DELAWARE RIVERKEEPER® NETWORK

June 26, 2012

Scott E. Walters
Chief, General Permits/Beneficial Use Section
Division of Municipal and Residual Waste
Bureau of Waste Management
Pennsylvania Department of Environmental Protection
P.O. Box 8472
Harrisburg, PA 17105-8472

Re: Comments on WMGR136

Dear Mr. Walters:

Delaware Riverkeeper Network (DRN) respectfully submits these comments and the attached expert report for your consideration in evaluating General Permit Application No. WMGR136, submitted by the Delaware County Solid Waste Authority (DCSWA) and proposing as a beneficial use the "use of pretreated leachate as alternate supply water for use in hydraulic fracturing associated with deep shale natural gas drilling." 41 Pa. Bull. 7023 (Dec. 31, 2011).

DRN is a nonprofit membership-supported organization dedicated to the Delaware River Watershed and works for its 10,000 members to protect, defend, and restore, the Delaware River, its habitats and communities. DRN speaks for its members who live and work throughout Pennsylvania, one of the four states that flow to the Delaware River.

Berks Gas Truth (BGT) is signing on to this letter as a local organization concerned about the proposed general permit and the use of leachate from the area landfill, the Rolling Hills Landfill. Berks Gas Truth is a grassroots community organization of over 500 concerned citizens who are fighting to stop unconventional natural gas drilling. Berks Gas Truth is dedicated to raising public awareness of the issues surrounding drilling and taking action to protect our environment, human health and safety from its consequences.

DRN and BGT request that Pennsylvania Department of Environmental Protection (PADEP) hold a Public Hearing on the proposed WMGR136. The public notice about this proposed

DELAWARE RIVERKEEPER NETWORK
925 Canal Street, Suite 3701
Bristol, PA 19007
Office: (215) 369-1188
fax: (215)369-1181
drn@delawareriverkeeper.org
www.delawareriverkeeper.org

permit was not well distributed and, generally, the public was not aware of the public comment period or the opportunity to request a public hearing on this important issue. In light of the potential impacts of the issuance of this permit on public health and the environment, including water resources, we strongly advocate for a public hearing to allow people the opportunity to present testimony and information to PADEP.

PADEP's authority to issue beneficial use general permits is contingent upon an applicant's affirmative demonstration that:

> The proposed beneficial use or processing activities will be conducted in a manner that will not harm or present a threat of harm to the health, safety or welfare of the people or environment of this Commonwealth through exposure to constituents of the waste during the proposed beneficial use or processing activities and afterwards. At a minimum, the use of the waste as an ingredient in an industrial process or as a substitute for a commercial product may not present a greater harm or threat of harm than the use of the product or ingredient which the waste is replacing.

25 Pa. Code § 287.624(2); see id. § 287.611(a)(3). As established in the attached report by hydrogeologist Paul A. Rubin, DCSWA's general permit application fails on both counts. Use of leachate in fracturing fluid will threaten the health, safety, and welfare of the people and environment of Pennsylvania because partially treated leachate does not meet Pennsylvania state drinking water standards and, once injected downhole, will necessarily migrate into existing local and regional groundwater flow systems and thereafter into drinking water supplies. Rubin at 1, 3. Further, the general permit application anticipates the use of pretreated leachate as "alternate supply water"—meaning that the leachate is intended to replace some portion of the ground- and surface-water presently used as an ingredient in hydraulic fracturing fluid. 41 Pa. Bull. 7023 (Dec. 31, 2011); see also Form 20 Narrative at 2 ("[T]his request pertains to use of a pretreated leachate as a substitute for potable water use. . . ."). Yet DCSWA's general permit application makes no demonstration that partially treated leachate is as safe as the supply water it is intended to replace. Rather, DCSWA's application demonstrates the opposite. As stated above, the partially treated leachate—which DCSWA intends to withdraw prior to the conclusion of the Rolling Hills Landfill's onsite treatment process[1]—does not meet Pennsylvania state drinking water standards. In any event, even use of leachate diverted following completion of the landfill's leachate treatment regimen would still 1) present a greater threat of harm than would use of freshwater, and 2) fail to protect the health, safety, and welfare of the people and

[1] DCSWA defines "pretreated leachate" to mean "[l]eachate treated to a point that satisfies the hydraulic fracturing requirements of the shale gas industry." Form 20 Narrative at 1; see also Form 20 Narrative at 3 ("DCSWA proposes to treat leachate to the standards established by the deep shale natural gas drilling companies."). This definition, combined with DCSWA's decision to evaluate a mid-stream effluent sample from the Rolling Hills Landfill leachate treatment system for submission with its general permit application, Form 20 Narrative at 2, demonstrates DCSWA's intent to remove any leachate permitted for beneficial use prior to the final stage of treatment.

environment of Pennsylvania. The landfill's treatment process anticipates a surface water discharge, while hydraulic fracturing fluid—and any leachate within it—will discharge primarily to groundwater. Compared to streams and rivers, groundwater flow systems have significantly reduced dilution potential. Rubin at 5-6 (indicating that the landfill's existing discharge to Manatawny Creek exceeds state drinking water standards). Because DCSWA has failed in making its required affirmative demonstrations, PADEP is without authority to issue the general permit.

Indeed, DCSWA's failure to submit a complete analysis of its leachate stream precludes its ability to affirmatively demonstrate anything at all, much less that leachate is as safe as water or that the continued health, safety, and welfare of Pennsylvania's citizens and environs is assured should partially treated leachate be used in fracturing fluid. Pursuant to 25 Pa. Code. § 287.621(b)(1), each application for the issuance of a general permit must contain:

> A description of the type of residual waste to be covered by the general permit, including physical and chemical characteristics of the waste. The chemical description shall contain an analysis meeting the requirements of § 287.132 (relating to chemical analysis of waste) for a <u>sufficient number of samples</u> of residual waste in the waste type to accurately represent the range of physical and chemical characteristics of the waste type.

