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Evaluating the Acceptability of Gas Well Development and Production-Related Wastewater at New York Wastewater Treatment Plants – 5/16/11

I. Introduction

The disputes over the issues of treating the wastewater from the hydrofracking (i.e. hydraulic fracturing) of shale-gas deposits continue to grow. This paper will attempt to put these issues into perspective for treatment plant operators considering whether their plant should accept and treat these wastes.

Horizontal hydrofracking is currently (spring, 2011) not allowed in New York State, a ban that is set to expire later this year. New York continues to allow hydrofracking in vertical wells as long as the total volume of hydrofrack fluid is 80,000 gallons or less. The New York City Department of Environmental Protection (NYCDEP) supports banning the practice of hydrofracking in their drinking-water-supply watersheds, and New York State Department of Environmental Conservation (NYSDEC) has indicated that any such drilling would have to meet site-specific requirements before NYSDEC would allow it in the New York watersheds which have been granted drinking water-related filtration avoidance waivers by USEPA. In the fall of 2010, the United States Environmental Protection Agency (USEPA) held public hearings across the country on the matter of hydrofracking and drew the largest crowd – people who spoke both in favor and against allowing hydrofracking – at the Binghamton, NY meeting. Hydrofracking and horizontal drilling is currently utilized in many southwestern and east of the Rocky Mountain states as well as in Pennsylvania and West Virginia. Based on the demonstrated level of interest and concern, it is certainly appropriate to review the issues connected with treating this unconventional-gas wastewater as it may be permitted very soon in New York State.

The development of the Utica and the Marcellus Shale gas Plays represents both tremendous economic opportunity and a series of water-resource-related challenges in New York State. Concerns range from water-supply protection to the treatment of drilling fluids, flowback fluids, and production fluids. This issue addressed by the white paper is the possible treatment of these latter three types of wastewater in wastewater treatment plants within New York.

This paper examines the issues associated with the ability of New York wastewater treatment plants to deal with gas well development and production wastewater ("GWWW"). It does **not** address the broader issues of the overall environmental acceptability of either vertical or horizontal fracturing, well pad design, the transport of drilling fluids, gas well design, or environmental impacts due to the hydrofracking process.

II. Questions Evaluated

This paper focuses on the following four questions in order to identify and discuss the most important issues which a POTW should consider if it is contemplating accepting gas well development and production related wastewater for treatment.

1. *What Are the Primary federal and State Laws and Regulations Which Can be Used to Control the Treatment and Discharge of Gas Well Development and Production- related Wastewater?*

2. *What is the composition of the wastewater fluids produced in various phases of well drilling, hydrofracking, and gas production?*

3. *Can this wastewater be successfully treated in existing wastewater treatment plants?*

4. *Is there sufficient treatment capacity available for the volume of wastewater produced?*

III. Assumptions

1. That the New York and federal Statutory schemes, particularly the sections listed below, are strong and flexible enough so that no new statutory authority is required to insure that any Gas Well development and Production related wastewater that is accepted for treatment at a WWTP can be regulated sufficiently to protect human health and the environment.

IV. Evaluation

1. *What Are the Primary federal and State Laws and Regulations Which Can be Used to Control the Treatment and Discharge of Gas Well Development and Production-related Wastewater?*

There should be no question that all process fluids must be treated and disposed of according to all applicable state and federal statutes and regulations. These include, at the State level, Article 17 of the New York Environmental Conservation Law (ECL) and its implementing regulations, which are primarily included in 6 NYCRR Parts 750, 703 and Parts 800 et seq. Similarly, applicable federal laws include the Clean Water Act and its implementing regulations, including 40 CFR Parts121-125, 129, 133 and Part 400 et seq.

For municipal wastewater treatment plants, often called "Publically Owned Treatment Works" or "POTWs", one of the most important set of regulations is the federal Industrial Pretreatment Program, whose implementing regulations are at 40 CFR, Part 403. Within New York, USEPA Region 2 implements this program, although NYSDEC and USEPA typically work in partnership to insure that the pretreatment program requirements are included as enforceable conditions within POTW SPDES permits.

