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Summary of Comments by Clean Water Action to the Environmental Quality Board (EQB) on the Triennial Review of Water Quality Standards; Chloride Criteria
August 21, 2012

Clean Water Action supports implementation of the proposed water quality standard for chlorides as contained in the Triennial Review of Water Quality Standards. There is a strong need for the chloride standard to be implemented due to existing discharges of chloride in several watersheds in the state. As recently as June, 2012, multiple wastewater treatment plants have reported to DEP discharges of chlorides exceeding 70,000 mg/L, several times saltier than seawater.

DEP's current draft proposal to utilize the chloride standard developed in Iowa in 2009 improves upon DEP's proposal in 2010 which was based on EPA's standard developed in 1988. The Iowa standard incorporates both more recent scientific knowledge, and in particular recognizes the relationship between chloride toxicity, the presence of sulfates, and hardness.

Clean Water Action recommends that EQB support the adoption of a safety factor for the chronic criteria prior to finalization of the standard in order to ensure that all uses will be protected. The safety factor is necessary due to lack of several factors not accounted for in the Iowa standard. Most notably, the Iowa standard is based solely on the toxicity of chlorides of sodium, while there is considerable evidence that chlorides of potassium, magnesium, and calcium have a greater toxic effect. In addition, a safety factor should encompass the current scientific uncertainty of the chronic effects of chloride on aquatic life.

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Re: Comments by Clean Water Action on the Triennial Review of Water Quality Standards; Chloride Criteria

Dear Environmental Quality Board members,

Thank you for the opportunity to comment on the proposed revisions to Chapter 93 of the Pennsylvania Code noticed in the July 7, 2012 edition of the Pennsylvania Bulletin (42 Pa.B. 4367). The University of Pittsburgh Environmental Law Clinic respectfully submits these comments on behalf of our client, Clean Water Action, along with an expert report by the Stroud Water Research Center. Clean Water Action supports the proposed criteria for chloride, but recommends the inclusion of a margin of safety for the chronic chloride criterion based on the current state of scientific and technical knowledge as fully described in the attached Review of the 2012 Proposed Water Quality Criteria for Chloride for the Protection of Aquatic Life In Pennsylvania by the Stroud Water Research Center.[1] In addition, as anticipated by the triennial review process, Clean Water Action fully expects that any future studies related to the acute or chronic aquatic life impacts of chloride will be incorporated into the chloride criterion every three years. Clean Water Action commends the Environmental Quality Board (the "EQB" or the "Board") for recognizing the need to adopt revised water quality criteria for chloride that will protect aquatic life in Pennsylvania, and strongly supports the amendment of Chapter 93 to achieve that purpose.

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[1] We incorporate the Stroud Review, attached to this comment as Attachment A, into this comment in its

I. An Immediate Need for a Chloride Water Quality Criterion Exists in Pennsylvania.

Currently, Pennsylvania's only existing numeric criteria for chloride protects a single use: potable water supply uses *at the point of a water supply intake.* Aquatic life uses between water supply intakes or in waters of the Commonwealth without a water supply intake are unprotected without a thorough investigation of potential violations of Pennsylvania's antidegradation policy. The lack of a numeric criterion to protect aquatic life uses of Pennsylvania's waters has resulted in surface water discharges of chloride in levels that far exceed the typical chloride concentration of seawater at 19,000 mg/l.[2]

In June of 2012, a single wastewater discharger reported a maximum daily effluent concentration of 73,726 mg/l of chloride into McKee Run.[3] The same discharger reported an average monthly concentration of 73,202 mg/l of chloride discharged to McKee Run.[4] Similarly, in June of 2012, Blacklick Creek experienced a maximum daily discharge of 78,179 mg/l of chloride and an average monthly discharge of 74,411 mg/l of chloride.[5] These discharge concentrations of chloride are unlimited in each respective NPDES permit because of the extraordinary distance from the point of discharge to the point of intake for downstream water supplies. In one recent Response to Public Comments on a draft NPDES permit, the Department stated that "[t]he Department recognizes the toxic effects of Chloride on aquatic life. Presently, the Department evaluates and controls the toxic effects of chloride indirectly through application of a water quality criterion for osmotic pressure."[6] Numeric criteria addressing the aquatic life impacts of chloride is necessary to allow permit writers to evaluate and control the toxic effects of chloride directly.

II. Adoption of the Iowa Criteria with a Margin of Safety fulfills DEP's Statutory Obligations Given the Immediate Need for a Numeric Aquatic Life Criterion.

The Board must exercise sound judgment and discretion when implementing a declaration of policy, or when adopting rules and regulations. 35 P.S. § 691.5(a). When proposing water quality criteria, the Board must consider the following five factors:

(1) Water quality management and pollution control in the watershed as a whole;
(2) The present and possible future uses of particular waters;

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[2] 2010 Stroud Report at 2, appended as Attachment B.
[3] June 2012 Discharge Monitoring Report of Hart Resource Technologies, Inc., NPDES Permit No. PA 0095443, *available at* http://www.ahs.dep.state.pa.us/NRS/ (PA DEP NPDES eDMR Data System).
[4] *Id.*
[5] June 2012 Discharge Monitoring Report of Pennsylvania Brine Treatment, Inc., NPDES Permit No. PA 0095273, *available at* http://www.ahs.dep.state.pa.us/NRS/ (PA DEP NPDES eDMR Data System).
[6] Brockway Area Sewer Authority, Borough of Brockway, Jefferson County, NPDES Permit No. PA0028428 Fact Sheet, Addendum – Fourth Draft, page 11, attached as Attachment C.

(3) The feasibility of combined or joint treatment facilities;
(4) **The state of scientific and technological knowledge;**
(5) The immediate and long-range economic impact upon the Commonwealth and its citizens.

Id (emphasis added). The Department's regulations acknowledge that it may develop criteria for any substance not already included in the table of specific water quality criteria and associated critical uses that "is determined to be inimical or injurious to existing or designated water uses using the best available scientific information, as determined by the Department." 25 Pa. Code § 93.7(c).

The criteria development standards used by the federal agency in its Water Quality Handbook to ensure that a sound scientific rationale exists for the federal minimum criteria are also used during Pennsylvania's development of criteria.[7] Under the federal scheme, chloride is a nonconventional pollutant because it is neither a conventional nor a toxic pollutant. 33 U.S.C. § 1311(b)(2)(F). Chapter 3.4.2 of the Water Quality Handbook is entitled *Criteria for Nonconventional Pollutants*. It states in part that:

> Criteria requirements applicable to toxicants that are not priority toxic pollutants (e.g. ammonia and chlorine), are specified in the 1983 Water Quality Standards Regulation (see 40 CFR 131.11). Under these requirements, States must adopt criteria based on sound scientific rationale that cover sufficient parameters to protect designated uses.

The relevant federal regulation, which embodies the policy stated in the Handbook, provides:

> States must adopt those water quality criteria that protect the designated use. Such **criteria must be based on sound scientific rationale** and **must contain sufficient parameters or constituents to protect the designated use**. For waters with multiple use designations, the criteria shall support the most sensitive use.

40 C.F.R. § 131.11 (emphasis added). Federal regulations and the 1988 EPA Criteria documents specifically authorize states to use a range of scientifically defensible methods in establishing water quality criteria, including the adjustment of national criteria to reflect site-specific information.[8]

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[7] Phone conversation with DEP Attorney Tom Barron (Attorney, Div. of Water Quality Standards, Pennsylvania Dept. of Environmental Protection) (Monday, June 7 2010). Mr. Barron said that when the Commonwealth proposes water quality criteria that are identical to the federal guideline criteria, then the relevant federal standards apply.
[8] 40 C.F.R. § 131.11(b); EPA, 1988 *Ambient Water Quality Criteria for Chloride* – 1988, EPA 440/5-88-001, pg 009.

In 1988, EPA published a Section 304(a) criteria document entitled "Ambient Water Quality Criteria for Chloride – 1988." EPA 440-5-88-001. Under these federal criteria, levels of chloride at a minimum should be kept to an acute level of 860 mg/l and to a chronic level of 230 mg/l. EPA's water quality criteria represent the floor for state requirements. The 1988 EPA Criteria recognize, however, that "in many situations States might want to adjust water quality criteria developed under Section 304 to reflect local environmental conditions and human exposure patterns before incorporation into quality standards."[9]

A. The current state of science supports the Iowa Criteria with the addition of a safety factor for the chronic criterion.

Since 1988, the science on chloride toxicity has changed dramatically. Significant flaws are now apparent in the 1988 EPA Criteria studies and more recent studies have been published in peer-reviewed literature that the Board must consider in determining the appropriate chloride criteria for Pennsylvania. As the attached Stroud Report demonstrates, EPA did not have the benefit of new toxicity studies or criteria development methodologies and did not adequately appreciate the need for safety factors for both acute and chronic criteria. In addition, EPA did not account for the synergistic effects of hardness, sulfate levels, or temperature, despite their well-documented influence on chloride toxicity.

Moreover, EPA repeatedly has admitted the shortcomings of the 1988 EPA Criteria. In 2003, the EPA published a document entitled "Draft Strategy: Proposed Revisions to the 'Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.'" That document declares the need to rethink the 1985 water quality criteria development guidelines that were used to arrive at the 1988 EPA Criteria.[10] Recently, EPA worked with Iowa to assist in the development of better chloride criteria that more adequately protect aquatic life. In 2009, Charles Stephan, the scientist responsible for reviewing the chloride toxicology studies for EPA in 1985 and 1988, admitted that some of the studies used to develop the 1988 EPA Criteria are no longer reliable.[11] The development of the 2009 Iowa Criteria reflects scientific knowledge that chloride toxicity to aquatic life changes depending on the presence of specific ions such as water hardness and sulfate concentrations. The attached Stroud Report details the state of the science on chloride toxicity and concludes the following:

> The chloride criteria proposed by the EQB on July 7, 2012 are an improvement over the criteria that were proposed in 2010. Specifically, the proposed criteria incorporate characteristics of the receiving waters that affect chloride toxicity. However, as was

[9] EPA, 1988 *Ambient Water Quality Criteria for Chloride – 1988*, EPA 440/5-88-001.

[10] EPA, *Draft Strategy: Proposed Revisions to the 'Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses'* (2003), *available at* http://www.epa.gov/waterscience/criteria/aqlife/.

[11] 2010 Stroud Report at 10.

> highlighted in our previous review, the newly proposed criteria based on the Iowa standard may not be protective of aquatic life in Commonwealth streams, rivers, and lakes. [] ...the EQB may address uncertainty [by] includ[ing] a safety factor in the derivation of the chronic criteria.

The Stroud Report acknowledges the current state of the science supports the Iowa chloride criteria and provides a mechanism to ensure that adoption of the Iowa criteria will not result in impairment of aquatic life uses of *Pennsylvania* waters. In adopting the Iowa chloride criteria with a safety factor for the chronic chloride criterion, Pennsylvania will be adopting criteria based on sound scientific rationale and accounting for local conditions to protect the aquatic life uses of our waterways.

B. The Iowa criteria, while more stringent than the federal guidelines, addresses many of the flaws in the 1988 Criteria.

Pennsylvania will not be the first state to recognize the need to exceed the federal standard. Subsequent to the release of the EPA 1988 EPA Criteria, several states adopted state-specific chloride criteria that exceed EPA's recommended minimum. Wisconsin established acute and chronic chloride criteria of 757 and 395 mg/l, respectively, to protect fish and aquatic life. Wis. Admin. Code NR § 105.06. Illinois has a total chloride criterion of 500 mg/l. Ill. Admin. Code, tit. 35 § 302.208(f) (2009).

Iowa provides an example of a state working with the EPA on departing from the 1988 EPA Criteria and instead adopting different and more protective criteria that take into consideration the state's particular needs. Iowa's Department of Natural Resources (IDNR) revised its water quality criteria for chloride in 2009. Prior to its rulemaking, The IDNR worked closely with the EPA to update the 1988 EPA Criteria document by performing a literature search and recalculating the 1988 acute and chronic chloride criteria based upon the new data.[12] The Iowa DNR determined that the 1988 acute criterion of 860 mg/L and the chronic criterion of 230 mg/L needed to be updated and recalculated because "the EPA national criteria were published in 1988, the derivation of the criteria was based on toxicity data available before 1987." As a result, IDNR worked closely with the EPA office of Research and Development and found several studies that were not considered in EPA's development of the national criteria for chloride and more toxicity data was needed to determine if four particular species were indeed sensitive to chloride. Consequently, EPA contracted with the Great Lakes Environmental Center in Columbus, OH and Illinois Natural History Survey at Champaign, IL to perform additional toxicity testing.[13] Therefore, the Iowa chloride criteria with a safety factor will address the flaws

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[12] Iowa Department of Natural Resources, *Water Quality Standards Review: Chloride, Sulfate and Total Dissolved Solids*, (February 9, 2009), *available at* http://www.iowadnr.gov/water/standards/files/ws_review.pdf.

[13] EPA, *Acute Toxicity of Chloride To Select Freshwater Invertebrates*. (September 26, 2008).

in the 1988 criteria and the uncertainty that remains for chronic toxicity to aquatic life in Pennsylvania.

III. The Board Should Adopt the Iowa Chronic Chloride Criterion with a Margin of Safety to Protect Aquatic Life Uses of Waters of the Commonwealth.

Whenever the Board proposes new water quality criteria, it must consider the Clean Streams Law prohibition against the introduction of pollutants that cause harm to "uses," such as the aquatic life use of Commonwealth waters, in light of the current state of scientific knowledge on the impacts to such uses. *See* 35 P.S. § 691.1 (defining "pollution" as "contamination of any waters of the Commonwealth such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to…uses, including…fish or other aquatic life, including but not limited to such contamination by alteration of the physical, chemical or biological properties of such waters"); *see also* 35 P.S. § 691.5(a)(4) (requiring consideration of the state of scientific knowledge in adopting rules and regulations). Section 93.3 of Title 25 of the Pennsylvania Administrative Code defines the protected water uses for the Commonwealth, which includes the aquatic life protected use. The Clean Streams Law does not define the term "aquatic life use," so the agency has defined it as comprising four distinct uses: CWF, WWF, MF, and TSF.[14]

The Commonwealth risks impairment of its aquatic life uses by chloride loading unless it incorporates a safety factor in the derivation of the chronic criterion. While the Iowa Criteria reflect the most significant developments in chloride toxicity research, scientific uncertainty related to the toxicity of the chlorides of potassium, magnesium or calcium, the application of the Iowa chronic criterion to Pennsylvania aquatic life such as freshwater mussels, and the lack of chronic data available remains prevalent. The toxicity of various species of chloride is especially relevant in Pennsylvania where shale gas wastewaters contain disproportionately high amounts of non-NaCl salts such as MgCl, CaCl and KCl.[15] Not only are those non-NaCl salts often more toxic to aquatic life than is NaCl, they can react in solution in a manner that impacts the toxicity of chloride. The Stroud Center's review of the proposed chronic chloride criterion recommends the inclusion of a safety factor in the derivation of the chronic criterion at a level below the species mean chronic values or the genus mean chronic values that will ensure that the Commonwealth will avoid impairment. The current state of scientific knowledge requires that the Board adopt the proposed chronic chloride criterion with a safety factor.

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[14] 25 PA. CODE §93.3 (2012).

[15] 2010 Stroud Report at 20.

IV. Conclusion

Clean Water Action agrees with the Department and the Board that an imminent need exists for the adoption of chloride water quality criteria that protect Pennsylvania's aquatic life uses. A distinct lack of chronic toxicity studies for chloride led the Stroud Center to conclude that a safety factor should be applied to chronic criteria to adequately protect the most sensitive aquatic species in Pennsylvania, such as trout and pollution-sensitive macroinvertebrate species characteristic of CWF waters. The state of scientific knowledge on adequate protection of aquatic life uses in Pennsylvania requires use of the Iowa chloride criteria with a margin of safety for the chronic criteria to protect Pennsylvania aquatic life.

Respectfully submitted,

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Review of the 2012 proposed water quality criteria for chloride for the protection of aquatic life in Pennsylvania

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1. Introduction

The Environmental Quality Board of Pennsylvania on July 7, 2012 proposed amending 25 Pennsylvania Code Chapter 93.7 relating to the water quality standard for chloride. The Board proposed adopting the Iowa equation-based aquatic life criteria for chloride based on the best available sound science (PA Bulletin 12-1292). This review is in response to the proposed standard for chloride in surface waters and builds on a previous report (Stroud Water Research Center 2010) that evaluated the water quality standard for chloride proposed by the EQB in 2010.

Chloride criteria for aquatic organisms are needed in Pennsylvania to protect aquatic life in our surface waters. Chloride can enter surface water via road salt runoff (e.g., following brine application for dust suppression, or following deicer application or storage), or through wastewater or other industrial discharge. In 2010, the EQB of Pennsylvania proposed adopting the recommended criteria from the US EPA (EPA 1988) for Aquatic Life Uses for Cold Water Fishes (CWF), Warm Water Fishes (WWF), Migratory Fishes (MF), and Trout Stocking (TSF). Those criteria were an acute criterion of 860 mg chloride/L and a chronic criterion of 230 mg chloride/L.

We found a number of faults with the criteria proposed in 2010 and the conclusions of the previous report are attached as **Appendix 1** at the end of this document. The changes proposed in 2010 were not adopted by the EQB, in part because they did not incorporate the latest available science. Some of the concerns identified by us in 2010 have been addressed by the proposed Iowa equation based criteria. However, the Iowa equation based criteria do not adequately address some critical scientific gaps which we feel will leave some species at risk of harm. In this comment, we suggest some options that the EQB may consider. Due to the large amount of uncertainty that remains, one option that may be rapidly incorporated would be to re-derive the chronic criterion and apply a safety factor to provide an enhanced level of protection.

The acute and chronic criteria equations proposed by the EQB of Pennsylvania are based on reports by Stephan (2009 a,b,c,d,e,f,g,h). We will use these reports as the basis of our review and critique.

2. Strengths of the proposed standard

2.1. EPA has not officially adopted new national criteria since 1988 (EPA 1988). The derivation of the 2009 Iowa criteria incorporated data from recent chloride toxicity studies.

2.2. The most significant development with the 2009 Iowa Criteria is an acknowledgement that the toxicity of chloride to aquatic organisms varies depending upon the other ions present. Specifically, the criteria use equations to account for changes in toxicity due to water hardness (i.e., cation content [primarily calcium and magnesium, but could also include iron and manganese] of water) and sulfate concentrations.

2.3. The 2009 Iowa criteria also clarified rules of data inclusion or exclusion. The 2009 criteria included static tests that were excluded in 1988 (Stephan 2009a). The approach was to include a test unless there was an obvious reason to exclude it (Stephan 2009a).

3. Weaknesses and concerns resulting from implementing the proposed standard

3.1. These proposed criteria are based on toxicity studies of dissolved chloride that has dissociated from sodium chloride (NaCl), although chlorides dissociated from calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), or potassium chloride (KCl) may be present in surface water and can be more toxic to aquatic organisms (e.g., Mount et al. 1997).

3.1.1. In 1988, the EPA noted that "the chlorides of potassium, calcium, and magnesium are generally more toxic to freshwater species than sodium chloride" (EPA 1988 p. 7), but there was insufficient data on the toxicity of the chlorides of calcium, magnesium, or potassium to derive criteria.

3.1.2. The relationship between the toxicity of the chloride of sodium and the toxicity of the chlorides of potassium, calcium and magnesium has held over time. Below are the *ratios* of the LC_{50} concentrations for the chloride of calcium (Ca), magnesium (Mg), or potassium (K) to the LC_{50} concentration for the chloride of sodium (Na) for the same species and test water (Stephan 2009a p. 10):

- Ca/Na (n=5): 0.57-0.98
- Mg/Na (n=3): 0.34-0.55
- K/Na (n=5): 0.11-0.25

Note: a ratio <1 indicates that the chlorides dissociated from calcium, magnesium, or potassium caused mortality at a lower concentration.

3.1.3. The chlorides of calcium, magnesium, or potassium may be present in the environment in such a way that they threaten surface waters.

- Potassium, magnesium, or calcium chlorides are used as deicers (Salt Institute 2004, Chang 2009).
- Potassium chloride can be present in the effluent from hydraulic fracturing for natural gas extraction (URS Corporation 2011), and is also commonly used as a water softener.
- Use of liquid brine salts as dust suppressants on roadways and at construction sites (Piechota et al. 2002)

3.2. The proposed chronic criteria may be above the level that causes adverse impacts to aquatic organisms in Pennsylvania.

3.2.1. The proposed criteria are based solely on studies of animals and do not consider toxicity to aquatic plants. Stephan (2009a, 2009b, 2009c, 2009d, 2009g) did not indicate why plants were not considered in the derivation of the Iowa Criteria. In 1988, the EPA noted that the alga *Spirogyra setiformis* was extremely sensitive to the effects of chloride (71 mg/L; growth, chlorophyll, C^{14} fixation; 10d; Shitole and Joshi 1984) as was the desmid *Netrium* *digitus* (200 mg/L; growth inhibition; 21d; Hosiaisluoma 1976). However, the 1988 criteria did not include plant species in the derivation because "a Final Plant Value, as defined in the Guidelines, cannot be obtained because no test in which the concentrations of chloride were measured and the endpoint was biologically important has been conducted with an important aquatic plant species" (EPA 1988). These concentrations for plants are below the SMCV observed for vertebrate and invertebrate animals (Table 1) suggesting that plants may be more sensitive to chloride than are animals.

3.2.2. Recent research with freshwater mussels suggests that the glochidia of some species may be more sensitive to chloride than the current suite of aquatic organisms for which data is available (Gillis 2011, Pandolfo et al. 2012). Stephan included data from juvenile freshwater mussels or freshwater mussels that do not have a glochidia stage (i.e., *Villosa delumbis* and *Lampsilis fsciola*, Bringolf et al. 2007; *Villosa iris* and *Lampsilis siliquoid,* Wang 2007; *Sphaerium simile,* GLEC and INHS 2008), but Stephan excluded all studies with glochidia because of their unique life-history which requires that they attach to a fish host in order to survive (Stephan 2009a p. 7[d]). The unique life history of most freshwater mussel species makes it difficult to design toxicology studies with them. However, freshwater mussels are among the most imperiled organisms in Pennsylvania (PNHP 2012), therefore it is important that water quality criteria be protective of them. One "very important question is 'What species-specific toxicity-test duration is ecologically relevant for glochidia?'" (Stephan 2009a p. 7[d]).

3.3. The proposed chronic criterion is not robust.

3.3.1. The genus mean chronic values (GMCV) should not have been calculated directly from the species mean chronic values (SMCV) without first correcting for hardness and sulfate.

3.3.1.1. The SMCV from different experiments were not normalized for hardness and sulfate (Stephan 2009c). As a result, the SMCV are not directly comparable because the toxicity of chloride varies depending upon the chemical composition of the water in which the test was done (e.g., Mount et al. 1997, Soucek 2007, Elphick et al. 2011). Therefore, calculating the GMCV as the geometric mean of the SMCV for a given species is not appropriate. It should be noted that the species mean acute values (SMAV) were corrected for hardness and sulfate before calculating the GMAV (Stephan 2009g).

