

Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges

April 11, 2009

Statement of the Problem

As the natural gas industry responds to increased energy market demands, Pennsylvania has become a hot-bed for gas exploration and development. Drilling and exploration have the potential to create a significant boost to the local economy, as they also provide opportunities for service companies such as earthmoving contractors, drilling companies, pipe and equipment suppliers and maintenance workers. The Commonwealth fully supports these activities and the development of the Marcellus play.

Development of gas wells in the Marcellus play requires the use of large volumes of water for hydraulic fracturing operations. This hydraulic fracturing has the potential to generate a considerable amount of wastewater, both initial flow back water from fracturing and longer term production brines. Estimates from the industry indicate that demand for brine water treatment in Pennsylvania will reach approximately nine Million Gallons per Day (MGD) in 2009, 16 MGD in 2010, and 19 MGD in 2011. Estimates from the Susquehanna River Basin Commission are 20 MGD for that same timeframe. The need for disposal pathways for these wastewaters has resulted in a rethinking of historic practices.

There are many pollutants of concern in the wastewater associated with hydraulic fracturing. The pollutants that are expected to dictate the allocation of the available assimilative capacity of surface waters are Total Dissolved Solids (TDS), sulfates and chlorides. Many of the areas where the drilling for natural gas is proposed have a history of mining activity and are affected by Abandoned Mine Drainage (AMD). Brine and fracturing wastewater have high concentrations of dissolved solids, and considering the already elevated levels of dissolved solids in the AMD-affected surface waters, the need to stringently control these dissolved solids likely will prevent other pollutants from exceeding water quality standards on a cumulative basis.

Background

TDS are a measurement of inorganic salts, organic matter and other dissolved materials in water. They can be naturally present in water or the result of mining or some industrial or municipal treatment of water. TDS contain minerals and organic molecules that provide benefits such as nutrients, but also may contain contaminants such as toxic metals and organic pollutants. The concentration and composition of TDS in natural waters is determined by the geology of the drainage, atmospheric precipitation and the water balance (evaporation/precipitation).

TDS cause toxicity through increases in salinity, changes in the ionic composition of the water, and toxicity of individual ions. The composition of specific ions determines toxicity of elevated TDS in natural waters. Also, as the hardness increases, TDS toxicity

may decrease. The major concern associated with high TDS concentrations relates to direct effects of increased salinity on the health of aquatic organisms.

Water quality analyses performed for the major watersheds of the Commonwealth to date show that many of the rivers and streams of Pennsylvania have a very limited ability to assimilate additional TDS, sulfates and chlorides because of elevated levels from historic practices. This phenomenon was most evident during the fall of 2008, when actual water quality issues related to these parameters emerged in the Monongahela River basin. While river flows reached seasonal lows, the concentrations of TDS and sulfates in the river increased to historic highs, exceeding the water quality standards at all of the 17 Potable Water Supply (PWS) intakes from the border with West Virginia to Pittsburgh. Violations of water quality standards for TDS and Sulfate persisted in the river through November and December of 2008. Elevated chloride levels were observed on at least one major tributary – South Fork Tenmile Creek – and for the first time, elevated bromide levels were observed in these streams.

During this period, several environmental agencies performed studies on the effects of TDS, sulfate and chloride discharges on the Monongahela and some of its tributaries. A study¹ conducted by the Environmental Protection Agency (EPA), the Pennsylvania Department of Environmental Protection (DEP) and the Allegheny County Health Department (ACHD) also identified bromides as a key parameter of concern in these waters. The study concluded that a high percentage of the Disinfection By-Products (DBPs) being formed in the drinking water systems were brominated DBPs, which pose a greater health risk than chlorinated DBPs; and, subsequent formation of brominated DBPs increases overall DBP concentrations, specifically trihalomethanes (THMs). The study also concluded that based on the speciation there appears to be a strong correlation between THM formation and elevated source water bromide concentrations in the Monongahela River.

