attainment
Remaining in region	Bradford	No monitor	Attainment
	Cameron	No monitor	Attainment
	Potter	No monitor	Attainment
	Sullivan	No monitor	Attainment
	Tioga	73	Attainment
DEP Northeast Region			
Allentown-Bethlehem-Easton Metropolitan	Carbon	No monitor	Nonattainment
Scranton-Wilkes-Barre-Hazleton Metropolitan	Lackawanna	74	Attainment
	Luzerne	75	Attainment
	Wyoming	No monitor	Attainment
New York-Newark-Edison Metropolitan	Pike	No monitor	Attainment
East Stroudsburg Micropolitan	Monroe	76	Nonattainment
Remaining in region	Schuylkill	No monitor	Attainment
	Susquehanna	No monitor	Attainment
	Wayne	No monitor	Attainment

*Taken from: Commonwealth of Pennsylvania, Pennsylvania Department of Environmental Protection, Proposed Designation Recommendations for the 2008 Eight-Hour Ozone National Ambient Air Quality Standard, Table 1, Feb, 2009

**EPA expects three years of complete data to designate attainment areas. A value of 75 or below is no
attainment.

The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide III

Marcellus Shale Natural Gas: Its Economic Impact

League of Women Voters of Indiana County
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Natural gas has become more accessible and affordable in North America. Improved fracing technology now makes it a major player in the energy market. The large domestic reserves of gas will reduce the nation's dependency on foreign energy sources and, consequently, contribute to reducing the trade deficit. Natural gas is the cleanest carbon based fuel and produces less than half as much carbon pollution as coal for the same power output. Many who have spent significant time and thought on global warming issues (Podesta and Wirth, 2009), as well as natural gas producers, have urged the use of natural gas as a transition source. This would promote energy efficiency and provide needed time for the development of renewable energy resources such as wind, solar and biofuels. Replacing oil and coal with natural gas in power generation and powering fleet vehicles such as buses, delivery trucks, taxis, and government vehicles is anticipated to be a key component of a strategy to reduce greenhouse gases (Considine, Watson, Entler, & Sparks, 2009; Podesta & Wirth, 2009).

Because a large part of the Marcellus Shale gas deposit lies within Pennsylvania, it has the potential to have a significant impact on Pennsylvania's economy through creating new jobs and generating income and wealth for future generations. The proximity of Pennsylvania's natural gas deposit to the heavily populated Northeast Corridor makes producing natural gas from the deep Marcellus Shale reserve financially lucrative. In an industry-funded study, Considine et al. (2009) estimates Marcellus Shale natural gas has a $.90 (ninety cents) per one thousand cubic feet (mcf) advantage over natural gas coming from the Barnett Shale play in Texas.

OVERALL ECONOMIC IMPACT

Marcellus Shale natural gas drilling and production is anticipated to have a huge economic impact in Pennsylvania over the next 20-50 years. Economic output numbers vary and are dependent on the source and the date of the estimate. Kelsey (2009) estimates that $500 billion will be added to the state's economy over twenty years. (As a point of reference, the state's total economy was $339 billion in 2006.) Considine et al. (2009) found the Marcellus natural gas industry generated $2.3 billion in total value added, more than 29,000 jobs, and $238 million in state and local taxes during 2008. They predicted that the economic output will top $3.8 billion in 2009, create 48,000 jobs, and provide more than $400 million in state and local tax revenues. By 2020, Considine et al. (2009) said the industry "could be generating $13.5 billion in value added and almost 175,000 jobs." They based their estimate on a model that predicts "for every $1 that the Marcellus industry spends in the state, $1.94 of total economic output is generated" (Considine et al., 2009). (The reader should note that the Considine et al. report was funded by and received its data from the Marcellus Shale Committee, a natural gas industry sponsored group.)

Economic impact can be divided into three categories, direct, indirect, and induced economic impact. Direct impact consists of the industry's need for services, labor, and locally supplied goods. It includes such things as drilling/production equipment, pipeline installation, exploration activities, transport of water, workers, legal services, royalty and tax revenue, and other capital and service expenditures. Indirect economic impact occurs when companies that serve the natural gas extraction companies buy services and goods from yet more companies.

Induced economic impacts occur when wages earned by employees increase household incomes, which in turn stimulate spending for local goods and services.

ECONOMIC ISSUES IN OTHER STATES

Experiences in other states assist us to anticipate economic issues in Pennsylvania. Studies of the economic impact of natural gas shale drilling and production have been made in Texas, Arkansas, and Wyoming. Although Kelsey (2009, February 2) suggested information from other states is instructive, he warned that extrapolating the data precisely to Pennsylvania is difficult. Economic impact studies are dependent on the existing economic relationships in the communities being studied. Pennsylvania drilling sites are not located in as sparsely populated areas as Wyoming nor in as urban a setting as Fort Worth, Texas. In most parts of Pennsylvania where drilling will occur, there is little if any existing industry and infrastructure. Therefore, at least initially, firms and employees from outside of Pennsylvania will conduct much of the economic activity. This will lessen the impact on existing local businesses. (Cautionary note to the reader: all of these studies were commissioned by interested parties, the Perryman (Texas) and Arkansas studies by industry and the Wyoming study by the Sublette County Commission.)

The Perryman Group (2008) analyzed the effect of the Barnett Shale drilling activity in the Fort Worth, Texas area based on 2007 data. Fort Worth and the urban counties overlying the Barnett Shale have a well-developed natural gas industry with supporting infrastructure. However, the comprehensive Perryman Report provided useful indications regarding the overall economic impact in Pennsylvania. In 2007, the Fort Worth area Barnett Shale natural gas industry accounted for $8.2 billion in annual output. This amounted to 8.1% of the total output in the regional economy with 83,823 jobs or 8.9% of the total jobs. Table 1 delineates the economic impact of the Barnett Shale natural gas industry according to type of economic activity, gross product, personal income and employment for the year, 2007. Experts suggested that the stability of the natural gas economy has shielded the Fort Worth region from the recent economic downturn. The economic impact in Pennsylvania communities could be much higher considering that the economy is relatively smaller.

Table 1: **Economic Impact of the Barnett Shale Natural Gas Industry in the Fort Worth, Texas, area in 2007 using input-output (IO) tables available from the Minnesota I-PLAN**

Types of Economic Activity	Gross Product	Personal Income	Employment
Exploration, Drilling, and Operations	67%	62%	58% of new jobs
Leasing and Royalties	11%	12%	14% of new jobs
Pipeline Infrastructure	22%	27%	28% of new jobs

In Arkansas, economists from the University of Arkansas found natural gas drilled in the Fayetteville Shale contributed $2.6 billion to the economy in 2007, employed 9,533 people, and provided $62,964,550 in state and local taxes (Perryman, 2008). The core counties in the Fayetteville Shale account for 12% of the state's population and are primarily rural with one urban area.

In Wyoming, the Ecosystems Research Group (2008) focused on the large, very rural Sublette County (6,000 pop.). Energy producers paid $1.1 billion in taxes on oil and gas production in 2008. Sublette County and its municipalities directly received $66.4 million (5.86% of total taxes paid by the industry).

In summary, experience from other states indicates that the Marcellus Shale industry will have a significant effect on Pennsylvania's economy. It is important to remember, however, that the amount of natural gas is finite; it will eventually "go bust." Larry L. Michael, executive director of Pennsylvania College of Technology's Work Force and Economic Development, reported the findings of the Marcellus Shale Workforce Needs Assessment at an economic summit held by the Williamsport-Lycoming Chamber of Commerce in September 2009. Performed by the college in partnership with the Penn State Cooperative Extension, the study found that 83% of the jobs are going to go away. To drill a single well is estimated to require about three weeks of time for 410 workers with 150 different occupations to complete. Workers generally labor 28 days straight and then take two weeks off. This can contribute to a high turnover rate. The hours worked during the drilling and well-completion portion of shale development will equal slightly more than 11.5 full-times jobs over the course of a year. For every 100 wells in production, 17 full time jobs are created. As more wells are drilled, more jobs will evolve.

FACTORS IN NEW BUSINESS DEVELOPMENT AND ECONOMIC OUTPUT

There are specific factors that affect how fast development of the Marcellus Shale natural gas development will occur. First, the cost of drilling is high because of the depth of the wells. Unless significant amounts of gas are produced, it is not economically viable to extract the gas. To date, the high output of existing Marcellus Shale wells makes Pennsylvania an attractive production site.

