Report on Selected Environmental Impacts of Exploratory Gas Drilling in the Delaware River Watershed

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Executive Summary

This report is concerned with the construction and operation of exploratory vertical gas wells in the Special Protection Waters portion of the Delaware River watershed.

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of exploratory well drilling. Regulators should proceed with caution in evaluating the impact of exploratory gas wells on surrounding surface waters. Current regulations in Pennsylvania do not require analysis of surrounding surface waters and there is no evidence that the well operators will perform or have performed any surface water analysis prior to, during or after drilling of these wells.

Stream buffer strips have proven to be an effective means of reducing the effect of land development on surface waters, both in general land development and in the particular case of drilling for oil and gas exploration and extraction. Pennsylvania regulations only require a 100 foot separation distance between a gas well and a surface water body. This is wholly inadequate as a stream buffer and will not provide needed protection to the Special Protection Waters of the Delaware River.

The loss of intact forest land and the increase of forest fragmentation associated with oil and gas development is well documented. In this Special Protection Waters area, development that results in such changes to the land should be carefully evaluated. Where such development is approved, mitigating steps or measures should be implemented in order to preserve water quality. Pennsylvania regulations do not provide adequate protection of forest and does not prevent or reduce forest fragmentation leading to inadequate protection of forest cover required to protect the Special protection Waters of the Delaware River Basin.

At issue here is the impact of multiple exploratory wells. It is important that, in evaluating the environmental impact of these wells, the evaluation consider not only the impact of each individual well site, but also of the cumulative impact of all sites operating together and simultaneously. When viewed in this manner, the impact of the exploratory wells in question is amplified. There is no evidence that any cumulative impact analysis of the potential impacts of and risks posed by the multiple exploratory wells on receiving water bodies, particularly the main stem Delaware River, has been done.

It has been found (The Nature Conservancy and Pennsylvania Audubon, 2010) (Exhibit 1) that, with proper planning in advance of well construction, integration of conservation features into the development of well sites can lead to significantly reduced impacts on surface waters. However, there is no evidence that such planning has occurred in the development of the exploratory well sites that are of interest here. As a result, it is prudent that the procedures used in selecting the sites for the exploratory sites, and the activities on these sites, be carefully reviewed. This is particularly important given the Special Protection Waters status of the watershed.

The opinions provided in this report are stated to a reasonable degree of scientific and professional certainty

Introduction

Exploratory gas wells have been or are permitted to be drilled in northeastern Pennsylvania as a part of a project to extract natural gas from the Marcellus shale formation. This gas extraction will use the process of hydraulic fracturing in the future to extract the gas from this deep geologic formation. The portions of the Delaware River watershed where the exploratory wells grandfathered under the Supplemental Executive Director Determination (SEDD) at issue in this hearing are located have been designated as Special Protection Waters (SPW) by the Delaware River Basin Commission (DRBC). Waters receiving this designation have been found to have exceptionally high scenic, recreational, ecological and/or water supply values. The regulations establishing SPW significantly restrict new and increased discharges of wastewater directly to the designated waterways by prohibiting discharges that create any measurable change in water quality.

Groundwater Contamination

An important issue in evaluating potential pollution pathways from exploratory gas wells is groundwater contamination from poorly constructed water wells. Generally, drinking water wells are shallower than natural gas wells, and their casing may not extend their entire depth. This is particularly the case for domestic water wells that may not be subject to the same level of oversight and scrutiny as municipal or privately owned water supply facilities. This is particularly true for older water wells and for spring wells, which are used in the regions of the Delaware River watershed that are underlain by Marcellus shale, including Wayne County, and the local areas immediately adjacent or quite close to where these grandfathered exploratory wells are located. A water well that is not cased from the surface, or is not constructed and cased properly, might allow contaminated water to flow from the ground surface and enter the water well, possibly compromising the quality of drinking water in the well, as well as the drinking water aquifer itself.