Several studies^{2,3} on the potential impacts to aquatic life from these large TDS discharges also were conducted on major tributaries flowing into the Monongahela River in Greene County, Pennsylvania. Each of these studies documents the adverse effects of discharges of TDS, sulfates and chlorides on the aquatic communities in these receiving streams. The former concludes that there is a high abundance of halophilic organisms (salt-loving) downstream from the discharges of TDS and chlorides and a clear transition of fresh water organisms to brackish water organisms in the receiving stream from points above the discharge to points below. It is evident from this study that increases in salinity have caused a shift in biotic communities.

The Monongahela River watershed is being adversely impacted by TDS discharges and many points in the watershed are already impaired, with TDS, sulfates and chlorides as

¹ Trihalomethane Speciation And The Relationship To Elevated Total Dissolved Solid Concentrations Affecting Drinking Water Quality At Systems Utilizing The Monongahela River As A Primary Source During The 3rd And 4th Quarters Of 2008, PA-DEP, February 2009.

² Cause and Effect Survey, South Fork Tenmile Creek, PA-DEP, February 2009.

³ Aquatic Survey of Lower Dunkard Creek, PA-DEP, October – November 2008.

the cause. However, the Monongahela is not an anomalous situation. Recent reports on the water quality of the Beaver and Conemaugh Rivers in southwestern Pennsylvania also show upward trends in TDS concentrations. In addition, watershed analyses conducted by DEP of the West Branch of the Susquehanna River watershed has documented that it is also severely limited in the capacity to assimilate new loads of TDS and sulfates.

The surveys, analyses and studies referenced establish that the extent of existing and potential pollution from TDS, sulfates and chlorides is widespread. DEP is constrained from approving any significant portion of the pending proposals and applications for new sources⁴ of discharge high-TDS wastewater, including sulfates and chlorides, and still protect the quality of Pennsylvania's streams. In addition, it is also clear that in many watersheds, existing discharges of TDS, sulfates and chlorides will have to be reduced and limited, to assure that watershed restoration is accomplished and that the purity of our streams is protected.

The Commonwealth's Clean Streams Law (P.L. 1987, No. 394) delegates the authority to preserve and improve the purity of its waters and develop remedies to purify those waters currently polluted to DEP, in the form of adopting rules and regulations as necessary to accomplish these tasks. This paper outlines the foundation and scientific rationale for promulgation of such rules and regulations necessary to address the existing and potential pollution of Pennsylvania's waters from large sources of TDS, sulfates and chlorides. That approach will rely upon the basic water quality management premise that discharges of these pollutants must be controlled through permit limitations required by the more stringent of treatment-based or water quality-based standards.

Pennsylvania's Water Quality Standards for TDS and Chlorides

Title 25 regulations currently have a numeric criterion for Osmotic Pressure (OP) in Chapter 93 that is supposed to provide protection to aquatic life from TDS. But OP effects can vary from effluent to effluent, depending on the actual constituents present in the discharge/stream matrix. DEP has evaluated these parameters with respect to the fish and aquatic uses, specifically their toxicity to these organisms, and has begun development of instream numeric criteria (concentrations) for TDS and chlorides that are designed to protect the aquatic life use, which may be applied in individual permitting decisions for the specific local points of discharge.

In addition to protection of aquatic life uses, TDS and chlorides are secondary contaminants under Pennsylvania's safe drinking water program. Adverse affects of secondary contaminants are usually related to taste and odor. Although water with TDS and chloride levels greater than the standards may have the potential to cause health affects, no reliable data exist currently that support this and no health-based (primary contaminant) standard will be proposed at this time. Pennsylvania's water quality

⁴ As used in this strategy the term "new sources" or "New Sources" shall have a generic meaning to include, but not be limited to, a new source, a new discharge, an additional discharge, an expanded discharge and an increased discharge. The term as used is not intended, nor shall it be construed, to refer to the regulatory definition of the term as set forth in 40 CFR §122.2 and 92 Pa Code § 92.1.

standards address this designated use through numeric criteria. At any potable water supply (PWS) surface intake, the criteria for TDS (500 mg/L as a monthly average value), sulfates (250 mg/l as a maximum value) and chlorides (250 mg/L as a maximum value) apply. The effects of the cumulative loads from all upstream discharges of TDS, sulfates and chlorides must be evaluated at each PWS intake.