Second, the price of gas determines whether drilling the expensive horizontal wells is profitable. After a peak in 2008, the price of natural gas has been drifting lower. Between August and October of 2009, natural gas prices have been fluctuating from under $3 to $4 per million British thermal units (MmBtu). This has slowed development. Analysts, examining Fayetteville Shale play, indicate that the price of gas must be $6.00+/MmBtu to make exploration and drilling profitable (Center for Business and Economic Research, 2009).

Third, the availability of four different types of infrastructure affects drilling and production profitability. Roads and water supplies are necessary for exploring and drilling. Thousands of miles of gathering pipelines must be put together in a network. Processing plants are required to remove water and other contaminating hydrocarbons found in Pennsylvania's "wet gas." Lastly, there must be interstate and intrastate pipelines, rail facilities, and/or truck facilities for by-products from the processing plants.

Fourth, supply and demand must be synchronized. For example, investment in drilling is dependent upon price volatility. This makes it difficult for producers and suppliers to plan. Time lines may vary from a few months to up to ten years for the process to evolve from exploration to permit approval. Demand for skilled workers may outstrip the supply as drilling and fracing are 24/7 activities that require advanced planning. Weather and water supply may also interfere

with the anticipated development of natural gas wells (Center for Business and Economic Research, 2009; Considine, 2009).

ECONOMIC BENEFITS: JOBS

Previously cited impact studies note an increase in permanent jobs that can last up to 40 years. Such employment resulted in a rise in median income in the counties studied (Perryman Group, 2008; Center for Business and Economic Research, 2009; Ecosystems Research Group, 2008). Jobs directly attributed to the gas and oil industry include those not only of drill crews, water haulers, processing plant employees, but also the people needed to identify properties to lease, write the leases, and to conduct related legal regulatory work. Jobs indirectly related to the gas and oil industry are those involving industry suppliers–service companies, local contractors, area surveyors, attorneys, local fuel operators, stone workers, and cement suppliers. Community colleges increase their revenue by offering certification classes for people who want to work in the industry. The higher paying jobs are in the drilling sector according Kelsey (Penn State Webinar presented in Indiana County, October 14, 2009). Kelsey estimated that three-quarters of the jobs require only a high school education, and local people are often hired as laborers and for security. Low paying jobs, such as those found in hospitality and local retail, are also created.

Since the shale gas industry is resource-based, employment opportunities will vary as the industry evolves. Analysts in Sublette County, Wyoming, projected that the largest number of jobs will occur in the first twelve years or the development phase. The number of jobs will fall off dramatically during the following six years. During the production phase fewer, but more permanent jobs, will emerge. With closure of the industry, even fewer reclamation jobs will be available. (See Table 2.) Although Pennsylvania's numbers and time estimates will be different, the pattern of employment is expected to be the similar (Michaels, 2009). Jobs will be gone when the reserve of natural gas is gone.

Table 2: **Annual Number of Full Time Employees Needed to Complete Development, Production and Post-production Reclamation Phases in Sublette County, Wyoming** (Adapted from Ecosystem Research Group, 2008)

Phase	# of jobs	Duration	Comments
Development	1894	11 years starting 2007	Employment strong for 11 years with a rapid decline for the next 6 years.
Production	250	Ca. 28 years	Gradual increase of jobs from year 1 to 15. Steady employment for the duration of the production phase, ca. 28 more years.
Reclamation	Less than 100	Ca. 12 years	

ECONOMIC BENEFITS FOR INDIVIDUALS: LEASING AND ROYALTY INCOME

Leasing and royalty income will account for a small share of the total economic impact. However, such funds will have a large impact on a few Pennsylvania residents. In July, 2009,

Range Resources reported that they had paid $9.4 million in lease bonuses since 2002 and $11 million in royalty payments, as of that date, just in the Mt. Pleasant/Hickory area (Westmoreland and Washington Counties). Since leasing bonuses are up front payments in exchange for an agreement to use the resources, the big money for individuals owning natural gas rights will be in royalty payments. For example, a group in Sullivan and Wayne Counties has recently leased 60,000 acres for $5500 an acre, with 20% royalty on the extracted gas (Israel, October 18, 2009).

Interestingly, leasing and royalty issues are different for different parts of Pennsylvania. In the Northeast, gas rights owners and surface property owners are frequently the same person. In the Southwest, they are often different parties. The person owning the gas rights has the potential to do very well financially while the person who owns the surface land is less fortunate. Such individuals suffer the many inconveniences of drilling–around the clock noise, traffic, and dust for four to six weeks–and perhaps the disruption and permanent change of the land with little or no remuneration (Kelsey, 2009).

POTENTIAL ECONOMIC BENEFITS AND COSTS FOR STATE AND LOCAL MUNICIPALITIES

In all counties studied in the shale natural gas area, there has been a significant increase in the population. In Denton, Texas, population increased 66%, growing from 317,850 in 1995 to 528,950 in 2004. In Sublette County, Wyoming, population increased 34% between 2000 and 2007. In Faulkner County, Arkansas, population grew 40% between 1990 and 2006. With such rapid increases in population, communities need to understand, plan, and adjust for similar benefits and costs of a boom/bust economy.

BENEFITS

- New Businesses: New local businesses may be created or existing businesses expanded to meet the needs of the natural gas companies and their employees. Increased employment has been reported in maintenance and repair, construction, hospitality, retail trade, and legal service businesses in Texas, Wyoming, and Arkansas.

- Personal income: Median income grew in all three states studied. As further evidence of increasing wealth, the Perryman Group in Texas noted dividend income, as reported on income tax returns, also increased.

- Owner Occupied Housing: Owner occupied housing expanded in all three shale areas. This provides an increasing tax base. In Pennsylvania, new structures increase property tax receipts. Older structures, once purchased, are reassessed to current property values.

- Charitable Giving: Using case study methodology, Murray and Ooms (2008) found charitable giving increased in the specific charities studied in natural gas producing areas. In addition to cases in which the natural gas industry provided large grants or "gala" events, there were, in general, significant gains in the charitable donations.

- Water: With many companies buying the water needed for drilling and fracing directly from municipal water companies, local revenue sources expand.

- Leasing Public Land: Lease bonuses and royalties provide increased revenue for local governments that own land on which producing wells are located. However, such income is

short term and will disappear when wells cease to operate. For this reason, Rodgers et al. (2008) strongly recommended that these funds not be used to fund on-going budgetary expenses, but to be targeted to improve infrastructure and the long term needs associated with population and business growth.

• Tax Revenues: Based on industry-provided data, Considine et al. (2009) projected the "present value of additional Pennsylvania state and local taxes earned from the Marcellus development between now and 2020 is almost $12 billion" (p. iv). During 2008, the Marcellus Shale natural gas industry in Pennsylvania contributed $2.3 billion to the economy. This included $238 million in taxes to the Commonwealth and local municipalities. The largest component of tax revenue increase came from the employees' federal, state, and local income tax returns. Taxes generated from indirect business taxes, such as excise taxes, property taxes and sales taxes, contributed significantly to the overall revenue sources. The Pennsylvania Budget and Policy Center (PBPC) refuted Considine et al.'s numbers and determined the $238 million paid in taxes to be "overstated" by more than $100 million (2009, October 1). The PBPC noted that 31% of Considine et al.'s tax figure is for property taxes that are not assessed on natural gas reserves or drilling equipment. Such commodities are not deemed to be "property" in Pennsylvania. Another 30% of Considine et al.'s tax figure comes from sales tax paid by drilling companies. PBPC notes that such figures are questionable because, even if machinery used by drillers were purchased in Pennsylvania, much would be exempt from sales tax due to the manufacturing exemption.

COSTS TO MUNICIPALITIES

● Non-violent Crime: As the number of wells increased, non-violent crime increased modestly. This can necessitate the need for more law enforcement in both rural and urban counties. Costs for additional police personnel are proportionately greater, in terms of budgetary impact, in small towns than in urban areas. (Kelsey, 2009; Murray & Ooms, 2008b; Ecosystem Research Group, 2008).

● Poverty Levels: The number of people living below the poverty line has increased in more populated areas (as opposed to the sparsely populated Sublette County, Wyoming). This places a larger financial burden on social services (Murray & Ooms, 2008b; Kelsey, 2009; Rodger et al., 2009). As the need for service industry workers increases, the number of working poor in an area also increases. In Pennsylvania, the Department of Public Welfare supplements family income of the working poor with food stamps, Medicaid, cash assistance, and daycare.