(emphasis added). 25 Pa. Code § 287.132(a)(1)(ii) further requires: "A detailed analysis that <u>fully characterizes</u> the physical properties and chemical composition of the waste. This analysis shall include available information from material safety data sheets or similar sources that may help characterize the physical properties and chemical composition of the waste." (emphasis added).

Despite these requirements, DCSWA submitted one outdated (year-old) analysis of leachate as drawn from early points in the landfill's treatment system as well as a barebones analysis of the lone contemporaneous effluent sample drawn from DCSWA's targeted mid-stream diversion point (after the clarifier). First, as the characteristics of the leachate may change over time (as different material is deposited in the landfill), it is necessary that DCSWA provide an up-to-date analysis of the waste (leachate). Second, characterizations of leachate drawn from early points in the treatment process may not substitute for an analysis of late- or end-stream leachate. It cannot be assumed that late- or end-stream parameter levels will remain equal to or below their early-stream levels because leachate constituents may interact with additives used at various points in the treatment process, causing fluctuations in the type and level of individual constituents present. Third, DCSWA failed to thoroughly analyze the lone contemporaneous mid-stream sample it did collect. That analysis covered an insufficient array of parameters and often failed to use methods capable of detecting the parameters that were tested at their established Maximum Contaminant Level concentrations. Rubin at 4. Finally, even if the contemporaneous mid-stream sample had undergone comprehensive testing, a lone sample is insufficient to accurately represent the range of physical and chemical characteristics of a landfill's leachate generally. Rubin at 2-5. The general permit application therefore fails to meet the requirements of 25 Pa. Code. § 287.621(b)(1) and § 287.132 as well.

Also missing from DCSWA's general permit application are "proposed concentration limits for contaminants in the waste which is to be beneficially used, and a rationale for those limits," § 287.621(b)(4), as well as "a demonstration that the waste is capable of performing the desired functions of the commercial product" the waste is intended to replace, § 287.621(b)(5)(i).[2] The application provides no proposed limits whatsoever. Instead, DCSWA asserts only that it will treat leachate to the minimal standards required by the shale gas industry—but without clearly establishing what those standards are. Form 20 Narrative at 1, 3.[3] Moreover, an assertion by "one of U.S. Environmental's shale gas clients" that, but for the sulfate concentration, the mid-stream leachate sample tested "appeared to be satisfactory," Form 20 Narrative at 2 (emphases added), does not equate to "a demonstration that the waste is capable of performing the desired functions of the commercial product" under 25 Pa. Code § 287.621(b)(5)(i). In order to demonstrate the feasibility of using leachate in fracturing fluid, DCSWA must obtain the unqualified endorsement of multiple shale gas development companies based on the analysis of a sample drawn from a single point in the treatment process in which each of the parameter concentrations satisfies industry's needs. DCSWA cannot rely on an unprovided "review of the recent historical data associated with full treatment," Form 20 Narrative at 2, to demonstrate an ability to comply with a 25 mg/l sulfate concentration cap and thereby satisfy § 287.621(b)(5)(i). Because DCSWA's general permit application fails to provide the necessary information and analyses as set forth in 25 Pa. Code § 287.621, PADEP cannot deem the application administratively complete and must require DCSWA to correct all deficiencies before PADEP may even consider issuing the general permit. 25 Pa. Code § 287.622.

Finally, in the event PADEP nevertheless approves a general permit for the use of leachate in fracturing fluid, PADEP should require that all persons and municipalities seeking inclusion under the general permit obtain a determination of applicability (DOA) prior to gaining coverage under the permit. See 25 Pa. Code §§ 287.631(a)(3), 287.641(d). The greater protections of the DOA process (as opposed to mere registration under the permit) are necessary in order "to prevent harm or a threat of harm to the health, safety [and] welfare of the people [and] environment of this Commonwealth." Id. § 287.641(d).

---

[2] The latter is required where the waste is to be substituted for a commercial product—here, water.

[3] DCSWA does not even commit to a particular level of pretreatment. As discussed above, DCSWA collected and partially analyzed one mid-stream effluent sample in preparing its general permit application. DCSWA then shared the results with the consulting firm U.S. Environmental, which in turn shared the results with at least one of its clients in the shale gas industry. Form 20 Narrative at 2. One U.S. Environmental client responded that the sample's leachate concentration was too high—the client indicated 25 mg/l as the maximum acceptable concentration—but that the parameters otherwise appeared satisfactory for use in fracturing fluid. Id. Thus, the leachate stream clearly requires an as-of-yet undefined level of additional treatment prior to diversion for beneficial use. At minimum, in order to propose concentration limits, DCSWA must provide an analysis of the leachate at a commercially-feasible diversion point.

Similarly, PADEP should also require that those covered by the general permit submit periodic reports and waste analyses to ensure that all leachate diverted for beneficial use continues to comply with approved parameters. See id. § 287.631(b). Landfills may accept different types of waste over time and the quality and overall composition of the leachate is therefore subject to change.

Greater public disclosure of the use of the proposed general permit under the DOA process or some other public process is needed. The public and the municipalities that could be affected by the general permit should be made aware of the use of leachate in fracturing fluids for two main reasons.

First, it could change the well monitoring protocol that a water well owner (or a municipality) would follow when conducting water quality tests prior to, during, and following gas well development. It should also be required that any subcontractor that employs leachate disclose the practice to the gas well owner and landowner where the well is located for this same reason.

Second, storage and transport of leachate in well-marked containers will facilitate proper handling of any spills or exposure of the materials, thereby providing a safety benefit to emergency personnel and the public. Similarly, a manifest that discloses the leachate parameters publicly and to local officials through a public reporting system, preferably on a public website, will provide for greater safety and oversight. These safety measures should be mandatory for the handling of leachate to protect public health and the environment.

Thank you for your consideration of these comments and the attached expert report.

Sincerely,

Maya K. van Rossum
the Delaware Riverkeeper

Karen Feridun, founder
Berks Gas Truth
260 East Main Street
Kutztown, PA 19530

Attachment: Rubin, Paul A., Hydrogeologic Implications of Using Partially Treated Landfill Leachate in the Hydraulic Fracturing Process, June 26, 2012.