In such instances, and particularly where natural gas drilling activities are nearby, leaky surface impoundments or careless surface disposal of drilling fluids at the natural gas operation could increase the risk of contaminating the nearby water well. While the quantity of chemicals used in the installation of exploratory wells may be less than for production wells, the potential for this type of contamination is significant. The grandfathered wells under the SEDD are each located close to groundwater wells or springs providing potable water to residents in, adjacent to, and downgradient from these exploratory well sites.

Surface Water Impacts of Well Drilling

The Pennsylvania Academy of Natural Sciences has called for a comprehensive research plan that would result in guidelines and an assessment tool for regulators and managers in order to minimize the environmental impact of Marcellus Shale gas drilling. Dr. David Velinsky Testimony (Exhibit 2) (available at http://www.ansp.org/about/news/marcellus-shale.php)

The research described by Dr. Velinsky found that there is very little information available as to the impacts of long-term exposure of a watershed to Marcellus Shale drilling activities. It is unknown if there is a cumulative impact of drilling activity on a small watershed. Initial research by Academy scientists shows the environmental impact of drilling may be directly related to the density of drilling in a specific area. This research has pointed out that a question that needs to be addressed is whether there is a threshold point past which a certain amount of drilling activity has an impact on the ecological health and services of the watershed, regardless of how carefully drilling is conducted. This is very important in regards to the exploratory wells that are being drilled in the Basin under the grandfathered wells provision of the SEDD. Three of the grandfathered wells in southern Wayne County drain over a short distance to a relatively small stretch of the Delaware River that influences vulnerable species such as dwarf wedge mussel, a federally listed endangered species, and other fish, wildlife and aquatic species that are sensitive to water quality and flow changes.

The Academy scientists examined small watersheds in northeastern Pennsylvania—three in which there had been no drilling, three in which there had been some drilling and three in which there had been a high density of drilling. At each site, they tested the water, the abundance of certain sensitive insects, and the abundance of salamanders. The presence of salamanders is particularly important because amphibians are especially vulnerable to changes in the environment. The absence of amphibians is often an ecological early-warning system. For each of the measures, there was a significant difference between high-density drilling locations and locations with no drilling or less drilling. The studies showed that water conductivity (which indicates the level of contamination) was almost twice as high in the high density sites as the other sites, and the number of both sensitive insects and salamanders were reduced by 25 percent.

Site preparation on the surface at the well site is likely to cause increased erosion and runoff into surrounding streams. For both exploratory and production wells, the wellbore acts as a conduit between adjoining geologic formations, which can allow contaminants to flow into shallow groundwater or surface waters.

It has been reported (DRBC 2009) that wastewater generated during the drilling of the Matoushek well (which was completed as a future production well but has not gone into production and therefore is similar to an exploratory well) was stored on site and then trucked to a municipal wastewater treatment plant in Athens, PA. It is known that the wastewater treatment processes used at municipal treatment plants, including the plant at Athens, are not capable of removing the industrial pollutants (organic chemicals, heavy metals, etc.) that are present in the wastewater that is generated by well drilling operations. As a result, it is likely that these pollutants were discharged into either surface or groundwater without treatment. The

grandfathered exploratory wells at issue here either have already generated wastewaters or will generate them when they are drilled and such wastewaters will most likely be transported from the well site to another treatment or disposal location that has not been identified by DRBC because it is not exercising any regulatory control over these wells.

Land Disturbance - General

Drill sites involve land disturbance, making sites susceptible to runoff during storm events that can cause pollution of streams, lakes, ponds, etc. downstream from the site. Construction of drill pads as a surface for operations and storage of large equipment/containers is completed prior to the commencement of drilling and can be as large as five acres. Roads may also need to be built for access to the site. Phase II Stormwater Regulations require that construction activities disturbing one or more acres of land must have a stormwater discharge permit. In New York such permits are issued by NYS DEC under its State Pollutant Discharge Elimination System (SPDES) General Permit for construction activities. As part of this permit, a Stormwater Pollution and Prevention Plan (SWPPP) would be required, with NYS DEC charged with ensuring the SWPPP is met. Apparently no such permitting of this type is required in Pennsylvania for oil and gas projects less than 5 acres. Stormwater runoff from the grandfathered exploratory well sites is a source of pollutants to the Special Protection Waters.