3.3.2. There is inconsistency in the meaning of the species mean chronic value (SMCV). The SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

3.3.2.1. Stephen (2009c) used the geometric mean of the no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) to determine the SMCV. The NOEC and LOEC refer to test concentrations used in the experiments, but the amount of impairment at the NOEC and LOEC varied among experiments (Table 1). Therefore the SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

3.3.3. Different researchers analyzing the same data have arrived at different results and different conclusions.

3.3.3.1. The guidelines that different researchers have used to determine which studies should be included and the interpretation of the EPA 1985 guidelines differ between researchers (e.g., EPA 1988, Stephan 2009a). As a result the rules to determine the appropriate studies and data to use to derive chloride criteria are not interpreted in a consistent manner and researchers have differed in the tests they included or excluded. For example, Stephan (2009c, 2009e) excluded an acute and chronic study of *Rana sylvatica* by Sanzo and Hecnar (2006) because they used technical grade sodium chloride, but Elphick et al. (2011) included this study when deriving a chronic criterion.

3.4. The proposed chronic criterion does not account for uncertainty in data and methods.

3.4.1. The proposed chronic criterion equation may allow for chloride concentrations in surface waters of Pennsylvania above the concentration shown to cause harm to aquatic organisms during laboratory experiments. For example, the SMCV for some species in Table 1 are near or exceed the normalized chronic criterion of 389 mg chloride/L which Iowa adopted for surface waters where sulfate and hardness are not known. The SMCV in Table 1 would need to be corrected for hardness and sulfate to confirm that the chronic criterion would exceed the SMCV. In 1988, the EPA affirmed that the proposed chronic criterion was below the three SMCV available at that time (EPA 1988). Stephan in 2009 did not affirm that the proposed chronic equation was below the level shown in laboratory experiments to impair aquatic organisms.

3.4.2. The proposed chronic criterion equation includes a correction for hardness and sulfate although the exponents for hardness and sulfate are based on studies in two labs (GLEC and INHS 2008, p29 & 36) of only one species (*C. dubia*) under acute conditions (Stephan 2009f). Stephan (2009f) presents evidence that "supports the concept" that "the sulfate exponent might be more negative than indicated by the GLEC and INHS (2008) data" (Stephan 2009f p. 4). A negative exponent for sulfate means that a higher sulfate concentration lowers the LC_{50} for chloride. Thus, reliance on the 2009 Iowa equations may not offer the intended level of protection to aquatic organisms in Pennsylvania.

3.4.3. The endpoints of chronic tests conducted under laboratory conditions (e.g., survival, reproduction) may not reflect the most sensitive response in nature. In nature, a stress response may occur at lower concentrations than what are observed under controlled laboratory settings. A similar pattern is seen with behavioral responses such as avoidance, coughing or rapid breathing by fish, or increased activity (Atchison et al. 1987, Scott and Sloman 2004, Hellou 2011). Behavioral responses have been poorly documented or not measured in most laboratory experiments of chloride toxicity, therefore it is unknown how the behavior of aquatic organisms in nature would be affected by elevated chloride.

3.4.4. There has been no attempt to account for the fact that the available data represents only a small percentage of the species found in Pennsylvania. Including studies conducted since the 2009 Iowa criteria were derived results in a different acute-to-chronic ratio (ACR) and acute and chronic criteria (e.g., Elphick et al. 2011). It is to be expected that additional data may change the criteria, such as occurred between the derivation of the 1988 criteria and the 2009 criteria (e.g., ACR= 7.594, EPA 1988; ACR = 3.187, Stephan 2009h; ACR = 3.50, Elphick et al. 2011). Focusing on species found in Pennsylvania may also alter the criteria.

3.4.5. Different methods to derive the chronic criterion may result in different criterion. Stephan (2009c, 2009h) used the ACR whereas Elphick et al. (2011) derived a chronic criterion directly from chronic studies. (chronic criterion = 307 mg/L, Elphick et al. 2011; chronic criterion = 428 mg/L, Stephan 2009h). It should also be noted that other factors, such as if how hardness and sulfate were accounted for, could also account for differences in the criterion.

3.4.6. The lack of robustness in the derivation of the chronic criterion is further evidence of uncertainty.

Table 1: Data used to derive the species mean chronic values (SMCV) by Stephan (2009c). The SMCV is the geometric mean of the NOEC and the LOEC. A subset of this data was used to calculate the genus mean chronic values and the acute-to-chronic ratio, which was used to derive the proposed chronic criterion.

Category	Species	Endpoint	NOEC (mg/L)	LOEC (mg/L)	SMCV(mg/L)	Reference
Fish – non-salmonid	Fathead minnow	33d; survival	352 (9% reduction)	533 (15% reduction)	433.1	(Birge et al. 1985)
Fish - salmonid	Rainbow trout	Early life stage; survival	643 (4% reduction)	1324 (46% reduction)	922.7	Spehar 1987[1]
Cladoceran	*Ceriodaphnia dubia*	7-9d; Reproduction	?[2]	? (EC50)	925	(Cowgill and Milazzo 1990)
Cladoceran	*Ceriodaphnia dubia*	7 d; ?	?	?	235	(Diamond et al. 1992)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A[3]	442.2[4] (IC25)	<442.2	WISLOH 2007 (mod. Hard water)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A	385.2 (IC25)	<385.2	WISLOH 2007 (Hard water)
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	340 (IC25)	<340	Lasier et al. 2004[5]
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction (12 studies)	<152-303	346-685 (IC50)	<322	(Aragão and Pereira 2003)
Cladoceran	*Ceriodaphnia dubia*	7d; Survival	1092	1456	N/C[6]	(Cooney et al. 1992)
		7d; Reproduction	<455-819	455-1092	<629	
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	370.6 (EC20)	370.6	(Harmon et al. 2003)
Cladoceran	*Daphnia ambigua*	10d; Reproduction	N/A	292.4 (EC20)	292.4	(Harmon et al. 2003)
Cladoceran	*Daphnia magna*	10d; Reproduction	2184	2597 (EC50)	2382	(Cowgill and Milazzo 1990)
Cladoceran	*Daphnia pulex*	21d; Reproduction	314 (0% reduction)	441 (27% reduction)	372	(Birge et al. 1985)
Frog	*Rana sylvatica*	90d; Survival	N/A	625 (62% reduction)	<625	(Sanzo and Hecnar 2006)

[1] Unpublished memorandum sent directly to C. Stephan from R. L. Spehar on June 24, 1987. Data is not available on-line (scholar.google.com, search "chloride author:Spehar", Aug. 3, 2012).

[2] Data not presented in Stephan (2009c) and document not available for download (Aug. 3, 2012)

[3] Stephan (2009c) did not use the NOEC to calculate the SMCV.

[4] WISLOH 2007 refers to an unpublished study that could not be found on the Wisconsin State Laboratory of Hygiene webpage (http://www.slh.wisc.edu/, search "chloride", Aug. 3, 2012). IDNR (2007) presents results from the WISLOH lab covering the period 2000-2007, however the results in that report (Table 4: *C. Dubia* chronic toxicity 703 mg Cl^-/L; Table 7: *C. dubia* chronic toxicity: 427 mg Cl^-/L) do not match those presented by Stephan (2009c). Corsi et al. (2010) present results from the WISLOH lab over the same time period, but the studies do not appear to be the same as the ones reviewed by Stephan (2009c) because the Corsi study focused on surface waters receiving road run-off.

[5] Data was presented in a poster at the SETAC meeting and is not available on-line (Aug. 3, 2012)

[6] The geometric mean for *C. dubia* survival in the study by Cooney et al. (1992) was not calculated by Stephan (2009c) because reproduction was more sensitive.

4. Point of Clarification

4.1. As written in PA Bulletin 12-1292 it appears that Pennsylvania will adopt the Iowa criteria *in toto*, including Iowa's criteria for waterbodies where sulfate and hardness are not known. Iowa defined normalized acute and chronic criteria to be applied to waterbodies where sulfate and hardness are not known that were based on the statewide background values for hardness (200 mg/L) and sulfate (63 mg/L). Average hardness and sulfate concentrations may be different in PA and therefore the normalized acute and chronic criteria for Iowa may not be appropriate for PA.

5. Summary and Recommendations

5.1. The chloride criteria proposed by the EQB on July 7, 2012 are an improvement over the criteria that were proposed in 2010. Specifically, the proposed criteria incorporate characteristics of the receiving waters that affect chloride toxicity. However, as was highlighted in our previous review, the newly proposed criteria based on the Iowa standard may not be protective of aquatic life in Commonwealth streams, rivers, and lakes. Examples of uncertainty are:

5.1.1. The proposed chronic criterion may allow for ambient chloride concentrations in surface waters in Pennsylvania above the concentrations shown to cause harm to aquatic organisms in laboratory experiments.
5.1.2. The criteria are based only on the chloride of sodium although the chlorides of calcium, magnesium or potassium may enter surface waters of Pennsylvania and are more toxic to aquatic organisms.
5.1.3. The proposed criteria are derived from only a few species found in Pennsylvania.
5.1.4. There are only seven species (6 after excluding the frog, *Rana sylvatica* which Stephan [2009g] excluded because the sodium chloride used in the experiment was technical grade) for which there are acceptable chronic data (Table 1).
5.1.5. Glochidia and plants were not included in the derivation of the acute or chronic criteria.
5.1.6. The proposed criteria may not be protective of our more sensitive stream dwelling invertebrate species, particularly early life history stages (e.g., glochidia of mussels or early life stages of other invertebrates).
5.1.7. Exponents for hardness and sulfate in the acute and chronic criteria equations may be under-protective.
5.1.8. The species mean chronic values (SMCV's) were not corrected for hardness and sulfate concentrations.
5.1.9. The SMCV refer to different levels of impairment for the different experiments and species.
5.1.10. The SMCV are not corrected for hardness or sulfate.
5.1.11. The endpoints of laboratory toxicity studies do not include behavioral responses. Behavior may be affected at lower chloride concentrations than are survival, reproduction or growth.

5.2. Following are some recommendations on how the EQB may address uncertainty.

5.2.1. Include a safety factor in the derivation of the chronic criterion. At a minimum, that safety factor should be sufficient to ensure that the chronic criterion is below the SMCV or GMCV. Following are some reasons that a safety factor should be used:

5.2.1.1. "Safety factors are used to provide an extra margin of safety beyond the known or estimated sensitivities of aquatic organisms" (EPA 1985 p 36).

5.2.1.2. The acute criterion incorporates a safety factor (i.e., 2) but the chronic criterion does not. The 1985 EPA guidelines indicate that a safety factor of 2 is always to be used when calculating the acute criterion (called the criterion maximum concentration in EPA 1985, p 54, item XI.B.) but does not give a rationale for this using this safety factor. Although the EPA did not include a safety factor when deriving the chronic criterion in 1988, the chronic value was below the level shown to cause harm to the three species for which data were available at that time (EPA 1988). It is unclear if the proposed chronic criterion is below the level shown to cause harm because the SMCV in Table 1 have not been corrected for hardness or sulfate.

5.2.1.3. The acute and chronic criteria are based solely on studies using the chloride of sodium, but the chlorides of potassium, magnesium or calcium may be present in surface waters of Pennsylvania and are more toxic to aquatic organisms than is the chloride of sodium.

5.2.1.4. Environmental impacts (including avoidance) may occur at lower concentrations then those that affect growth or survival.

5.2.1.5. British Columbia (Nagpal et al. 2003) used a safety factor of 5 in the derivation of the chronic guideline. Their justification for this safety factor was as follows:

- Chronic data available from the literature were scant;
- In a recent study, Diamond et al. (1992) found a LOEC/NOEC ratio for reproduction of 3.75 in *C. dubia* exposed to NaCl for 7 days. Also, LC_{50}/LC_0 of 3 and LC_{100}/LC_0 of 4 were obtained by Hughes (1973), whereas the DeGreave et al. (1991) data yielded LC_{50}/NOEC ratios that ranged from about 1.0 to 6.9;
- Additional protection may be required for those species that are more sensitive but have not yet been tested in the literature.

5.2.2. A new review of chloride toxicity studies should be conducted to generate a more complete and up-to-date list of species and genus mean acute and chronic values. The references sited at the end of this comment include a few studies that have been published since 2009. A new review should:

5.2.2.1. Resolve the controversy regarding aquatic plants and glochidia.

5.2.2.2. Clearly define rules to include or exclude a study and document the rationale for studies that are excluded;

5.2.2.3. The species mean acute values and species mean chronic values should be calculated using a consistent and biologically meaningful endpoint. For example, Elphick et al. (2011) used probit regression to determine an endpoint that was consistent among species (e.g., the IC10).

5.2.2.4. Derive species mean chronic values normalized for hardness and sulfate;

5.2.2.5. Explore the possibility of deriving chronic criterion directly from the data rather than using the ACR (e.g., Elphick et al. 2011);

5.2.2.6. Include in the review toxicity studies with the chlorides of potassium, magnesium or calcium. Although conducting additional experiments with species found in Pennsylvania is the preferred approach, it may be appropriate to use the ratios cited above (3.1.2) to derive the SMAV or SMCV. For example, the chloride of potassium appears to be 4-10x more toxic to aquatic organisms than is the chloride of sodium.

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Conclusions

After reviewing four different approaches for deriving water quality chloride criteria to protect aquatic life (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) and the data underpinning PA's proposed criteria (EPA 1988) and the Iowa criteria (Stephan 2009a,b,c), it is clear that:

1) All approaches set chloride criteria that are at least several times greater than natural baseline chloride concentrations, and therefore represent a measurable and significant change in the chemical composition of freshwater ecosystems in the NE United States. The question that the current evidence is unable to answer is: will these criteria result in significant biological change? There is limited evidence of the biological impact of previous elevated chloride levels in aquatic ecosystems in the U.S. or Canada. Past monitoring efforts (see introduction) suggest that some streams regularly reach the acute criterion, but there has not been a noted change in biota following these pulses, largely because of a dearth of biological data following these episodic events. One study has demonstrated that macroinvertebrate drift increases in response to pulsed chloride input (Blasius and Merritt 2002). Another study has demonstrated losses of species in stream fish communities with small changes in chloride levels across a regional-scale analysis (Meador and Carlisle 2007), and the composition of algal species has been observed to change when chloride concentrations increase (Evans and Frick 2001). Nonetheless, there are limited data on biological changes accompanying changing chloride concentrations in the natural environment. We could not find any studies evaluating the influence of chloride on vital stream functions such as primary production, stream metabolism, or nutrient uptake or processing, all of which are important indicators of water quality for aquatic ecosystems.

2) All of these criteria are based on data for invertebrate and fish species that are not a random subset of stream invertebrate and fish species. Rather, most of the species with chloride data are known to be not especially sensitive to changes in environmental condition, which is one reason they survived well in the laboratory and became standards in laboratory bioassay protocols. The most recent iteration of the taxa that qualify based on EPA standards (in Stephan 2009a,b,c) doesn't include any classically sensitive stream invertebrate species such as stoneflies, mayflies, and caddisflies, all of which are important indicators of stream condition and are integral in the regulatory definition of stream impairment. Our concern is that criteria intended to protect most (e.g., 90% or 95%) of the species with chloride data might actually protect a much smaller proportion of all species that occur in a natural community because the natural community includes many species known to be sensitive to environmental change while the laboratory studies are biased toward species known to be at least moderately tolerant of environmental change. This is one reason to approach the acute and chronic criteria with a strong safety factor.

3) Data available are primarily from acute toxicity studies, but the chronic criterion may be more important for long-term structuring stream communities and maintaining designated use for aquatic life. For example, fish tend to be moderately tolerant of acute chloride stress relative to macroinvertebrates, but they are one of the more sensitive taxa to chronic chloride stress. For example, fat head minnows (Birge et al. 1985) experienced the greatest mortality between days 9 and 21 and therefore had one of the highest acute-to-chronic ratios examined. The dearth of chronic studies on both invertebrates and fish is troubling. It is likely that, like some amphibians (e.g., spotted salamander), embryonic and early life stages of some fish will be more sensitive than is currently recognized.

4) The majority of chloride criteria developed to date are limited to or dominated by data on NaCl chloride toxicity, the least toxic salt. This point is routinely justified by the fact that NaCl is the most anthropogenically abundant of these four salts. However, no special guidance is given for permitting salt applications or industrial effluents known to include significant amounts of chloride derived from the more toxic non-sodium salts, including Marcellus Shale wastewater.

5) Using the data provided in Stephan 2009a (Table 2 herein), we have calculated both the acute (CMC) and chronic (CCC) criteria using the methods of the EPA (Stephan et al. 1985, EPA 1988), Evans and Frick (Evans and Frick 2001), British Columbia (Nagpal et al. 2003), and Iowa (Iowa DNR 2009) and have compared the range of values with the proposed PA values (Table 3). The range of acute values is 564 – 830 mg/l Cl- and the range of the chronic values is 91 – 428 mg/l Cl-. This comparison eliminates the variability in the choices each of the authors have made with regard to studies included or excluded. We note that the PA proposed acute value is the least protective criterion, primarily because it is not based on more recent acute toxicity studies. We recommend that PA adopt an acute criterion that is reflective of these new data. The method adopted by British Columbia is the most protective of aquatic life among these approaches. BC invoked a precautionary principle that acknowledged both the uncertainty of the available data and analyses and the importance of protecting their aquatic life. Since BC adopted their criteria, only new acute datasets have become available and the values in Table 3 utilize those data but use the BC approach to arrive at a final value (i.e., lowest SMAV/2[safety factor]). The BC use of a safety factor of 2 for the acute criteria was also consistent with what the EPA had done. However, BC was the only entity to apply a safety factor for the chronic criterion (5). We feel that the use of a safety factor for chronic criteria derived from the use of an ACR is clearly justified given the very limited number of chronic toxicity studies, and the desire to protect species that may be more sensitive than those used in the standard laboratory bioassays. We recommend that PADEP adopt the same methodology that BC has used for calculating both acute and chronic data. We feel that this is particularly important for the chronic criteria, as there is the potential for permitted discharges (particularly from the Marcellus Shale gas drilling industry) to raise chloride concentrations in streams to near the chronic criteria level. Given the paucity of data determining thresholds for chronic effects, this approach is warranted. At the very least, a safety factor should be applied to any of the other methods producing a chronic criterion.

We have a number of concerns that are specific to the actions and options available for PADEP:

6) Protecting CWFs and TSFs based on ACRs that included more chloride-tolerant *Daphnia* is not justified when it may expose rainbow trout to chloride concentrations approaching their chronic

levels (1,324 mg/l Cl^- killed 46% of individuals in an early life stage test and at 643 mg/l Cl^- killed <4%). Trout are an integral component in the definition of these two aquatic life uses. The proposed chronic value of 230 mg/l is potentially a concern for biotic assemblages in Pennsylvania. For example, Meador (2007) suggests that optimum Cl^- values are low (3-35 mg/l) and we infer that if those Cl^- concentrations are exceeded it may result in changes in fish community structure. Similarly, not having a temperature component also seems to invite season-specific impairments of macroinvertebrates in TSFs and WWFs based on the recent findings of Silver et al. (2009), based on the seasonal movement of organisms into and out of various life history stages, and based on variation in their metabolic rates in response to seasonal changes in water temperature. Adding a temperature component to the chloride criteria would require further research on temperature effects.

7) The Evans and Frick (2001) method has the benefit of being reproducible and open to interpretation. Their use of nearly all of the valid acute LC_{50} data in Fig. 7-2 (Evans and Frick 2001), and the calculation of a sigmoid curve function (including 95% confidence intervals) that describes the percent of genera affected versus chloride concentration, is readily digestible by the public. However, the sigmoid curve function can be generated using various numbers of terms (parameters) in the equation and/or various equations (e.g., sigmoid, logistic, Weibull). The result of choosing a slightly different function can result in differences in acute and chronic values. To use this approach requires a valid justification for the choices made in fitting the curve to these data. Furthermore, these data still represented a small subset of aquatic species, and were biased towards lab friendly species that are easiest to culture (e.g., *Daphnia*). Since the selection of taxa was not a random subset of the aquatic species at large, most criteria based on the animals selected are primarily protective of those species tested (e.g., being protective of 95% of those taxa might only be protective of 50% of all species). This point is not limited to Evans and Frick but is valid for all of the approaches we have reviewed. This is the primary reason that the application of a safety factor is needed. The Evans and Frick (2001) study did not apply a safety factor to either their acute LC_{50} relationship or the derived chronic relationship.

8) More data is generally better, but there is a need for more consideration of how data gets incorporated. The Stephan (2009a,b,c) approach of calculating a predicted genus mean chronic value from the species mean acute values does not seem justified in this case. The GMCVs are not much better than guesses, and there is no attempt to correct for this inherent uncertainty. Adding GMCV values above the lowest four gives the false sense of increased precision of the true distribution of the GMCV, which has the result of increasing the final chronic value (FCV). We feel it would be appropriate to apply a safety factor to the chronic criteria to acknowledge the uncertainty in the FCV.

9) The use of hardness and sulfate equations (Iowa DNR 2009) in PA will improve protections and application of the chloride criteria only to a limited extent since the range of criteria in PA would be narrow (based on EMAP site values for hardness and sulfate in PA). Secondly, the hardness and sulfate exponents in the Iowa criteria were based on data from an acute toxicity study of only one species (*C. dubia*), although four species were studied and three were sensitive to hardness. No data were available on the relationship between hardness or sulfate and chronic toxicity. In the end, Iowa uses a default value for hardness and sulfate if no other data are available. This is akin to setting a fixed criterion value but allowing site-specific deviations if one

gathers the appropriate data. Clearly, more species-specific data are needed to better understand the relationship between chloride toxicity and hardness or sulfate.

10) As noted above, previous reviews of chloride considered only NaCl and considered road salt to be the most likely source of chloride. We feel that the current proposed standard should explicitly acknowledged that these criteria are specific to NaCl derived chloride, and guidance should be given to address cases when significant chloride is derived from salts (i.e., KCl, $MgCl_2$ and $CaCl_2$) that have proven to be more toxic sources of chloride.

Our review of four approaches (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) for deriving chloride criteria to protect aquatic life identified a number of weaknesses in the available data and the analyses used to derive criteria. We were especially concerned with (1) the near absence of important stream-inhabiting and stream-classifying species such as mayflies, stoneflies, and caddisflies, (2) the dependence on relatively few chronic studies, and (3) the choice of excluding some studies that were very important (e.g., fat head minnow Birge et al. 1985). We believe these weaknesses justify using a very conservative approach to assigning criteria. All four approaches to set acute and chronic criteria would result in chloride concentrations at least several times greater than base flow concentrations commonly observed in Pennsylvania streams in their most natural condition (i.e., Exceptional Value and High Quality Waters). The lowest criteria for chloride were derived by the Canadian Province of British Columbia (Nagpal et al. 2003) – they acknowledged the weaknesses in available data, and applied safety factors of 2 for the acute criterion and 5 for the chronic criterion. Given the limits in the available data, and the potential that treated wastewaters from Marcellus Shale drilling may result in near-criterion chloride concentrations 356 days per year (versus the 30 days of a standard chronic bioassay), we believe the British Columbia criteria (either the originally adopted criteria or our re-calculated criteria in Table 2) would be the most protective of aquatic life for Pennsylvania streams, especially for the trout and many pollution-sensitive macroinvertebrate species that characterize Cold Water Fishes streams.