HydroQuest
P.O. Box 387
Stone Ridge,
NY, 12484
845-657-8111
URL: hydroquest.com
hydroquest@yahoo.com

Hydrogeologic Implications of Using Partially Treated Landfill Leachate in the Hydraulic Fracturing Process

Report to:

Delaware Riverkeeper Network

Prepared by:

Paul A. Rubin
Hydrogeologist
HydroQuest

June 26, 2012

This page intentionally left blank

Introduction

HydroQuest, a professional hydrogeologic consulting firm, hereby provides hydrogeologic justification in support of prohibiting the addition of untreated or less than 100 percent "fully" treated landfill leachate to any and all hydraulic fracturing related fluids. Leachate used in hydraulic fracturing fluid will migrate within deep regional groundwater flow systems and necessarily within more local, shallow, groundwater flow systems that discharge to valley bottom aquifers and waterways. As such, no leachate should be added to hydraulic fracturing fluid unless that leachate 1) meets all federal and state primary and secondary drinking water standards; 2) contains no chemical constituents, even in trace concentrations, that are toxic or carcinogenic; and 3) does not exceed existing background chemical concentrations. Furthermore, "*acceptable*" treated landfill leachate should not include any unknown or proprietary chemical components whose undocumented presence might potentially pose a public health risk. The November 2011 Rolling Hills Landfill General Permit Application (Request to use pretreated landfill leachate as an alternate supply water for hydraulic fracturing in deep shale formations: Permit ID 100345) should not be approved as it fails to provide this level of protection.

As a threshold matter, gas development activities as regulated under Pennsylvania law are insufficiently protective of water resources. Current drilling practices fail to ensure the protection of water resources from contamination. Until all outstanding issues (e.g., long-term integrity of sealant materials used to isolate freshwater aquifers, toxicity of proprietary and other fracking chemicals, cumulative contaminant loading, recognition of hydrogeologic flow systems transporting chemicals between gas wells and freshwater aquifers) are satisfactorily addressed and resolved, it would be inadvisable to add leachate[4] to fracturing fluid, as it can reasonably be expected to migrate into existing local and regional groundwater flow systems. Contamination of water resources will impact, inter alia, private homeowners, businesses, municipalities, bottled water companies and natural ecosystems.

Moreover, even without considering the adverse impacts of additional chemical/contaminant loading incident to groundwater and fresh water resources, the draft permit is wholly inadequate. It provides very limited, one-time, chemical test results, fails to test for many chemicals that may well be present at elevated concentrations in treated leachate (e.g., assorted metals), and sometimes uses test methods incapable of detecting chemicals at their specified Maximum Contaminant Level (MCL) concentrations. The application, as it stands now, should not be considered in the absence of strictly defined concentration limits for all chemical species present in the treated leachate, none of which should be allowed in excess of existing shallow groundwater concentrations.

Hydrogeologic Considerations

Because chemicals injected into gas wells under high pressure will flow to down gradient freshwater aquifers, no chemicals should be placed downhole that exceed MCL drinking water standards. Hydrologically, no toxic chemicals – whether from landfill leachate or otherwise – should be added to our groundwater flow systems. Simply stated, contaminants injected into the subsurface will, in time, migrate to freshwater aquifers and surface water resources. It is only a matter of time before they surface at down gradient locations (wells, streams, reservoirs, major and lesser aquifers). It is important to recognize that potential dilution by groundwater will not remove the health risks associated with long-term chronic exposure to toxic chemicals, especially when considering the cumulative levels reached by injecting hundreds of toxic chemicals through the thousands of gas wells placed within aquifer flow systems. Toxicologists and doctors have recently brought this concern to the forefront.

---

[4] As used herein, "leachate" refers to leachate failing to meet the requirements set forth in the introductory paragraph.

The Rolling Hills Landfill's existing surface discharge of treated effluent (NPDES Permit # PA0040860) allows for dilution, re-aeration, and photo-degradation – all under state regulatory pollutant discharge guidance designed to insure that the chemical assimilative capacity of surface waterways is not exceeded. In contrast, downhole chemical loading within groundwater is covered by no water quality criteria or monitoring requirement. Contaminant transport within fractured bedrock flow systems will occur preferentially along fracture pathways[1,2 & 3] that cannot be identified or monitored until they discharge upward at down gradient locations. Once these flow systems are contaminated, there is no potential for remediation[1,2].

Although the permit application anticipates no degradation to the environment, the addition of less than 100 percent treated landfill leachate to fracturing fluids will assuredly degrade the environment. Such addition will increase the downhole cumulative chemical load migrating with groundwater flow systems and discharging to freshwater aquifers and surface waterways and reservoirs. This ill-conceived application is anything but a "*beneficial use*." Instead, the downhole injection of landfill leachate would unnecessarily exacerbate existing gas industry practices which even now cannot maintain the long-term integrity of Pennsylvania's water resources.

Quality of Rolling Hills Treated Leachate

Palmer[2] and Myers[3] provide hydrogeologic documentation of both local and regional shallow and deep groundwater flow, demonstrating how contaminants placed within deep groundwater portions of the landscape will ultimately surface down gradient within freshwater resources. This will occur both with and without failure of gas well cement sheaths and casing material (HydroQuest[1] and HydroQuest[4]) and whether or not improperly plugged wells are located nearby. For this reason, no toxic or carcinogenic chemicals should be placed or injected downhole. At a bare minimum, chemicals placed downhole must meet Pennsylvania Drinking Water standards and not exceed existing background chemical concentrations. Thus, review of the Rolling Hills Landfill permit application was conducted using Pennsylvania Drinking Water standards as a baseline comparative tool.[5]

The General Permit application relies on one mid-stream (after the clarifier) leachate sample collected and analyzed by the Delaware County Solid Waste Authority (DCSWA). DCSWA shared this lone sample with the consulting firm U.S. Environmental, which in turn shared it with one of its clients from the shale gas industry. That client noted that the sample appeared generally satisfactory for use in shale gas development – with the notable exception of the sulfate concentration, which the client stated could be no higher than 25 mg/l. General Permit Application, Form 20 Narrative at 2. Relying on end-stream data, DCSWA asserts that additional treatment is capable of reducing sulfate to a concentration below 25 mg/l but does not commit to treating leachate to this point. Indeed, the General Permit application includes no discussion of any specific effluent standards or minimum treatment requirements the applicant proposes to adhere to in operating under the permit. What is presented is completely open-ended and, if permitted, amounts to a near blanket approval for use of pretreated leachate as fracturing fluid, divorced from specified treatment levels, minimal acceptable water quality standards, and testing requirements.

