**Risks Associated with Permitting Exploration Wells in the Delaware River Basin to**

**Delaware Riverkeeper Network and Damascus Citizens for Sustainability**

**By**

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The following comments are a response to a request for a determination of the risk of chemical contamination from exploration gas wells. In my professional opinion, the chemicals introduced into the environment during exploratory well construction, along with the naturally occurring substances that may be introduced to the surface system via drilling, pose a significant threat to ground and surface waters in the Delaware River Basin. Additionally, the Delaware River Basin Commission's lack of oversight with respect to siting of these wells increases the risk of harm from these wells, an issue that will be further exacerbated should they allowed to be converted to production wells.

1. **The 11 wells listed by the Delaware River Basin Commission (DRBC) are not truly exploration wells, since they are not planned to be plugged and capped at the end of the exploratory period.** While others have examined this issue in more detail (see S. Harvey's report), it is reasonably clear that these wells are intended to be used for production, should they tap into a sufficient gas reservoir. However, it is apparent that these wells have not undergone the same level of detailed scrutiny that a normal production well would undergo. Normal siting criteria for an exploratory well would include, at a minimum, the following:

    a. Potential for groundwater contamination from leakage or chemical additive release;
    b. Potential for surface water contamination from migration of gases or drilling additives from the exploration well;
    c. Potential for release of odors that could affect nearby residents;
    d. Potential for impacts on a variety of organisms that may suffer adverse effects from activities associated with the exploration wells; and
    e. Impacts on sensitive ecological areas from activities and releases from drilling the wells.

    Siting characteristics are critical component of protecting human health and the environment from gas wells, and allowing "exploration" well construction without the rigorous hard look for the potential for water and air contamination is creating an unnecessary increase in risk.

2. **Additives and the quantities of those additives used in drilling of the wells are not specifically indicated, but should be, in order to assess the risk of these wells.** Following review of Material Safety Data Sheet (MSDS) data from several of the PaDEP permits for the 11 well sites grandfathered under the Supplemental Executive Director Determination, it is clear that a variety of chemical additives and cement products are used during the exploratory well construction (Exhibit 1). The amount of each of these substances is not reported and certain of these compounds present an uncertain risk. Some of the chemicals of concern include the following:

    a. Halad 344 Cement additive: This appears to be a modified acrylamide copolymer. No indication is present as to the amount of monomer present in the polymer. The monomer is more chemically active (or "available") to interact with other chemicals and organisms (including aquatic animals and people) and very often provides the primary risk for use of polymers. This is a particular concern due to the carcinogenicity of acrylamide. Also not indicated is how the polymer will be used, or the amount of polymer used.

    b. Ethylene glycol monobutyl ether (EGBE) and diethylene glycol monobutyl ether. These are fairly low toxicity to humans, but can still contribute to water quality degradation, simply by adding in organic carbon that will be a source of microbial reactions. EGBE (also known as 2-butoxyethanol) has been identified as a carcinogen in animals for formation of adrenal tumors, but not in humans, Exposure to EGBE can cause irritation of mucous membranes and other respiratory problems including pulmonary edema and coma at high doses. It is used in more limited quantities

    c. HR-601: Modified lignosulfates. These materials are not well chemically characterized and can add also add organic carbon that can adversely affect water quality.

    d. Cellulose derivative: No information is provided on what type of derivative is used. This material is presumably a modification of cellulose (which is not a risk, when unmodified) but no information is presented on what that modification is.

    e. Diesel and motor oil: Both of these materials, when used in wells, can release organics including benzene, toluene, ethylbenzene and xylene to surface and ground waters. Benzene presents the largest cancer risk, in that it is known human carcinogen. The other compounds, although less toxic, are general indicators of fuel contamination, are flammable, and, at high concentrations are central nervous system depressants (Klaassen, et. al., 1996)

    h. Quaternary ammonium compounds: Essentially no information is provided as to which compounds are being used. The toxicity will vary with the type of compound. All the structural information that is provided with the term "quaternary ammonium compounds" is that the molecule contains a nitrogen bonded to four carbon atoms, but does not provide information sufficient to even speculate on the risks of this class of compounds.

i. Duratone HT: This additive contains nonylphenol, a compound which is biologically long-lived, slightly bioaccumulative, and is a toxic substance and an endocrine disruptor in aquatic organisms (US EPA, 2010).