Review of the 2012 proposed water quality criteria for chloride for the protection of aquatic life in Pennsylvania

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1. Introduction

The Environmental Quality Board of Pennsylvania on July 7, 2012 proposed amending 25 Pennsylvania Code Chapter 93.7 relating to the water quality standard for chloride. The Board proposed adopting the Iowa equation-based aquatic life criteria for chloride based on the best available sound science (PA Bulletin 12-1292). This review is in response to the proposed standard for chloride in surface waters and builds on a previous report (Stroud Water Research Center 2010) that evaluated the water quality standard for chloride proposed by the EQB in 2010.

Chloride criteria for aquatic organisms are needed in Pennsylvania to protect aquatic life in our surface waters. Chloride can enter surface water via road salt runoff (e.g., following brine application for dust suppression, or following deicer application or storage), or through wastewater or other industrial discharge. In 2010, the EQB of Pennsylvania proposed adopting the recommended criteria from the US EPA (EPA 1988) for Aquatic Life Uses for Cold Water Fishes (CWF), Warm Water Fishes (WWF), Migratory Fishes (MF), and Trout Stocking (TSF). Those criteria were an acute criterion of 860 mg chloride/L and a chronic criterion of 230 mg chloride/L.

We found a number of faults with the criteria proposed in 2010 and the conclusions of the previous report are attached as **Appendix 1** at the end of this document. The changes proposed in 2010 were not adopted by the EQB, in part because they did not incorporate the latest available science. Some of the concerns identified by us in 2010 have been addressed by the proposed Iowa equation based criteria. However, the Iowa equation based criteria do not adequately address some critical scientific gaps which we feel will leave some species at risk of harm. In this comment, we suggest some options that the EQB may consider. Due to the large amount of uncertainty that remains, one option that may be rapidly incorporated would be to re-derive the chronic criterion and apply a safety factor to provide an enhanced level of protection.

The acute and chronic criteria equations proposed by the EQB of Pennsylvania are based on reports by Stephan (2009 a,b,c,d,e,f,g,h). We will use these reports as the basis of our review and critique.

2. Strengths of the proposed standard

2.1. EPA has not officially adopted new national criteria since 1988 (EPA 1988). The derivation of the 2009 Iowa criteria incorporated data from recent chloride toxicity studies.

2.2. The most significant development with the 2009 Iowa Criteria is an acknowledgement that the toxicity of chloride to aquatic organisms varies depending upon the other ions present. Specifically, the criteria use equations to account for changes in toxicity due to water hardness (i.e., cation content [primarily calcium and magnesium, but could also include iron and manganese] of water) and sulfate concentrations.

2.3. The 2009 Iowa criteria also clarified rules of data inclusion or exclusion. The 2009 criteria included static tests that were excluded in 1988 (Stephan 2009a). The approach was to include a test unless there was an obvious reason to exclude it (Stephan 2009a).

3. Weaknesses and concerns resulting from implementing the proposed standard

3.1. These proposed criteria are based on toxicity studies of dissolved chloride that has dissociated from sodium chloride (NaCl), although chlorides dissociated from calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), or potassium chloride (KCl) may be present in surface water and can be more toxic to aquatic organisms (e.g., Mount et al. 1997).

3.1.1. In 1988, the EPA noted that "the chlorides of potassium, calcium, and magnesium are generally more toxic to freshwater species than sodium chloride" (EPA 1988 p. 7), but there was insufficient data on the toxicity of the chlorides of calcium, magnesium, or potassium to derive criteria.

3.1.2. The relationship between the toxicity of the chloride of sodium and the toxicity of the chlorides of potassium, calcium and magnesium has held over time. Below are the *ratios* of the LC_{50} concentrations for the chloride of calcium (Ca), magnesium (Mg), or potassium (K) to the LC_{50} concentration for the chloride of sodium (Na) for the same species and test water (Stephan 2009a p. 10):

- Ca/Na (n=5): 0.57-0.98
- Mg/Na (n=3): 0.34-0.55
- K/Na (n=5): 0.11-0.25

Note: a ratio <1 indicates that the chlorides dissociated from calcium, magnesium, or potassium caused mortality at a lower concentration.

3.1.3. The chlorides of calcium, magnesium, or potassium may be present in the environment in such a way that they threaten surface waters.

- Potassium, magnesium, or calcium chlorides are used as deicers (Salt Institute 2004, Chang 2009).
- Potassium chloride can be present in the effluent from hydraulic fracturing for natural gas extraction (URS Corporation 2011), and is also commonly used as a water softener.
- Use of liquid brine salts as dust suppressants on roadways and at construction sites (Piechota et al. 2002)

3.2. The proposed chronic criteria may be above the level that causes adverse impacts to aquatic organisms in Pennsylvania.

3.2.1. The proposed criteria are based solely on studies of animals and do not consider toxicity to aquatic plants. Stephan (2009a, 2009b, 2009c, 2009d, 2009g) did not indicate why plants were not considered in the derivation of the Iowa Criteria. In 1988, the EPA noted that the alga *Spirogyra setiformis* was extremely sensitive to the effects of chloride (71 mg/L; growth, chlorophyll, C^{14} fixation; 10d; Shitole and Joshi 1984) as was the desmid *Netrium* *digitus* (200 mg/L; growth inhibition; 21d; Hosiaisluoma 1976). However, the 1988 criteria did not include plant species in the derivation because "a Final Plant Value, as defined in the Guidelines, cannot be obtained because no test in which the concentrations of chloride were measured and the endpoint was biologically important has been conducted with an important aquatic plant species" (EPA 1988). These concentrations for plants are below the SMCV observed for vertebrate and invertebrate animals (Table 1) suggesting that plants may be more sensitive to chloride than are animals.

3.2.2. Recent research with freshwater mussels suggests that the glochidia of some species may be more sensitive to chloride than the current suite of aquatic organisms for which data is available (Gillis 2011, Pandolfo et al. 2012). Stephan included data from juvenile freshwater mussels or freshwater mussels that do not have a glochidia stage (i.e., *Villosa delumbis* and *Lampsilis fsciola*, Bringolf et al. 2007; *Villosa iris* and *Lampsilis siliquoid*, Wang 2007; *Sphaerium simile*, GLEC and INHS 2008), but Stephan excluded all studies with glochidia because of their unique life-history which requires that they attach to a fish host in order to survive (Stephan 2009a p. 7[d]). The unique life history of most freshwater mussel species makes it difficult to design toxicology studies with them. However, freshwater mussels are among the most imperiled organisms in Pennsylvania (PNHP 2012), therefore it is important that water quality criteria be protective of them. One "very important question is 'What species-specific toxicity-test duration is ecologically relevant for glochidia?'" (Stephan 2009a p. 7[d]).

3.3. The proposed chronic criterion is not robust.

3.3.1. The genus mean chronic values (GMCV) should not have been calculated directly from the species mean chronic values (SMCV) without first correcting for hardness and sulfate.

3.3.1.1. The SMCV from different experiments were not normalized for hardness and sulfate (Stephan 2009c). As a result, the SMCV are not directly comparable because the toxicity of chloride varies depending upon the chemical composition of the water in which the test was done (e.g., Mount et al. 1997, Soucek 2007, Elphick et al. 2011). Therefore, calculating the GMCV as the geometric mean of the SMCV for a given species is not appropriate. It should be noted that the species mean acute values (SMAV) were corrected for hardness and sulfate before calculating the GMAV (Stephan 2009g).

3.3.2. There is inconsistency in the meaning of the species mean chronic value (SMCV). The SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

3.3.2.1. Stephen (2009c) used the geometric mean of the no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) to determine the SMCV. The NOEC and LOEC refer to test concentrations used in the experiments, but the amount of impairment at the NOEC and LOEC varied among experiments (Table 1). Therefore the SMCV determined by Stephen (2009c) refer to different levels of impairment for different species.

3.3.3. Different researchers analyzing the same data have arrived at different results and different conclusions.

3.3.3.1. The guidelines that different researchers have used to determine which studies should be included and the interpretation of the EPA 1985 guidelines differ between researchers (e.g., EPA 1988, Stephan 2009a). As a result the rules to determine the appropriate studies and data to use to derive chloride criteria are not interpreted in a consistent manner and researchers have differed in the tests they included or excluded. For example, Stephan (2009c, 2009e) excluded an acute and chronic study of *Rana sylvatica* by Sanzo and Hecnar (2006) because they used technical grade sodium chloride, but Elphick et al. (2011) included this study when deriving a chronic criterion.

3.4. The proposed chronic criterion does not account for uncertainty in data and methods.

3.4.1. The proposed chronic criterion equation may allow for chloride concentrations in surface waters of Pennsylvania above the concentration shown to cause harm to aquatic organisms during laboratory experiments. For example, the SMCV for some species in Table 1 are near or exceed the normalized chronic criterion of 389 mg chloride/L which Iowa adopted for surface waters where sulfate and hardness are not known. The SMCV in Table 1 would need to be corrected for hardness and sulfate to confirm that the chronic criterion would exceed the SMCV. In 1988, the EPA affirmed that the proposed chronic criterion was below the three SMCV available at that time (EPA 1988). Stephan in 2009 did not affirm that the proposed chronic equation was below the level shown in laboratory experiments to impair aquatic organisms.

3.4.2. The proposed chronic criterion equation includes a correction for hardness and sulfate although the exponents for hardness and sulfate are based on studies in two labs (GLEC and INHS 2008, p29 & 36) of only one species (*C. dubia*) under acute conditions (Stephan 2009f). Stephan (2009f) presents evidence that "supports the concept" that "the sulfate exponent might be more negative than indicated by the GLEC and INHS (2008) data" (Stephan 2009f p. 4). A negative exponent for sulfate means that a higher sulfate concentration lowers the LC_{50} for chloride. Thus, reliance on the 2009 Iowa equations may not offer the intended level of protection to aquatic organisms in Pennsylvania.

3.4.3. The endpoints of chronic tests conducted under laboratory conditions (e.g., survival, reproduction) may not reflect the most sensitive response in nature. In nature, a stress response may occur at lower concentrations than what are observed under controlled laboratory settings. A similar pattern is seen with behavioral responses such as avoidance, coughing or rapid breathing by fish, or increased activity (Atchison et al. 1987, Scott and Sloman 2004, Hellou 2011). Behavioral responses have been poorly documented or not measured in most laboratory experiments of chloride toxicity, therefore it is unknown how the behavior of aquatic organisms in nature would be affected by elevated chloride.

3.4.4. There has been no attempt to account for the fact that the available data represents only a small percentage of the species found in Pennsylvania. Including studies conducted since the 2009 Iowa criteria were derived results in a different acute-to-chronic ratio (ACR) and acute and chronic criteria (e.g., Elphick et al. 2011). It is to be expected that additional data may change the criteria, such as occurred between the derivation of the 1988 criteria and the 2009 criteria (e.g., ACR= 7.594, EPA 1988; ACR = 3.187, Stephan 2009h; ACR = 3.50, Elphick et al. 2011). Focusing on species found in Pennsylvania may also alter the criteria.

3.4.5. Different methods to derive the chronic criterion may result in different criterion. Stephan (2009c, 2009h) used the ACR whereas Elphick et al. (2011) derived a chronic criterion directly from chronic studies. (chronic criterion = 307 mg/L, Elphick et al. 2011; chronic criterion = 428 mg/L, Stephan 2009h). It should also be noted that other factors, such as if how hardness and sulfate were accounted for, could also account for differences in the criterion.

3.4.6. The lack of robustness in the derivation of the chronic criterion is further evidence of uncertainty.

Table 1: Data used to derive the species mean chronic values (SMCV) by Stephan (2009c). The SMCV is the geometric mean of the NOEC and the LOEC. A subset of this data was used to calculate the genus mean chronic values and the acute-to-chronic ratio, which was used to derive the proposed chronic criterion.

Category	Species	Endpoint	NOEC (mg/L)	LOEC (mg/L)	SMCV(mg/L)	Reference
Fish – non-salmonid	Fathead minnow	33d; survival	352 (9% reduction)	533 (15% reduction)	433.1	(Birge et al. 1985)
Fish - salmonid	Rainbow trout	Early life stage; survival	643 (4% reduction)	1324 (46% reduction)	922.7	Spehar 1987[1]
Cladoceran	*Ceriodaphnia dubia*	7-9d; Reproduction	?[2]	? (EC50)	925	(Cowgill and Milazzo 1990)
Cladoceran	*Ceriodaphnia dubia*	7 d; ?	?	?	235	(Diamond et al. 1992)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A[3]	442.2[4] (IC25)	<442.2	WISLOH 2007 (mod. Hard water)
Cladoceran	*Ceriodaphnia dubia*	6-7d; Reproduction	N/A	385.2 (IC25)	<385.2	WISLOH 2007 (Hard water)
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	340 (IC25)	<340	Lasier et al. 2004[5]
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction (12 studies)	<152-303	346-685 (IC50)	<322	(Aragão and Pereira 2003)
Cladoceran	*Ceriodaphnia dubia*	7d; Survival	1092	1456	N/C[6]	(Cooney et al. 1992)
		7d; Reproduction	<455-819	455-1092	<629	
Cladoceran	*Ceriodaphnia dubia*	7d; Reproduction	N/A	370.6 (EC20)	370.6	(Harmon et al. 2003)
Cladoceran	*Daphnia ambigua*	10d; Reproduction	N/A	292.4 (EC20)	292.4	(Harmon et al. 2003)
Cladoceran	*Daphnia magna*	10d; Reproduction	2184	2597 (EC50)	2382	(Cowgill and Milazzo 1990)
Cladoceran	*Daphnia pulex*	21d; Reproduction	314 (0% reduction)	441 (27% reduction)	372	(Birge et al. 1985)
Frog	*Rana sylvatica*	90d; Survival	N/A	625 (62% reduction)	<625	(Sanzo and Hecnar 2006)

[1] Unpublished memorandum sent directly to C. Stephan from R. L. Spehar on June 24, 1987. Data is not available on-line (scholar.google.com, search "chloride author:Spehar", Aug. 3, 2012).
[2] Data not presented in Stephan (2009c) and document not available for download (Aug. 3, 2012)
[3] Stephan (2009c) did not use the NOEC to calculate the SMCV.
[4] WISLOH 2007 refers to an unpublished study that could not be found on the Wisconsin State Laboratory of Hygiene webpage (http://www.slh.wisc.edu/, search "chloride", Aug. 3, 2012). IDNR (2007) presents results from the WISLOH lab covering the period 2000-2007, however the results in that report (Table 4: *C. Dubia* chronic toxicity 703 mg Cl^-/L; Table 7: *C. dubia* chronic toxicity: 427 mg Cl^-/L) do not match those presented by Stephan (2009c). Corsi et al. (2010) present results from the WISLOH lab over the same time period, but the studies do not appear to be the same as the ones reviewed by Stephan (2009c) because the Corsi study focused on surface waters receiving road run-off.
[5] Data was presented in a poster at the SETAC meeting and is not available on-line (Aug. 3, 2012)
[6] The geometric mean for *C. dubia* survival in the study by Cooney et al. (1992) was not calculated by Stephan (2009c) because reproduction was more sensitive.

4. Point of Clarification

4.1. As written in PA Bulletin 12-1292 it appears that Pennsylvania will adopt the Iowa criteria *in toto*, including Iowa's criteria for waterbodies where sulfate and hardness are not known. Iowa defined normalized acute and chronic criteria to be applied to waterbodies where sulfate and hardness are not known that were based on the statewide background values for hardness (200 mg/L) and sulfate (63 mg/L). Average hardness and sulfate concentrations may be different in PA and therefore the normalized acute and chronic criteria for Iowa may not be appropriate for PA.

5. Summary and Recommendations

5.1. The chloride criteria proposed by the EQB on July 7, 2012 are an improvement over the criteria that were proposed in 2010. Specifically, the proposed criteria incorporate characteristics of the receiving waters that affect chloride toxicity. However, as was highlighted in our previous review, the newly proposed criteria based on the Iowa standard may not be protective of aquatic life in Commonwealth streams, rivers, and lakes. Examples of uncertainty are:

- 5.1.1. The proposed chronic criterion may allow for ambient chloride concentrations in surface waters in Pennsylvania above the concentrations shown to cause harm to aquatic organisms in laboratory experiments.
- 5.1.2. The criteria are based only on the chloride of sodium although the chlorides of calcium, magnesium or potassium may enter surface waters of Pennsylvania and are more toxic to aquatic organisms.
- 5.1.3. The proposed criteria are derived from only a few species found in Pennsylvania.
- 5.1.4. There are only seven species (6 after excluding the frog, *Rana sylvatica* which Stephan [2009g] excluded because the sodium chloride used in the experiment was technical grade) for which there are acceptable chronic data (Table 1).
- 5.1.5. Glochidia and plants were not included in the derivation of the acute or chronic criteria.
- 5.1.6. The proposed criteria may not be protective of our more sensitive stream dwelling invertebrate species, particularly early life history stages (e.g., glochidia of mussels or early life stages of other invertebrates).
- 5.1.7. Exponents for hardness and sulfate in the acute and chronic criteria equations may be under-protective.
- 5.1.8. The species mean chronic values (SMCV's) were not corrected for hardness and sulfate concentrations.
- 5.1.9. The SMCV refer to different levels of impairment for the different experiments and species.
- 5.1.10. The SMCV are not corrected for hardness or sulfate.
- 5.1.11. The endpoints of laboratory toxicity studies do not include behavioral responses. Behavior may be affected at lower chloride concentrations than are survival, reproduction or growth.

5.2. Following are some recommendations on how the EQB may address uncertainty.

5.2.1. Include a safety factor in the derivation of the chronic criterion. At a minimum, that safety factor should be sufficient to ensure that the chronic criterion is below the SMCV or GMCV. Following are some reasons that a safety factor should be used:

5.2.1.1. "Safety factors are used to provide an extra margin of safety beyond the known or estimated sensitivities of aquatic organisms" (EPA 1985 p 36).

5.2.1.2. The acute criterion incorporates a safety factor (i.e., 2) but the chronic criterion does not. The 1985 EPA guidelines indicate that a safety factor of 2 is always to be used when calculating the acute criterion (called the criterion maximum concentration in EPA 1985, p 54, item XI.B.) but does not give a rationale for this using this safety factor. Although the EPA did not include a safety factor when deriving the chronic criterion in 1988, the chronic value was below the level shown to cause harm to the three species for which data were available at that time (EPA 1988). It is unclear if the proposed chronic criterion is below the level shown to cause harm because the SMCV in Table 1 have not been corrected for hardness or sulfate.

5.2.1.3. The acute and chronic criteria are based solely on studies using the chloride of sodium, but the chlorides of potassium, magnesium or calcium may be present in surface waters of Pennsylvania and are more toxic to aquatic organisms than is the chloride of sodium.

5.2.1.4. Environmental impacts (including avoidance) may occur at lower concentrations then those that affect growth or survival.

5.2.1.5. British Columbia (Nagpal et al. 2003) used a safety factor of 5 in the derivation of the chronic guideline. Their justification for this safety factor was as follows:

- Chronic data available from the literature were scant;
- In a recent study, Diamond et al. (1992) found a LOEC/NOEC ratio for reproduction of 3.75 in *C. dubia* exposed to NaCl for 7 days. Also, LC_{50}/LC_0 of 3 and LC_{100}/LC_0 of 4 were obtained by Hughes (1973), whereas the DeGreave et al. (1991) data yielded LC_{50}/NOEC ratios that ranged from about 1.0 to 6.9;
- Additional protection may be required for those species that are more sensitive but have not yet been tested in the literature.

5.2.2. A new review of chloride toxicity studies should be conducted to generate a more complete and up-to-date list of species and genus mean acute and chronic values. The references sited at the end of this comment include a few studies that have been published since 2009. A new review should:

5.2.2.1. Resolve the controversy regarding aquatic plants and glochidia.

5.2.2.2. Clearly define rules to include or exclude a study and document the rationale for studies that are excluded;

5.2.2.3. The species mean acute values and species mean chronic values should be calculated using a consistent and biologically meaningful endpoint. For example, Elphick et al. (2011) used probit regression to determine an endpoint that was consistent among species (e.g., the IC10).

5.2.2.4. Derive species mean chronic values normalized for hardness and sulfate;

5.2.2.5. Explore the possibility of deriving chronic criterion directly from the data rather than using the ACR (e.g., Elphick et al. 2011);

5.2.2.6. Include in the review toxicity studies with the chlorides of potassium, magnesium or calcium. Although conducting additional experiments with species found in Pennsylvania is the preferred approach, it may be appropriate to use the ratios cited above (3.1.2) to derive the SMAV or SMCV. For example, the chloride of potassium appears to be 4-10x more toxic to aquatic organisms than is the chloride of sodium.

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Conclusions

After reviewing four different approaches for deriving water quality chloride criteria to protect aquatic life (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) and the data underpinning PA's proposed criteria (EPA 1988) and the Iowa criteria (Stephan 2009a,b,c), it is clear that:

1) All approaches set chloride criteria that are at least several times greater than natural baseline chloride concentrations, and therefore represent a measurable and significant change in the chemical composition of freshwater ecosystems in the NE United States. The question that the current evidence is unable to answer is: will these criteria result in significant biological change? There is limited evidence of the biological impact of previous elevated chloride levels in aquatic ecosystems in the U.S. or Canada. Past monitoring efforts (see introduction) suggest that some streams regularly reach the acute criterion, but there has not been a noted change in biota following these pulses, largely because of a dearth of biological data following these episodic events. One study has demonstrated that macroinvertebrate drift increases in response to pulsed chloride input (Blasius and Merritt 2002). Another study has demonstrated losses of species in stream fish communities with small changes in chloride levels across a regional-scale analysis (Meador and Carlisle 2007), and the composition of algal species has been observed to change when chloride concentrations increase (Evans and Frick 2001). Nonetheless, there are limited data on biological changes accompanying changing chloride concentrations in the natural environment. We could not find any studies evaluating the influence of chloride on vital stream functions such as primary production, stream metabolism, or nutrient uptake or processing, all of which are important indicators of water quality for aquatic ecosystems.

2) All of these criteria are based on data for invertebrate and fish species that are not a random subset of stream invertebrate and fish species. Rather, most of the species with chloride data are known to be not especially sensitive to changes in environmental condition, which is one reason they survived well in the laboratory and became standards in laboratory bioassay protocols. The most recent iteration of the taxa that qualify based on EPA standards (in Stephan 2009a,b,c) doesn't include any classically sensitive stream invertebrate species such as stoneflies, mayflies, and caddisflies, all of which are important indicators of stream condition and are integral in the regulatory definition of stream impairment. Our concern is that criteria intended to protect most (e.g., 90% or 95%) of the species with chloride data might actually protect a much smaller proportion of all species that occur in a natural community because the natural community includes many species known to be sensitive to environmental change while the laboratory studies are biased toward species known to be at least moderately tolerant of environmental change. This is one reason to approach the acute and chronic criteria with a strong safety factor.