The one midstream analysis conducted includes very little information.

[5] It should be borne in mind that many chemicals have no designated MCLs.

Normally, for example, documentation of potential contamination in a single homeowner's well requires confirmation based on more than one analysis. Here, in a precedent-setting permit application potentially opening the door to widespread injection of landfill leachate (sourced from multiple landfills) throughout an entire state (and possibly beyond), the permitting agency is asked to rely on a one-time limited analysis with little related supporting narrative. Clearly, the far-reaching nature of potential consequences (i.e., degradation of freshwater throughout the state) warrants substantial additional analyses, for many more parameters, and under multiple treatment scenarios. As the permit application itself notes, concentrations will vary over time, as well as under different conditions.[6]

Additional testing must be conducted and should include paired sample collection and analysis by independent parties. Once testing is complete, chemical concentration data should be compared to all relevant standards, including Pennsylvania Drinking Water standards. Drinking Water standards provide an initial baseline means of assessing leachate chemistry. However, under no circumstances should use of partially treated landfill leachate be permitted where leachate constituents exceed natural background shallow groundwater chemical concentrations.

Analysis of the one mid-stream effluent sample provided documents that concentrations of some of the parameters tested for are both undesirable and likely to degrade the environment. Examples include:

Parameter	Concentration (mg/l)	MCL (mg/l)	Times MCL
Chloride	11,000	250 (2ndary)	44
Sulfate	100	250 (2ndary)	4
TDS	23,346	500 (2ndary)	46.7
Aluminum	0.67	0.2 (2ndary)	3.4
Barium	3.53	2	1.8
Manganese	0.652	0.05 (2ndary)	13

Examination of the chemical parameters listed on the M.J. Reider Associates, Inc. Certificate of Analysis reveals that DCSWA did not test for most Pennsylvania Drinking Water chemicals in preparing its application to use landfill leachate in hydraulic fracturing fluid. Chemical parameters potentially present within landfill leachate that were **not** analyzed but for which either primary or secondary Pennsylvania Drinking Water standards have been established include:

Asbestos
Cyanide
Fluoride
Mercury
Nitrate
Nitrite
Nitrate and Nitrite (as Nitrogen)
Thallium

[6] For example, Total Dissolved Solids (TDS) may vary from 50,000 to 100,000 mg/l depending on a number of factors including dilution/concentration as a function of seasonal temperature variation, through flow and infiltration and collection location. See General Permit Application, Form 20 Narrative at 2.

Color
Corrosivity
Foaming Agents
Iron
Odor
Silver
Volatile Organic Chemicals (21 listed parameters)
Synthetic Organic Chemicals (30 listed parameters)
Disinfection Byproducts (4 listed parameters)
Disinfectants (3 listed parameters)
Radionuclides (4 listed parameters)

The Pennsylvania Department of Environmental Protection (PADEP) should not approve DCSWA's General Permit application absent comprehensive testing of multiple leachate samples for <u>all</u> primary and secondary Drinking Water MCLs using chemical methods capable of detecting all Drinking Water chemicals at their established MCLs. Among the scant parameters tested to date in the lone mid-stream sample, the reporting limit used was occasionally higher than the Pennsylvania state MCL. As a result, it is not possible to assess whether or not the treated effluent exceeds state drinking water standards based on the data provided. Examples include:

Arsenic (Reporting Limit: 0.05 mg/l; MCL: 0.010 mg/l)
Antimony (Reporting Limit: 0.05 mg/l; MCL: 0.006 mg/l)
Beryllium (Reporting Limit: 0.005 mg/l; MCL: 0.004 mg/l)
Lead (Reporting Limit: 0.01 mg/l; MCL: 0.005 mg/l)

The testing conducted to date is simply too limited to reliably ascertain what the minimum and maximum chemical concentrations are for leachate samples that may be collected at the same locations at different times. Furthermore, as discussed above, numerous additional parameters should be analyzed for. One-time analysis cannot provide an adequate leachate chemical characterization to support a planned long-term use. Finally, sample collection and analysis should be conducted by an independent party and Material Safety Data Sheets for all potential leachate analyses should be included within any application material.

NPDES Permit No. PA 0040860, Flow Characteristics and Potential Contaminant Dilution

Nor should PADEP simply transfer the effluent limitations associated with the landfill's preexisting surface discharge into any permit authorizing the use of leachate in hydraulic fracturing fluid. Hydraulic fracturing fluid – and therefore any leachate contained within it – ultimately discharges to groundwater flow systems. Such systems have minimal dilution potential compared to surface streams, making the effluent limitations set forth in NPDES Permit # PA0040860 insufficiently protective when applied to an anticipated groundwater discharge.

The high effluent limitation concentrations permitted for discharge into surface waters under the landfill's NPDES permit, if injected underground as part of hydraulic fracturing fluid, will needlessly increase contaminant loads to down gradient aquifers and waterways. Surface runoff and groundwater base flow provide rivers with a continuously renewed source of water. As a result, rivers are far better suited than fractured bedrock media to assimilate partially treated leachate (or any other industrial wastewater). The most important characteristic of water flow relative to its capacity for assimilating contaminants is its discharge (volume per unit of time). Because surface streams are continuously replenished by surface runoff and groundwater, regular permitted contaminant NPDES additions can be assimilated effectively. This is not the situation in tight low permeability shales[2] (attached) and other deep bedrock formations. Groundwater flow is slow and laminar (i.e., not turbulent like a stream). As such, it cannot effectively assimilate large quantities and high concentrations of multiple contaminants (as may be expected with contaminants discharged via multiple wells, each undergoing repeated hydraulic fracturing applications).