● Emergency Responders: In all cases, as the number of wells increased, the number of emergency runs directly increased. This requires more emergency vehicles and crews. In rural areas, new emergency vehicles with high clearance are often required to access the back roads. Pennsylvania Emergency Management Agency (PEMA) plans require modifications to deal with natural gas well emergencies and with the toxic substances that are used in or result from drilling and fracing (Kelsey, 2009; Murray & Ooms, 2008b; Rodgers et al., 2008). Municipalities that operate their own fire and ambulance services see a direct increase in costs. In areas where private services and volunteer fire departments operate, costs accrue to those services that are, in turn, passed on to local citizens and service users.

● Roads: To access drill sites, particularly in rural counties, more roads are needed. Existing roads are not capable of sustaining the heavy pounding of drilling industry trucks. Road bonding

amounts are low ($12,500 per mile) and inadequate to repair/replace existing roadways at current prices (Kelsey, 2009; Rodgers et al., 2008).

● Health Care Services: An increase in population expands the need for health care. Small rural medical centers in Wyoming have reported the demands for medical care exceed their ability to provide services both in terms of personnel and finances (Ecosystem Research Group, 2008).

● Housing Infrastructure: An increased demand for more housing is a direct result of population growth. If there is inadequate housing, the influx of workers cannot find a place to live within a community and contribute to its tax base. On the other hand, the need for development phase workers will decrease significantly in the short term (10+) years. Some communities need to weigh the value of temporary housing to protect the value of long term resident housing. The building of "Man Camps" has been proposed in some areas to house transient workers (Long, 2009). Kelsey noted that if new homes are built in response to an influx of workers, the municipalities may have a glut of housing after the drilling phase is over in ten to twelve years (Webinar presented in Indiana County, October 14, 2009). Demand for drinking water, sewage treatment, and waste management will increase and require appropriate governmental response and funding

● Impact on Other Businesses: With the onset of higher salaries and availability of overtime, employees of local businesses may leave for higher paying jobs. To attract replacement employees, wages must rise with a concomitant rise in costs. In areas that rely on tourists attracted to the "wilds" of Pennsylvania, hotel rooms can be clogged with transient workers. Disruption of sites that attract tourists and hunters in such an area can also occur (Kelsey, 2009). Kelsey (2009) further pointed out that little new revenue is coming into the coffers of local municipalities. Why? Natural gas is not subject to local taxes; earned income tax is paid where people live; and transient workers (drilling and fracing crews) move with the rigs so they tend to live in more central areas with larger populations. For example, State College and Bloomsburg may benefit from additional taxes while the expenses are passed on to towns where the actual drilling is occurring. To further confound matters, the Pennsylvania Oil and Gas Act prohibits local municipalities from regulating drilling activity. Thus municipalities cannot control or reduce their costs by passing them on to drilling sites. However, two recent court cases may have provided some leeway in this area. Based on an analysis of financial data, areas with less population are affected more proportionally by these increased costs (Murray and Ooms, 2008).

● Clean and Green Act: Clean and Green (P.L. 973 of 1974) is a program that provides preferential tax assessment for eligible farm and forest lands. Land is assessed as it is currently used, e.g., as farmland, not as it could potentially be used, e.g., as a housing development. The law does not state whether leasing land for natural gas drilling makes the land ineligible for Clean and Green. County commissioners will need to consider how they will treat such land. Decisions in this matter impact all of the players from the industry and surface owners to neighboring residents and gas rights owners.

● Social Conflict: An influx of new people into well-established communities can create a "social cost." Older residents may like the town the way it was and resist change. Rig crews may

enjoy a style of life that may be in conflict with traditionally accepted norms. When new costs to the community are funded by existing revenue sources, people who have not benefited from the natural gas boom may resent paying the price of higher taxes.

To determine how locally elected leaders viewed the costs to their community, an informal survey was conducted. Officials in Washington, Susquehanna, Butler, Armstrong, Wyoming, Fayette, and Indiana Counties were asked about costs they were experiencing. Generally, officials really did not know what the costs were to their communities. Perhaps more accurately, there was no tracking of such costs to their communities. In Indiana County, a commissioner described how it is impossible to learn even where the Marcellus Shale natural gas drilling is going to be. In Wyoming County, officials reported that courthouse staff is being overwhelmed with the processing of deeds and leases. In Susquehanna, Butler, and Armstrong Counties, officials reported wear and tear on roads. Roads were bonded, and, in some cases, the drilling companies have repaired the roads. Lack of information by local officials is not surprising given the early stage of the industry activity in these areas.

ENVIRONMENTAL COSTS TO THE STATE

Environmental problems emerging in the Western states suggest that natural gas extraction may cause unanticipated problems that will have long-lasting costs.

● Abandoned wells: If an environmental cleanup is required after a bond is released, the lease expired, or the property has changed owners, the State is responsible. First they must track down the owner. If there is no agreement as to the responsibility of the former owner, the current landowner is legally responsible. If the costs are prohibitive to the current owner, the State looks for others to share the costs. In the absence of others to assume financial responsibility, taxpayers foot the bill.

● Reclamation: Pennsylvania has and will continue to have high costs for post-mineral extraction cleanup. For example, the coal industry has left expensive environmental reclamation costs. DEP estimates that the 2,500 miles of damaged streams and 250,000 acres of unrestored surface coalmine land will cost approximately $15 billion to restore. Cleanup costs from the gas industry may also be both indirectly and directly paid by the state. After a bond is released, a lease expired, or the ownership of a property transferred, the State is responsible for tracking down who is financially responsible for any environmental damages. If others are not legally responsible or cannot pay, Pennsylvania taxpayers will pay the cleanup costs. Given the environmental problems emerging from natural gas extraction in other states, it appears that Pennsylvania may experience unanticipated problems that will have long lasting costs.

● Growing Greener: Growing Greener provides bond money to support partnerships between state, local and non-profit agencies (usually volunteers) to deal with environmental issues. Its funds are nearly depleted. Marcellus Shale drilling will require additional financial resources to cleanup inevitable accidents, spills, and unforeseen, cumulative effects.

● Radioactive Waste: An unanticipated cost, yet to be determined, involves radioactive waste. As of November 10, 2009, the radioactive levels publicly reported in flowback from Pennsylvania's Marcellus Shale natural gas wells fall within naturally occurring radioactive material (NORM) guidelines. However, the radioactive levels from eleven of thirteen wells drilled in New York did not (Lustgarten, November 9, 2009). While radioactive material can be

filtered out of the flowback at wastewater treatment plants, plants must be designed to do so. The resulting hazardous waste may then need to be taken to special disposal sites in Idaho and Washington. The flowback can also leave a radioactive sludge in the pipes used in the drilling process. In one such incident in Louisiana, radioactive well pipe was recycled into school bleachers (OSHA Hazard Information Bulletins, 2009, October 26).

● Administrative and Monitoring Costs: The Department of Environmental Protection (DEP) needs to expand its workforce to handle the increasing paperwork required for permits and to monitor such factors as compacted soils, disrupted habitats of flora and fauna, water pollution, and land contamination. Although permit fees and surcharges contribute to DEP's budget, the need to oversee the current 63,000 natural gas wells and the new drilling of hundreds more each year will significantly increase the workload for DEP inspectors. Many of these positions and services will be funded by increasing permit fees paid by drilling companies.

PUBLIC HEALTH COSTS TO THE STATE

Potential health risks and costs are related to fracing fluids that go down the well and then return to the surface with added dissolved minerals. Because fracing fluids are exempt from regulations of the Federal Safe Drinking Water Act of 2005, little research has been done on their level of toxicity. A recent paper by Witter et al. (2008, August 1) reviewed studies done between 2003 and 2008 that focused on the effects of low level exposure to toxins used in the gas and oil industry. She found:

> Few studies had been published on the health effects of oil and gas exploration and extraction on communities living and working in the vicinity of these activities. A lack of specific evidence, however, does not negate the fact that oil and gas operations use and produce toxic contaminants that adversely affect human health. Available studies show that exposure to air pollutants, toxic chemicals, metals, radiation, noise, and light pollution cause a range of diseases, illnesses, and health problems. . . . Neighborhoods, schools, and workers in close proximity to oil and gas activities may be at increased risk for cancer, cardiovascular disease, asthma, and other disorders due to uncontrolled or high exposures.

In a subsequent White Paper, Witter et al. (2008, September 15) called for a Health Impact Assessment to be part of any environmental impact assessments.

Dr. Theo Colburn (2007, October 31), founder of The Endocrine Disruption Exchange, testified before the House Committee on Oversight and Government Reform hearing on the Applicability of Federal Requirements to Protect Health and the Environment for Oil and Gas Development. She reported that she had found many highly toxic chemicals from sample wells and wastewater pits in Colorado, Wyoming, and New Mexico. These have been known to wreak havoc on laboratory animals, especially females and the aging. One, 2-BE, has been reclassified by the EPA as a possible human carcinogen.