3) Data available are primarily from acute toxicity studies, but the chronic criterion may be more important for long-term structuring stream communities and maintaining designated use for aquatic life. For example, fish tend to be moderately tolerant of acute chloride stress relative to macroinvertebrates, but they are one of the more sensitive taxa to chronic chloride stress. For example, fat head minnows (Birge et al. 1985) experienced the greatest mortality between days 9 and 21 and therefore had one of the highest acute-to-chronic ratios examined. The dearth of chronic studies on both invertebrates and fish is troubling. It is likely that, like some amphibians (e.g., spotted salamander), embryonic and early life stages of some fish will be more sensitive than is currently recognized.

4) The majority of chloride criteria developed to date are limited to or dominated by data on NaCl chloride toxicity, the least toxic salt. This point is routinely justified by the fact that NaCl is the most anthropogenically abundant of these four salts. However, no special guidance is given for permitting salt applications or industrial effluents known to include significant amounts of chloride derived from the more toxic non-sodium salts, including Marcellus Shale wastewater.

5) Using the data provided in Stephan 2009a (Table 2 herein), we have calculated both the acute (CMC) and chronic (CCC) criteria using the methods of the EPA (Stephan et al. 1985, EPA 1988), Evans and Frick (Evans and Frick 2001), British Columbia (Nagpal et al. 2003), and Iowa (Iowa DNR 2009) and have compared the range of values with the proposed PA values (Table 3). The range of acute values is 564 – 830 mg/l Cl- and the range of the chronic values is 91 – 428 mg/l Cl-. This comparison eliminates the variability in the choices each of the authors have made with regard to studies included or excluded. We note that the PA proposed acute value is the least protective criterion, primarily because it is not based on more recent acute toxicity studies. We recommend that PA adopt an acute criterion that is reflective of these new data. The method adopted by British Columbia is the most protective of aquatic life among these approaches. BC invoked a precautionary principle that acknowledged both the uncertainty of the available data and analyses and the importance of protecting their aquatic life. Since BC adopted their criteria, only new acute datasets have become available and the values in Table 3 utilize those data but use the BC approach to arrive at a final value (i.e., lowest SMAV/2[safety factor]). The BC use of a safety factor of 2 for the acute criteria was also consistent with what the EPA had done. However, BC was the only entity to apply a safety factor for the chronic criterion (5). We feel that the use of a safety factor for chronic criteria derived from the use of an ACR is clearly justified given the very limited number of chronic toxicity studies, and the desire to protect species that may be more sensitive than those used in the standard laboratory bioassays. We recommend that PADEP adopt the same methodology that BC has used for calculating both acute and chronic data. We feel that this is particularly important for the chronic criteria, as there is the potential for permitted discharges (particularly from the Marcellus Shale gas drilling industry) to raise chloride concentrations in streams to near the chronic criteria level. Given the paucity of data determining thresholds for chronic effects, this approach is warranted. At the very least, a safety factor should be applied to any of the other methods producing a chronic criterion.

We have a number of concerns that are specific to the actions and options available for PADEP:

6) Protecting CWFs and TSFs based on ACRs that included more chloride-tolerant *Daphnia* is not justified when it may expose rainbow trout to chloride concentrations approaching their chronic

levels (1,324 mg/l Cl^- killed 46% of individuals in an early life stage test and at 643 mg/l Cl^- killed <4%). Trout are an integral component in the definition of these two aquatic life uses. The proposed chronic value of 230 mg/l is potentially a concern for biotic assemblages in Pennsylvania. For example, Meador (2007) suggests that optimum Cl^- values are low (3-35 mg/l) and we infer that if those Cl^- concentrations are exceeded it may result in changes in fish community structure. Similarly, not having a temperature component also seems to invite season-specific impairments of macroinvertebrates in TSFs and WWFs based on the recent findings of Silver et al. (2009), based on the seasonal movement of organisms into and out of various life history stages, and based on variation in their metabolic rates in response to seasonal changes in water temperature. Adding a temperature component to the chloride criteria would require further research on temperature effects.

7) The Evans and Frick (2001) method has the benefit of being reproducible and open to interpretation. Their use of nearly all of the valid acute LC_{50} data in Fig. 7-2 (Evans and Frick 2001), and the calculation of a sigmoid curve function (including 95% confidence intervals) that describes the percent of genera affected versus chloride concentration, is readily digestible by the public. However, the sigmoid curve function can be generated using various numbers of terms (parameters) in the equation and/or various equations (e.g., sigmoid, logistic, Weibull). The result of choosing a slightly different function can result in differences in acute and chronic values. To use this approach requires a valid justification for the choices made in fitting the curve to these data. Furthermore, these data still represented a small subset of aquatic species, and were biased towards lab friendly species that are easiest to culture (e.g., *Daphnia*). Since the selection of taxa was not a random subset of the aquatic species at large, most criteria based on the animals selected are primarily protective of those species tested (e.g., being protective of 95% of those taxa might only be protective of 50% of all species). This point is not limited to Evans and Frick but is valid for all of the approaches we have reviewed. This is the primary reason that the application of a safety factor is needed. The Evans and Frick (2001) study did not apply a safety factor to either their acute LC_{50} relationship or the derived chronic relationship.

8) More data is generally better, but there is a need for more consideration of how data gets incorporated. The Stephan (2009a,b,c) approach of calculating a predicted genus mean chronic value from the species mean acute values does not seem justified in this case. The GMCVs are not much better than guesses, and there is no attempt to correct for this inherent uncertainty. Adding GMCV values above the lowest four gives the false sense of increased precision of the true distribution of the GMCV, which has the result of increasing the final chronic value (FCV). We feel it would be appropriate to apply a safety factor to the chronic criteria to acknowledge the uncertainty in the FCV.

9) The use of hardness and sulfate equations (Iowa DNR 2009) in PA will improve protections and application of the chloride criteria only to a limited extent since the range of criteria in PA would be narrow (based on EMAP site values for hardness and sulfate in PA). Secondly, the hardness and sulfate exponents in the Iowa criteria were based on data from an acute toxicity study of only one species (*C. dubia*), although four species were studied and three were sensitive to hardness. No data were available on the relationship between hardness or sulfate and chronic toxicity. In the end, Iowa uses a default value for hardness and sulfate if no other data are available. This is akin to setting a fixed criterion value but allowing site-specific deviations if one

gathers the appropriate data. Clearly, more species-specific data are needed to better understand the relationship between chloride toxicity and hardness or sulfate.

10) As noted above, previous reviews of chloride considered only NaCl and considered road salt to be the most likely source of chloride. We feel that the current proposed standard should explicitly acknowledged that these criteria are specific to NaCl derived chloride, and guidance should be given to address cases when significant chloride is derived from salts (i.e., KCl, $MgCl_2$ and $CaCl_2$) that have proven to be more toxic sources of chloride.

Our review of four approaches (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) for deriving chloride criteria to protect aquatic life identified a number of weaknesses in the available data and the analyses used to derive criteria. We were especially concerned with (1) the near absence of important stream-inhabiting and stream-classifying species such as mayflies, stoneflies, and caddisflies, (2) the dependence on relatively few chronic studies, and (3) the choice of excluding some studies that were very important (e.g., fat head minnow Birge et al. 1985). We believe these weaknesses justify using a very conservative approach to assigning criteria. All four approaches to set acute and chronic criteria would result in chloride concentrations at least several times greater than base flow concentrations commonly observed in Pennsylvania streams in their most natural condition (i.e., Exceptional Value and High Quality waters). The lowest criteria for chloride were derived by the Canadian Province of British Columbia (Nagpal et al. 2003) – they acknowledged the weaknesses in available data, and applied safety factors of 2 for the acute criterion and 5 for the chronic criterion. Given the limits in the available data, and the potential that treated wastewaters from Marcellus Shale drilling may result in near-criterion chloride concentrations 356 days per year (versus the 30 days of a standard chronic bioassay), we believe the British Columbia criteria (either the originally adopted criteria or our re-calculated criteria in Table 2) would be the most protective of aquatic life for Pennsylvania streams, especially for the trout and many pollution-sensitive macroinvertebrate species that characterize Cold Water Fishes streams.

Stroud Water Research Center Expert Report on the Proposed Rulemaking by the Pennsylvania Environmental Quality Board [25 PA. CODE CH. 93] for Ambient Water Quality Criterion; Chloride (Ch) [40 Pa.B. 2264] [Saturday, May 1 2010]

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1 Report Goal and the Proposed Pennsylvania Chloride Criteria

The Pennsylvania Environmental Quality Board has proposed to amend Table 3 in 25 Pa. Code § 93.7 (Specific Water Quality Criteria) which currently sets a Chloride (Ch_1) criteria for Potable Water Supplies at a maximum concentration of 250 mg/l. The proposed amendment adds chloride criteria (Ch_2) for Aquatic Life Uses for Cold Water Fishes (CWF), Warm Water Fishes (WWF), Migratory Fishes (MF), and Trout Stocking (TSF) for chronic conditions not to exceed a four-day average of 230 mg/l and for acute conditions not to exceed a one-hour average of 860 mg/l. Both chronic and acute criteria should not be exceeded more than once every 3 years on the average. These criteria are identical to those recommended by the US EPA (EPA 1988).

This report examines Pennsylvania's currently proposed ambient water quality criteria for chloride for the adequate protection of aquatic life uses in Pennsylvania. To that end, the report examines closely the scientific rationale behind the 1988 set of chloride criteria set by the EPA (which the Environmental Quality Board has decided to use as their criteria), and chloride criteria adopted by other states like Iowa, and the Canadian province of British Columbia. The report evaluates the methodologies utilized in formulating the various sets of chloride criteria to determine which methodologies best protect aquatic life uses of the Commonwealth's water resources. The report addresses the chloride problem in the Pennsylvania context in order to fashion a recommendation that will apply to the Commonwealth's particular issues. Finally, the report recommends that the Board propose a set of chloride criteria using the British Columbia approach that is based on scientifically sound rationale and will adequately protect aquatic life uses in Pennsylvania.

This report reflects the scientific opinion of three scientists at the Stroud Water Research Center, Drs. D.B. Arscott, W.H. Eldridge, and J.K. Jackson after their review of the proposed standard, existing standards (EPA, Iowa, Ohio, Canada), and a substantial proportion of the scientific literature on chloride in the environment and toxicity effects. This report was prepared during the 45-day review period starting on 1 May 2010.

2 Introduction

2.1 *Salt in nature*

Salinity is the total concentration of salts in water. In chemistry, salts are ionic compounds that can result from the neutralization reaction of an acid and a base. Salts are composed of cations (positively charged ions) and anions (negatively charged ions). The component ions can be inorganic (such as chloride), as well as organic (such as acetate: CH_3COO^-). There are several types of salt, but this report focuses on the chloride-containing salts which include (but are not limited to) sodium chloride (NaCl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and potassium chloride (KCl). When dissolved in water, these salts dissociate into their free ions (i.e., the cations Na^+, Ca^{2+}, Mg^{2+}, K^+ and the anion Cl^-).

Aquatic organisms vary in their salt tolerance. Salt tolerance also varies depending on the specific cation involved. For example, Ca^{2+} is essential for algal growth. Most plants require Mg^{2+} since it is a component of the chlorophyll molecule. Na^+ and K^+ are involved in ion transportation and exchange across cell membranes in most organisms and chloride plays a role in the osmotic salinity balance and the exchange ions. However, an organism's requirement for each of these varies from cation-to-cation and from species-to-species and this results in different toxicity thresholds for each cation specific to each organism of interest.

Organisms that tolerate a wide range of salinities are "euryhaline" and are typically present in estuaries where salinities can change hourly due to tidal fluctuations, or are diadromous species that migrate between fresh water and salt water. Stenohaline organisms can only tolerate a narrow range of salinities. Stenohaline species can be further subdivided into those that live in low-salinity environments (e.g., freshwaters) and those adapted to high salinity environments (e.g., marine systems). Prior to selecting organisms for assessment of the toxicity of chloride or other salt-derived ions, it is important to consider whether the organisms are known to be salt tolerant or salt sensitive or whether there are other known life stages that may be adapted to different saline conditions (e.g., anadromous fish like salmonids of the genus *Oncorhynchus*). Understanding general salt sensitivity is important because developing chemical criteria to protect a broad array of aquatic organisms will only be successful if the studies underpinning the criteria have focused on the proportion of taxa that will be the first to experience its toxic effects. Since chemical toxicity is primarily related to concentration, this would mean that the sensitive organisms would experience chemical stress at the lowest concentrations compared to more tolerant organisms. Understanding each organism's life history sensitivities is also important since negative impacts to any component of the life history will typically result in a decrease in survival of the population.

2.2 Sources and pathways of salt that enters aquatic ecosystems

Natural sources of salts to water resources include (1) the oceans; (2) the natural weathering of bedrock, surficial materials, and soils; (3) geologic deposits containing halite, or saline groundwater (brines); and (4) volcanic activity (Mullaney et al. 2009). Oceans typically contain about 19,000 mg/l of chloride resulting in the atmosphere above the oceans being dominated Na^+ and Cl^-. This results in the deposition of Na^+ and Cl^- being highest along the coast. The contribution of wet deposition to natural concentrations of Cl^- in streams in the northern US is estimated to be ~0.1 – 2.0 mg/l (Mullaney et al. 2009) varying with distance from the coast. In forested watersheds in the northern US, stream Cl^- concentrations typically ranged (as measured from 1991-2000 by USGS) from ~5-30 mg/l (approximated 25th and 75th percentile by eye from Fig. 15 in Mullaney et al. 2009). But in the snowy region of the U.S., natural sources represent only a fraction of the salt that enters the ground water and surface water.

Of the chloride salts discussed here (NaCl, $CaCl_2$, $MgCl_2$, and KCl), sodium chloride (NaCl) is the most commonly produced and used in environmental applications. Its primary environmental use is as a deicing agent. NaCl is used to soften water in suburban and rural homes and Cl^- is then released to drainfields where it eventually flows to groundwater. Sodium chloride is also used as a food additive and condiment, in manufacturing pulp and paper, setting dyes in textiles and fabrics, and the production of soaps and detergents. In 2002, world production was estimated at 210 million metric tons (Feldman 2005). Magnesium chloride has many applications but its primary environmental use is as a deicing agent and as a dust and erosion control agent. It is also used in the manufacture of textiles, paper, fireproofing agents, cements, and refrigeration brine. Potassium chloride is primarily used as a fertilizer but is also used in food processing, and as a sodium-free substitute for table salt or as an alternative water softener. KCl is sometimes used in petroleum and natural gas operations. Calcium chloride is also used as an ice-melting compound and is more effective than NaCl at lower temperatures. The Salt Institute states that the optimum temperature for ice melting by Na-, Mg-, and Ca-chloride is -6, -28, and -67 °F, respectively (Salt Institute 2004). Other environmental uses for $CaCl_2$ include use in fire extinguishers, in wastewater treatment as a drainage aid, in blast furnaces, in food processing (e.g., pickles), and in fabric softeners (as a thinner).

The common pathways through which salt enters ground and surface waters are atmospheric deposition, the dissolution of deicing salts from normal use on streets, parking lots, highways, and other paved surfaces; storage and handling of deicing salts; release of brines from oil and gas production; leaching from landfills; the treatment of drinking water and wastewater; and discharge of wastewater from treatments facilities and septic systems (Mullaney et al. 2009). The major anthropogenic sources of Cl^- in surface waters of the US are deicing salt, urban and agricultural runoff, and discharges from municipal wastewater plants, industrial plants, and the drilling of oil and gas wells (EPA 1988). The use of salt in the US has increased from 42.9 million tons in 1975 to ~58.5 million tons in 2005. The major use of salt in 2005 was for deicing of roads, parking lots, and other impervious surfaces (Mullaney et al. 2009).

Prior to 2005, the largest use of salt had been in the chloralkali industry that produces chlorine and sodium hydroxide (Mullaney et al. 2009). Potassium and sodium chloride salts are also a common additive to hydraulic fracturing fluid used by the natural gas industry (GWPC 2009). The chemical composition of the fracturing fluid can change when injected in the geological formation by chemically dissolving other materials stored in the rock formation and the hydrocarbons being extracted. The concentration of salts in fracking fluid can increase substantially in geological formations containing large quantities of salt or formations derived from marine sediments, e.g., Marcellus Shales in NW and SW PA. Chloride salts dissolved into this fluid may contain KCl, $MgCl_2$, $CaCl_2$, NaCl and/or other metal chlorides. Unused fluid and the "flowback" fracking fluid is either reused or treated as waste. In some instances, the treated fracking fluid may be permitted to discharge to surface waters. In this case, permitted discharges of treated flowback from salt-laden geological formations may be of concern for their chloride content.

2.3 Salinity trends in freshwaters

The salinity of many streams, rivers, and lakes in the northeast United States has been increasing over the last couple of decades (Siver et al. 1996, Rosenberry et al. 1999, Kaushal et al. 2005b, Kelly et al. 2008, Gardner and Royer 2010). For example, Cl^- concentrations in stream baseflow of a NY stream have increased by 1.5 mg/l/yr from ~15 to >40 mg/l Cl^- over the 20-yr period 1985-2005 (Kelly et al. 2008). In these NY tributaries to the Hudson River, the average annual input of NaCl was 1.4 million kg/yr (Kelly et al. 2008). 83% was from road salt, 8% was from parking area salt, 4% was from sewage, and 3% was from water softeners. Natural sources (i.e., wet and dry deposition and weathering) accounted for <1% each. Minimally impacted watersheds in the NE U.S. probably typically had Cl^- concentrations ≤ 30 mg/l with many streams ≤ 10 mg/l (estimated from Mullaney et al. 2009). Kaushal et al. (2005b) measured Cl^- concentrations of up to 25% of the concentration of seawater in streams of Maryland, New York, and New Hampshire. Rosenberry et al. (1999) measured Cl^- concentrations in a New Hampshire stream changing from 3.5 mg/l in 1970 to 53 mg/l in 1994. Chang and Carlson (2005) surveyed tributaries of Spring Creek (in PA) during spring snowmelt and documented peak Cl^- concentrations of 362 and 551 mg/l Cl^- in two of ten tributaries sampled during the winter-spring of 2001-2002. Studies of road-side wetlands have measured Cl^- in ranging from 18–2700 mg/l (e.g., Benbow and Merritt 2004, Silver et al. 2009). The increases in Cl^- concentrations in freshwater in the northeastern US threatens salt-sensitive biota and may result in the extirpation of certain species that may ultimately cause changes in community structure and function (e.g., loss of algae, invertebrates, and fish) of these stream ecosystems.

The type of water body has a significant impact on the chloride concentration. According to Evans and Frick (2001), the highest chloride concentrations in freshwater habitats are typically found in roadside ditches where melt-water is concentrated (up to 19,135 mg/L, full strength sea water is about 19,250 mg/L). The next highest levels are in rivers and streams in populated areas with significant road salt use (up to 4,310 mg/L). Small lakes and ponds typically have higher levels than larger lakes, but levels in small lakes were below 200 mg/L. Lakes and ponds that are large and/or have many streams flowing in and out have more dilution capacity than rivers and streams which keeps chloride concentrations low. More stagnant lakes and ponds may slowly accumulate chloride salts and develop a saltier hypolimnion (bottom strata) (Evans and Frick 2001).

There is a strong seasonal component to chloride concentrations. In 100 streams in the northern US that were sampled 10 or more times for chloride between 1991 and 2004, the highest values were generally found during the winter and spring months (Nov-April) coinciding with winter deicing activity (Mullaney et al. 2009). High concentrations of chloride that occurred in late spring and summer when there was no deicing activity may be due to the discharge of groundwater containing high concentrations of chloride or could be related to wastewater discharges containing chloride during a low-flow period.

In the same 100 streams as above, mean annual chloride loads were 6.4 tons/mi^2 from the forested basins, 15.4 tons/mi^2 from the agricultural basins, and 88 tons/mi^2 from the urban basins (Mullaney et al. 2009). The median baseflow chloride concentration was 3.5 mg/L for forested basins, 21 mg/L for agricultural basins, and 81 mg/L for urban basins (Mullaney et al. 2009). The maximum measured chloride concentrations exceeded the EPA chronic criterion (230 mg/L) in 13 sites with urban land use and 2 sites with agricultural land use. Six sites had concentrations greater than the EPA 230 mg/L in 10 % or more of the samples collected. At three sites, samples were greater than the acute criterion (860 mg/L). Significant terms explaining variability of chloride yield were highway density, number of major discharges upstream of the monitoring site in the USEPA PCS database, potential evapotranspiration, and the difference between the percent urban and agricultural land. Major discharges included municipal wastewater treatment facilities with discharges greater than 1 million gallons per day, and other facilities that the EPA rates as major based on volume and type of pollutants and type of receiving waters.

Data were available to test for temporal trends in chloride loading for 19 sites (Mullaney et al. 2009). At three urban sites, increases in chloride load over time could be attributed to changes in the application of deicing salts, the expansion of the road network and impervious surfaces that needed deicing, increases in the number of septic systems, increases in the volume of wastewater discharge, and the arrival of saline groundwater plumes from landfills and salt-storage facilities over time.

Increased chloride concentration in groundwater is beginning to raise the baseline chloride concentration in streams in rural areas. During the period 1986-2005, chloride concentration increased 1.5 mg/L per year and chloride export increased 33,000 kg/year in tributaries to the Hudson River (Kelly et al. 2008). Road salt use and increased population density were not sufficient to account for the increased Cl^-. Increase in streamwater concentration was more likely due to a lag effect of long-term road salt use and subsurface buildup.

In the New York City drinking water supply watersheds, groundwater is a major contributor to streams. Groundwater discharge accounts for at least 60% of total annual stream flow in the Croton watershed (Heisig 2000). Chloride concentration in groundwater supplies exhibits a relatively linear relationship to road-salt application rate or two-lane road density throughout the year. In surface-water supplies, chloride concentration depends on salting intensity, soil type, climate, topography, and water volume, with larger water bodies exhibiting lower concentrations through the process of dilution (Heisig 2000). Deicing salts applied to roads during winter have been the primary source of solutes to groundwater in the Croton watershed, where chloride concentrations in baseflow of sampled streams ranged from 18 to 280 mg/l (Heisig 2000).

Baseline chloride levels are also increasing in rural streams of the northeast that have not seen an increase in road density (Baltimore MD, Hudson Valley NY, and Hubbard Brook NH) (Kaushal et al. 2005a). Possible causes are increased use of road salt and higher concentrations of chloride in groundwater.

3 Review of Existing Chloride Criteria

3.1 EPA 1988 Criteria

The PA DEP has proposed criteria that are the same as those derived by the EPA in 1988. Therefore we will use the EPA 1988 criteria as a starting point for this review.