While not heavily used in New York, some states, including Ohio, have disposal/injection wells permitted under the Safe Drinking Water Act into which GWWW can be disposed, through injection into the subsurface far below the lowest usable groundwater layer. Because this is not a likely disposal scenario within New York at this time, this option is not discussed further in this paper.[1]

One potential regularly "gap" in New York's existing regulations is the lack of radiological water quality standards for New York waters other than Class A surface waters. The lack of water quality

[1] DEC Division of Mineral Resources website: http://www.dec.ny.gov/energy/29856.html) -- permitted brine injection wells in New York State – Read more: http://www.timesunion.com/local/article/Unrealistic-treatment-plan-for-hydrofracking-water-561146.php#ixzz1HvcUcnas "Of the six injection wells that operate in New York, only one is licensed to accept oil and gas wastewater. It's owned by Lenape Resources Inc., which uses it exclusively for wastewater from its own gas fields."

standards for NORM (Naturally Occurring Radioactive Materials) does not mean that New York can not regulate such discharges. In fact, the State has an entire set of regulatory requirements that apply to radioactive discharges.[2] Among other things, a separate (but integrateable) permit must be obtained prior to discharge of radioactive material to waters of the State.[3] That permit can only be issued if the application clearly contains the following information and demonstrates that the following requirements will be met:

> (1) An identification of each point of discharge and the effluent rate through each discharge point; and
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> (2) An identification of all radionuclides to be discharged, and an estimate of the total activity and average concentration of each radionuclide in the effluent through each discharge point in one year; and
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> (3) A description of the discharge treatment systems, if any, that will be used to minimize the radionuclides in the effluent, how such systems will be maintained, and how wastes produced during treatment will be disposed of; and
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> (4) If a discharge treatment system will be used, an estimate of the total annual activity and average annual concentration of each radionuclide in the effluent both before and after treatment; and
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> (5) Analysis and procedures to ensure that doses are maintained ALARA ["As Low As is Reasonably Achievable", an enforceable State and federal requirement] and within the dose limits [established by these regulations];

Part 380.7 requires that

> Each permittee shall develop, document, and implement a discharge minimization program for maintaining discharges of licensed material to the environment as low as is reasonably achievable (ALARA).

Further more, the permittee must be "at intervals not to exceed 12 months, review the discharge minimization program content and implementation."

With respect to NORM, Part 380, these requirements only apply to NORM which is "processed and concentrated". Thus NYWEA recommends that NYSDEC clarify, in the final SGEIS or elsewhere, whether it has determined that GWWW containing NORM is covered by Part 380.

Another potential regulatory gap is the lack of clear methodology for evaluating the potential toxicity to either the WWTPs biological treatment process or the related receiving waters. However, Appendix 23 to the pending draft SGEIS *NYSDEC – Division of Water, Hydrofracturing Chemical (HFC) Evaluation Requirements for WWTPs* address this concern.

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[2] See, 6 NYCRR Part 380.

[3] See, 6 NYCRR §380.3

2. ***What is the composition of the wastewater fluids produced in various phases of well drilling, hydrofracking, and gas production?***

An understanding of what these different fluids are is the first step in understanding whether a wastewater treatment plant has, or can develop the technology to adequately treat these wastes and protect the land and water resources of New York.

(i) ***Drilling fluids –*** these fluids are the residuals from the drilling of the vertical and horizontal parts of each gas well, prior to being hydrofracked. Normally the vertical part of each well is drilled "on air" which means that little or no drilling additives are used unless drill-cutting circulation problems (mud-caking of the wellbore) develops as the vertical hole is drilled. Once the vertical part of the well is completed a larger drilling rig is required to drill the curved part of the well bore (from vertical to horizontal sections of the well bore) and then the horizontal section which may reach several thousands of feet in length in the gas-bearing part of the bedrock. In this process a drilling "mud" (various additives and a clay-like mud) is circulated down the drilling rods and out through the drill bit – to keep the drill bit cool and to facilitate the transport of bedrock cuttings back to land surface. On the surface the cuttings settle out in the pit and the mud is re-circulated back down the well bore. Once the drilling is complete, the fluids in the pit are usually removed, while the cuttings are either buried in place or removed off-site to a properly designed landfill. The drilling fluids containing various chemistries are collected, transported, and then treated for reuse or properly disposed.