In Hobbs, New Mexico, a study looked at the air borne particles and soil samples from a six block area of homes built in 1976 on an oil well site that had been active from 1927 until it was shut down in the 1960s (Dalhgren, et al, 2007). Dalhgren found benzene, toluene, and xylene, chemicals used in fracing. The residents suffered Systemic Lupus Erythematous (SLE) and rheumatic diseases at a rate ten times greater than those in the study's control population.

The on-going costs of health care will be passed on to everyone.

PLANNING AND PROBLEM SOLVING

A boom/bust economy requires careful planning at both the state and local levels. Kelsey (2009) and Rodgers et al. (2008) strongly recommended the formation of a local task force composed of all of the community and business players. Such a group can dedicate itself to considering and dealing with evolving natural gas issues that require a wide range of expertise, authority, and time. Nevertheless, planning commissions can be effective. For example, in Bedford County, pipeline routes were altered to meet the needs of more persons. In Washington County, a gas company made donations toward the purchase of new emergency vehicles.

In examining policy and planning issues, local groups need to consider the following questions:

- How are local municipalities financed to meet the expenses resulting from the natural gas industry?
- How can it be ensured that "financial winners" pay a fair share of the taxes/costs?
- How can natural gas companies and employees be convinced to spend money locally?
- How can local businesses and workers compete for lucrative business opportunities?
- How can new business start-ups, technical assistance, and workforce training programs be developed?
- How are potentially threatened businesses like tourism/recreation to be protected from Marcellus Shale natural gas development?
- How can local planning be accomplished regarding infrastructure, balancing the demand for water between increasing population and natural gas industry needs, emergency plans (PEMA), zoning, capital planning, road bonding and law enforcement?

The extraction of Marcellus Shale natural gas will provide a large economic boost to Pennsylvania and many of its local communities. However, these economic gains will come with a variety of economic costs, especially to local communities. How Pennsylvania decides to deal with these issues will affect not only the near-term economy but also have implications for the long-term economic well being of the commonwealth and its communities.

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The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide IV

Taxing Natural Gas Extraction from Marcellus Shale

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How can the residents of Pennsylvania best benefit from the development of Marcellus Shale natural gas? In what ways does the Marcellus Shale "economy" currently serve as a source of revenue? Should natural gas extracted from the Marcellus Shale be taxed in Pennsylvania? If so, how should it be taxed and how should the tax money be allocated?

There is a great deal of money in the extraction of natural gas from Marcellus Shale. Because these wells will produce for thirty to fifty years with reduced transportation costs to customers, the return on investment in Marcellus Shale wells averages 30%, twice that of a conventional well. People who own both the land and mineral rights can negotiate leases or agreements that give companies the right to enter the property, conduct tests, and explore its potential for a specific period of months or years. A company may entice the property owner who owns the mineral rights and surface rights to lease by offering a one-time, up-front payment or signing bonus. Those who own mineral rights, in conjunction with or apart from the surface land, are guaranteed a minimum 12.5% royalty as provided by Pennsylvania law. A royalty, in this context, is a fractional share on the future sales of gas or other minerals extracted from the land. Owners of properties under which mineral rights have been previously sold possess surface rights. Their ability to negotiate is limited because a company that buys mineral rights also buys the right to enter the property and remove the resource at a future time. The Commonwealth of Pennsylvania, like private citizens, owns land and mineral rights that enable the state to lease acreage, negotiate lease bonuses, and earn royalties.

PERMIT FEES, SURCHARGES, AND BONDING

Pennsylvania and its municipalities obtain revenue from natural gas extraction in a variety of ways. Initially, to drill a new Marcellus Shale natural gas well in Pennsylvania, the operator must obtain a well permit from the Department of Environmental Protection (DEP). Within the past year, the base fee for a permit was increased from $100 to $900 and now requires an additional $100 per 500 feet of well bore drilled past 1,500 feet (DEP, 2009, April). These changes were made to assure adequate funding for the review and inspections of permit applications within the Marcellus Shale formation. In accordance with the Oil and Gas Act of 1984, natural gas drillers pay an additional surcharge for "Abandoned Wells" and "Orphan Wells." The surcharge for an orphan well, abandoned prior to 1985, is $200 per gas well, and the surcharge of an abandoned well, one whose owner cannot be found, is $50 per well. These surcharges are paid into the Orphan Well Plugging and Abandoned Well Plugging Funds (DEP, 2007, April).

DEP also requires a bond that serves as a financial incentive to ensure that the operator will adequately perform the drilling operations, address any water supply problems the drilling activity may cause, reclaim the well site, and properly plug the well upon abandonment. The bond amount for a single well is $2,500; a blanket bond to cover any number of wells is $25,000. A bond is not released or returned to the company until the wells are plugged and the site is reclaimed. Guidelines for obtaining bonds are included in the Operators Manual (DEP 2009, October 23).

The publication "Marcellus Shale: What Local Government Officials Need To Know" informed local officials that they have the option of requiring companies to post bonds. However, such a process requires careful, advanced planning and diligence in following procedures to recover costs if a gas company causes damage. Since 1978, state law has allowed local officials to require owners of overweight vehicles to obtain travel permits and post bonds of

up to $12,500 per road mile. The company provides security for potential road repairs by a line of credit, a performance bond, or a certified check. When needed, these funds help pay for damage to roads caused by the frequent traffic of heavy trucks involved in the extraction of natural gas from Marcellus Shale. If road repair is not required, the funds are released back to the company.

REVENUE FROM LEASING STATE LANDS

In 2008, the Department of Conservation and Natural Resources (DCNR) announced a lease sale of 74,023 acres of State Forest Land in north central Pennsylvania. According to the DCNR website, such leasing is seen as a way to be responsive to society's energy demands and ensure the sustainability of the State Forest system. The highest bids posted for eighteen (18) tracts ranged from $2 million to $33 million for a total of nearly $200 million. Under the draft conditions on the DCNR website, wells are to be drilled within the first five years of the ten-year lease and continue from year-to-year thereafter so long as production is financially viable or appears to be so. In addition to regulations, bonding, and insurance requirements, the draft includes a 16% royalty payment (DCNR, 2008).

During the 2009 budget debate, H.B. 1050 proposed that an additional 390,000 acres of State forest land be leased over a three-year period for a minimum of $2000 per acre. With royalty rates set at 16%, the estimated income to Pennsylvania for the first year would be $260 million. Representatives of the gas and oil industry supported this leasing proposal. However, questions continue to be raised about how much of the State land is actually available for leasing. Of the 2.1 million acres of land that Pennsylvania owns, 1.6 million acres overlie the Marcellus Shale natural gas deposit. Of those 1.6 million acres, 600,000 acres are already leased. Acting Director of DCNR John Quigley reported that 225,000 acres of State Forest Land are available to lease for Marcellus Shale natural gas drilling, not the 390,000 acre figure H.B. 1050 uses (Novak, 2009, July 10). While the State owns 22% of the land over the Marcellus Shale formation (Department of Conservation and Natural Resources, 2009, July 11), it may not own the mineral right. Other acreage includes state parks, environmental recreation areas, designated wildlife regions, and/or significant natural habitats. The recently adopted 2009-2010 budget requires the Department of Conservation and Natural Resources to raise $60 million by leasing up to 10,000 more acres of public forest land to drillers in the next year.

TAXING NATURAL GAS IN PENNSYLVANIA

Currently, natural gas is taxed directly and indirectly in Pennsylvania. Direct taxes are those placed on income by residents and corporations who earn money from the actual production of gas. If a permanent resident receives royalties or lease bonuses from the natural gas industry, these are subject to 3.07% personal income tax. In regard to corporations, they are subject to a net income tax of 9.99%. However, if such corporations are organized as limited liability corporations (LLC), limited liability partnerships (LLP), or master limited liability partnerships (MLLP), they pay the same rate as individual personal income tax, 3.07%. Based on data obtained by examining names on DEP drilling permits, the Pennsylvania Budget and Policy Center (2009, June 29) determined that 70.6% of the natural gas wells drilled were owned by businesses in the 3.07% paying status.

Indirect taxes include sales, wage, and property taxes. Residential users pay a 0.5% tax on their total bill while commercial users pay 0.2% plus a 6% sales tax. Wage taxes, paid by those who work in the industry, are paid at a rate determined by the municipality where they live, not where they work. In regard to taxing properties, municipalities can assess coal, timber, and gravel as real estate. However, as a result of a 2000 PA Supreme Court ruling in Independent Oil and Gas Association of PA v. the Board of Assessment Appeals of Fayette County, assessing and levying property taxes on oil and gas wells is not explicitly authorized under the law. The PA Association of Township Supervisors is supporting legislation (H.B. 10) that would re-enable municipalities to tax oil and natural gas reserves as property tax.