3. Gaseous odors from the well sites have been demonstrated, and have the clear potential for release of unknown chemical and unhealthful exposure to chemicals from the wells. Drilling of the Woodland Management Gas Drilling Site near Damascus in September, 2010 (Exhibit 2, statement by Greg Swartz and Tannis Kowalchuk) released a "sulfuric chemical odor." While the source of this odor was unclear, it may have come from the well, the water stored in the pond, or during emptying of the pond. While a limited set of water samples was analyzed, the source of the odor remains unclear. What is concerning is that there was no serious attempt to determine the source of the odor, or the chemical characterization of the odor. If it was from the well, it could represent a serious source of hydrogen sulfide; if it was from biological reduction of sulfate, it would have required carbon sources to reduce sulfate to sulfide. Yet the analysis of the water (WMP-Tophole), did not show hydrocarbons normally present in gas releases from gas wells (e.g. toluene, xylene, ethyl benzene, etc.). It did, however have a high biological oxygen demand (BOD) of 432 mg/L. The source of this biological reduction equivalent was, however, not clear. Whether it was chemical additives used during drilling or organic chemicals from the produced water was unclear. While the source of the water was not described, the water had characteristics that may have indicated that it was produced water, including elevated salinity as well as elevated barium, strontium and iron. The lack of concern of the regulatory agency was noted in a comment regarding hydrogen sulfide that said that "$H_2S$ is primarily an eye irritant", while in fact, hydrogen sulfide is highly toxic, and has a toxic $LC_{50}$ value of 444-585 ppm (ATSDR, 2008). Gases can come from several sources at these wells, and often contain a variety of odorous materials, including hydrogen sulfide, other sulfides, and a variety of malodorous organic compounds. While odors in a completely cased and sealed well may be minimal, these very volatile compounds often find ways to be emitted to the surface air, most commonly from either inadequately sealed wells, or from transport pathways created from the formation during the well construction. These odors can have a serious impact on the quality of life of surrounding residents, since odors are unpredictable and, in my experience with odors, very difficult to regulate.

4. **Exploration gas wells have not gone through the siting analysis that would have been conducted for production wells.** This involves consideration of the receptors, including surface and groundwater, as well as nearby residents, schools and work places that may be affected by proximity to the wells. Natural

gas is not simply methane, and contains a variety of hydrocarbons and contaminants that may present risks to persons and other organisms exposed to these chemicals. These include benzene and a variety of organic small molecules (toluene, xylenes and other alkyl aromatics, alkanes). These will move more slowly in soil and groundwater systems but ultimately can migrate to surface water systems. Benzene in particular is a known carcinogen, and transport to groundwater systems is a serious problem.

Transport mechanisms will vary with the specific conditions of the gas well. Spills can occur at the site, or from the near surface casing that experiences a failure. Contaminating chemicals, including produced water, or additives used in the drilling process, and these chemicals can then be introduced directly into the near-surface aquifers, or in surface water from runoff. Gas pressure that is released during drilling can push natural gas to the surface when a migration pathway is created. This is likely to also carry a variety of volatile hydrocarbon constituents that exist in the formation. Finally, blowouts, although infrequent, can result in uncontrolled release of contaminated water that will result in degradation of water quality in near surface aquifers, and surface water.

Because exploration wells will not undergo any siting analysis by DRBC, the risks from these wells can potentially be larger than from production wells. As has been argued by others, gas producers will likely seek to convert exploration wells into production wells in the Delaware River Basin if they intercept gas reservoirs that are economic. Drilling additional wells under an exploration permit is unwise, and has an increased potential to affect human health and the environment in the Delaware River Basin.

References:

ATSDR (Agency for Toxic Substances and Disease Registry), (2006). "Toxicological Profile for Hydrogen Sulfide" US Public Health Service. US Dept. of Health and Human Services"

Klaassen, C.D. (1996) Casarett and Doull's Toxicology, The Basic Science of Poisons. McGraw Hill, New York.

ATSDR (Agency for Toxic Substances and Disease Registry), (2006). "Toxicological Profile for Hydrogen Sulfide" US Public Health Service. US Dept. of Health and Human Services"

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

Signature ______________________ Date 11-16-2010

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