(ii) ***Hydraulic fracturing fluids and flowback fluids –*** the hydrofrack fluids are composed of primarily water (90+ percent), sand (9+ percent) and proprietary chemistry (usually less than 1 percent) of the volume of what goes downhole to accomplish the fracturing of the rock outside the horizontal well casing. The flowback fluid is the spent/used hydrofrack fluid, which is chemically altered during the fracturing process, along with natural (formation) water that exists within or around the rock that is fractured. In Pennsylvania, the volume of the flowback water averages about 10 percent of what is injected downhole during the hydrofracking process (the range of flowback volume is less than 5 percent to greater than 50 percent). This flowback water contains an admixture of chemistry including heavy metals, NORM (especially from the Marcellus Shale), brine (very salty water, 5 or more times saltier than seawater), and residual chemistry which was injected and altered downhole during the hydrofracking process. This flowback water might contain organic chemical constituents, surfactants, and biocides, usually in very small concentrations. It may also contain formation water and any of the natural water constituents described above – heavy metals, NORM and brine (high TDS).

(iii) ***Produced water –*** Once a gas well is drilled and put into production, a watery fluid continues to be collected along with the recovered gas. This fluid initially is a mixture of residual flowback water and natural brine that is found at depth. The transition from flowback to produced water is subtle during the first several months as the well is put into gas production. Following this transition period, the produced water is the natural bedrock formation water which again may contain high TDS, generally from the brine, heavy metals and, possibly, NORM.

Understanding the composition of the latter two types of fluids is perhaps the most challenging issue to wastewater treatment plant operators. There is no standard waste stream produced by all drillers all the time. In fact, even with the above characterization of the three fluid types, each well can have highly variable water quality for each type of fluid. **This must clearly be taken into account while initially considering whether GWWW is acceptable for treatment at any wastewater treatment plant.** Further, if GWWW is acceptable, careful consideration is needed as to what on-going monitoring, stipulations, limits and other requirements should be put in place to insure protection of human health, the environment and the wastewater treatment infrastructure and personnel.

3. *Can this wastewater be successfully treated in existing wastewater treatment plants?*

From a POTW standpoint, to satisfy current pretreatment regulations, the composition of any waste proposed for treatment should be determined prior to a waste treatment plant accepting the stream. Total dissolved solids, i.e. brine, (as typically measured by the indicator parameter TDS) appear to be the dominant feature of GWWW. However, brine does not necessarily pose the biggest challenge[4]. But organics, heavy metals and highly variable NORM concentrations may also present a threat to a WWRP's biological treatment system, particularly if the WWTP doesn't regularly test for them coming into the plant or in the treated discharge.[5]

Elevated TDS levels are not removed in conventional activated sludge (biological treatment) facilities In fact, because biological WWTPs frequently add chemical salts to assist in particular treatment processes, such facilities would likely have difficulty meeting the Pennsylvania discharge limit of 500 mg/L of TDS **[**August 2010 rule**]** even if it does not accept GWWW. New York has established a TDS water quality standard ("WQS") of 500 mg/l which is applicable to most surface waters in the State[6]. Within New York, consistent with EPA guidance and as done in most states, end of the pipe effluent limits designed to protect Water Quality (often termed "Water Quality-based Effluent Limits" or "WQBELs"), are typically established by multiplying the numeric WQS by a mixing factor. The mixing factor, in turn, is a site-specific factor which is intended to be based on critical low flow or critical mixing scenarios in flowing waters, ponds and lakes. Thus, a WWTP that discharges into a small stream in which it is the major source of incoming water during extended dry periods would get an enforceable WQBEL for TDS or 500 mg/L, while another discharging into a large, well mixed river, such as the Niagara River, might get a TDS WQBEL as high as 2,500 mg/L[7].

This does not mean that GWWW wastewater which is high in TDS **(**or NORM**)** cannot be treated however. Existing or new WWTPs that utilize Physical/Chemical treatment processes may have the ability to successfully treat specific GWWW streams. and could be a viable option, as long as the plant understands the composition of the waste, has the ability to treat a specific GWWW, each of which will likely have its own variable physical, chemical, and radiological components.

Biological treatment plants which do not also have an advanced physical/chemical treatment component likely will not be able to accept GWPPP, other than drilling "mud" for treatment unless it has first been

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4 See, *Accommodating a New Straw in the Water: Extracting Natural Gas from the Marcellus Shale in the Susquehanna River Basin* Susquehanna River Basin Commission, February 2009, and NYSDEC, Memoranda *Guidelines for Disposal of Spent Drilling Fluids from Hydrofracturing Well Development to POTWs* and *Disposal of Spent Drilling Fluids to POTWs.* October, December, 2008.