Until it is phased out after 2014, Pennsylvania also has a Capital Stock and Franchise Tax. This is levied on all companies that are classified as corporations for Federal income tax purposes and do business in the State. This capital stock tax is based on a formula depending on both the net worth and net income of a corporation. Since its inception in 1967, the rate of taxation has varied from a high of 13.0 mills in 1991 to .089 mills in 2010.

MARCELLUS SHALE NATURAL GAS EXTRACTION TAX

The United States Census Bureau reports that 35 states have some kind of severance tax; 31 of those states have both corporation and severance taxes; and 27 states have a severance tax for natural gas (Wood & Ward, 2009, April). Currently Pennsylvania is an importer of natural gas and its consumers pay severance taxes to states from which it is extracted. As the Marcellus Shale play is developed, Pennsylvania will become an exporter. Pennsylvania utilities will pass along all taxes to their customers (personal communication with Dan Donovan, Dominion Peoples Gas, September 25, 2009).

How much money can be garnered from taxes on natural gas extracted from Marcellus shale wells? In a press release, Seneca Resources Corporation President and Chief Executive Officer David F. Smith predicted such gas wells would produce twenty to thirty million cubic feet per day. At a "very low" unit price of $2.035 per million British thermal units, Seneca Resources would earn nearly $4 million from one well in a year.

A severance tax, comparable to that in West Virginia, was the focus of much discussion during the lengthy budget debate of 2009. That tax is 5% of the gross value of gas extracted, assessed at the wellhead. Additionally, there is a tax of 4.7 cents per thousand cubic feet assessed on natural gas ready to be moved to the customer (H.B. 1489/1531). Stripper wells (wells that are near the end of their useful lives and are unable to produce more than 60,000 cubic feet per day of natural gas) were exempt from taxation. With the number of wells increasing, revenue projections look quite strong. In fact, the Budget and Policy Center (2009, June 29) estimated that had the severance tax been in effect on October 1, 2009, it would have brought in $107 million for fiscal year 2009-10. By 2013-2014, they estimated that this tax could bring in $632 million in revenue.

When considering the drafting of an extraction tax on natural gas, Wood and Ward (2009, April) noted that the structure of a tax is critical. Simplicity, clarity and rate issues are essential elements of good tax regulation. For example, because of the inclusion of complex deductions, Alabama collects less money than states with a lower tax rate. Utah lost a suit to Exxon Mobil because of ambiguous language. By setting its rate too low, Arkansas collects less money than states with a higher tax rate. In fact, this state collected $620,000 over 50 years instead of the $99.9 million it would have collected at the Texas rate.

As of 2007, of the fourteen states that produced more natural gas than Pennsylvania, only Wyoming does not have an income tax as well as a severance tax (Levdansky, 2009, June).

POSITIONS REGARDING A SEVERANCE TAX

Proponents and opponents of a severance tax present well-articulated and passionate views on the issue. Key arguments are summarized below:

Table 1 Positions Regarding a Severance Tax

Advocates for a Severance Tax	Opponents of a Severance Tax
Capitalizes on relatively risk-free investment given seismic pre-testing and production success	Creates a strain on the capital of fledgling, start-up companies given $3.5 to 4 million drilling costs for each well
Incentives for drilling are based on well production and not the presence or absence of severance taxes based on a Wyoming study by Gerking (2000, December 1); Decker (2009, February 26) found that reducing taxes failed to promote drilling	An industry-funded study of Considine et al. (2009, July 24) predicted a 30% reduction in drilling as companies move rigs to other states (Louisiana and Arkansas) where taxing climate is more favorable to the gas industry
Over 70% of PA drilling companies organized to pay income tax at 3.07% individual rate; based on US Census Bureau data, Wood (2009, April) notes that 71% of corporations paid $0 taxes on Comprehensive Net Income Tax returns in 2004	Excessive taxes deter corporations with PA's corporate 9.9% tax rate, the third highest in nation; severance tax "burdensome;" PA Capital Stock and Franchise Tax now paid by companies based on their net worth and income and will not phase out until after 2014
PA only one of 15 top natural gas producing states not to have severance tax; only Wyoming does not have both severance and income tax; impose severance tax on all resources comparable to other states	PA does not have severance taxes on other resources such as coal and timber extracted from the state so it is unfair to impose them on natural gas
PA residents already pay for severance taxes to other states; if enacted, severance taxes paid by PA residents for natural gas produced will stay in state	PA consumers of natural gas will pay the price; whatever the severance tax rate, the costs will be transferred from the companies to natural gas customers. With no PA severance tax, consumers should pay less for natural gas.
Severance taxes paid by companies to the state are directed to local needs and deductible from Federal taxes that are, in turn, reduced.	Without a severance tax, companies will pay higher Federal taxes that generally address broader, national needs rather than those of the state.

LEGISLATION RELATED TO MARCELLUS SHALE NATURAL GAS EXTRACTION

In addition to taxes from royalties, leases, and bonuses, numerous bills are under consideration to

address the development of Marcellus Shale. Although Pennsylvania has significant regulations for gas and oil well drilling, horizontal drilling is relatively new to the Commonwealth. As a result, pending legislation addresses a myriad of related issues from safeguarding water resources to regulating taxation. They are summarized in the following table:

Table 2 Pending Legislation Related to Marcellus Shale Natural Gas Extraction

House Bills	Content	Background
HB 10	Re-enables counties, municipalities, school districts to assess and tax natural gas, coal bed methane, and oil as property for local revenue purposes	After years of local agencies taxing these resources as property, the PA Supreme Court ruled that, unlike timber and coal, the legislature had not specified that natural gas, oil, and coal bed methane could be so taxed (12/19/02).
HB 208	Amends the "Clean and Green" (PL973 of 1974) to roll back the tax on one acre of "agricultural land" to its previous levels when it is used as the site of a natural gas well	"Clean and Green" protects farmland from urban development pressures; it allows farmers to opt for lower taxes on agricultural land. If the land changes use, the difference between the lower taxes on "farm" land and assessed taxes on the modified land on the must be paid.
HB 297	Authorizes PennDot to determine road repair costs and to revise bonding amounts accordingly every three years.	Currently road bonding is set at $12,500/ paved mile. This is less than the cost of repair. Taxpayers foot the difference in cost.
HB 473	Provides landowners without mineral rights up to two years to file a complaint for surface damages. If a resolution cannot be reached within 6 months of the complaint, owners can request a DEP investigation. If drilling is found at fault, a driller has six months to make repairs.	Owners of surface rights, without mineral rights, currently have no recourse for damaged land caused by drilling.
HB 808	Amends Gas and Oil Act of 1984 by doubling drillers bonding and surcharges as follows: Plugging Well - $5000 Blanket Bond - $50,000 (covers all wells of given driller) Surcharges for Plugging Wells Abandoned Well - $100 Newly orphaned Oil Well - $200 Newly orphaned Gas Well - $400	Currently funds from bonding and surcharges are used to pay for the plugging of orphaned wells (those abandoned prior to 1985) and abandoned wells (those for which no owner can be found). DEP (2007, April) reported its average cost for plugging abandoned and orphaned wells was $9650 between 2004 and 2007.
HB 984	Amends Gas and Oil Act of 1984 by allowing mineral rights owner to read gas meter at well head every	Since royalties to those who own mineral rights are based on the amount of gas severed at wellhead, a verification process to determine

	six months and to request from DEP copy of annual production report as pertains to that well.	production is needed.
HB 977	Amends Oil and Gas Conservation Law of 1961 to include horizontal drilling by requiring drillers to notify surface rights owners if drilling is occurring below their land; by specifying the calculation of royalties prior to production, and by clarifying the minimum 12.5% royalty based on the market value of the natural gas.	Since horizontal drilling can be done extensively in all directions at great depths, a driller may access mineral rights without the knowledge of owners. Because gas extracted from Marcellus Shale requires extensive processing and costs prior to reaching the consumer, clarification is needed as to the basis on which a royalty is calculated.
HB 1139	Reduces the distance between wells on a given site from 1000 to 900 feet .	Currently, wells can be no closer than 1000 feet apart. The closer wells are drilled on a site, the greater a company's profit.
HB 1205	Amends Oil and Gas Act of 1984 by requiring drillers to have PA certified lab test water sources within 2000 feet of well prior to drilling and to retest water up to 24 months after drilling at a landowner's request	Drillers are presently not required to test water before or after drilling. However, a company is presumed responsible for water problems when drilling is within 1000 feet of well. A landowner has six months from well completion to request a DEP investigation.
Senate Bills	Content	Background
SB 297	Amends Gas and Oil Act of 1984 by requiring well operators to submit semi-annual production reports to DEP. DEP would post on website.	Production of natural gas from Marcellus Shale is difficult to determine without analysis of the quarterly statements to stockholders. Transparency is needed.
SB 298	Amends "Clean and Green" (P.L. 793 of 1974) by rolling back taxes to be paid on well site as per H.B. 208; Maintains "agricultural" status for farmland above pipelines	Given that well sites are built on farmlands that are eligible for lower taxes under "Clean and Green," clarification is needed as to a "new use" for tax purposes. The status of farmlands above pipelines requires similar clarification.