Deep groundwater flow in local and regional basins occurs predominantly along bedrock fracture pathways – in effect, the superhighways of deep basin groundwater and contaminant flow[2] (attached). At depth, fracture and fault pathways have narrow apertures (i.e., widths). As such, the coefficients of transmissivity (i.e., indicating the rate at which water will move through a geologic formation) and storage (i.e., indicating how much can be removed by pumping and draining) are important because they define the hydraulic characteristics of a water-bearing formation. Chemicals forced into deep formations that are hydraulically tight will preferentially move toward valley bottom aquifers and rivers. The low coefficients of transmissivity and storage preclude the significant degree of dilution afforded by fast moving, continuously recharged, streams and rivers. Instead, the addition of ever more gas wells with their attendant toxic contaminant loads will provide a long-term contaminant source with comparatively less dilution potential.

The DCSWA is authorized to discharge partially treated contaminants from the Rolling Hills Leachate Treatment Plant to Manatawny Creek and Furnace Run in Watershed 3-C in accordance with effluent limitations set forth in NPDES Permit No. PA 0040860. A number of the daily maximum and instantaneous maximum chemical concentrations far exceed Pennsylvania MCL Drinking Water standards.

Examples of "treated" leachate constituents currently permitted for discharge from Outfall 001 to the Manatawny Creek at levels that exceed Drinking Water MCLs include:

Parameter	Effluent Limitations (mg/l)		MCL (mg/l)
	Daily Maximum	Instantaneous Maximum	
Total Dissolved Solids (TDS)	30,000*	75,000	500 (2ndary)
Arsenic	1.100#	1.100	0.010

*: Recent Discharge Monitoring Reports for Outfall 001 indicate TDS concentrations of 20,023 mg/l (1-26-12), 17,225 mg/l (2-23-12), and 14,666 mg/l (3-22-12). High specific conductance values also provide evidence of other unidentified chemical components of the landfill leachate (i.e., 27,100 umhos/cm [1-26-12], 23,600 umhos/cm [3-22-12]).
#: The arsenic concentration detected on 2-23-12 (0.013 mg/l) exceeded the MCL value of 0.010 mg/l. The concentration detected on 3-22-12 (0.008 mg/l) also provides concern that less than fully, 100 percent, treated leachate will degrade groundwater quality.

Importantly, many of the parameters listed on the two-page Pennsylvania DEP listing of Drinking Water MCLs are not included in the leachate treatment plant's Final listed surface discharge effluent limitations [see Permit # PA 0040860 Effluent Limitations for Outfall 001 (page 4 of 26)] (missing Drinking Water parameters include VOCs, SOCs, disinfectants, and inorganic chemicals). As such, the full extent of partially and incompletely treated leachate chemicals cannot be ascertained based on the limited number of parameters listed on the NPDES permit. Iron, for example (which is not listed on the required Outfall 001 Effluent Limitations list), was detected at the 001 Outfall in a concentration of 0.41 mg/l on 1-26-12, a value in excess of the 0.3 mg/l secondary MCL, indicating its likely presence in treated leachate. This example indicates that other Drinking Water parameters may also be present in outfall effluent but are going undetected because the landfill's NPDES permit does not require testing for them. Indeed, the testing and monitoring required by the Landfill's NPDES permit does not address most of the parameters currently assessed in Pennsylvania Drinking Water standards, much less many others that may be present and are toxic. As such, monitoring in line with the landfill's NPDES permit may fail to fully characterize the waste stream. Monitoring of the leachate stream used for hydraulic fracturing fluid should include the additional parameters included in Pennsylvania Drinking Water standards.

Where chemical parameters present in both Effluent Limitations and Pennsylvania Drinking Water standards do occur, the key parameter that exceeds drinking water standards, TDS, is not broken out into its individual components, some of which may be toxic or carcinogenic. Some chemicals present may be corrosive and may potentially further reduce the already limited life expectancy of cement and steel sealant materials. Clearly, a number of landfill leachate contaminants contribute to the high TDS values currently permitted. Unless all these have been demonstrated to be non-toxic, no consideration should be given to injecting this leachate downhole into the groundwater flow system.

Outstanding Gas Extraction Issues Permitting Contamination of Water Resources

Numerous outstanding issues relative to gas field technology must be addressed and resolved before any consideration is given to adding landfill leachate to hydraulic fracturing fluids. DCSWA erroneously implies that current gas industry practices are tested and inherently safe:

> *"Although this request pertains to use of a pretreated leachate as a substitute for potable water use in the natural gas well development process, no degradation to the environment is anticipated. When the gas wells are drilled, they will be cased through existing water aquifers preventing contact with the hydraulic fracturing liquid. In addition, the hydraulic fracturing occurs at depths approximately 6,000 feet from the surface which is well below the depths of potential water aquifers."*

General Permit Application, Form 20, page 2. Yet this statement directly conflicts with much of the gas industry's own published literature (see, for example, HydroQuest[1, 4-11]). The basic underlying premise advanced in the permit application and in the statement above is that hydraulic fracturing can be conducted safely such that long-term water quality is assured. This is not true, as documented in industry literature and as demonstrated by regional groundwater flow characterizations (Palmer[2]; Myers[3]). Gas, cement, and steel industry literature provides field and model-based documentation confirming that even under the best of conditions, the cement and steel casing materials used to isolate freshwater aquifers will fail in 100 years or less. Moreover, industry insiders admit that the real situation is significantly more dire. For example, while conducting a tour of the TMK IPSCO facility[7] in Wilder, KY on June 1, 2012, Plant Manager Jim Truskot specifically addressed the life expectancy of the steel well casing and tubing products, stating directly and definitively to Stephen Gross of Hudson Highlands Environmental Consulting that such products have:

[7] TMK IPSCO operates 24 production facilities around the world.

> *"No better than a five year life expectancy when used for fracking because of the highly corrosive nature of the fracking chemicals used. After that, it would need to be replaced."*

(Steve Gross, pers. comm. to Paul Rubin)

Obviously, five years or less is an alarmingly shorter life expectancy than that traditionally cited by the gas industry.