5 See, Draft Supplemental Environmental Impact Statement (DSGEIS); Appendix 13 – Marcellus Radiological Data from Production Brine, and Appendix 22 – Hydro-fracturing Chemical (HFC) Evaluation Requirements for POTWs, October, 2009.

6 See, 6 NYCRR Part 703. Class A-Special waters have a 200 mg/L TDS water quality standard in New York.

7 See, NYSDEC TOGS 1.3.1 *TMDLs and WQBELs* Principles and Conditions "s".

pretreated. To be acceptable for treatment at a typical biological WWYP, the GWWW would likely first have to be pretreated to remove the more difficult components of these waste streams (and properly dispose of the residuals) before delivering the pretreated wastes to a biological WWTP for final treatment and discharge. If this is the case, then it may be more cost effective to simply "pretreat" the GWWW to the point where it can either be re-used for further gas well development or directly discharged to the environment pursuant to the appropriate N/SPDES or Safe Drinking Water Act Disposal (Injection) Well permit.

4. *Is there sufficient treatment capacity available for the volume of wastewater produced?*

While the gas industry is increasing the amount of flowback water that is being recycled/reused, there will still be a considerable volume of these fluids that will require some form of treatment before they can be disposed of, as well as an unknown volume of solid wastes that will require proper land-filling, as these wastes cannot be applied to the land surface the way some wastewater residuals from activated sludge operations are currently being applied.

The Susquehanna River Basin Commission estimated the volume of "frack" wastewater in Pennsylvania to be 28 mgd on an annualized basis[8]. It is likely that, within a few years of New York putting its regulatory system in place and beginning to allow hydrofracking, a similar volume may be produced in New York. Given that most biological WWTPs will not be able to accept GWWW for treatment without significant pretreatment, there is a real possibility within New York that existing treatment capacity may be insufficient as Marcellus Shale production beginning, at least for the next several years.

V. Recommendations

Each WWTP considering accepting GWWW for treatment should:

1. First examine its capabilities versus the types of GWWW that might be delivered for treatment. This capability review should include:
    - Its ability to treat and remove GWWW constituents to the point where it can consistently meet both technology-based and WQBEL limits on its effluent. **While headworks analyses can be used to determine if a particular GWWW profile is one that can be treated, establishing that profile should be done with care because of the inherent variability in flowback water and or produced water from the same wellhead.**
        - ♦ Revisiting, with input from NYSDEC, the assimilative capacity of the receiving water bodies. While the assimilative capacity may have been acceptable for waste dilution in the past, the discharge of a combined effluent which includes GWWW treated wastes may be quite different from standard WWTPs discharges and will need to be carefully considered. Cumulative impacts from several discharges along a particular stream or river might have water-quality impacts further downstream (i.e., drinking water intakes) or might create bio-accumulation problems in the long-term.
    - Confirm that it can protect its treatment plant personnel and equipment from harm/damage related to the GWWW.

[8] See, *Accommodating a New Straw in the Water: Extracting Natural Gas from the Marcellus Shale in the Susquehanna River Basin* Susquehanna River Basin Commission, February 2009.

- To the extent that treatment of GWWW will materially change the nature, constituents and/or the quality of the treatment plant sludge/residuals, whether the WWTP can cost effectively manage and dispose of the sludge/residuals.

2. Confirm that it has the regulatory/statutory/contractual authority to stipulate what type of monitoring data it will require before accepting GWWW and what monitoring requirements it will place on such wastewater if it does accept it for treatment.

    - This review of its authority should include its authority to turn away a load of GWWW "at the WWTP door" if that GWWW does not meet the agreed upon waste profile that has been embodied in the contract or other enforceable document under which the GWWW is being accepted for treatment.

3. Determine the responsibility for testing of the waste water, both prior to acceptance and periodically throughout the time it is being accepted for treatment.

    - Consideration should be given to initially having each load tested by the producer for a range of parameters. Further consideration should be given to having instrumentation on hand at the WWTP to screen each "as delivered" load for some of the same parameters which are both amendable to instantaneous analyses and which serve as good indicators of the GWWW quality.

    - If elevated NORM is a concern, consideration should be given to either requiring each load of GWWW delivered to be first monitored for radioactivity, and perhaps re-monitored at the time it reaches the WWTP.

4. Negotiate a fair price for accepting and treating the GWWW that covers at a minimum the full cost of the treatment and residual disposal (including funds to be applied toward on-going maintenance and replacement of treatment plant components).