ALLOCATING INCOME FROM MARCELLUS NATURAL GAS EXTRACTION

If Pennsylvania collects revenue from the extraction of natural gas from Marcellus Shale, how should it be allocated? As the state struggled with a 2.3 billion dollar deficit in the 2009-2010 budget, some advocated that moneys from this source be used to supplement or replace tax dollars for on-going expenses. However, others questioned the wisdom of paying operating costs in the General Fund from a non-renewable resource. In addition to paying for the salaries of legislators, the General Fund is responsible for providing critical services such as those for police protection, education, mental health, community action, libraries, the arts, and Growing Greener

programs. Because of the on-going nature of these programs, many individuals believe that these should be funded by sustainable, available sources.

Pennsylvania, like an individual landowner who holds mineral rights, will receive on-going royalties and one-time lease bonuses for its state-owned lands. According to H.B. 1050 that addressed the leasing of state lands, lease bonuses are set at a minimum of $2000 per acre and royalties at 16%. However, the earnings from royalties will wane as production levels out and decreases over time. In looking at revenue, Rep. Dave Reed estimates that Pennsylvania will earn about $260 million annually from these two sources. Ultimately, the fate of these monies is dependent on the legislature. Under H.B. 1050, revenue will be divided with 80% going to the General Fund, 12.5% to communities with active natural gas wells, 2.5% to communities with Marcellus Shale natural gas wells, and 5% to Conservation Districts.

Another option for allocating revenue was proposed by H.B. 1489 and H.B.1531. Under these parameters, a Natural Gas Severance Tax Fund would be established from which the Treasury could allocate money on a quarterly basis. Sixty per cent would go to the General Fund, 15% to an Environmental Stewardship Fund, 5% to augment the liquids fuels tax fund, 4.5% to municipalities with active wells, 4% for hazardous clean-up, 3% to the public welfare department for home energy assistance, and 2% each to the Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission. Both bills would also eliminate funding the Oil and Gas Lease Fund, created in 1955 by the General Assembly to purchase and maintain state forests and parks. Presently, this fund is not supported by appropriations from the General Assembly.

The Pennsylvania Budget and Policy Center recommended using severance tax money for purposes that will benefit all Pennsylvanians for many decades to come (Wood & Ward, 2009, April). Given that all the costs associated with Marcellus Shale natural gas extraction are not yet known, the Pennsylvania Budget and Policy Center advocates that these monies should be allocated to a fund that will address potential problems related to the impact of extraction on Pennsylvania's infrastructure and environment.

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The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide V

Regulation and Permitting of Marcellus Shale Drilling

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OVERVIEW

Regulation of Marcellus Shale drilling operations is complex. It involves authorities at federal, state, and municipal levels. The regulatory enigma is perhaps best summed up by Dr. Roxana Witter of the Colorado School of Public Health, Denver, Colorado:

> Natural gas is such a unique industry in that there are tens of thousands of point sources, hundreds of thousands across the country. They are essentially hundreds of thousands of factories. The industry is completely different in terms of monitoring or regulating it because it is not like a single, stationary factory or refinery. I don't think public-health researchers or the regulatory agencies have gotten their hands around that problem. (Vaughn, 2009, October 4)

Because of the rapid push to develop natural gas from Marcellus Shale, various authorities and agencies have been forced to balance significant, long-term concerns with industry demands for expedient reviews and acceptance of drilling permits. Economic concerns, coupled with imperatives to reduce carbon dioxide and promote energy independence, accelerate the timelines required to achieve the essential goals of clear parameters and failsafe enforcement.

In Pennsylvania, the main regulatory entities include, but are not necessarily limited to:

Federal:

U.S. Environmental Protection Agency (EPA)
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Department of Interior - Bureau of Land Management
Occupational and Safety Health Administration (OSHA)

State:

PA Department of Environmental Protection (DEP) - Bureau of Oil and Gas Management,
Bureau of Air Quality
PA Department of Conservation and Natural Resources (DCNR)
PA Fish and Boat Commission
PA Emergency Management Agency (PEMA)
PA Department of Labor and Industry
PA Department of Transportation (PennDOT)

Municipal/Regional:

Susquehanna River Basin Commission (SRBC)
Delaware River Basin Commission (DRBC)
PA Municipalities
PA County Courts
PA County Conservation Districts (Note: DEP withdrew the involvement of Conservation Districts in the permitting and review process as of April 2009.)

The above agencies uphold numerous laws and regulations pertinent to Marcellus Shale gas operations including the following:

Federal

Clean Water Act (CWA) - regulates surface water quality, pollutant discharges, and storm water runoff; implements National Pollutant Discharge Elimination System (NPDES) permitting

Safe Drinking Water Act (SDWA) - regulates supply of public drinking water (but does not regulate private wells serving under 25 people); authorizes EPA to determine national standards for maximum allowed contaminant levels; regulates Underground Injection Control (UIC) program to protect ground water from injected contaminants; grants states authority ("primacy") to implement the SDWA within their boundaries; provides funding for water system improvements

Energy Policy Act of 2005 - includes two exemptions relevant to shale gas drilling: (1) amended the SDWA by clearly excluding hydraulic fracturing from the definition of "underground injection" and (2) amended the CWA to effectively exempt "uncontaminated storm water discharges from oil and gas field activities" from federal NPDES permits (*U.S. Storm water rules,* 2006, January 4)

Clean Air Act - authorizes EPA to set limits on particular air pollutants; authorizes EPA to limit air pollutant emissions from point sources

Endangered Species Act - supports the conservation of threatened and/or endangered plants, animals, and their respective habitats

Resource Conservation and Recovery Act (RCRA) - authorizes EPA to manage the generation, transportation, treatment, storage, and disposal of hazardous waste
(Certain oil and gas exploration and production wastes are exempt from Subtitle C of RCRA, but may be covered under Subtitle D or regulations other than RCRA.) (Ground Water Protection . . . ,2009, April, p. 38)

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) - taxes chemical and petroleum industries; authorizes direct federal response in the event of releases or threatened releases of hazardous substances that may pose a danger to public health or the environment

Emergency Planning and Community Right to Know Act (EPCRA) - protects public health, safety, and the environment from chemical hazards through requirements for planning and reporting

Occupational Safety and Health Act - requires employers to maintain a safe and healthy work environment; administered by the Occupational Safety and Health Administration (OSHA)

Note: Some federal laws (including the SDWA, RCRA, and CERCLA) contain exemptions relevant to Marcellus Shale operations. These are usually very specific in nature and do not

necessarily exempt the industry from complying with other sections of the same law or act, nor do they preclude the states' rights to regulate the same.

Pennsylvania

Oil and Gas Act - regulates oil and gas exploration and production, including permitting, drilling, operating, casing, plugging, reporting, financial responsibility, registration, restoration, and gas storage

Oil and Gas Conservation Law – includes special regulations for "conservation wells" that are wells at least 3,800 feet deep and penetrate the Onondaga formation

Coal and Gas Resource Coordination Act - sets forth means of coordinating activities of coalmine and non-conservation gas well operators

Clean Streams Law - authorizes DEP to control water pollution, especially through regulation of discharges to state waters; provides for DEP's implementation of the federal NPDES program in the state; sets forth enforcement policies and penalties for violations

Solid Waste Management Act - authorizes DEP to regulate solid wastes, including municipal, residual (non-hazardous industrial), and hazardous wastes

Dam Safety and Encroachment Act - regulates activities in, along, or across bodies of water

Safe Drinking Water Act - authorizes DEP to enact the federal SDWA within Pennsylvania; authorizes DEP to set maximum allowable levels for contaminants which the EPA has not yet addressed; does not give the state authority to regulate underground injection wells as PA has opted for a direct federally implemented program (Pennsylvania Department of Environmental Protection, n.d., Ch. 2, p. 12)

Water Resources Planning Act – establishes a state water plan that periodically compiles data on how much water is available, how much is currently being used, how much will be used in the future, and where water use will exceed the available water supply (Swistock, B. & Blanchet, H., n.d.)