Thus, failure of cement sheaths and casing materials used to isolate freshwater aquifers will assuredly occur in less than 100 years, quite possibly in less than the five year life expectancy of steel exposed to corrosive hydraulic fracturing chemicals, and possibly in under a year. When failure this occurs, downhole contaminants (including partially treated landfill leachate) will be under sufficient upward hydraulic pressure to disperse upward into freshwater aquifers, first via failed sealant materials and then via fractures, faults, and improperly plugged and/or abandoned oil and gas wells. See attached illustration by HydroQuest[12]. Palmer[13] (attached) presents a sample calculation detailing the operable hydraulic conditions and factors that will drive contaminants upward to the level of freshwater aquifers when sealant failure occurs and providing a way to estimate the rate of upward flow from the bottom of a cased injection well back to the surface along a micro-annulus formed where the casing has separated from the surrounding cement. Palmer's calculations demonstrate that, given the pressures involved, even tiny apertures in a failed cement sheath can yield a very large amount of contaminant leakage upward into freshwater aquifers.

Lustgarten[14] summarizes documentation of the upward migration of toxic chemicals, including phenol, from Aristech Chemical Corporation's 6,000 foot deep disposal wells to shallow aquifers. These Ohio wells were among the most stringently regulated and monitored in the country. State and federal regulators believed the hazardous material would remain safely isolated from overlying freshwater aquifers for at least 10,000 years. Yet a December 2004 analytical test indicates that phenol reached shallow aquifers in less than 17 years. These findings coincide with the calculations of Palmer[13] and demonstrate that the downhole injection of landfill leachate and hydraulic fracturing fluids will ultimately contaminate freshwater aquifers and waterways along pathways depicted in the attached figure[12].

HydroQuest[1], Palmer[2&13], and Myers[3] all document that gas industry practices will degrade freshwater aquifers and waterways, thereby providing solid rationale against disposing of landfill leachate downhole. As documented by HydroQuest[1&10], and recently in a documentary by Fox[15], a high percentage of casing failure is well known within the gas industry.

Fox[15] cites a number of examples which document the significance of these failures, including an industry document published by Schlumberger in Oilfield Review that showed that Sustained Casing Pressure (i.e., casing failure) occurred in 6 percent of wells immediately upon drilling with 50 percent casing failure within 30 years. Of wells drilled in the Gulf of Mexico, 45 percent of 6,650 wells had well integrity (i.e., leakage) issues. Of wells drilled in the North Sea, UK, 34 percent of 1,600 wells had well integrity (i.e., leakage) issues (information from a conference presented by Archer on Better Well Integrity[15]). Recent PADEP statistics from 2010 to 2012 show well failure/gas leakage rates of between 6.2 and 7.2 percent for newly installed wells. Clearly, these percentages will rise significantly through time as sealant material degrades and both earthquake and repeated episodes of hydraulic fracturing produce ground motion that cracks cement sheaths (see below). Statistics of this nature make it clear that gas and other contaminants will eventually discharge into overlying freshwater aquifers.

Today's gas field technology is not capable of isolating our freshwater aquifers from gas field contaminants. For this reason, there are no hydrofracking procedures which can assure protection of our finite and valuable water resources now or into the future. As a result, toxic and carcinogenic contaminants are already and will continue to move with our groundwater flow systems to our most prolific valley bottom aquifers and rivers. Landfill leachate contaminants, if added to fracturing fluid, pose the same real threat. The enormous magnitude of planned gas well installations (i.e., thousands) will result in large-scale and widespread water contamination that cannot be remediated. As aptly stated by Cyla Allison, Ph.D. of the Eight Rivers Council, WV: *"The damage may not show up for years, the ruination of our water may at first be invisible and in the end irreparable."* (pers. comm. to Paul Rubin)

Herein, HydroQuest provides a synopsis of many of the key hydrogeologic justifications that – by demonstrating the capacity of shale gas development to result in water resource contamination – individually and collectively support a ban on using landfill leachate as an additive to hydraulic fracturing fluids. These same concerns relate directly to any toxic and carcinogenic contaminants injected downhole in gas wells. **Until such time as the gas industry can adequately address the issues raised below, all of which would be compounded by the addition of even more chemical contaminants (i.e., landfill leachate) to hydraulic fracturing fluid, downhole injection of landfill leachate should be prohibited.** While some of the issues below may at first glance appear unrelated to permitting use of landfill leachate in fracturing fluids, it must be recognized that it is unreasonable to issue assorted gas industry related permits in a piecemeal fashion when the cumulative impacts must be addressed all at once in a comprehensive format. All citations are herewith incorporated by reference:

- **The durability and mechanical properties of gas well sealant materials (primarily cement and steel) are not sufficiently advanced such that freshwater aquifers will be safely protected for even as long as 100 years, much less the hundreds of thousands of years required**. Failure of cement sheaths (i.e., the cement designed to seal well casing to bedrock) due to shrinkage, debonding, cracking, corrosion, and other mechanisms is well documented throughout gas industry literature[1, 10, 11]. The aquifers we enjoy today took approximately one million years to form. Absent unnatural alteration from gas drilling activities, these aquifers should be capable of providing potable water to future generations for another one million plus years. Industry documentation establishes that, even under the best of circumstances, cement and steel used to effect zonal isolation may last no more than 100 years and 80 years, respectively – often far less. Recognized sealant failure mechanisms, inclusive of corrosive gases, will degrade any and all "protective" surface casings and ultimately allow contaminant transfer to freshwater aquifers. The addition of landfill leachate to fracking fluids would only increase cumulative contaminant loading and down gradient degradation of freshwater resources;