Technology-based Discharge Standards

Methods that have historically been used to control wastewater discharges containing TDS, sulfates and chlorides in Pennsylvania have been limited to simple dilution, i.e. adjusting discharge flow rates in proportion to stream flows on any given day. In addition, federal Effluent Guidelines and Standards (ELGs) for the industrial categories of greatest concern to Pennsylvania do not address TDS, sulfates or chlorides. Therefore, to develop a treatment-based water quality management approach that properly addresses these pollutants, DEP will rely on the authority it has been given under the Pennsylvania Clean Streams Law. This approach must be tailored to specific categories of industrial discharges of greatest concern, and is described below.

Permitting Strategy

As with the current NPDES permitting procedure, final effluent limitations are to be set at the more stringent of the effluent standard and the Water Quality-based effluent Limitation (WQBEL). However, a strategy for permitting these discharges also must involve an allocation strategy to address those situations in which multiple discharges cause or contribute to downstream water quality standards violations, even if only predicted through modeling. An allocation strategy is the plan to allocate the assimilative capacity of the watershed (the acceptable loading in lbs/d of TDS and/or chlorides) among multiple sources.

The goal of this permitting strategy is that by January 1, 2011, new sources of High-TDS wastewaters will be prohibited from Pennsylvania's waters. To achieve this goal, the Department proposes to amend Chapter 95 – relating to wastewater treatment requirements – to establish new effluent standards. In addition, to assuring the current protection afforded to the use of streams as Potable Water Supplies, the Department proposes to develop new numeric water quality criteria for TDS and Chlorides for the protection of all designated stream uses in Chapter 93 and to amend Chapter 93 – Water Quality Standards – to include these criteria. Changes to both Chapters 93 and 95 necessary to accomplish these tasks will be submitted to the Environmental Quality Board (EQB) as proposed rulemaking in the next few months and will be completed prior to January of 2011.

The Department's interim strategy over the next two years for permitting discharges of new sources of High-TDS wastewaters will focus on those new sources that have the greatest potential to adversely affect the quality of Pennsylvania's receiving streams. Currently, those sources are wastewaters generated from fracturing and production of oil and gas wells in the Marcellus Shale formation.

During the interim period between April 1, 2009 and January 1, 2011, the interim strategy will be to maximize the use of available assimilative capacity of receiving streams where that is feasible. Effective January 1, 2011, all new sources of high-TDS wastewater will be subject to new regulations as described above. Specifically, DEP's interim permitting strategy is as follows:

(1) New Sources of High-TDS Wastewater

- (a) DEP will not issue permits for new sources of High-TDS industrial waste unless the applicant proposes to install adequate treatment for TDS on or before January of 2011.
 - (b) For new sources of High-TDS industrial waste proposing treatment for TDS, an allocation of available assimilative capacity may be authorized (see subsections (i) and (ii) below). Such an allocation will terminate on January 1, 2011. Beyond that date, the discharge of TDS will be limited to the more stringent of the effluent standards established under regulation as described above. Wastewaters discharged from these facilities also must meet any other applicable treatment standards and requirements.
 - (i) Where analysis of a watershed determines that sufficient assimilative capacity exists to allow short-term discharges of TDS and other pollutants of concern from oil and gas wastewaters, such capacity will be allocated as allowable maximum daily mass loads, and permit limitations will be set using these allocations. Actual allocation strategies may vary by watershed, based on the specific characteristics and existing water quality of each watershed.
 - (ii) Where analysis of a watershed determines that sufficient assimilative capacity does not exist to allow new discharges of TDS or any other pollutants of concern from new sources, meaning that the receiving stream is impaired, federal regulations prohibit discharges from new sources of pollutants that cause or contribute to the impairment. In these cases, new sources can only be authorized if permits limits are set equal to the numeric water quality criteria for the pollutant(s) of concern.
 - (c) Pretreatment Facilities – New Pretreatment facilities that accept new sources of High-TDS wastewaters and discharge pretreated wastewater to a Publicly Owned Treatment Works (POTW) will be subject to local limits established by the receiving POTW, in accordance with (2)(b) below.
- (2) Existing Facilities - DEP will permit the continued treatment and disposal of existing sources of High-TDS wastewaters at existing permitted facilities as follows:
- (a) Existing industrial sources of High-TDS wastewaters will be able to continue to operate under their existing permit limits and conditions until such time as they