In 1988, the EPA published a recommended Ambient Water Quality Criteria for Chloride (EPA 1988). To prepare the criteria, they reviewed the available chloride toxicity studies in August 1985, and included some more recent literature. The EPA acknowledged that the chlorides of potassium, magnesium, and calcium were generally more toxic to aquatic organisms than sodium chloride, but they limited their analyses to sodium chloride because the most data was available for this salt, and because most of the anthropogenic salt in the environment is likely to be sodium chloride (EPA 1988). All of these other forms of Cl- salts are typically found in Marcellus Shale waste water effluent. They noted that there was not sufficient data to indicate that toxicity would change with hardness, alkalinity, or pH.

To generate the Criterion Maximum Concentration (CMC), the EPA relied on studies by independent labs that identified the concentration of contaminant that caused mortality or a sub-lethal fitness effect to 50% of the individuals in a 96-hour exposure (LC_{50} or EC_{50}, respectively) to establish the acute criteria. Rules that the EPA followed when selecting studies are outlined in the "Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses" (Stephan et al. 1985) (hereinafter "1985 guidelines"). These EPA recommended rules require them to give preference to studies that used a flow of fresh water through the system (flow-through) over studies that used static water or that recycled water through a biofilter (renewal). EPA's review included 45 values for the 96-hr LC_{50} or EC_{50} from 15 species representing 13 genera. Of these 45 values, 23 were dropped because the salt used was not NaCl. Of the remaining 22 values, 4 were dropped because the study was not conducted in flow-through water and a value for the same species using flow-through water was available. The species mean acute value (SMAV) was the geometric mean of tests on the same species. The genus mean acute value (GMAV) was the geometric mean of tests on the same species. In 1988, there were 12 GMAVs.

The EPA used a procedure detailed in the 1985 Guidelines to calculate the Final Acute Value (FAV). The FAV is used to calculate the criterion maximum concentration (CMC). EPA's procedure to calculate the FAV is designed to protect 95% of the species, as there is a 95% confidence interval in their formula (however, it is not clear if this is intended to protect 95% of species in the environment or 95% of the species used in determining the criteria (EPA 1985)). First, the four lowest GMAVs are identified. In 1988, the four lowest GMAVs were 1974 (*Daphnia,* a water flea), 2540 (*Physa,* a snail), 2950 (*Lirceus*, an isopod), and 3795 (*Cricotopus*, a midge) in mg/L Cl^-. From these values, and the count of the total number of GMAV available (in this case 12), they calculated the FAV to be 1720 mg/L. The FAV is then divided in half (i.e., a safety factor of 2 is applied) to determine the CMC of 860 mg/L.

The same approach can be used to calculate the criteria continuous concentration (CCC) if there is sufficient data from chronic exposure studies, but in 1988 sufficient data did not exist. Rather, the EPA took advantage of the fact that there was a great deal more information on acute toxicity than there was on chronic toxicity to use the acute-to-chronic ratio (ACR) approach. Chronic studies had been conducted on three species: fathead minnows, rainbow trout, and *Daphnia pulex*. The chronic value for these species was calculated as the geometric mean between the lowest observed effect concentration (LOEC) and the no observed effect concentration (NOEC). The ACR for a given species was the ratio of the acute LC_{50} or EC_{50} to the chronic value. In 1988, the EPA determined the ACR for fathead minnows (15.17), rainbow trout (7.308), and *Daphnia pulex* (3.952). The EPA then calculated the geometric mean of the three species' ACRs, which was 7.594. The CCC is then determined to be the FAV divided by the ACR. The CCC was determined to be 230 mg/L (1720/7.594 rounded to the nearest ten). The data from the chronic studies were used only to set the ACR, and did not factor in the determination of the CCC in any other way. The ACR approach is acceptable when there are animals in at least three different families, provided that 1) at least one is a fish, 2) at least one is an invertebrate, and 3) at least one is an acutely sensitive freshwater species (EPA 1985). The Final Acute-to-Chronic Ratio geometric mean ACR was 7.594.

There are three factors in the derivation of the CMC, or acute criterion, which make the EPA approach protective. First, the EPA uses data from 96-hour exposure experiments to derive a CMC which is not to be exceeded for more than one hour every three years. The toxicity of chloride is time dependent. Chloride levels that are lethal over 96-hours may not have an impact when exposure is less than one day (Evans and Frick 2001). The second factor that makes the EPA approach protective is in the equations used to calculate the FAV, which are designed to protect 95% of the species represented in the testing. These equations may result in a FAV that is lower than the lowest observed GMAC. Finally, the EPA applies what appears to be a safety factor of two to the FAV to arrive at the CMC. This safety factor may be used to account for the fact that the FAV reflects a value at which acute mortality will occur in some species, but the aim of the criterion is to prevent chloride levels from reaching these toxic levels. One concern, however, is that the FAV equations are sensitive to the number of genera for which there are GMAVs, but not necessarily to their toxicity values. The artifact arises because the equations for FAV are designed to account for the precision with which one knows the variance among the GMAVs (W. Eldridge, personal observation[1]). When there are few studies, one is less sure of the true distribution of the GMAVs, and the equations have a correction factor which lowers the FAV. As studies are added, the precision should increase. Therefore, adding an additional GMAV that is larger than the lowest four will increase the FAV. Only by finding a GMAV that is more sensitive than the fourth lowest will the FAV become lower.

On the other hand, the derivation of the criteria continuous concentration (CCC; or the chronic criteria) does not include any additional protections that we could see. For instance, the CCC is determined from the FAV before the safety factor is applied. In addition, the chronic values used by the EPA are the geometric mean of the NOEC (no observable effect concentration) and the LOEC (lowest observable effect concentration). Therefore, one cannot be certain that no effect will occur. In addition, the chronic value is completely dependent upon the derivation of the FAV and the ACR. For a given FAV, dividing by a smaller ACR will result in a higher CCC. And the lack of protections comes despite chronic studies having been conducted for only three species. The ACRs varied from 3.9 (*Daphnia*) to 15.17 (fathead minnow). These chronic studies were limited in "sensitive" life history components (i.e., embryonic, eggs, juvenile fish). In addition, no plant, algae or amphibian toxicity data were included. *Spirogyra setiformis* was extremely sensitive (71 mg/l produced inhibition of growth, chlorophyll, and C fixation). Plants and algae are foundational resources for stream food webs. The loss of taxa or their abundance may have impacts to higher trophic levels such as invertebrates and fish.

The EPA 1988 criteria also do not account for the synergistic effects of hardness, sulfate, or temperature. Since 1988, each of these variables have been shown to significantly influence chloride toxicity (Iowa DNR 2009). Current efforts by the EPA (as reflected in the Iowa criteria described below) attempt to address hardness and sulfate interactions but not temperature. The 1988 criteria also were derived only from NaCl toxicity studies despite data cited in that study indicating greater toxicity to Cl^- derived from KCl and $MgCl_2$. The study (EPA 1988) also states specifically that the criterion probably will not be adequately protective when the chloride is associated with potassium, calcium, or magnesium, rather than sodium. If PA adopts the 1988 federal chloride criteria, PA should acknowledge that the criteria is not protective when the chloride is associated with potassium, calcium, or magnesium, as there is sufficient evidence that acute and chronic values for Cl^- derived from KCl and $MgCl_2$ would be considerably lower than the 1988 acute criterion (there is just not enough data to calculate acute criteria). Currently, the Commonwealth does not regulate Mg, K, or Ca, but should consider adding Mg^{2+} to the metal concentration criteria.

3.2 *Evans and Frick 2001*

In 2001, Evans and Frick (2001) published a review of the available chloride toxicity data, which included a unique method to derive chloride criteria for aquatic life. They were tasked with evaluating the impact of road salt on aquatic life in Canada. Evans and Frick (2001) present a different method of deriving the criteria. The Canadian method involves a three tier approach. The first and second tiers

[1] Authors observations on the result of the formula after adding or subtracting studies from the equation.

provide for the determination that the substance under consideration reaches levels in the environment that could have an adverse impact. Tier three assessments provide for the analysis of the likelihood that the substance under consideration will have a harmful impact on the environment. It does so by considering the distribution of exposures or effects among organisms (Evans and Frick 2001). Evans and Frick (2001) reviewed the available chloride toxicity data and the criteria for other jurisdictions. From all the acute studies (less than 7 days), they used just those involving a 2-4 day exposure. They normalized the 2-day and 3-day exposures studies to a 4-day exposure by using a correction factor based on Cowgill and Milazzo (1990) who investigated LD_{50} responses of two species of cladocerans to sodium chloride at daily intervals over a 7-day period (Evans and Frick 2001). They noted the lack of chronic studies, and therefore relied on the EPA 1988 ACR (7.59) to calculate a chronic value for the same species for which they had acute data. They used these chronic data to prepare a cumulative distribution curve of the % of taxa that would be affected for a given concentration of chloride. They fit a sigmoid function through that curve and calculated 95% confidence intervals around that regression. The procedure for choosing the sigmoid function was not described. Several options exist for fitting sigmoid curves (e.g., 3, 4, or parameters, logistic, Weibull, Gompertz, Hill, or Chapman equations). Differences in these equations can result in considerable variations in the fit (particularly at the tails of the regression where chloride criteria would be derived). Also, compared to data available in 2010, the available data (acute data forming their 96 hr curve) for their review were limited; therefore the distribution begins at 10% of species affected with a mean of 240 mg/L Cl^-.

One strength of this approach is that the authors were able to generate confidence intervals for their distribution. The lower bound to the 95% confidence interval (for their chronic curve) at which 10% of species were affected was 194 mg/L and the upper bound was 295 mg/L (Evans and Frick 2001). However, their approach was heavily dependent upon the ACR, as was the EPA 1988 approach. Their approach is also sensitive to the derivation of the sigmoid curve. Curve fitting is sensitive to the equation for the curve as well as the data that is being fitted. SigmaPlot, which Evans and Frick used to fit the sigmoid curve, has three different equations for the sigmoid curve: a 3-, 4-, or 5- parameter equation. It is not apparent which version they used, or even what their rationale was for fitting a sigmoid curve. There are other equations for the sigmoid curve that might also be appropriate. The amount, distribution and transformation of these data (Evans and Frick log transformed their data before fitting) will also affect the fit of the curve. Using a different equation for the curve or not transforming the data would result in a slightly different predicted value for the 5% species cutoff, which makes this approach less robust than other approaches for calculating criteria.

3.3 British Columbia 2003

The British Columbia Ministry of Environment adopted an Ambient Water Quality Guideline for Chloride in 2003 (Nagpal et al. 2003). Their guideline for Freshwater and Aquatic Life states that the average of 5 weekly measurements taken over a 30-day period should not exceed 150 mg/L with an instantaneous maximum not to exceed 600 mg/L. British Columbia considered the available scientific literature, existing guidelines from other jurisdictions, and environmental conditions in British Columbia. In British Columbia, background chloride concentrations are 1-100 mg/L Cl^- with maximum concentrations from 13-140 mg /L Cl^-. Most of the chloride that enters the environment in British Columbia is from the storage and application of road salt for accident prevention, which is predominantly NaCl. Their standards are based on two reviews – Evans and Frick (2001) and Bright and Addison (2002). British

Columbia considered the scientific literature on chloride toxicity to be "not always conclusive because it is usually based on laboratory work that, at best, only approximates field conditions." British Columbia invoked a "precautionary principle" to incorporate built-in safety factors that are conservative relative to the EPA 1988 guidelines, but considered natural and background conditions in the province.

The acute and chronic rationales were as follows:

> *Acute rationale*: The guideline for maximum chloride concentration was derived by applying a **safety factor of two** to the 96-h EC_{50} of 1204 mg/L for the tubificid worm, *Tubifex tubifex* (Khangarot 1991), and rounding the number to the nearest tenth. A safety factor of two is applied to the acute data because of the relative strength of the acute data set (28 values, 20 species, 15 studies).
>
> *Chronic rationale*: The recommended water quality guideline was derived by **dividing the lowest LOEC** (lowest observed effect concentration) from a chronic toxicity test **by a safety factor of 5**. The lowest LOEC for a chronic toxicity test was 735 mg/L for *Ceriodaphnia dubia* (DeGreave et al. 1992). That chloride concentration resulted in a 50% reduction in reproduction over the 7 day test duration. Utilizing this value and following the application of a safety factor of five, the chronic guideline is 150 mg/L (rounded to the nearest tenth place). The safety factor of 5 in the derivation of the chronic guideline was justified as follows: (a) chronic data available from the literature were scant; (b) in a recent study, Diamond et al. (1992) found a LOEC/NOEC ratio for reproduction of 3.75 in *C. dubia* exposed to NaCl for 7 days. Also, LC_{50}/LC_0 of 3 and LC_{100}/LC_0 of 4 were obtained by Hughes (1973), whereas the DeGreave et al. (1992) data yielded LC_{50}/NOEC ratios that ranged from about 1.0 to 6.9; (c) additional protection may be required for those species that are more sensitive but have not yet been tested in the literature.

The guidelines are used to set site-specific objectives. In most cases, the objectives are the same as the guidelines, but they could be higher or lower depending upon background levels and the value and significance of the waterbody. The guidelines and objectives have no legal standing, but they can be used to develop waste management permits, orders and approvals that do have legal standing.

3.4 Iowa 2009

In 2009, Iowa adopted new chloride criteria for the protection of aquatic life after consultation with the EPA and the publication of new data produced by the Great Lakes Environmental Center (GLEC) and the Illinois National History Survey (INHS) on chloride toxicity to four invertebrate species (Iowa DNR 2009). Those studies assessed the water flea (*Ceriodaphnia dubia*), planorbid snail (*Gyraulus parvus*), tubificid worm (*Tubifex tubifex*), and fingernail clam (*Sphaerium simile*) sensitivity to chloride under varying hardness concentrations. (For purposes here, hardness is a measure of the concentration of dissolved calcium carbonate – $CaCO_3$). Results indicated that the water flea, clam, and worm had decreased sensitivities to chloride with increasing hardness. The water flea was tested for the influence of sulfate concentrations on chloride sensitivity and was found to be negatively influenced by SO_4 concentrations. As a result, the State of Iowa proposed 12 options (both acute and chronic) for setting chloride criteria with 8 of those options varying with hardness and sulfate concentrations, 4 varying with hardness only, and 4 flat criteria. Ultimately, Iowa adopted two of the options that vary with hardness and sulfate: acute chloride criteria = $287.8*[\text{hardness}]^{0.205797}*[\text{sulfate}]^{-0.07452}$ and chronic chloride criteria = $177.87*[\text{hardness}]^{0.205797}*[\text{sulfate}]^{-0.07452}$. Figure 1 illustrates how the chloride criteria vary with hardness assuming a constant sulfate concentration of 37.9 mg/l (an average of PA streams from an EPA EMAP study, see below). The Iowa DNR states that if no hardness or sulfate data are available, the statewide default values will be used but there is no further guidance in that document that present the default values (Iowa DNR 2009). However, the Iowa fact sheet states that background hardness and sulfate concentrations are 200 mg/l as $CaCO_3$ and 63 mg/l SO_4 (http://www.iowadnr.gov/water/standards/files/ws_fact.pdf).

Iowa worked with the EPA to develop their chloride criteria. Iowa instituted three major changes from the 1988 EPA Criteria. The first was to add acute and chronic studies and to remove what were determined to be questionable studies. In the end, the Iowa DNR increased the number of genera used to calculate the FAV and CMC from 13 in 1988 to 29 (Stephan 2009a). Another change was to develop a pair of criterion equations rather than a pair of criterion values. The equations were to account for the secondary interactions of hardness and sulfate to chloride toxicity. The third major change was in the way they calculated the criterion chronic concentration (CCC). Rather than use the ACR method used by the EPA in 1988, they used the ACR and genus mean acute value (GMAV) to calculate a predicted genus mean chronic value (pGMCV). They then used the pGMCV to calculate a final chronic value (FCV) using the same equations used for the FAV. These changes resulted in a lower CMC but higher CCC for most observed values of hardness and sulfate. The Iowa approach is better able to account for site specific conditions, but the method to determine the CCC is still reliant on the ACR and therefore will be subject to the same criticism.

The review and analysis of existing toxicity studies was presented in a series of draft letters and amendments written by Charles Stephan of the EPA in Duluth, MN dated Jan. 15, 2009 (Stephan 2009b) and Feb. 3, 2009 (Stephan 2009c, a) and in the Water Quality Standards Review (Iowa DNR 2009). According to Stephan (2009b), some studies that were used in 1988 were no longer appropriate. Short acute tests were not used because they sometimes give higher LC_{50}s than standard tests (Stephan 2009b). Data from Dowden (1960) and Kostecki and Jones (1983) were not used because, according to Stephan (2009), there were problems with the source of the dilution water. Hamilton et al. (1975) was not used because the midges were not adequately acclimated (according to Stephan 2009b). Acute tests where organisms were fed were not used in EPA 1988 criteria, but these tests were used by Stephan in 2009 and are given preference over unfed acute tests when the test organisms were cladocerans. In addition, tests that were conducted in static or renewal water were not used by the EPA in 1988. But Stephan (2009c, a) thought that "for chloride, as long as the concentration of dissolved oxygen is sufficiently high, it seemed appropriate to give static and renewal acute tests the same weight as flow-through acute tests in the derivation of the SMAV for a species."

Since the 1988 review by the EPA, a study by Wurtz and Bridges (1961) was uncovered, which included six species including two species suspected of being sensitive to chloride (Iowa DNR 2009). A second study (Khangarot 1991) included acute toxicity data for the tubificid worm (*Tubifex tubifex*), which indicated that this species might also be highly sensitive to chloride, but these data were considered unacceptable because the test temperature was high and the acute value for *Daphnia magna* in the same water was unusually low (Stephan 2009). Given the importance of these data, and the lack of verification by other laboratories, the IDNR and EPA determined that more toxicity data were warranted to independently determine if those species were indeed sensitive to chloride (Iowa DNR 2009). The 1985 guidelines for deriving water quality criteria (Stephan 1985) also allow for the use of a criteria equation rather than a criteria value if there is sufficient evidence that toxicity varies in a predictable manner with one or more environmental variables.

EPA contracted with the GLEC in Columbus, OH and the INHS at Champaign, IL to perform the additional toxicity testing of potentially sensitive species, and to evaluate the impact of hardness or sulfate to chloride toxicity. They evaluated the acute toxicity of chloride to four freshwater invertebrate species: water flea (*Ceriodaphnia dubia*), fingernail clam (*Sphaerium simile*), planorbid snail (*Gyraulus parvus*), and tubificid worm (*Tubifex tubifex*). The experiments were conducted under different levels of water hardness (all four species) and sulfate concentrations (*C. dubia* only). Rank order of sensitivity to acutely lethal chloride at a given water hardness is in order (most to least): *S. simile*>*C. dubia*>*G. parvus*>*T. tubifex.*

The addition of the new studies indicated that the EPA 1988 criterion maximum concentration (CMC) was too high. Incorporating new toxicity values for sensitive taxa resulted in a final acute value (FAV) of 1364 mg/L Cl^-, which was divided by 2 to arrive at a CMC of 682 mg/L. This value is lower than the 1988 EPA CMC (860 mg/L). Although Iowa did not use this value for their CMC, they did present it as an option (Iowa DNR 2009).

The studies by the GLEC and INHS demonstrated that the toxicity of chloride varied with both hardness and sulfate (Stephan 2009b). Stephan (2009b) used regression of log transformed hardness and LC_{50}s from four species to determine how acute responses varied with hardness. Three of the four species showed a strong positive relationship with hardness; i.e., as hardness increased, more chloride was needed to achieve an acute response. The fourth species, the snail *Gyraulus parvus*, showed no response. One species, *C. dubia*, showed a negative relationship with sulfate, although the effect was less than had been observed with hardness. Stephan (2009b) noted that the average of the exponents (describing the hardness response) for three species (*S. simile, G. parvus, T. tubifix*) was similar to that of *C. dubia*, which he used to justify exclusive use of *C. dubia* to derive the exponents used in the Iowa criteria. Multiple regression was used to determine the exponents for hardness and sulfate using log transformed *C. dubia* LC_{50}'s, hardness, and sulfate.

Iowa explored four different options for accounting for changing toxicity as a result of site-specific hardness and sulfate concentrations. Under Option A, acute values were not normalized for either hardness or sulfate and the criteria were not dependent upon either hardness of sulfate (a fixed standard similar to the EPA 1988). Under Options B, C, and D the acute values were either not normalized for hardness and sulfate (Option B) or were normalized (Options C and D), and were either dependent upon both hardness and sulfate (Options B and C) or just hardness (Option D). In the end, Iowa elected to go with Option C, but the CMC and CCC equations were updated to reflect additional data that became available between the time the draft criteria were published and the time the final rule was presented. The final rule was still based on Option C but with the new values (constants) that represented an increase in the values for the CMC and the CCC.

Stephan (2009c, a) also determined the ACR to be lower than the one used by the EPA in 1988. In 1988, the EPA calculated a geometric mean ACR of 7.594 based on two studies of three species: fathead minnows [ACR=15.17], *Daphnia pulex* [ACR= 3.951] (Birge et al. 1985), and rainbow trout [ACR=7.308] (SPEHAR 1987). But the acute and chronic tests with the fathead minnow were performed in different waters and Stephan (2009) determined that the ACR should not be used. Five additional ACRs were available from the scientific literature in 2009 for species for which both acute and chronic values were calculated in the same water. The additional ACRs were all from invertebrate cladocerans and were much smaller than the ACR for fathead minnow and rainbow trout: three ACRs for *Ceriodaphnia dubia* (1.508, >3.841, and 2.601), one for *Daphnia ambigua* (4.148) and one for *Daphnia magna* (1.974) (presented in Stephan 2009). For a given acute value, a smaller ACR will result in a higher CCC. As a result of the smaller ACRs used in 2009, the Iowa CCC (417 mg/L) is higher than the EPA 1988 value (230 mg/L).

The ACR has a large influence over the CCC value; therefore, Iowa explored four different methods of selecting the ACR. CCC1 was derived using ACR = 4.826 which is the geometric mean of the ACRs for rainbow trout (7.308) and the geometric mean of the three *Daphnia* species (3.187). CCC1 was determined to be too high for species at the 5th percentile (Iowa DNR 2009). CCC2 was derived using ACR = 3.187 which is the geometric mean of the ACRs for the three *Daphnia* species. CCC2 was determined to be appropriate for species at the 5th percentile (Iowa DNR 2009). The IDNR document did not state the exact value of CCC3 but claims that "CCC3 was derived from predicted Genus Mean Chronic Values that were calculated using ACR = 7.308 of Rainbow Trout for vertebrates and ACR = 3.187 of *Daphnia* for invertebrates." This statement implies that the ACR for CCC3 was the average of those two values or 5.248. However, we calculated CCC3 to be 3.357 after dividing 1148 (the FAV in the review document) by 342 (342 is the CCC3 value given for Option A in the review document). The review document provides no additional insight into how Iowa derived the ACR of 3.357, but the arithmetic mean of the three ACRs for *D. ambigua*, *D. magna*, and *D. pulex* equals 3.357. There appears to be an additional issue in the CCC3 equation under Option C. If the ACR of 3.357 for CCC3 is correct, then the multiplier would not be 161.5, which is the value in their Table 4 (Iowa DNR 2009) but rather should be 151.5 (i.e., 2*CMC/CCC3-ACR = CCC3, or 2*254.3/3.357 = 151.5). This formula is appropriate for Options A, B, and D and we expect that the formula for Option C would be the same. If we are correct that the CCC should be 151.5, the resulting chronic criteria would be reduced by 10-30 mg/l Cl^- at a sulfate concentration of 37.9 mg/l. Iowa selected Option C for the acute criterion and CCC3 under Option C as their final proposed chloride criteria after input from the EPA and a special Technical Advisory Committee "based on the scientific justification" (Iowa DNR 2009).