- **The placement of gas production wells within seismically active regions significantly increases the risk of contaminant dispersal upward into overlying aquifers as ground shaking/motion will damage the integrity of cement seals.** While assessment is warranted to establish acceptable threshold values, appropriate maximum values for Richter magnitude and modified Mercalli shaking-vibration intensity may be on the order of 3.0 (III) or less for both. Philadelphia, PA, for example, recently experienced structural damage to buildings from an earthquake some 200 miles to the southwest. Clearly, if the related earthquake intensity of 4.7 could damage buildings, it could damage the integrity of cement sheaths as well, especially with repeated seismic events through time. Seismic hazard risk must be evaluated over the duration of the life of aquifers – 1,000,000 plus years. Much of Pennsylvania and New York are seismically active. For example, HydroQuest used a USGS model to assess earthquake probability for Howes Cave, NY[2]. Earthquake probabilities for a 5.0 magnitude earthquake were found to be 2-3%, 10-12%, 15-20%, 60-80%, and 80-90% for 100 year, 500 year, 1,000 year, 5,000 year, and 10,000 year time periods respectively. HydroQuest conducted similar assessments for Philadelphia[3&4] and other locations in and near Pennsylvania (e.g., proposed Bittinger injection well situated near the NY/PA border southwest of Jamestown, NY and southeast of Erie, PA; at the Cabot #2 well in Bucks Co., PA approximately midway between Allentown and New Brunswick; and Philadelphia, PA). These analyses examined the probability of earthquakes with a magnitude of greater than 5.0 occurring within a 50 kilometer radius of each location:

Years	Bittinger Well	Bucks Co. PA	Philadelphia PA
100	1-2	4-6	4-6
500	6-8	20-25	15-20
1,000	12-15	30-40	30-40
5,000	50-60	80-90	80-90
10,000	60-80	90-100	90-100

Thus, even if sealant material doesn't fail from the mechanisms discussed in the first bulleted item above, ground shaking from earthquakes will assuredly result in grout failure (e.g., cracking) in a relatively short period of time. Contamination of freshwater resources will follow. Again, the introduction of landfill leachate contaminants will only increase the chemical loading present within deep and shallow groundwater, thereby increasing the risk and magnitude of down gradient water quality degradation;

- **Repeated hydrofracking episodes in gas wells will also result in cracking and failure of cement sheaths that are intended to protect our freshwater aquifers.** Repeated stress from multiple fracking episodes per well, as well as from fracking in nearby wells, has a high likelihood of degrading the integrity of cement sheaths used to isolate freshwater aquifers[1]. As described above, once cracked, cement sheaths will provide a contaminant transport pathway into overlying aquifers;

- **"Protective" setback distances between gas wells and water resources, as proposed in state regulations, do not contemplate groundwater flow or the migration of contaminants in groundwater, and ARE NOT based on any empirically-based data.** The concept of setback distance is inappropriate hydrologically[2]. If groundwater flow was accounted for in statewide regulatory documents, no setback distance could be considered protective of down gradient contaminant receptors. However, since hydraulic fracturing is permitted, it is of some use to provide minimally protective setback distances based upon a sound scientific rationale. To date, HydroQuest has provided the only empirically based value for setback distance[7]. Pumping tests can be used to establish hydraulic interconnections along bedrock fractures[6&8]. Two large-scale aquifer tests were analyzed to conservatively propose potential regulatory setback distances. One test was conducted in the area of Fleischmanns, NY, and the other in Deerpark, NY[9]. Minimum fracture interconnection distances of 2,100 feet and 4,300 feet, respectively were documented. These tests show that homeowner wells connected via bedrock fractures to gas production wells will have a high likelihood of groundwater quality degradation following the failure of well sealant materials in gas producing wells. At a minimum, these analyses establish that regulatory based setback distances from gas production well arrays should be greater than 4,300 feet – as measured from the outer boundary of the horizontal arrays rather than from the vertical borehole[7] – from water bodies (e.g., reservoirs, lakes, rivers, streams, and wetlands), dams, pipelines, homeowner wells, and other vulnerable features. Pennsylvania's Act 13 dictates far smaller setback distances:

- 200 feet from a building or water well (conventional well)
- 500 feet from a building or water well (unconventional well)
- 1,000 feet from existing water wells, surface water intakes, reservoirs or other extraction points (unconventional wells)
- 100 feet (conventional well) or 300 feet (unconventional well) from streams, springs and water bodies

These setback distances (which are measured from the vertical wellbore) lack any scientific foundation whatsoever and are devoid of empirically-based hydrologic support.

- **Upward hydraulic gradients in failed wellbores will provide contaminant pathways.** In some hydrogeologic settings, upward hydraulic gradients will force contaminants into overlying aquifers via failed wellbores. Once failure of protective cement sheaths and casing material occurs, wellbores will function as open pathways allowing migrations of contaminants upwards through naturally protective bedrock layers into freshwater aquifers above. This will result in long-term aquifer contamination by naturally-occurring deep chemicals and gases, toxic hydrofracking chemicals (including any leachate used), and saline water. A crack in a cement sheath of only 0.001 inch is sufficient to allow upward gas migration. As crack width expands, upward fluid migration will follow;

- **Toxic hydraulic fracturing fluid contaminants, when injected into gas wells, move within the deep basin hydrologic flow system that ultimately discharges upward into our major river valleys (i.e., where our major groundwater aquifers are used by large population centers).** Even if dilution of contaminants occurs during flow, population centers are likely to experience low level chronic exposure to toxic chemicals. Contaminants that migrate slowly to down gradient aquifers will continue to discharge pollutants far into the future, persistently exposing people to toxins with the potential to impact their health. Inclusion of landfill leachate in the fracturing fluid will compound this issue. It is not a question of whether contaminants will degrade well water, but rather one of when and in what concentration;

- **Pre-existing networks of fractures, faults, and joints are present in bedrock and are potential pathways for migration of hydraulic fracturing fluids and gas from gas wells to near surface bedrock and unconsolidated overburden aquifers.** Long before development of the petroleum industry, thousands of openings existed in subsurface bedrock from deep gas-bearing rock formations to near surface outcrops. Professor Robert Jacobi[16] at the University of Buffalo has studied the fractures in New York State for over 35 years. His maps plotting fracture locations look like a black mass of lines covering the southern tier of New York. Many of these fractures can be extrapolated into Pennsylvania where less fracture mapping has been conducted. Professor Jacobi has found that methane measurements in soils indicate the presence or absence of vertical fractures. Where no fractures have been detected, the background concentration of methane is about 4 ppm.