propose to expand or to increase their existing daily discharge load of any pollutant of concern⁵. At that point, such a facility would be subject to the following schedule:

- (i) Prior to January 1, 2011, the New Sources strategy in (1)(b) above.
 - (ii) After January 1, 2011, the more stringent of the applicable effluent standards or water quality based effluent limitations.
- (b) POTWs –POTWs currently accepting through an approved permit, or planning to accept High-TDS wastewaters, an allocation of available assimilative capacity may be authorized, where analysis of a watershed determines that sufficient assimilative capacity exists to allow short-term discharges of TDS and other pollutants of concern from these wastewaters (see (1)(b) above).
- (i) Such an allocation would terminate on January 1, 2011. Beyond that date, the discharge will be limited to the more stringent of the applicable effluent standards.
 - (ii) Wastewaters discharged from these facilities also must meet any other applicable treatment requirements.
 - (iii) These facilities must obtain EPA approval of a Pretreatment Program and install appropriate pre-treatment facilities prior to January 1, 2011.
- (c) Pretreatment Facilities – Existing sources of High-TDS wastewaters will be able to continue to operate under their existing permit limits and conditions until such time as they propose to expand their existing daily discharge load of any pollutant of concern. At that point, such a facility would be subject to local limits established by the receiving POTW, in accordance with (2)(b) above.

⁵ Note that monitoring and reporting requirements for TDS will likely be added to the permit to track existing discharge loads.

Oil & Gas Well Wastewaters

To support development of the Marcellus Shale formation, acceptable wastewater treatment and disposal pathways must be clearly defined. DEP staff have met with numerous industry representatives seeking to participate in the wastewater treatment and disposal market related to Marcellus Shale development. Some of the proposed treatment and disposal pathways do not involve the discharge of high-TDS wastewaters (non-discharge options). Other proposals involve the partial removal of TDS from wastewater (low-discharge options). Both non-discharge and low-discharge options may be designed to maximize reuse of wastewater, and production of a viable end product from the recovered solids (e.g. road salt). Still, proper treatment and disposal of these wastewaters via surface discharge will be necessary.

Methods that have historically been used to treat and discharge brine wastewater in the Commonwealth involve the use of Centralized Waste Treatment (CWT) facilities, Publicly-owned Treatment Works (POTWs), or a combination of the two (Pretreatment). Numerous additional facilities using these same treatment options have been proposed to address brine wastewater discharges and for which applications are pending. The challenge is that nearly all of the existing and proposed facilities do not treat the main pollutants of concern – these are passed through the treatment system with little or no reduction in pollutant loading – as TDS and chlorides are not removed using current treatment methods.

EPA Headquarters recommends that POTWs not accept this type of wastewater due to the potential for “pass through” or “interference.” (See 40 CFR Part 403.5.) However, there is no prohibition (no pretreatment standards) for transporting oil and gas wastewaters to a POTW. In these instances, existing industrial pretreatment programs must still comply with the general pretreatment standards in 40 CFR Part 403. All non-domestic discharges to publicly owned treatment works (POTWs) (“indirect dischargers”), even those not subject to categorical pretreatment standards, are subject to general pretreatment standards, including a prohibition on discharges causing “pass through” or “interference.” All POTWs with approved pretreatment programs must develop local limits to implement the general pretreatment standards. All other POTWs must develop such local limits where pollutants have contributed (or will contribute) to “pass through” or “interference” and where water quality violations are likely to recur.