With regard to land disturbance, the grandfathered exploratory wells that are at issue here are generally the same as production wells. This includes disturbance on the well site itself, placement of well facilities such as the well pad and pit, and in the construction of access roads to the site, and traffic on such roads.

It should be noted that the Marcellus shale formation underlies a significant portion of the watershed of the New York City water supply system in southeastern New York State and the watershed for water supply to Philadelphia, central and southern New Jersey, and all of the communities along the Delaware River. The New York City public water supply is unusual in that there is no filtration applied to the water diverted from the Delaware River Basin before delivery to the public. New York City has been granted a waiver from federal regulations that require such filtration. The granting of this waiver is dependent on enforcement of various regulations in the watershed that are designed to maintain water quality. The goals and associated requirements of the Special Protection Waters status of the portion of the Delaware River watershed where the grandfathered exploratory wells are located are applicable to protect the downstream water users and are similar in many ways to the requirements that exist in the watershed of the New York City water supply system.

The entire New York City watershed located west of the Hudson River (the Catskill and Delaware portions of the watershed) is underlain by Marcellus shale, and gas development has been proposed in this area. In response to this potential gas development, the New York City Dept. of Environmental Protection completed a study to evaluate the impact of gas development on general water quality in the watershed, and specifically on the risk to the federal filtration waiver (Hazen and Sawyer 2009)(Exhibit 3).

While this study was concerned with both gas exploration and production, many of the findings and recommendations apply to the grandfathered exploratory wells in question here, because, as reported by Dr. Rubin in recent comments to the U.S. Environmental Protection Agency (Exhibit 4), the geology of the Delaware River Basin watershed below the New York City reservoirs is the same as the geology of the areas of New York state addressed by Hazen and Sawyer. Among other conclusions, the Hazen and Sawyer study found that land disturbance associated with gas exploration and development would lead to increased risk to the water supply. With regard to land disturbance, these conclusions also apply to the Special Protection Waters of the Delaware River watershed. The Hazen and Sawyer study more generally documented the problems that may be associated with well drilling (exploratory or production), such as migration of drilling muds, hydrocarbons, and naturally occurring radioactive compounds into surface and groundwater.

Projects that involve only exploratory wells have been found to result in problems affecting surrounding land and water resources (U.S. Forest Service, 2005). Monitoring of the Gunnison Energy Exploratory Gas Drilling Project in the Grand Mesa/Uncompahgre/Gunnison (GMUG) National Forest and the Willsource Exploratory Project in the White River National Forest demonstrated unexpected negative environmental impacts after exploration began. Gunnison Energy Corp., the developer at the GMUG National Forest, experienced the movement of significant quantities of sediment from well sites into nearby streams. Measures that were designed to prevent an increase in runoff from well sites were found to not be effective. At the Willsource Exploratory Project, sediment from access roads was deposited in nearby stream channels, and runoff from well sites was not properly controlled. The grandfathered well sites at issue here present similar runoff pollution risks.

Land Disturbance - Buffer Zones

A riparian forest buffer is a streamside forest composed of native trees, shrubs and herbaceous plants (Lee et al. 2004). Use of such buffer areas provides various benefits. Buffers are natural filters. Leaf litter on the forest floor traps sediments before they can enter the stream. In addition, the presence of trees and shrubs along a stream's banks minimizes erosion and the effects of flooding. Buffers also encourage groundwater infiltration. Trees convert the excess nutrients in stormwater runoff into a form that actually sustains the growth of the forest. In addition, buffers provide shade necessary to maintain cool water temperatures and higher dissolved oxygen levels. Native trout, for example, require water temperatures below 68^{o}F to survive, and forested streams are as much as 10 degrees cooler than streams that flow through meadows (Lee et al. 2004). In addition, insects, the primary food for trout, are abundant both above and in wooded streams and cannot survive in water temperatures that exceed 68^{o}F.