Higher concentrations ranging from 40 to 1000^+ ppm have been found over bedrock fractures buried beneath the soil. Thus, a pre-existing system of fractures developed from deep within the bedrock to the land surface is found in potential drilling areas. These natural systems provide pathways for pollutants to migrate to aquifers, surface waters, and to the land surface;

- **The boreholes of old abandoned wells present additional pre-existing pathways for contaminant flow.** Many wells were drilled throughout Pennsylvania before drilling permits were required. Many of these old wells were not properly plugged when abandoned. While programs designed to find and plug old wells exist, their overall effectiveness is unknown because the total number and locations of old abandoned wells are unknown. These old wellbores provide another pathway for pollutants to migrate from nearby drilling to aquifers, surface waters, and to the land surface;

- **The process of hydraulic fracturing increases the density and interconnectivity of the network of potential pathways for fluid transmissivity through bedrock.** In order to fracture the shale and allow natural gas to flow up the wellbore, the hydraulic fracturing process introduces 4 to 5 million gallons of toxic fluid into thin bedrock openings, thereby exerting forces on the order of 10,000 pounds per square inch on the fluids and rock material. When pressure declines in gas producing wells, another hydraulic fracturing treatment is used to revitalize gas flow. Increasing the pressure inside the wellbore and out into geologic formations forces fluid and gas upward through available pathways of least resistance;

- **Individual and repeated hydraulic fracturing episodes provide an extreme hydraulic driving force that propels contaminants outward and upward from gas wells. This exacerbates contaminant transport to down gradient receptors far beyond the time period required for hydraulic fracturing pressures to subside.** As detailed in a recently published paper, Tom Myers[3] used a computer simulation to estimate that it takes approximately 300 days for pressure to return to pre-injection levels following hydraulic fracturing. This general timeframe has been verified by field testing conducted by Oak Ridge National Laboratory about 40 years ago. The high pressures and injection of fluid upsets the hydraulic equilibrium of the fluid-gas-rock system and, according to model simulations, it takes about 3 to 6 years for the system to reach a new equilibrium (Myers[3]), after which contaminant transport continues with regional groundwater flow systems. During hydraulic fracturing periods with variable semi-unstable conditions, pressurized fluids not only rise up the wellbore, but also up any other opening in the vicinity of the well. Myers estimates that contaminant fluids and gas can rise up from fractured wells to aquifers in less than 10 years with continued down gradient transport thereafter. By the time contamination is discovered, aquifers will be irreparably damaged. Remediation of gas field contaminated groundwater is impossible.

Conclusion

Partially “treated” landfill leachate added to hydraulic fracturing fluids will migrate within groundwater flow systems that discharge to valley bottom aquifers and waterways. As such, the cumulative contaminant load incident to Pennsylvanian water supplies will increase the unnecessary public health risks associated with toxic pollutants already permitted and moving within the state’s groundwater flow systems. In my professional opinion, approval of the November 2011 Rolling Hills Landfill General Permit Application is therefore ill-advised. No leachate should be added to hydraulic fracturing fluid unless that leachate 1) meets all federal and state primary and secondary drinking water standards; 2) contains no chemical constituents, even in trace concentrations, that are toxic or carcinogenic; and 3) does not exceed existing background chemical concentrations.

Paul A. Rubin

Referenced testimony may be viewed at: http://hydroquest.com/Hydrofracking/ except where noted:

[1]: HydroQuest DRBC Draft Regulations Comment Report 4-09-11. [Includes April 9, 2011 DRBC Comment Report Figures (Folder includes 21 figures & 2 addenda)]
[2]: Palmer, A.N., 2012, Potential Contaminant Paths from Hydraulic Fracturing of Shale Gas Reservoirs
[3]: Myers, T., 2012, Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers, Ground Water, National Ground Water Association, preprint, accepted for publication February 2012.
[4]: HydroQuest – Schoharie Valley Watch NYS dSGEIS Comment Report 1-10-12. Found at: http://hydroquest.com/Schoharie/ (see folder titled: Earthquake Probability Figures/)
[5]: HydroQuest - Seismic Hazard Expert Fact Sheet Front 9-4-11
[6]: HydroQuest - Seismic Hazard Expert Fact Sheet Back 9-4-11
[7]: HydroQuest – Schoharie Valley Watch NYS dSGEIS Comment Report 1-10-12. Found at: http://hydroquest.com/Schoharie/ (see folder titled: Setback Distance from Gas Well Laterals)
[8]: HydroQuest – Schoharie Valley Watch NYS dSGEIS Comment Report 1-10-12. Found at: http://hydroquest.com/Schoharie/ (see folder titled: Fracture Pumping Test Schematic)
[9]: HydroQuest - Fracture Interconnections (Deerpark)
[10]: HydroQuest - Aquifer Protection Expert Fact Sheet Front 9-2-11
[11]: HydroQuest - Aquifer Protection Expert Fact Sheet Back 9-2-11
[12]: HydroQuest - Graphic Figure – Gas-Contaminant Migration Pathways
[13]: Palmer, A.N., 2011, Upward Leakage through Micro-Annulus of Injection Well (Unpublished calculation and hydrogeologic assessment: 12-10-11); 3 pages.
[14]: Lustgarten, A., 2012, Whiff of Phenol Spells Trouble (Injection Wells: The Hidden Risks of Pumping Waste Underground). ProPublica June 21, 2012, 10 am.
[15]: Fox, J., 2012, The Sky is Pink (an 18-minute documentary video revealing facts behind gas well failures: 6-20-12) [http://vimeo.com/44367635]
[16]: Jacobi, R.D., 2002, Basement faults and seismicity in the Appalachian Basin of New York State in Neotectonics and Seismicity in the Eastern Great Lakes Basin, R. Fakundiny, R. Jacobi, and C. Lewis (eds.): Tectonophysics, v. 353, page 75-113.