If trout were indeed not used in the selection of the CCC3-ACR value for the Iowa chronic criteria, then it follows that this ACR was derived from three different *Daphnia* studies. The Stephan (2009b) report suggests that these three studies were Harmon et al. (2003), Cowgill and Milazzo (1990), and Birge et al. (1985). One of these studies had a very low ACR for *Daphnia magna* (i.e., resulting from a high chronic value relative to other studies) (Cowgill and Milazzo 1990). *D. magna* is known to be atypical of cladocerans because of its high salinity tolerance (Ebert 2005).

The fourth approach that Iowa explored to determine the CCC was not presented in the Water Quality Standards Review dated Feb. 9, 2009, which contained the final proposed chloride criteria, but was presented in a March 2, 2009 update to their proposed chloride criteria (Stephan 2009a, c). It was in this new document that the method of calculating the CCC fundamentally changed from what the EPA had done in 1988. Rather than use the ACR from four species to calculate the CCC (Iowa DNR 2009), this approach relied on the predicted GMCV from 29 genera (Stephan 2009a). This method still relied on the ACR, but changed how it was used (Stephan 2009a). In addition, the predicted GMCV did not represent new research, but rather were derived from the existing GMAVs and ACRs. Stephan (2009a) divided the GMAV for each species by the ACR to calculate a genus mean chronic value (GMCV). The GMCVs were then used to calculate a FCV using the same equations that were used to calculate the FAV. Stephan (2009a) noted that the ACR for vertebrates appeared to be large (rainbow trout 7.308 and fathead minnow 15.17) relative to the ACR for invertebrates (*Daphnia* geometric mean ACR 3.187). Therefore, he applied the rainbow trout ACR to all vertebrates and the *Daphnia* geometric mean ACR to all invertebrates, and arrived at a FCV=CCC of 417.0 mg/L Cl^-. Using two ACRs had a substantial effect on the CCC value when compared to a single geometric mean ACR. With an ACR of 4.826 the FCV=CCC would have been 282.6 mg /L Cl^- (Stephan 2009a).

Stephan (2009a) justified the alternative approach based on the "good science" clause in section XII.B of the 1985 guidelines. This approach is based on the fact that the four low SMACRs for chloride were obtained with invertebrates, whereas the single high acceptable SMACR was obtained with a vertebrate, and another unacceptable SMACR for fathead minnows was also high (Stephan 2009a). This can be interpreted to mean that vertebrates have a higher ACR on the average than invertebrates (Stephan 2009a).

3.5 Delaware, Maryland, New Jersey, New York, Ohio, Virginia, West Virginia

New Jersey, Virginia, and West Virginia have already adopted the EPA (1988) recommended criteria. New York State has chloride criteria set at 250 mg/l for protecting surface and ground water designated as a water supply for drinking. Ohio, Maryland, and Delaware do not have water quality criteria protecting aquatic life from chlorides. However, Ohio has a statewide aquatic life criterion for total dissolved solids of 1,500 mg/l and human health criteria for the Ohio River main stem at 250 mg/l Cl^-.

The Delaware River Basin Commission (DRBC) has classified certain waters for "special protection" because they have exceptionally high scenic, recreational, ecological, and/or water supply value. Accordingly, the DRBC has stated that those "special protection" waters (SPW) shall have no measurable change in their existing water quality (2008). The DRBC defines a "Measurable Change to Existing Water Quality" as an actual or estimated change in a seasonal or non-seasonal mean (for SPW waters upstream of and including River Mile 209.5) or median (for SPW waters downstream of River Mile 209.5) in-stream pollutant concentration that is outside the range of the two-tailed upper and lower 95 percent confidence intervals that define existing water quality. All of these waters requiring special protection had median chloride levels less than 50 mg/l Cl^- which suggested that increases over 50 mg/l would near violation of the rule. This example is similar to PA's Antidegradation Law that protects biota and water quality of each stream within its designated and existing use in PA (e.g., EV = exceptional value streams, HQ = high quality streams). (PADEP defines a measurable if the instream concentration of a pollutant exceeds the upper 95 percent confidence limit of the median value in the data set used to determine the instream water quality objective). The DRBC documented the location of the "Outstanding Basin

Waters" and "Significant Resource Waters" as reaches along the Upper Delaware (river miles 330.7-250.1), portions of intrastate tributaries, the Middle Delaware (river miles 250.1-134.34), and portions of tributaries located within the Delaware Water Gap National Recreation Area. Furthermore, the DRBC established specific aquatic life use criteria for chloride based on the naturally dilute background levels of the Delaware River for two zones river mile 133.4-108.4 where maximum 15-day average Cl^- is 50 mg/l and from river mile 108.5 to 95.0 where maximum 30-day average concentrations of Cl^- is 180 mg/l.

3.6 EPA Revision to the 1988 Chloride Criteria

The US EPA is currently reviewing the 1988 chloride criteria (see Stephan 2009b) and has considered revising their 1985 "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (EPA 2003). The most recent analyses by the EPA (Stephan 2009a, b, c), which were used by Iowa to set their criteria in 2009, do not explicitly propose new EPA chloride criteria. However, the indication from Stephan (2009b) is that the new EPA guidelines will shift to a weight of evidence approach. It is our impression based on Stephan (2009a, b, c) that one fundamental change in the guidelines will be in the rules for determining which studies to include and how information will be used (i.e., which studies are used to calculate FAV, ACR and FCV, and which studies will be used as guidance). Another possible shift will be in the method that chronic criteria are generated, although the justification behind Stephan (2009a) adopting the FCV approach has yet to be critically reviewed. The use of criterion equations in Iowa does not reflect a fundamental shift from the 1985 guidelines, however this was a new approach for chloride regulation in the US. The implication is that the EPA may consider environmental variables, such as hardness and sulfate that are likely to affect chloride toxicity when they update their criteria.

3.7 Calculation of CMC and CCC criteria using 4 methods

The criteria described above were determined with different sets of data, therefore **we explored which criteria would arise from the different methods if the same data set was used.** The four methods that we explored were EPA 1988, Evans and Frick 2001, British Columbia 2003, and Iowa 2009. **All methods were re-calculated using the GMAVs from the Stephan 2009a report, and are presented in Tables 1 and 2.** For each method, we calculated or determined the FAV, CMC, FCV and CCC using what we think best represents the method. For the methods that relied on an ACR, we used three different values to demonstrate the sensitivity of the CCC value to the ACR. For the Iowa 2009 method, we determined the criterion values (i.e., ignoring hardness or sulfate), not the equations, for better comparison with the other methods.

All methods indicate that the FAV and CMC would be less than 830 mg/L, which is the EPA value and the value proposed by PA (Table 2). The Evans and Frick 2001 method resulted in the most similar value (824 mg/L) and the British Columbia method resulted in the smallest value (564 mg/L). The EPA 1988 and Iowa 2009 methods resulted in the same value (640 mg/L) because the same set of equations were used.

The four methods resulted in slightly different values for the FCV but vastly different values for the CCC (Table 2). The Evans and Frick and British Columbia methods resulted in lower values than the proposed criterion; the EPA 1988 and Iowa methods resulted in higher values. The most conservative method, by far, was British Columbia's, which resulted in a CCC of 91 mg/L. The reason the Evans and Frick method gave a lower value than EPA 1988 and Iowa was because of the ACR. We used an ACR of 7.59 for Evans and Frick. Iowa used two ACRs, one for vertebrates (7.308) and another for invertebrates (3.187), which we would have expected to result in a lower FCV; but in this case, the value for FCV using this approach is only slightly smaller than the value derived using the EPA 1988 approach, which used just the 3.187 value. The probable reason the change is slight is that the Iowa method relied on only the four lowest predicted GMCVs to calculate the FCV, and in this case only one vertebrate was among those four.

It is not clear which method works best. All methods make a number of assumptions, and each is sensitive to the data used. There is less discrepancy among the values for the CMC but the CCC values are particularly sensitive to the method used. In the face of such uncertainty, it would be best to err on the side of caution and use a safety factor when deriving the CCC criterion.

4 General Comments on Chloride Toxicity Literature

There are several reviews of the chloride toxicity literature that provide greater detail than we will go into here (see EPA 1988, Evans and Frick 2001, Iowa DNR 2009, Stephan 2009a,b,c). Based on our inspection of these reviews and a limited search of the relevant literature we have attempted to identify limitations to the general body of literature and to point out potential gaps in knowledge.

The quantification of the impact of chloride concentrations on aquatic organisms has been primarily approached from a toxicological perspective where laboratory studies are used to isolate organisms of interest and subject them to varying concentrations of chloride in the form of NaCl, $CaCl_2$, $MgCl_2$, or KCl. The majority of studies has been limited to the use of NaCl but Evans and Frick and to some extent Stephan (2000B) summarize those studies. In addition, the majority of studies has conducted short-term or acute studies (1 week or less; typically 96 hrs but 24 and 48 hrs studies are common) where concentrations of salt vary dramatically and the primary response variable is mortality (lethality). As such, acute studies primarily result in the documentation of LC_{50} values (lethal concentrations where 50% mortality occurs). There are a limited number of longer-term or chronic studies and even fewer studies that have conducted both acute and chronic studies using the same organisms as part of the same study. Chronic studies typically involve other life stages that may vary in toxicity response. Non-lethal response variables include % hatching success, growth rate, metabolic rate, or size at maturity, for example. The limited nature of both acute and chronic information produced within a study for the same organism is very important to the derivation of ACRs (see Iowa Criteria above and through this report) used in nearly all of the proposed criteria in the United States and is also extensively discussed in the Canadian review conducted by Evans and Frick (2001).

As mentioned previously, there are far fewer studies examining $CaCl_2$, $MgCl_2$, or KCl toxicity to aquatic organisms than for NaCl toxicity. Evans and Frick (2001) and Stephan (2009b) summarize most of those studies. In 1988, the EPA presented acute toxicity data for $CaCl_2$, $MgCl_2$, and KCl, but limited the derivation of the acute and chronic criteria to only NaCl toxicity studies. Both reviews found that KCl tends to be the most toxic salt followed by $MgCl_2$, $CaCl_2$, and then NaCl. The majority of chloride criteria developed to date are limited to or dominated by data on NaCl chloride toxicity, the least toxic salt. This point is routinely justified by the fact that NaCl is the most anthropogenically abundant of these four salts. Marcellus shale discharges constitute an example of anthropogenic contributions of other salts.

One of the more intriguing studies we reviewed was a study conducted on Eastern Australia's aquatic macroinvertebrate fauna (Dunlop et al. 2007). Dunlop et al. (2007) collected 102 species from 4 regions in E. Australia and conducted acute (72 hr) chloride toxicity tests. They observed regionally-specific salinity tolerances and suggested that local ambient conditions influenced sensitivities within species. They also provided exemplary analysis that ranked the acute toxicity of the major taxonomic groups studied. The only other study we reviewed that attempted to do this was Evans and Frick (2001), but they used information from many disparate studies and did not find several representatives within each major taxonomic group to parallel Dunlop et al. (2007). The rank order reported in Dunlop et al. (2007) indicated that the known evolutionary invasions of various taxonomic groups to freshwater tended to groups of organisms predisposed to salinity tolerances. For example, decapods (primarily crayfish) invaded freshwater directly from salt water environments; out of all of the groups tested, they had the highest salinity tolerances. Ephemeroptera, on the other hand, were the most sensitive and were among the first insects to invade freshwaters millions of years ago from the terrestrial environment. It was interesting to note that Australian aquatic taxa may be better adapted to more saline conditions than North American taxa (logically following that the Australian continent is very dry and consequently inland waters have elevated salt concentrations due to evaporative losses and subsequent concentration of salts in residual pools of water). It was also intriguing to note that no comparable study has been conducted in the US (i.e., no single study has so exhaustively included so many taxa from an extensive geographical range).

Two studies on chloride toxicity in the embryonic survivorship of the spotted salamander suggest that these eggs are sensitive to low chloride concentrations (perhaps as low as 150 mg/l Cl^-) (Turtle 2001, Karraker et al. 2008). However, both studies were field studies where pollutants other than chloride may have influenced survivorship, and the Karraker et al. (2008) study only measured specific conductivity as a surrogate for salinity. Other amphibian studies (Dougherty and Smith 2006, Sanzo and Hecnar 2006) document chloride impacts to larval stages of various frogs, and one study (Dougherty and Smith 2006) observed lower LC_{50}s for $MgCl_2$ derived Cl^- (as low as 116 mg/l Cl^-) compared to NaCl derived Cl^- (as low as 406 mg Cl^-/l) for *Rana clamitans*. The EPA 1988 criteria do not include data from amphibians and the recent EPA review by Stephan (2009) only includes two acute amphibian studies (Bullfrog tadpole and Chorus frog). Evans and Frick (2001) provide a fairly comprehensive review and include amphibians in their acute and chronic chloride risk characterization. Amphibian species in Pennsylvania that occur in streams or in water bodies immediately adjacent to streams are listed in Table 3. Not including stream dwelling or stream-side wetland dwelling amphibians may ultimately yield a less protective criteria.

There have been a very limited number of studies on the synergistic effects of salt cations on chloride toxicity. Evans and Frick (2001) point out that those salt solutions that contain different salts (particularly Na, Ca, Mg, and K) in certain proportions can be physiologically-balanced to neutralize or reduce the specific toxicity of each through antagonistic action. This can lead to reduced toxicity of cations to aquatic organisms. Evans and Frick (2001) cite three studies that have investigated this ion synergy: Garrey (1916) using minnows; Grizzle and Mauldin (1995) using juvenile striped bass, red drum, and channel catfish; and Borgmann (1996) using a freshwater amphipod. A common thread appears to be that, at the right concentration, **Ca tends to reduce the toxicity of NaCl**. The GLEC and INHS studies (see Iowa DNR 2009, Stephan 2009b) quantified the influence of hardness on Cl^- toxicity in 4 species known to be sensitive to Cl^- and also the influence of sulfate on *Ceriodaphnia* Cl^- toxicity (see analysis of Iowa criteria below). Those studies found that 3 of the 4 taxa studied had increased tolerances of chloride with increasing $CaCO_3$ hardness; *Ceriodaphnia* had decreased tolerance of Cl^- with increasing SO_4 concentrations. All of the studies on the ion synergies and chloride toxicity are for acute tests only. **We have found no studies that have evaluated these relationships on a chronic basis.**

Silver et al. (2009) studied chironomid larvae (non-biting midges) responses to road deicing salt in two constructed wetlands in NE Pennsylvania. Specific conductivity (as an indicator of salt concentration) during runoff events in winter approached that of seawater (30 mS/cm). Conductivity remained high during winter (4 mS/cm) and returned to 1 mS/cm in spring. They conducted laboratory tests using NaCl to test the influence of NaCl and temperature on chironomid survival and found that lower temperatures resulted in higher survivorship. In fact, at low temperature, survival appeared to be higher in the presence than in the absence of salt. As temperature increased, salt appeared to have an increasingly negative effect at decreasing concentrations, until at 22°C, any amount of salt depressed survival significantly. Silver et al. (2009) suggested that at low temperatures, NaCl uptake by midge larvae may help induce supercooling and external NaCl may depress the freezing point to prevent inoculative freezing. Also, at lower temperatures, midges may enter diapause and be physiologically inactive, so metabolic costs of osmoregulation are lowered. These data suggest that seasonal changes in temperature may be an important factor to consider with regard to chloride toxicity, especially higher summer temperatures associated with warm water fisheries.

Meador and Carlisle (2007) examined distributions of 105 stream fish species from 773 sites throughout the US for relationships with 10 chemical and physical variables measured by the USGS National Water Quality Assessment Program. They calculated tolerance indicator values for all physical-chemical variables based on changes in fish community patterns. Chloride tolerance indicator values were relatively low. For example, Brook Trout and Cutthroat Trout had a calculated tolerance value of 3.1 and 4.4 mg/l Cl^-, respectively. A classification of Tolerant, Moderate, and Intolerant was developed for each physicochemical variable. Chloride tolerance categories were 35-42 mg/l Cl^- (tolerant), 23-31 mg/l Cl^- (moderate), and 10-24 mg/l Cl- (intolerant). The remaining fish taxa were associated with each group. Several other physicochemical variables were correlated with Cl^- concentrations (e.g., suspended sediments and total phosphorus). Other unmeasured variables may be influencing these patterns; and at such a broad spatial scale, the ultimate factors and mechanisms responsible for fish distributions are likely to be complex. These results suggest that changes in chloride concentrations that are less than the EPA 1988 (and the proposed PA criteria) chronic criteria value may still influence fish distributions and ultimately alter site-specific fish community structure.

5 Examples of baseflow chloride concentrations in PA (EMAP survey 1993-96)

From 1993-1996, the USGS collected water chemistry samples from 246 streams in Pennsylvania as part of a national Environmental Assessment and Monitoring Program (EMAP). Concentrations of major anions, cations, major nutrients, and organic and inorganic carbon are available online[2] along with other

[2] http://oaspub.epa.gov/emap/webdev_emap.show_frames?entry_id_in=275

related datasets[3]. Hardness (mg $CaCO_3$/L) was calculated from Ca^{2+} and Mg^{2+} concentrations using Standard Method 2340B (Standard Methods 1998).

Sample sites were located throughout the state but were primarily from the Appalachian Plateau and Ridge and Valley physiographic provinces (Fig. 2). The average chloride, sulfate, and hardness concentrations (± 95% confidence intervals) were 7.7 (6.3-9.1), 37.9 (21.6-54.2), and 68.6 (54.3-82.9) mg/l, respectively. Only 19 of 246 sites had Cl^- concentrations > 20 mg/l, and 4 sites were >50 mg/l Cl^- (Fig. 3). The concentrations of chloride, sulfate, and hardness varied by aquatic use designation (Fig. 4) such that EV and HQ streams had the lowest concentrations and WWF and TSF had the highest concentrations. All four approaches to set acute and chronic criteria would result in chloride concentrations at least several times greater than base flow concentrations commonly observed in Pennsylvania streams in their most natural condition (i.e., Exceptional Value and High Quality waters).

It is also instructive to note that the range of concentration of hardness in Pennsylvania was considerably lower than that found in Iowa. For example, the Iowa DNR report (2009) provides a map of hardness concentrations mostly ranging from 200 to 400 mg/l $CaCO_3$ compared to 29 of the 246 EMAP sites in PA >150 mg/l $CaCO_3$ and 18 of 246 sites >200 mg/l $CaCO_3$. Within Pennsylvania, the streams in southwest PA tended to have higher hardness and sulfate concentrations than elsewhere in the state (Fig. 5).

6 Stream Chloride Concentrations in Pennsylvania from EMAP Data and the Iowa Criteria

EMAP data were used to calculate acute and chronic chloride criteria based on the Iowa formulation. Those data indicate that the Iowa criteria would lower the acute chloride criteria from the proposed 860 mg/l to an average of 500.9 ± 10.6 mg/l (95% CI), and raise the chronic standard from the proposed 230 mg/l to 309.6 ± 6.5 mg/l (Fig. 6). The range of values calculated for the 246 EMAP sites using the acute and chronic Iowa criteria were 342.8 – 742.0 and 211.8 – 458.6 mg/l Cl^-, respectively and the full distribution of data are shown in the middle and lower panels of Fig. 6.

EMAP data were paired with information on the PA designated use assigned to each sampling site. The site-specific criteria derived using the Iowa criteria equations were then partitioned based on the designated use (Fig. 7). Based on those data, EV and HQ designations would have lower chloride criteria applied to those sites (if they were to be included in a chloride criteria; currently Antidegradation Criteria protect EV and HQ streams) compared to CWF, WWF, and TSF.

Finally, EMAP data were used to calculate Iowa chloride criteria (chronic and acute) over the range of hardness or sulfate occurring in the database (Fig. 8). The resulting panels in Fig. 8 illustrate the relationship between the chronic and acute chloride criteria and either hardness or sulfate over the entire range of hardness and sulfate conditions occurring in the EMAP PA dataset (left panels) and for the majority of sites (right panels; i.e., x-axis concentrations range over the 95% confidence intervals for either sulfate [upper right panel] and hardness [lower right panel] in the EMAP dataset).

[3] http://www.epa.gov/emap/html/data/surfwatr/data/mastreams/9396

7 Conclusions

After reviewing four different approaches for deriving water quality chloride criteria to protect aquatic life (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) and the data underpinning PA's proposed criteria (EPA 1988) and the Iowa criteria (Stephan 2009a,b,c), it is clear that:

1) All approaches set chloride criteria that are at least several times greater than natural baseline chloride concentrations, and therefore represent a measurable and significant change in the chemical composition of freshwater ecosystems in the NE United States. The question that the current evidence is unable to answer is: will these criteria result in significant biological change? There is limited evidence of the biological impact of previous elevated chloride levels in aquatic ecosystems in the U.S. or Canada. Past monitoring efforts (see introduction) suggest that some streams regularly reach the acute criterion, but there has not been a noted change in biota following these pulses, largely because of a dearth of biological data following these episodic events. One study has demonstrated that macroinvertebrate drift increases in response to pulsed chloride input (Blasius and Merritt 2002). Another study has demonstrated losses of species in stream fish communities with small changes in chloride levels across a regional-scale analysis (Meador and Carlisle 2007), and the composition of algal species has been observed to change when chloride concentrations increase (Evans and Frick 2001). Nonetheless, there are limited data on biological changes accompanying changing chloride concentrations in the natural environment. We could not find any studies evaluating the influence of chloride on vital stream functions such as primary production, stream metabolism, or nutrient uptake or processing, all of which are important indicators of water quality for aquatic ecosystems.

2) All of these criteria are based on data for invertebrate and fish species that are not a random subset of stream invertebrate and fish species. Rather, most of the species with chloride data are known to be not especially sensitive to changes in environmental condition, which is one reason they survived well in the laboratory and became standards in laboratory bioassay protocols. The most recent iteration of the taxa that qualify based on EPA standards (in Stephan 2009a,b,c) doesn't include any classically sensitive stream invertebrate species such as stoneflies, mayflies, and caddisflies, all of which are important indicators of stream condition and are integral in the regulatory definition of stream impairment. Our concern is that criteria intended to protect most (e.g., 90% or 95%) of the species with chloride data might actually protect a much smaller proportion of all species that occur in a natural community because the natural community includes many species known to be sensitive to environmental change while the laboratory studies are biased toward species known to be at least moderately tolerant of environmental change. This is one reason to approach the acute and chronic criteria with a strong safety factor.