Discharges from a CWT facility treating gas extraction produced waters are subject to the effluent limitations and pretreatment standards established under 40 CFR Part 437. However, additional limits and conditions are needed to address pollutants that were not considered in developing the federal CWT Effluent Guidelines and Standards (ELGs). For example, there is the potential for several pollutants to be found in produced waters (e.g., TDS, radionuclides, chlorides) that were not regulated or considered in the development of the CWT ELGs.

Consequently, for a CWT facility that accepts produced waters or other waste from oil and gas extraction facilities, the permitting authority (DEP) needs to develop technology-based effluent limits to address those pollutants not considered or regulated by the CWT Effluent Guidelines and incorporate these limits in the facility's NPDES permit. This process requires a great deal of individual professional judgment, takes a great deal of time, and does not result in a level playing field for all CWTs with regard to required treatment levels.

In addition, permits must also contain limitations necessary to assure that the receiving stream's designated water uses are protected. Designated uses in Pennsylvania include aquatic life, water supply and recreation. These uses are protected with narrative and, for some parameters, numeric criteria. Where numeric criteria exist, permit limitations can be calculated to assure that these criteria are met.

When developing this wastewater management approach, DEP considered the need to protect the aquatic life use, the industrial water use, and the potable water supply use. Collectively, these specific uses comprise what DEP believes to be the most sensitive of the possible water quality constraints on any discharge or combination of discharges of TDS, sulfates and chlorides. In addition, DEP proposes to require an effluent standard for TDS, sulfate and chloride discharges. Each discharge would have to meet the more stringent of the water quality-based limitations or the effluent standards.

DEP proposes to establish such an effluent standard through development of a revision to the regulations at Chapter 95. The following is a general description of the proposed regulation change.

- Add effluent standards for Oil and Gas wastewaters of 500 mg/L for TDS, 250 mg/L for sulfates and 250 mg/L for chlorides as daily maxima. In addition, add effluent standards of 10 mg/L for Total Barium and Total Strontium, as these pollutants are also prevalent in Marcellus waste waters.
- POTWs that accept wastewater from this Category will be required to have an EPA-approved pretreatment program, which addresses TDS through local limits on these sources and at the above standards.

Existing wastewater treatment facilities, industrial waste and sewage, would be given two years to come into compliance with these new requirements, if their existing discharge does not comply with these standards.

Mining Wastewaters

As stated above, this strategy applies primarily to new sources of High-TDS wastewaters. While there are many existing sources of mine discharges in the Commonwealth, water discharged from existing mine sites generally falls within a few discrete categories, which are described below.

(1) New Sources (New Mines)

It is not possible to predict what the concentrations of TDS, sulfates and chlorides will be in mine water and sampling currently is typically not required for TDS, sulfates and chlorides. Therefore, for new mine sources (discharges) authorized after the implementation of this policy, permittees must sample the discharge for TDS, Sulfates and Chlorides on a monthly basis for a period of one (1) year and submit the results within 30 days of the anniversary date of the discharge authorization. If the discharge shows or is known to contain levels of TDS/Sulfates/chlorides that would indicate that the discharge is a High-TDS discharge, that discharge will be subject to the standards established by this strategy as set forth above under "Permitting Strategy, (1) New Sources of High-TDS Wastewater."

(2) Existing Sources

(a) Abandoned Mines

Under this strategy no action will be required to reduce TDS, sulfates and chlorides at Abandoned Mine Discharge (AMD) sites (which includes mine sites where bonds have been forfeited) for the following reasons. There is no responsible party for abandoned mine sites and, therefore, no party with legal responsibility for the pollutant discharge emanating from the sites. Sulfate, chloride and TDS loading from abandoned mines are not amenable to being managed through a discharge permit because there is no responsible party available to hold a permit. Due to geologic and hydrogeologic reasons it is not possible to relocate the discharge or cause the generation of mine drainage to cease. Abandoned mines typically have no funds associated with them (some discharges are being treated by volunteers) to address mine drainage treatment or only a finite amount of money available for this purpose.