Worker and Community Right to Know Act - mandates that employers and chemical suppliers provide identification and hazard data for substances used in any workplace

Vehicle Code - sets forth weight restrictions on vehicles and roadways, as well as posting and bonding requirements

Municipalities Planning Code - addresses zoning, subdivision, and land development at the local level

The Role of the Pennsylvania Department of Environmental Protection

The bulk of Marcellus Shale gas regulatory authority in Pennsylvania falls on the State's Department of Environmental Protection and its Bureau of Oil and Gas Management. DEP's website describes this bureau as:

> . . . responsible for the statewide oil and gas conservation and environmental programs to facilitate the safe exploration, development, and recovery of Pennsylvania's oil and gas reservoirs in a manner that will protect the Commonwealth's natural resources and the environment. The bureau develops policy . . . and programs for the regulation of oil and gas development and production, . . . oversees the oil and gas permitting and inspection programs; develops statewide regulation and standards; conducts training programs for industry; and works with the Interstate Oil & Gas Compact Commission and the Technical Advisory Board. (Pennsylvania Department of Environmental Protection, 2009, October 23)

In this capacity, DEP reviews and approves bond and well permits; inspects drilling operations, wells, and environmental controls; permits and inspects waste management; enforces state laws pertaining to resource management, well construction, and waste management; responds to complaints concerning water quality issues; and provides industry-relevant training programs.

To better guide operators in the state's requirements, DEP has created the *Oil and Gas Operators Manual*. This handbook summarizes statutes, regulations, DEP assistance, and procedures relevant to oil and gas operations. It contains information on permitting, drilling, best management practices (BMPs) for erosion and sediment control, environmental controls, waste management practices, plugging of wells, and associated activities. Copies of laws and regulations, forms, bonding guidelines, and information on oil and gas wastewater permitting are included as appendices (Pennsylvania Department of Environmental Protection, n.d.).

In its enforcement capacity, DEP has several tools at its disposal. For example, recently DEP has taken the following actions: issued a cease and desist order to U.S. Energy Development Corporation for numerous repeat violations; fined Gas Field Specialist Inc. for residual wastewater violations; and imposed a temporary stop order on all hydraulic fracturing operations by Cabot Oil and Gas in Susquehanna County after three spills occurred within one week. In each of these instances, accountability was clear-cut. However, this is not always the case. Whether from negligence or accident, violations will occur and, most likely, increase with the expansion of natural gas production. As in the case of Pennsylvania's coal legacy, circumstances can become aggravated over time or responsibility cannot easily be determined. Companies come and go, landowners sell their property, corporate officers transfer, and bankruptcies occur. These events make DEP's enforcement role most challenging.

PERMITS AND APPROVALS

Before drilling a Marcellus Shale well, an operator must obtain several permits and approvals. As of October 2009, these include:

> Well Drilling Application
> Water Management Plan (This supersedes former Application Addendum)
> Erosion, Sediment and Storm Water Control Plan or Permit
> (A plan is allowable when earth disturbance occurs on fewer than five acres; permit is required if earth disturbance occurs on five or more acres.)
> Preparedness, Prevention and Contingency Plan
> Water Withdrawal Permits

Obstruction and Encroachment Permit
Water Quality Management Permit (This is for pit impoundments of a treatment facility.)
Air Quality Permits (Depending on scope of project, separate permits may be needed for generators, compressors, gas flaring, and diesel trucks.)

In addition, a well site bond must be posted before any drilling activity occurs. This is one way "to ensure that the operator will adequately perform the drilling operations, address any water supply problems the drilling activity may cause, reclaim the well site, and properly plug the well upon abandonment" (Pennsylvania Department of Environmental Protection, 2009, October). To comply with state Vehicle Code regulations a roadway bond is usually required as well.

As interest in Marcellus Shale gas exploration and drilling has steadily climbed, so too has the DEP's related workload. Through August 2009, the number of Marcellus Shale drilling permits granted by the DEP showed a 45 percent gain over the total number of similar permits issued for the entire 2008 year (Stouffer, 2009, September 1). A new fee structure took effect in April 2009. It raises the initial permit cost for a Marcellus Shale well from a flat $100 to $900. There is also a sliding scale surcharge based on well bore type and length. The higher fees help provide funding not only for the increased volume of permit reviews and site inspections but also for the addition of more than 30 new staff members to perform related duties.

Although the DEP handles most shale gas regulatory issues, two federal-interstate compact government agencies also have jurisdiction: The Susquehanna River Basin Commission (SRBC) and the Delaware River Basin Commission (DRBC) have legal authority over water quality and quantity regulation in their respective areas. Because of the large amount of water required for hydraulic fracturing and the equally high volume of industrial-classified wastewater resulting from drilling activities, these commissions are very concerned about natural gas extraction operations. As a result, to drill within SRBC or DRBC areas, operators must apply for and obtain additional approvals from these respective commissions and submit them to the DEP.

The Water Management Plan (listed above) is another important component of the permitting process. Developed through the cooperative efforts of the DEP, SRBC, and DRBC, this plan helps address the high volume of water necessary for drilling, particularly in areas that are not covered by the SRBC and DRBC, i.e., in the Ohio, Potomac, Erie, and Genesee Basins. It contains a set of statewide permitting rules for water withdrawal, usage, treatment, and disposal. Additionally, it requires operators to provide a description of anticipated impacts of drilling and water withdrawals on water resources.

The Role of Municipalities

Municipal regulation of shale gas drilling is extremely limited due to preemption by the Pennsylvania Oil and Gas Act. Aside from road bonding and maintenance agreements, local officials have very little control over the location of wells, on-site safety, water supply protection, permit notification, and well-site bonding. While zoning, subdivision, and/or land development ordinances may be used "to guide growth and development that results from the gas boom and to protect community assets" (Pennsylvania Department of Conservation and Economic Development, n.d.), they cannot be used to regulate gas operations already covered by the Oil and Gas Act. Attempts to clarify their authority, or lack thereof, have left municipalities without recourse except through court action.

For example, local officials have gone to court to reconcile their legislative powers as set forth in the state's Municipal Planning Code with the largely preemptive state Oil and Gas Act.

In February 2009, the Pennsylvania Supreme Court handed down decisions in two pivotal cases, Huntley & Huntley v. Borough Council of the Borough of Oakmont and Range Resources-Appalachia, LLC v. Salem Township. Although far from identical, both rulings validate some degree of municipal authority through traditional zoning ordinances that designate particular land uses. Not surprisingly, the rulings also leave room for interpretation. But, Holly M. Fishel of the Pennsylvania State Association of Township Supervisors (PSATS) pointed out, "These are important rulings for local government because oil and gas well drilling is now treated like every other use and subject to reasonable land use regulations" (2009, August 19). Elam Herr, a director of the same association further said, "We are not asking to regulate drilling, which would duplicate state regulations, but to have oversight of well locations, like other uses" (Hawbaker, 2009, January).

The PSATS has identified several other salient issues. These include: road damage caused by extensive heavy truck use and 30-year-old road bonding limits far below current repair costs; the lack of notification requirements to the appropriate municipalities and counties once DEP has granted a permit; possible contamination of private water wells; insufficient number of treatment facilities for wastewater; limited resources and expertise available to local and volunteer fire departments for handling well fires; and the current exclusion of oil and gas reserves from property tax assessment (coal and other minerals are allowed to be assessed with a property tax).

The Role of Conservation Districts

Pennsylvania's County Conservation Districts, dedicated to conserving the state's natural resources, are involved at the regional level. These districts are designated "to work in close cooperation with landowners and occupiers, agencies of Federal and State Government, other local and county government units and other entities . . ." Conservation District Law, n.d., Section 2, "Declaration of Policy"). Until April 2009, these well-informed agencies served an important role as part of the review and permitting process with oversight over erosion, sedimentation, and storm water control. As of that date, with virtually no advanced notice, DEP rescinded the involvement of conservation districts by creating a more "efficient" centralized system. Now all reviews are performed by one of DEP's own regional offices. Some question these revised procedures and believe that each conservation district had the local expertise needed for protecting public health and the environment. Others wonder if DEP's staff understands the limitation of the local areas and if recent staff increases are sufficient to manage the ever-increasing workload.