The results demonstrate the positive impact of forest buffer zones in reducing the influence of agricultural nutrients and chemicals on surface stream waters (Anbumozhi et al. 2005).
Some of the adverse effects of impervious surfaces (such as paved roads, parking lots, and manmade structures) and agricultural areas can be mitigated by tree cover and streamside vegetation buffers, which reduce the force of overland flows, uptake excess nutrients, maintain stream bank integrity, and provide shade that reduces solar warming of waterways (Goetz et al.

2004). In addition, it has been found that forest cover provides more optimal land cover for protecting water quality than many of the potential uses to which that land may be converted (Hall et al. 2008).

There is solid evidence that providing riparian buffers of sufficient width protects and improves water quality by intercepting nonpoint source pollution (NPSP) in surface and shallow subsurface water flow (Lowrance et al. 1984; Pinay and Decamps 1988). The spatial placement of buffer strips within a watershed can have profound effects on water quality. Riparian buffers in headwater streams (i.e., those adjacent to first-, second-, and third-order systems) have much greater influences on overall water quality within a watershed than those buffers occurring in downstream reaches. Downstream buffers have proportionally less impact on polluted water already in the stream (Fischer and Fischenich, 2000).

The areas that have been or will be disturbed by the construction of the grandfathered well sites at issue here include forested and other land areas that will be or have been disturbed. This will compromise buffer zones to streams and creeks in close proximity to the well sites. These streams and creeks are mostly classified as high value or exceptional value streams and provide spawning habitat for native trout, among other important aquatic species.

It has been found that species richness was positively correlated with wetland area, forest cover, and the amount of wetlands on adjacent lands and negatively correlated with road density (Houlahan and Findlay, 2003). Lowrance et al. (1997) found that riparian forest buffers retain 50%–90% of the total loading of nitrate in shallow groundwater, sediment in surface runoff, and total nitrogen in both surface runoff and groundwater, thereby reducing the loading of these nutrients to downstream waters.

In a study of Pennsylvania streams by Brenner et al. (1991), riparian woodlands were effective in reducing fecal coliform, suspended solids, and total phosphorus. The establishment and maintenance of wetlands and riparian vegetation were determined to be a cost effective means of non-point source pollution abatement. Stormwater treatment strategies that focus on infiltration and take advantage of trees and intact forest buffers can counter the unhealthy effects of development. The areas surrounding the grandfathered well sites generally provide all or most of these land features.

Pennsylvania's Independent Regulatory Review Commission (IRRC) recently passed two new regulations that provide protections for water resources and for drinking water and watersheds from the impacts of natural gas drilling pollution as well as other new development projects. The rules fall under Title 25, in the PA code, Chapter 95, Wastewater Treatment Requirements, and Chapter 102, Erosion and Sedimentation Control. Changes to Chapter 102 state regulations approved by the IRRC will require some developers to maintain or create a 150-foot natural vegetative buffer beside Pennsylvania's best rivers and streams. These rules affect so-called E&S permitting or Erosion and Sedimentation Control measures implemented with construction projects to reduce impact on streams and rivers. Streams in the top 20% statewide for water quality will be subject to the increased protections. This would presumably include streams designated as Special Protection Waters. Unfortunately, natural gas projects are exempted from the additional buffer width requirements that are being adopted for Pennsylvania's best streams.

The subject exploratory wells will not employ these extra buffer protections, exposing the high and exceptional water quality of the tributaries and main stem Delaware River in the Wayne County region to degradation in proximity to the places where the grandfathered wells have been or will be located.