3) Data available are primarily from acute toxicity studies, but the chronic criterion may be more important for long-term structuring stream communities and maintaining designated use for aquatic life. For example, fish tend to be moderately tolerant of acute chloride stress relative to macroinvertebrates, but they are one of the more sensitive taxa to chronic chloride stress. For example, fat head minnows (Birge et al. 1985) experienced the greatest mortality between days

9 and 21 and therefore had one of the highest acute-to-chronic ratios examined. The dearth of chronic studies on both invertebrates and fish is troubling. It is likely that, like some amphibians (e.g., spotted salamander), embryonic and early life stages of some fish will be more sensitive than is currently recognized.

4) The majority of chloride criteria developed to date are limited to or dominated by data on NaCl chloride toxicity, the least toxic salt. This point is routinely justified by the fact that NaCl is the most anthropogenically abundant of these four salts. However, no special guidance is given for permitting salt applications or industrial effluents known to include significant amounts of chloride derived from the more toxic non-sodium salts, including Marcellus Shale wastewater.

5) Using the data provided in Stephan 2009a (Table 2 herein), we have calculated both the acute (CMC) and chronic (CCC) criteria using the methods of the EPA (Stephan et al. 1985, EPA 1988), Evans and Frick (Evans and Frick 2001), British Columbia (Nagpal et al. 2003), and Iowa (Iowa DNR 2009) and have compared the range of values with the proposed PA values (Table 3). The range of acute values is 564 – 830 mg/l Cl- and the range of the chronic values is 91 – 428 mg/l Cl-. This comparison eliminates the variability in the choices each of the authors have made with regard to studies included or excluded. We note that the PA proposed acute value is the least protective criterion, primarily because it is not based on more recent acute toxicity studies. We recommend that PA adopt an acute criterion that is reflective of these new data. The method adopted by British Columbia is the most protective of aquatic life among these approaches. BC invoked a precautionary principle that acknowledged both the uncertainty of the available data and analyses and the importance of protecting their aquatic life. Since BC adopted their criteria, only new acute datasets have become available and the values in Table 3 utilize those data but use the BC approach to arrive at a final value (i.e., lowest SMAV/2[safety factor]). The BC use of a safety factor of 2 for the acute criteria was also consistent with what the EPA had done. However, BC was the only entity to apply a safety factor for the chronic criterion (5). We feel that the use of a safety factor for chronic criteria derived from the use of an ACR is clearly justified given the very limited number of chronic toxicity studies, and the desire to protect species that may be more sensitive than those used in the standard laboratory bioassays. We recommend that PADEP adopt the same methodology that BC has used for calculating both acute and chronic data. We feel that this is particularly important for the chronic criteria, as there is the potential for permitted discharges (particularly from the Marcellus Shale gas drilling industry) to raise chloride concentrations in streams to near the chronic criteria level. Given the paucity of data determining thresholds for chronic effects, this approach is warranted. At the very least, a safety factor should be applied to any of the other methods producing a chronic criterion.

We have a number of concerns that are specific to the actions and options available for PADEP:

6) Protecting CWFs and TSFs based on ACRs that included more chloride-tolerant *Daphnia* is not justified when it may expose rainbow trout to chloride concentrations approaching their chronic levels (1,324 mg/l Cl^- killed 46% of individuals in an early life stage test and at 643 mg/l Cl^- killed <4%). Trout are an integral component in the definition of these two aquatic life uses. The proposed chronic value of 230 mg/l is potentially a concern for biotic assemblages in

Pennsylvania. For example, Meador (2007) suggests that optimum Cl^- values are low (3-35 mg/l) and we infer that if those Cl^- concentrations are exceeded it may result in changes in fish community structure. Similarly, not having a temperature component also seems to invite season-specific impairments of macroinvertebrates in TSFs and WWFs based on the recent findings of Silver et al. (2009), based on the seasonal movement of organisms into and out of various life history stages, and based on variation in their metabolic rates in response to seasonal changes in water temperature. Adding a temperature component to the chloride criteria would require further research on temperature effects.

7) The Evans and Frick (2001) method has the benefit of being reproducible and open to interpretation. Their use of nearly all of the valid acute LC_{50} data in Fig. 7-2 (Evans and Frick 2001), and the calculation of a sigmoid curve function (including 95% confidence intervals) that describes the percent of genera affected versus chloride concentration, is readily digestible by the public. However, the sigmoid curve function can be generated using various numbers of terms (parameters) in the equation and/or various equations (e.g., sigmoid, logistic, Weibull). The result of choosing a slightly different function can result in differences in acute and chronic values. To use this approach requires a valid justification for the choices made in fitting the curve to these data. Furthermore, these data still represented a small subset of aquatic species, and were biased towards lab friendly species that are easiest to culture (e.g., *Daphnia*). Since the selection of taxa was not a random subset of the aquatic species at large, most criteria based on the animals selected are primarily protective of those species tested (e.g., being protective of 95% of those taxa might only be protective of 50% of all species). This point is not limited to Evans and Frick but is valid for all of the approaches we have reviewed. This is the primary reason that the application of a safety factor is needed. The Evans and Frick (2001) study did not apply a safety factor to either their acute LC_{50} relationship or the derived chronic relationship.

8) More data is generally better, but there is a need for more consideration of how data gets incorporated. The Stephan (2009a,b,c) approach of calculating a predicted genus mean chronic value from the species mean acute values does not seem justified in this case. The GMCVs are not much better than guesses, and there is no attempt to correct for this inherent uncertainty. Adding GMCV values above the lowest four gives the false sense of increased precision of the true distribution of the GMCV, which has the result of increasing the final chronic value (FCV). We feel it would be appropriate to apply a safety factor to the chronic criteria to acknowledge the uncertainty in the FCV.

9) The use of hardness and sulfate equations (Iowa DNR 2009) in PA will improve protections and application of the chloride criteria only to a limited extent since the range of criteria in PA would be narrow (based on EMAP site values for hardness and sulfate in PA). Secondly, the hardness and sulfate exponents in the Iowa criteria were based on data from an acute toxicity study of only one species (*C. dubia*), although four species were studied and three were sensitive to hardness. No data were available on the relationship between hardness or sulfate and chronic toxicity. In the end, Iowa uses a default value for hardness and sulfate if no other data are available. This is akin to setting a fixed criterion value but allowing site-specific deviations if one

gathers the appropriate data. Clearly, more species-specific data are needed to better understand the relationship between chloride toxicity and hardness or sulfate.

10) As noted above, previous reviews of chloride considered only NaCl and considered road salt to be the most likely source of chloride. We feel that the current proposed standard should explicitly acknowledged that these criteria are specific to NaCl derived chloride, and guidance should be given to address cases when significant chloride is derived from salts (i.e., KCl, $MgCl_2$ and $CaCl_2$) that have proven to be more toxic sources of chloride.

Our review of four approaches (Stephan et al. 1985, Evans and Frick 2001, Nagpal et al. 2003, Iowa DNR 2009) for deriving chloride criteria to protect aquatic life identified a number of weaknesses in the available data and the analyses used to derive criteria. We were especially concerned with (1) the near absence of important stream-inhabiting and stream-classifying species such as mayflies, stoneflies, and caddisflies, (2) the dependence on relatively few chronic studies, and (3) the choice of excluding some studies that were very important (e.g., fat head minnow Birge et al. 1985). We believe these weaknesses justify using a very conservative approach to assigning criteria. All four approaches to set acute and chronic criteria would result in chloride concentrations at least several times greater than base flow concentrations commonly observed in Pennsylvania streams in their most natural condition (i.e., Exceptional Value and High Quality waters). The lowest criteria for chloride were derived by the Canadian Province of British Columbia (Nagpal et al. 2003) – they acknowledged the weaknesses in available data, and applied safety factors of 2 for the acute criterion and 5 for the chronic criterion. Given the limits in the available data, and the potential that treated wastewaters from Marcellus Shale drilling may result in near-criterion chloride concentrations 356 days per year (versus the 30 days of a standard chronic bioassay), we believe the British Columbia criteria (either the originally adopted criteria or our re-calculated criteria in Table 2) would be the most protective of aquatic life for Pennsylvania streams, especially for the trout and many pollution-sensitive macroinvertebrate species that characterize Cold Water Fishes streams.

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Table 1: Chloride genus mean acute values (GMAV in mg Chloride/L) ranked highest to lowest. The GMAV is the geometric mean of the species mean acute values (SMAV). Table reproduced from Stephan 2009a.

Rank	GMAV	Genus	Species	Species	SMAV
29	17161	*Anguilla*	American eel	*Anguilla rostrata*	17,160.6
28	16203	*Cambarus*	Crayfish	*Cambarus sp.*	16,203.2
27	14897	*Fundulus*	Plains killifish	*Fundulus kansae*	14,897.1
26	14843	*Libellulidae*	Dragonfly	*Libellulidae*	14,843.4
25	13453	*Gasterosteus*	Threespine stickleback	*Gasterosteus aculeatus*	13,452.6
24	>11860	*Poecilia*	Guppy	*Poecilia reticulata*	>11,860
23	9933	*Gambusia*	Mosquitofish	*Gambusia affinis*	9,933.4
22	9157	*Lepomis*	Green sunfish	*Lepomis cyanellus*	9,974.9
			Bluegill	*Lepomis macrochirus*	8,406.5
21	8971	*Notropis*	Red shiner	*Notropis lutrensis*	8,971.1
20	8043	*Oncorhynchus*	Rainbow trout	*Oncorhynchus mykiss*	8,042.6
19	7442	*Ameiurus*	Black bullhead	*Ameiurus melas*	7,442.4
18	6515	*Pimephales*	Fathead minnow	*pimephales promelas*	6,515.3
17	6219	*Tubifex*	Tubificid worm	*Tubifex tubifex*	6,218.6
16	6111	*Cyprinella*	Bannerfin shiner	*Cyprinella leedsi*	6,111
15	6072	*Chironomus*	Midge	*Chironomus dilutus*	6,072
14	5897	*Rana*	Bullfrog (tadpole)	*Rana catesbeiana*	5,897
13	5444	*Lumbriculus*	Aquatic worm	*Lumbriculus variegatus*	5,444
12	5078	*Hyalella*	Amphipod	*Hyalella azteca*	5,077.7
11	4686	*Pseudacris*	Chorus frog	*Pseudacris sp.*	4,686
10	4369	*Nephelopsis*	Leech	*Nephelopsis obscura*	4,369
9	3946	*Diaptomus*	Copepod	*Diaptomus clavipes*	3,946.1
8	3891	*Lirceus*	Isopod	*Lirceus fontinalis*	3,890.7
7	3728	*Gyraulus*	Snail	*Gyraulus parvus*	3,727.7
6	3350	*Physa*	Snail	*Physa gyrina*	3,350
5	3086	*Villosa*	Mussel	*Villosa delumbis*	3,821.1
				Villosa iris	2,491.6
4	2835	*Lampsilis*	Mussel	*Lampsilis fasciola*	2,907.1
				Lampsilis siliquoidea	2,764.4
3	2326	*Daphnia*	Cladoceran	*Daphnia ambigua*	1,649.7
				Daphnia magna	3,773.1
				Daphnia pulex	2,020.5
2	1542	*Ceriodaphnia*	Cladoceran	*Ceriodaphnia dubia*	1,542.3
1	1128	*Sphaerium*	Fingernail clam	*Sphaerium simile*	1,127.9

Table 2: The chloride criterion maximum concentration (CMC or acute criterion in mg Chloride/L) and criterion chronic concentration (CCC or chronic criterion in mg Chloride/L) calculated using four different methods based on the 29 GMAV values in Table 2 (GMAV values from Stephan 2009a). The CMC is calculated by dividing the final acute value (FAV) by the safety factor, and the CCC is calculated by dividing the final chronic value (FCV) by the safety factor. Three of the methods relied on the acute-to-chronic ratio (ACR) to convert the FAV into an FCV.

Method		FAV	Safety factor	CMC
PA Proposed				**860**
EPA 1988[a]		1,364	2	*682*
E&F 2001[b]		1,648	2	*824*
BC 2003[c]		1,128	2	*564*
Iowa 2009[d]		1,364	2	*682*
Method	**ACR**	**FCV**	**Safety factor**	**CCC**
PA Proposed				**230**
EPA 1988[a]	3.187	428	1	*428*
E&F 2001[b]	7.59	217	1	*217*
BC 2003[c]	-	455	5	*91*
Iowa 2009[d]	7.308 & 3.187	422	1	*422*

[a] The EPA's 1985 equations were used to calculate the FAV. The ACR is the geometric mean of 3 *Daphnia* species and was taken from Stephan 2009a. The FCV is the FAV/ACR.

[b] E&F = Evans & Frick 2001. A 3-parameter sigmoid curve was fit to the cumulative percentage of genera lost as a function of the natural log transformed GMAVs using the nls function in R. The equation was % genera lost=a/(1+exp(-(ln(GMAV)-c)/b)) and the fitted values were a=1.035, b=0.431, c=8.692. The FAV is the value at which 5% of genera are predicted to be lost. Evans &Frick (2001) did not specify a safety factor for the CMC, so a safety factor of 2 was assumed. The ACR is the same one used by the EPA in 1988 based on fathead minnow, rainbow trout and *Daphnia pulex*. The FCV is the FAV/ACR.

[c] The FAV is the lowest observed GMAV (1128 mg/L for *Sphaerium simile*) and the FCV is the lowest observed effect concentration (LOEC, 455 mg/L for *Ceriodaphnia dubia* by Aragao and Pereira (2003) reported in Stephan 2009b).

[d] The EPA's 1985 equations were used to calculate the FAV. The FCV was calculated using the same equations with the predicted GMCVs which were calculated by dividing the GMAV by the ACR of 7.308 for vertebrates or 3.187 for invertebrates.

Table 3: Amphibian species in Pennsylvania associated with streams or stream-side pools. Data from PA Fish and Boat Commission (http://www.fish.state.pa.us/amp_rep.htm).

Species	Common name	Habitat	Egg	Larva	Juvenile	Adult
Acris crepitans crepitans	Northern Cricket frog	streamside (occasionally)	submerged grasses	yes	no	no
Bufo americanus americanus	Eastern American Toad	eggs and larva sometimes in slow moving streams	yes (sometimes)	yes (sometimes)	no	yes - streamside
Bufo woodhousii fowleri	Fowler's Toad	streamside (occasionally)	yes (sometimes)	yes (sometimes)	no	yes - streamside
Cryptobranchus alleganiensis alleganiensis	Easern Hellbender	Large order stream Fast moving	yes under rocks or logs	yes	yes	yes
Desmognathus fuscus fuscus	Northern dusky salamander	Headwaters and seeps	eggs are laid near water	yes	yes	yes - streamside
Desmognathus monticola monticola	Appalachian seal salamander	Streamside and headwaters	Eggs attached to moist rocks	yes	streamside	streamside
Desmognathus ochrophaeus	Mountain dusky salamander	Lotic	near water	yes	streamside	streamside
Eurycea bislineata bislineata	Northern two-lined salamander	streamside and stream rocky brooks	submerged rocks/logs	yes	yes	yes - streamside
Eurycea longicauda longicauda	Longtail salamander	associated with caves; shale and limestone creeks	swallow water	yes	yes	yes - streamside
Gyrinophilus porphyriticus porphyriticus	Northern Spring salamander	springs	under rocks	yes	yes	yes
Hemidactylium scutatum	Four-toed salamander	seeps and boggy areas	single eggs on streamside moss above water	yes	yes/no	no
Necturus maculosus maculosus	Mudpuppy salamander	Lotic (most orders of streams) and lentic	Streamside nest points to water	yes	yes	yes
Notophthalmus viridescens viridescens	red-spotted newt	Lotic (headwaters) and lentic	yes, attached to vegetation	yes	No, terrestrial	yes
Pseudacris brachyphona	Mountain Chorus Frog	mountains streamside	yes	yes	streamside	streamside
Pseudacris feriarum feriarum	Upland Chorus Frog	riparian floodplains	yes	yes	streamside	streamside
Pseudacris feriarum kalmi	New jersey Chorus frog	Rare frog Woodland frog	yes	yes	streamside	streamside
Pseudacris triseriata	Western chorus frog	farmland grasslands near water	yes	yes	streamside	streamside
Pseudotriton montanus montanus	Eastern mud salamander	muddy springs and mucky areas along streams, swamps, and bogs	yes	yes	streambank/ mud	streambank/ mud
Pseudotriton ruber ruber	Northern red salamander	clean small streams, springs	yes	yes	yes	yes
Rana catesbeiana	Bullfrog	mainly large bodies of water; large slowmoving- heavy vegetative streams	yes	yes	yes	yes
Rana clamitans melanota	Northern Green Frog	Smaller streams shallow water (occasionally) (reproduction)	yes	yes	yes	yes
Rana palustris	Pickerel frog	Smaller streams shallow water (occasionally) (reproduction)	yes	yes	streamside	streamside
Rana pipiens	Northern Leopard frog	Smaller streams shallow water (occasionally) (reproduction)	yes	yes	streamside	streamside
*Rana sphenocephala**	Coastal Plain Leopard frog	Smaller streams shallow water (occasionally) (reproduction)	yes	yes	streamside	streamside
Rana sylvatica	Wood Frog	Smaller streams shallow water (occasionally) (reproduction)	yes	yes	streamside/ terrestrial	streamside/ terrestrial

All *Ambystoma* species excluded typically breed in vernal pools
All *Plethodon* species excluded because of terrestrial habits
Hyla crucifer crucifer, Hyla versicolor versicolor and *Pseudacris crucifer crucifer* excluded typically breed in vernal pools

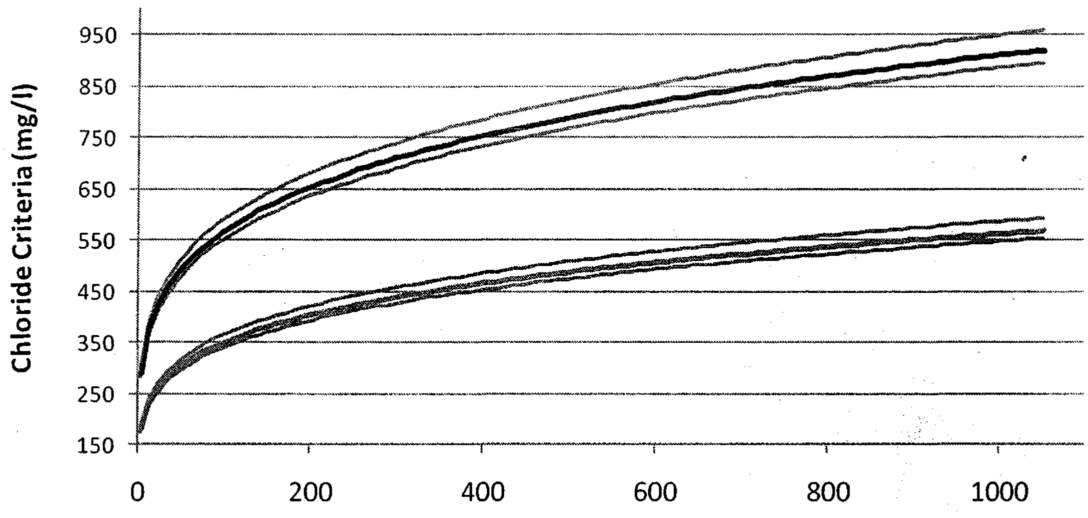

Figure 1: Iowa acute (red = upper line) and chronic (orange = lower line) chloride criteria at constant sulfate concentration of 37.9 m/l (average SO_4 concentration of 246 sites in PA from the EMAP database 1991-2000). Grey lines are 95% confidence intervals for sulfate concentrations from 246 sites in PA.

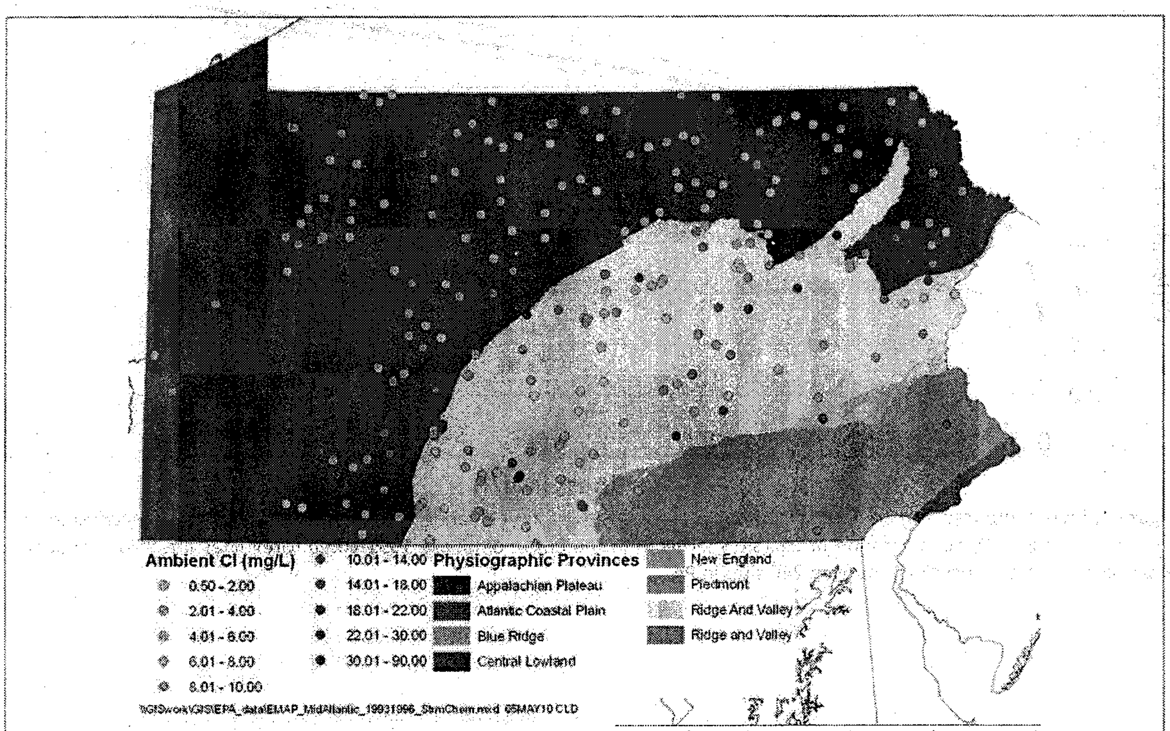

Figure 2: Stream chloride concentrations (color referenced in legend) from the EMAP data set (1993-1993) at 246 sites throughout Pennsylvania (Physiographic Provinces color coded in legend).

