The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide II

Marcellus Shale Natural Gas: Environmental Impact

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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

<u>Water Management</u>

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.