ISSUES AND CONCERNS

Federal Water Issues

Federal regulations address pertinent water issues involved in natural gas extraction from Marcellus Shale. Currently, Congress is considering two bills that address hydraulic fracturing. One is in the Senate (S. 1215) and the other is in the House (H.R. 2766). This Fracturing Responsibility and Awareness of Chemicals (FRAC) Act seeks, among other things, to require drilling companies to fully disclose all chemicals used in their hydraulic fracturing operations and places hydraulic fracturing under the jurisdiction of the federal government. It would remove an exemption from the federal Safe Drinking Water Act (SDWA) for hydraulic fracturing which was inserted in the Energy Policy Act of 2005. Currently, "the EPA does not

have authority to investigate the fracturing process under the Safe Drinking Water Act" (Lustgarten, 2009, August 25). Opponents of the FRAC Act maintain that the states already adequately regulate hydraulic fracturing. Proponents argue that federal oversight is imperative to protecting the nation's water supply, especially as it will facilitate broad EPA impact studies. On October 29, 2009, the House approved an appropriations bill that provides for a new EPA study on hydraulic fracturing and its impacts on drinking water supplies. The bill is pending Senate approval and signature by President Obama.

State Water Issues

Compared to some states, Pennsylvania has relatively comprehensive hydraulic fracturing regulations (Wiseman, 2009, Spring) that require full chemical disclosure. A summary of Marcellus Shale fracturing solutions is available at the DEP's website. The specific quantities used in any given solution, however, are still considered proprietary information.

Despite the state regulations already in place, there is "one critical yet overlooked aspect in Pennsylvania, the lack of a requirement to monitor groundwater quality in a drilling zone" (McConnell, 2009, June 10). Testing for water quality before, during, and after drilling is voluntary. Although the state's Clean Streams Law would cover groundwater if pollution did occur, "this state law . . . does not require proactive water quality testing, including aquifers, making pollution detection difficult" (McConnell, 2009, June 10). Compounding the issue is the fact that groundwater contamination by hydraulic fracturing has not been definitively confirmed nor disproved (Gjelten, 2009, September 23).

Another area of growing concern is the elevated level of total dissolved solids (TDS**)** polluting Pennsylvania's waterways. Sources of TDS range from storm water runoff to sewage and industrial discharges, including gas well drilling. Pennsylvania's water systems are even less able to handle TDS due to the chronic discharges from abandoned coal mines. Starting in the fall of 2008, samples taken at the Monongahela River exceeded water quality limits for TDS. Although remedial steps have been taken, the problem persists.

In April 2009, the DEP proposed new limits for high TDS wastewater discharges to be in place by January 2011. Until that date, the DEP plans to follow an interim Permitting Strategy that "will focus on those new sources that have the greatest potential to adversely affect the quality of Pennsylvania's receiving streams. Currently, those sources are wastewaters generated from fracturing and production of oil and gas wells in the Marcellus Shale formation" (Pennsylvania Department of Environmental Protection, 2009, April 11, p.4). This plan addresses the important issue of cumulative effects:

> . . . a strategy for permitting these discharges also must involve an allocation strategy to address those situations in which multiple discharges cause or contribute to downstream water quality standards violations, even if only predicted through modeling. An allocation strategy is the plan to allocate the assimilative capacity of the watershed (the acceptable loading in lbs/d of TDS and/or chlorides) among multiple sources. (Pennsylvania Department of Environmental Protection, 2009, April 11, p. 4)

If implemented, this provision would be a significant, new direction for state regulations. As Jan Jarrett, president and CEO of PennFuture testified, "Neither the Oil and Gas Act nor the Oil and Gas regulations in Chapter 78 require, or even contemplate, that DEP will assess the probable

cumulative impacts of gas drilling on the natural resources . . .” (2009, March 31, p. 12). This DEP proposal for new limits on high TDS wastewater discharges is being studied and evaluated by the Chapter 95 Task Force. This special group, composed of representatives of industry, environmental, and state agencies, was formed under the guidance of the Water Resources Advisory Committee (one of several DEP advisory groups). Another joint effort is embodied in the Marcellus Shale Wastewater Partnership, a collaborative venture between the DEP and natural gas industry. However, unlike the Chapter 95 Task Force, no members from the environmental sector are involved in this partnership that primarily focuses on wastewater and new technologies designed for its treatment. With regard to erosion, sediment control and storm water management, the DEP has submitted relevant proposed changes. According to Acting Secretary of the DEP John Hanger, “We are shifting the focus of water quality protection from reviewing paperwork to holding permittees more accountable, conducting more on-the-ground inspections to verify that best management practices are being implemented and maintained, and increasing protections for our waterways” (Pennsylvania Department of Environmental Protection, 2009, August 31). One aspect of the proposal is a permit-by-rule option aimed at shortening the permit processing time for “eligible low-risk construction projects” (Pennsylvania Department of Environmental Protection, 2009, August 31). The 90-day public comment period on this particular proposal is scheduled to close November 30, 2009.

Air Quality Issues

Wells drilled after 1980 have been exempted from the National Emission Standards for Hazardous Air Pollutants (NESHAP), which falls under the Clean Air Act. NESHAP regulates small sources of toxic air pollution grouped in close proximity. With this exemption, natural gas and oil drill sites are not treated as an aggregated unit if they are located outside of areas with a population of one million or more (Horwitt, 2009, March; Mall, Buccino, & Nichols, 2007, October; Legal Information Institute, n.d.). Since most Marcellus Shale natural gas wells will not occur in urban areas of this population density, air quality permits will be granted per “point source,” e.g., a compressor engine, a dehydrator. Each of these point sources, basically pieces of mechanical equipment, typically meets the DEP administrative and technology standards. Permits are thus granted routinely within 30 days (Barbara Hatch, personal communication, August 5, 2009). However, with multiple Marcellus wells likely being drilled in a restricted geographic area, the aggregate pollution of the many small sources of air pollution could become problematic. This has been the experience in Colorado (Earthworks, 2006). To underscore the importance of this issue, the National Park Service has warned its employees of this potential source of air pollution in the Eastern United States (National Park Service, 2008).

To determine the nature and extent of air pollution, air quality monitors are needed. Providing air quality monitors involves both the Federal EPA and the Commonwealth DEP. EPA sets the criteria for air quality monitor placement and the Commonwealth has the ability to place additional monitors in specific places. Currently, many of the counties in which natural gas is being extracted from Marcellus Shale have few, if any, such monitoring devises. As a result, there is no data regarding the nature of air quality prior to drilling, during drilling, and/or during production.

Streamlining the Process

Numerous application forms, coupled with long lead times, have become costly and frustrating to both companies and authorities alike leading to pressure to streamline the process. But

streamlining only makes sense if it can be done without sacrificing regulatory integrity. A case in point occurred in August and September 2009 when the Chesapeake Bay Foundation filed appeals with the PA Environmental Hearing Board. The charges assert that the DEP granted drilling permits (for Fortuna Energy Inc. and Ultra Resources, Inc.) without adequately evaluating erosion and sediment control ramifications. The Foundation specifically cited an expedited permitting option implemented by the DEP in April 2009. Matt Royer, an attorney for the Chesapeake Bay Foundation, pointed out that this procedure does not require the DEP to do a technical review concerning "the environmental impacts on wetlands or streams . . . which is illegal under state and federal clean streams law" (Hopey, 2009, September 10). In response to the Chesapeake Bay Foundation's action, the DEP re-evaluated the questionable permits. Its investigation found enough deficiencies to warrant revocation of the permits. As a result of this action by a "watchdog" group, DEP also issued violation notices to several licensed professionals responsible for upholding regulations.

Within its jurisdiction, the SRBC has also addressed the need for expediency. One of its main objectives has been "to streamline the approval process for consumptive use, yet simultaneously require all consumptive water users in the basin to comply with monitoring, reporting, and mitigation requirements. This allows the SRBC to better manage the cumulative impact of such consumptive use" (Susquehanna River Basin Commission, 2009, January, p. 3).

CLOSING

Owing in part to its multi-tiered framework, Marcellus Shale gas drilling regulation is inherently problematic. On an extremely simplified level, much of the confusion and debate revolves around at least one of the following:

- the scope and content of the regulations themselves;
- the process creating the regulations;
- the enforcement of the regulations; and
- accountability for violations.

In addition to vigilant oversight and related enforcement, the nature of regulation and monitoring of natural gas extraction from Marcellus Shale will determine its legacy. It is imperative that all agencies – municipal, regional, state, and federal – work together to preserve the public good and provide clear guidance to the natural gas industry.

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