The above facts demonstrate that imposition of a TDS, sulfates and chloride standard and permit, for abandoned discharges that currently are being treated to some degree, would be futile and counter productive to the AMD remediation strategy and this TDS control strategy. Costs would increase exponentially, likely resulting in abandonment of the existing treatment due to the lack of funds, and fewer treatment facilities would be constructed for abandoned discharges that are currently not treated.

(b) Funded Forfeited Mines

Under this strategy no action will be required to reduce TDS, sulfates and chlorides at former mines where the responsible party no longer exists but some money is available to treat the discharge. These are not new sources and subjecting these sites to new effluent limits also would be contrary to the mine drainage control strategy and to this TDS control strategy. The available money comes from bonds or trust funds posted for the operation by the now defunct

operator. The amount of money available for continued treatment at these sites varies, but the best funded are based on the cost of perpetually treating standard AMD parameters to meet the mine sites former permitted effluent limits. Imposing new requirements to treat for TDS, sulfates and chlorides would result in an accelerated depletion of the full cost bond funds. The net result would be no treatment once the funds were exhausted and a discharge of metals and acidity as well as the TDS.

(c) Inactive Mines Treating Post-mining Discharges

Under this strategy no action will be required to reduce TDS, sulfates and chlorides at mine sites where reclamation has been completed except for the treatment of the post-mining discharge. These mines were permitted, bonded and mined based on the water being treated to meet the sites former permitted effluent limits. The mines no longer provide a source of revenue to generate additional funding to pay for treatment to reduce TDS, sulfates and chlorides. Due to geologic and hydrogeologic reasons it is not possible to relocate the discharge or to stop the generation of mine drainage.

(d) Existing Active Mines Discharging Storm Water Runoff

Many active mines are equivalent to a construction site as the discharge is composed of storm water runoff and typically does not contain high TDS, sulfates and chlorides. Accordingly, all mining sites with storm water runoff only NPDES permits are beyond the scope of this strategy.

(e) Active Mines Discharging More Than Storm Water Runoff

The final group of existing mine discharges consists of those at permitted mines that include more than storm water runoff. These mines were designed and planned based on the current ELG or WQBEL. They are typically transitory in nature and will cease discharging when the mine is closed and reclaimed. DEP will allow existing active mines discharging "high TDS" to continue to do so under their permit as follows:

- (i) Mining permits typically do not contain limits or monitoring for TDS, sulfates and chlorides. Beginning no later than October 1, 2009 the permittee of an existing mine is to sample the discharge for TDS, sulfates and chlorides on a monthly basis for a period of one year and immediately thereafter submit the results to DEP. Permittees that are discharging "high TDS," as shown by the one year of monitoring data, will be subject to the strategy set forth in paragraph (1) above. Permittees which implement measures to reduce their discharges of TDS in order to be below the "high TDS" threshold will be able to continue to discharge at that lower amount.

- (ii) Existing active mines discharging "high TDS" will be able to continue to operate under their existing permit limits until such time as their NPDES permit is to be reissued or they propose to increase their existing daily discharge load for TDS, sulfates or chlorides. At that time the permittee will develop a compliance schedule to be implemented over the next five years to meet the more stringent of the applicable effluent standards or water quality based effluent limits.

Other High TDS Wastewater Discharges

Other sources of high-TDS wastewaters, including sulfates and chlorides, with existing ELGs should continue to use those ELGs as technology-based limitations. These discharges may still be subject to any water quality-based effluent limitations should those be more stringent.

For additional information, please contact the Bureau of Water Standards and Facility Regulation at 717-787-5017.