Streamside buffers are widely considered to be the best and most effective long-term solution for protection water quality. Buffers help filter water, reduce the impacts of flooding, shade and reduce water temperatures creating better habitat for fish and aquatic species. Over 200 municipalities within Pennsylvania require streamside buffers for such development projects. Again, no natural gas well, exploratory or production well, will be required to follow this rule to which all other development projects are now subject.

Land Disturbance - Intact Forest Land Cover and Forest Fragmentation

Ecosystem fragmentation generally causes large changes in the physical environment as well as biogeographic changes (Saunders et al. 1991). The exchange of solar radiation, water, and nutrients across the land surface and landscape are altered significantly. These in turn can have important influences on the biota within remnant areas, especially at or near the edge of the remnant. It has generally been found that intact forests that have not been subject to fragmentation by construction of roads and pipelines support more diverse and healthier ecosystems (Spellerberg 1998).

Areas of high ecological integrity that may serve as core refugia include: intact old growth forests, native forest ecosystems operating within the bounds of historic disturbance regimes, intact watersheds and large roadless areas (DellaSala et al. 2003). Intact natural vegetation helps to reduce or control floods and retain moisture in the soils (O'Neill et al. 1997; Hunsaker and Levine. 1995). Construction of logging and other roads in forested areas has been correlated with decrease in the acreage of intact forest (Heilman et al. 2002).

For gas well drilling in forested areas, trees and vegetation are removed for the well pad, access roads, and pipelines (Woodring 2009). This habitat destruction and forest fragmentation has the potential to seriously disrupt and endanger flora and fauna. Furthermore, noise from traffic could have a negative effect on local wildlife and clearings for pipelines may present an opportunity for increased traffic from off-road vehicles (Woodring 2009). Indirect impacts include road-building and pipeline development, which may result in habitat fragmentation and increased access to remote areas. While larger intact forest ecosystems may withstand the impacts of mining and oil development, smaller fragments are likely to be particularly sensitive to clearing (Mooney et al. 1995). Several of the sites where grandfathered wells have been or will be located will suffer forest fragmentation from the construction of these well sites.

General decline in the diversity of animal populations has been observed as a result of forest fragmentation in Pennsylvania (Yahner 1996). One potential repercussion of forest fragmentation is a decline in migratory bird populations, which become more vulnerable without continuous forest cover (Robinson et al. 1995). It has been found that maintenance of intact forests encourages the vitality of bird populations in Pennsylvania (Porneluzi et al. 1993). Food

supply for various bird species in Pennsylvania has been found to be reduced as a result of forest fragmentation (Robinson 1998).

Forest fragmentation has been found to increase the susceptibility of forests to damage from unusual weather events. For example, in the first autumn after fragmentation, a period with high winds caused severe blowdown and other forest damage in all five fragments of a previously intact forest. Total tree mortality after 67 months showed a steep increase with decreasing area of contiguous forest areas (Esseen 1994). Because the Executive Director of the Delaware River Basin Commission decided in the SEDD not to exercise the Commission's review jurisdiction over the grandfathered sites, there is no assessment from the Commission staff whether the cumulative effect of these grandfathered projects could result in similar forest fragmentation and its consequences.

Conclusions

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of drilling the grandfathered exploratory wells.
The loss of intact forest land and the increase of forest fragmentation associated with grandfathered exploratory gas wells can be expected to have measurable impact in the Special Protection Waters area. Mitigating steps or measures, such as the provision of stream buffers, will not be required by the Commission because it is not exercising jurisdiction over the grandfathered wells. Such mitigation measure should be taken in order to preserve water quality.

The multiple exploratory wells that are at issue here should not only be reviewed as to the individual impact of each site, but also the cumulative impact of all exploratory sites in the Special Protection Waters. The surface waters of the Delaware River Basin, in particular the Special Protection Waters are at significant risk of degradation associated with construction and operation of exploratory gas wells. These waters are not protected adequately by present regulations.

The opinions expressed herein are stated to a reasonable degree of scientific and professional certainty.

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