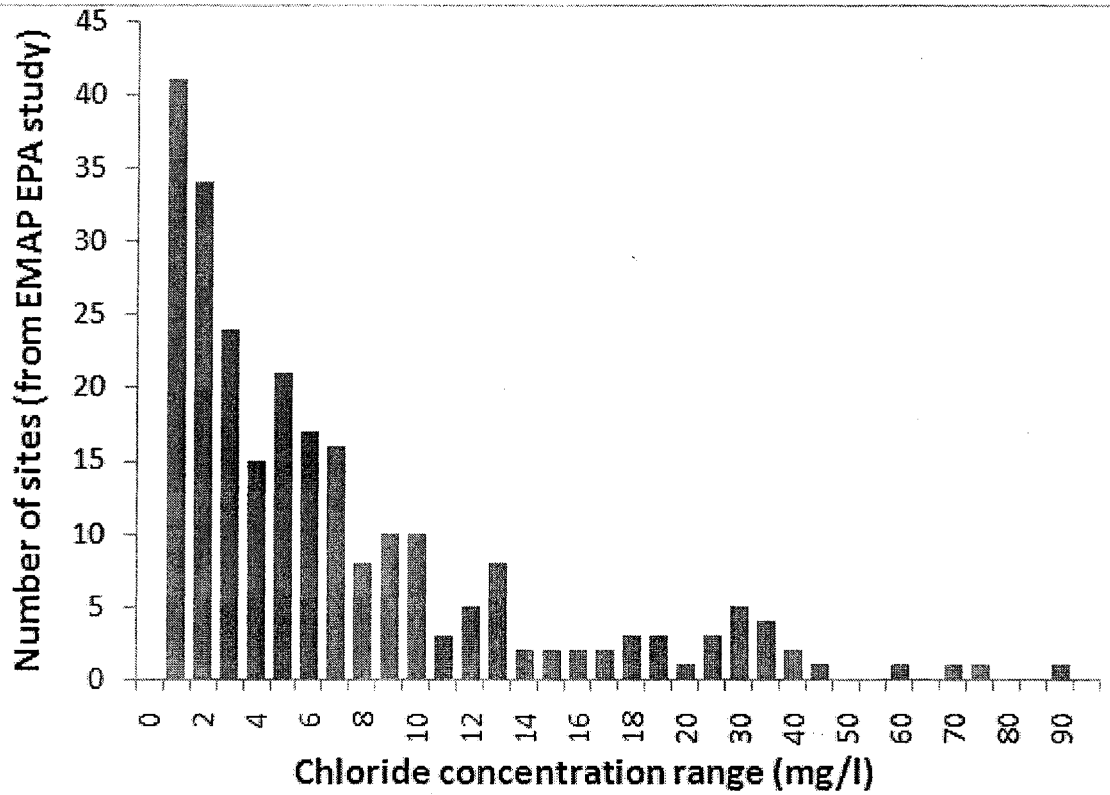

Figure 3: Frequency distribution of EMAP sites in each 2 or 5 mg/l Chloride bin (note after 20 mg/l bin size changes from 2 to 5).

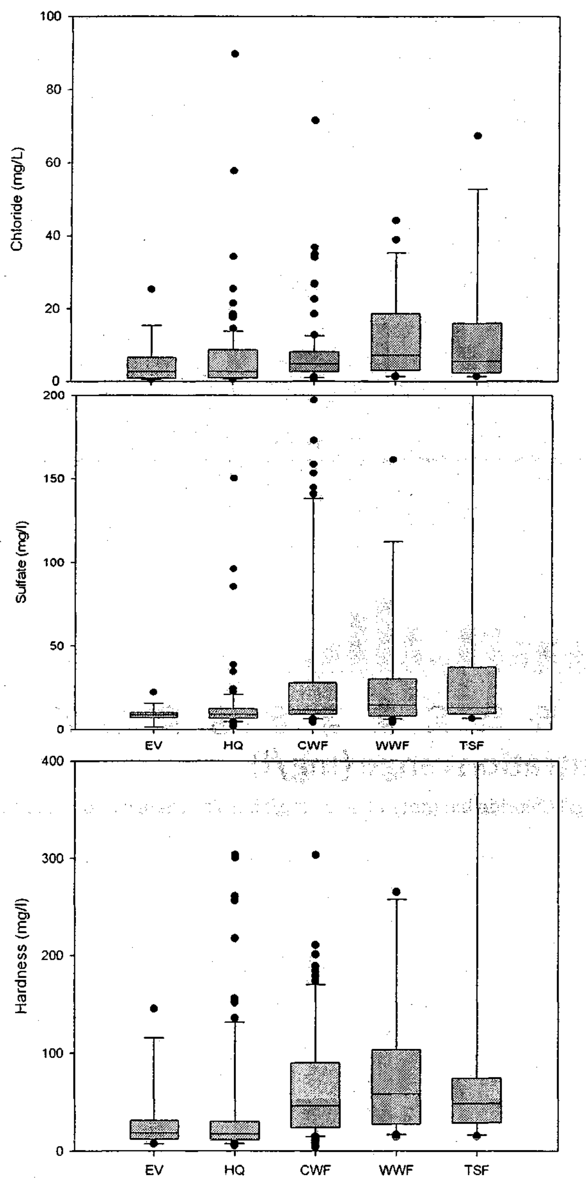

Figure 4: Box plots (middle line = mean; upper and lower box limits = 25th and 75th percentiles, error bars = 5th and 95th percentiles, and black circles are outliers) of stream concentrations of chloride (upper left), sulfate (upper right), hardness (bottom) in mg/l by Pennsylvania designated use (EV = Exceptional Value, HQ = High Quality, CWF = Cold Water Fishery, WWF = Warm Water Fishery (WWF), and TSF = Trout Stock Fishery, note now MF or Migratory Fishery site in EMAP dataset). Data from EMAP dataset 1993-1996.

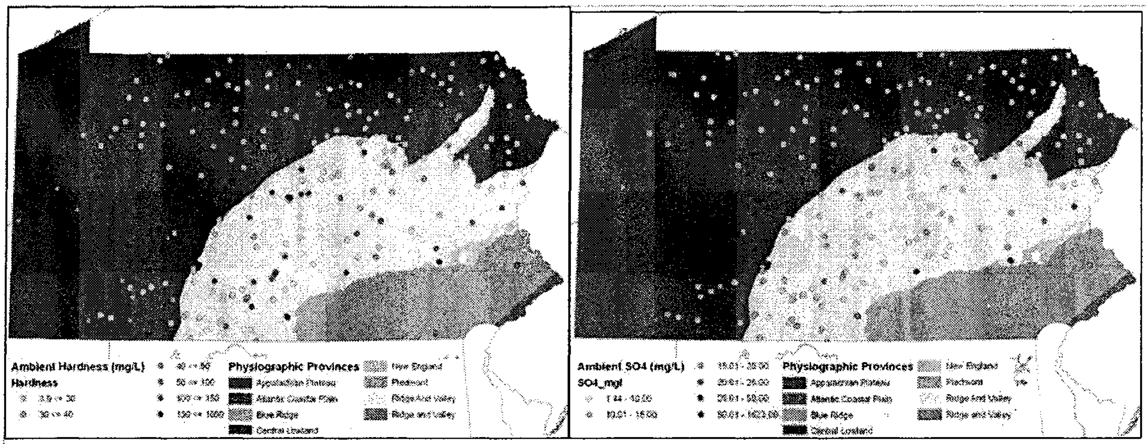

Figure 5: Hardness (left) and sulfate (right) concentrations (color coded yellow = low to red = high) measured at the 246 EMAP sites from 1993-96.

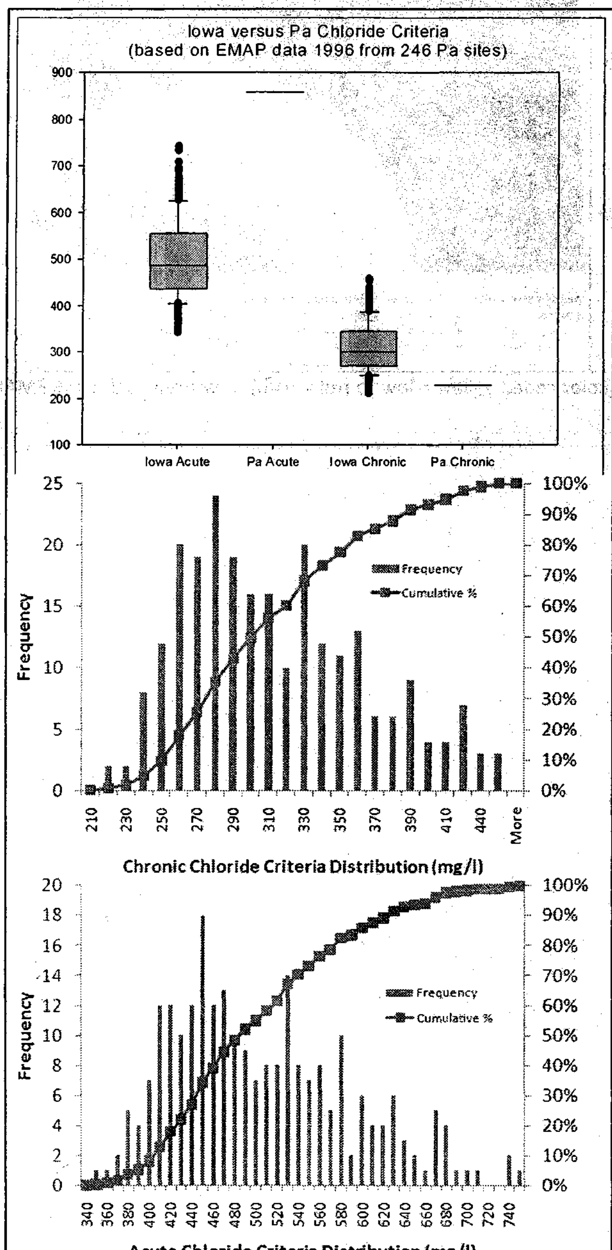

Figure 6: Box plots (upper panel) showing the acute and chronic criteria from the Iowa formulation (box percentiles same as in Fig. 4) that accounts for hardness and sulfate versus the proposed PA criteria (flat line at either 860 or 230 mg/l. Middle and lower panels are frequency distributions for the chronic (middle) and acute (lower) chloride criteria calculated for each of the 246 USGS EMAP sites by 10 mg/l chloride bins.

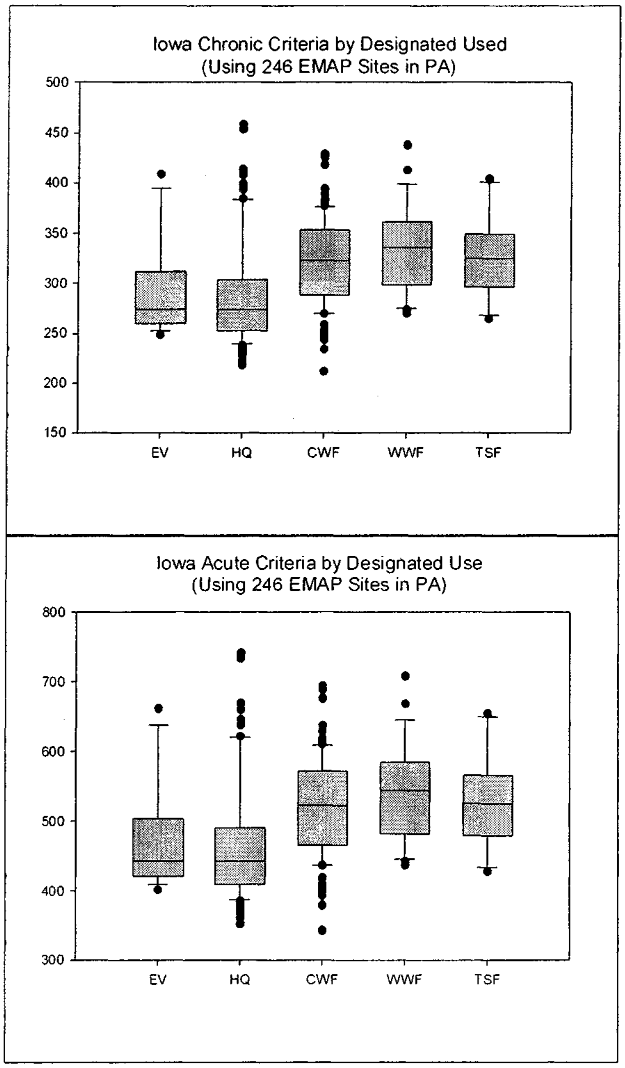

Figure 7: Iowa chronic (upper) and acute (lower) criteria (mg/l Cl^-) calculated for the 246 EMAP sites partitioned by PA designated uses (EV = exceptional value; HQ = high quality; CWF = cold water fisheries; WWF = warm water fisheries; TSF = trout stock fisheries). Boxes are same as describe in Fig. 4)

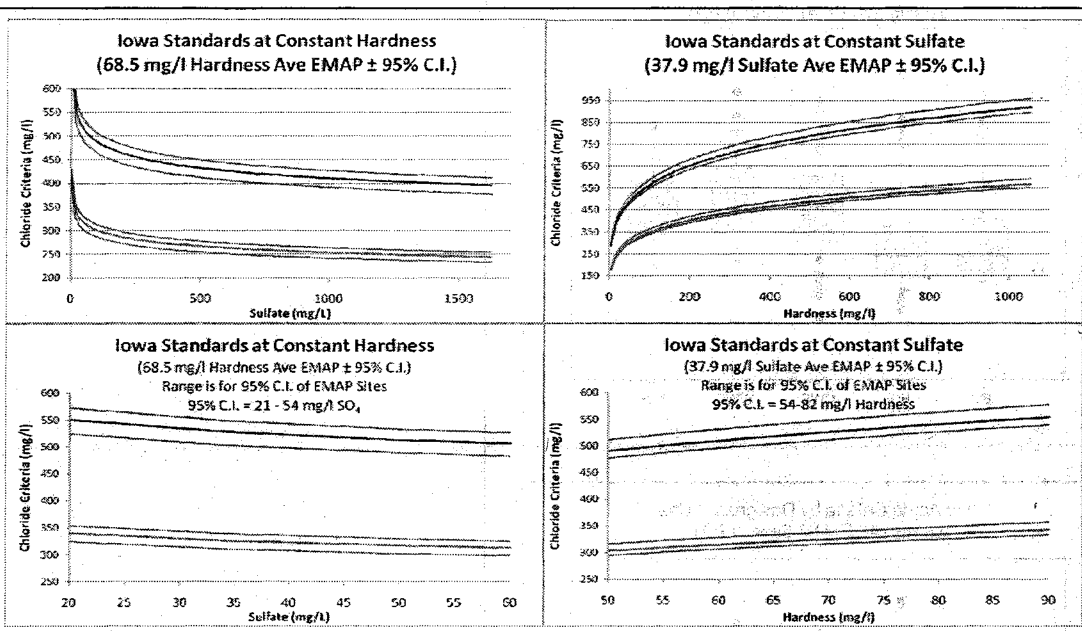

Figure 8: Relationship between the resulting chloride criteria (chronic = upper red line; acute = lower orange) and either sulfate holding hardness constant (upper panels with hardness constant at 68.5 mg/l) or hardness holding sulfate constant (lower panels with sulfate constant at 37.9 mg/l). Panels on the left are for the entire range of either sulfate or hardness found in the EMAP data set. Panels on the right magnify the x-axis around the 95% confidence intervals for sulfate (upper) and hardness (lower). Grey lines above and below each curve were computed using the 95% confidence concentrations for either sulfate or hardness.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Northwest Regional Office

July 3, 2012

Mr. Lou Waldeck
Chairman
Brockway Area Sewage Authority
501 Main Street
Brockway, PA 15824

Re: Sewage
Brockway WWTP
NPDES Permit No. PA0028428
APS ID No. 494075
Brockway Borough, Jefferson County

Dear Mr. Waldeck:

Your Final NPDES Permit is enclosed. Also enclosed is a copy of the Fact Sheet generated along with the NPDES Permit. The Fact Sheet includes an Addendum that lists all the comments received, and the Department's responses to those comments, through the four Draft NPDES Permit public notices.

Read the permit and special conditions carefully. The permit is valid for five years. You must reapply for renewal 180 days before the expiration date on the first page of the permit.

Please be advised that this NPDES Permit now requires you to submit DMRs electronically using the Department's electronic DMR (eDMR) program. This requirement can be found in Special Condition No. II in Part C of your NPDES Permit. Since your facility is already signed up for eDMR, no further action is required. However, in the event that a paper DMR is required, we have provided a Discharge Monitoring Report (DMR) and Supplemental Reporting Forms.

Please complete the enclosed Laboratory Accreditation Form and submit it with your initial DMR. You are not required to submit this Form again during the remainder of the permit term unless a change is made to the laboratory or methods used to analyze parameters in your permit.

Any person aggrieved by this action may appeal, pursuant to Section 4 of the Environmental Hearing Board Act, 35 P.S. §7514, and the Administrative Agency Law, 2 Pa.C.S.A. Chapter 5A, to the Environmental Hearing Board, Second Floor, Rachel Carson State Office Building, 400 Market Street, P.O. Box 8457, Harrisburg, PA 17105-8457, 717.787.3483. TDD users may contact the Board through the Pennsylvania Relay Service, 800.654.5984. Appeals must be filed with the Environmental Hearing Board within 30 days of receipt of written notice of this action unless the appropriate statute provides a different time period. Copies of the appeal form and the Board's rules of practice and procedure may be obtained from the Board. The appeal form and the Board's rules of practice and procedure are also available in Braille or on audiotape from the

Secretary to the Board at 717.787.3483. This paragraph does not, in and of itself, create any right of appeal beyond that permitted by applicable statutes and decisional law.

IF YOU WANT TO CHALLENGE THIS ACTION, YOUR APPEAL MUST REACH THE BOARD WITHIN 30 DAYS. YOU DO NOT NEED A LAWYER TO FILE AN APPEAL WITH THE BOARD.

IMPORTANT LEGAL RIGHTS ARE AT STAKE, HOWEVER, SO YOU SHOULD SHOW THIS DOCUMENT TO A LAWYER AT ONCE. IF YOU CANNOT AFFORD A LAWYER, YOU MAY QUALIFY FOR FREE PRO BONO REPRESENTATION. CALL THE SECRETARY TO THE BOARD (717.787.3483) FOR MORE INFORMATION.

If you have any questions, please call Stephen McCauley of the Permits Section at 814-332-6136.

Sincerely,

John A. Holden, P.E.
Regional Manager
Clean Water Program

Enclosures

cc: U.S. Environmental Protection Agency
Ms. Rayza Santiago, University of Pittsburgh School of Law (with enclosures)
Mr. Robert Decker, Nittany Engineering & Associates, LLC (with enclosures)
Monitoring and Compliance
BWSFR Data Systems and Analysis
NPDES File

JAH:SAM

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
CLEAN WATER PROGRAM

APS Id	494075	Site Id	263008
Client Id	202231	Auth. Id	751643
For Department Use Only			

FACT SHEET / STATEMENT OF BASIS

NAME OF APPLICANT: Brockway Area Sewer Authority
PROJECT LOCATION: Borough of Brockway, Jefferson County
APPLICATION NUMBER: PA0028428

BRIEF DESCRIPTION OF PROJECT AND DISCUSSION

This application is for a renewal of a Part I (NPDES) Permit, for an existing discharge of treated sewage from a Municipal STP.

The Brockway WWTP was Authorized on 4/17/2007 through an NPDES Permit Amendment to accept up to 14,000 gallons per day (gpd) of natural gas-related wastewater.

This facility is classified as an Authorized Load / No Increase under the treatment requirements of Chapter 95.10.

This is a Major discharge. The EPA Waiver is not in effect.

The Mailing Information is:	The Permittee Information is:	The Site / DMR Information is:
Mr. Lou Waldeck Chairman Brockway Area Sewage Authority 501 Main Street Brockway, PA 15824	Brockway Area Sewage Authority 501 Main Street Brockway, PA 15824	Brockway Area WWTP 70 Industrial Park Drive Brockway, PA 15824

The Responsible Official is: Mr. Lou Waldeck, Chairman - phone: 814-268-6565

A Part II Water Quality Management permit is not required at this time.

Act 14 - Proof of Notification was submitted and received.

The 2010 Chapter 94 report was reviewed and this facility remains neither hydraulically nor organically overloaded.

The applicant should be able to continue to meet the limits of this permit and protect the uses of the receiving stream.

RECOMMENDATION AND ACTION

Approve - Issue By Region	Approve - Issue By Central Office	Refuse	Signature	Date
X			STEPHEN A. MCCAULEY, E.I.T. REVIEWING ENGINEER [signature] √DRAFT [signature] √FINAL	12/22/2011 6/18/2012
X			DAVID G. BALOG, P.E. PERMITS SECTION CHIEF [signature]	6/29/12
X			JOHN A. HOLDEN, P.E. REGIONAL MANAGER [signature]	6/29/12

PART C - PERMIT CONDITIONS:

STANDARD: I.
- A. Stormwater into sewers
- B. Right of way
- C. Department revocation of permit
- D. Solids handling
- E. Ultraviolet (UV) Disinfection
- F. Whole Effluent Toxicity Testing
- G. Radiation Protection Action Plan

SPECIAL:
- II. Requirement to Use eDMR System
- III. Drilling Waste Volume
- IV. Receipt of Residual Waste
- V. Solids Management
- VI. Acceptance of Natural Gas-Related Wastewaters Requirements

Receiving Stream: Little Toby Creek (Stream Code 50229)

Watershed: 17-A

Protected Water Uses: Cold Water Fishes
Aquatic Life
Water Supply
Recreation

Secondary Waters: Clarion River (Stream Code 49224)

For the purpose of evaluating effluent requirements for TDS, NO_2-NO_3, Fluoride, and Phenolics, the nearest downstream potable water supply considered during the evaluation is the PA American Water Company on the Clarion River approximately 45.0 miles below the point of discharge. No requirements are necessary.

Brockway receives 53% of its flow from the Borough of Brockway. Snyder Township contributes 32% and Horton Township (Elk County) contributes 15% of the flow to the Brockway WWTP. There are no combined sewers in the Brockway system.

Treatment consists of the following: a fine screen, two aerated stormwater storage basins with a total capacity of 325,000 gallons, two 750,000 gallon oxidation ditches, two 239,848 gallon Spiraflo final clarifiers, an aerobic sludge digestion tank, Ultraviolet (UV) light disinfection, and post aeration. The sewage treatment facilities received a major upgrade in 2006 and the new facilities are permitted under WQM permit number 3303403.

Modeling resulted in less stringent limits for $CBOD_5$ and NH_3-N, but the previous permit limits for $CBOD_5$ and NH_3-N were retained since the facility has not had any problems meeting the more restrictive limits. The winter limit for Fecal Coliforms was reduced from 8,200/100ml to 2,000/100 ml to comply with the 2006 updates to Chapter 93.7.

The previous permit required monthly monitoring and reporting for Lead due to the Brockway WWTP accepting brine water. Using the sampling results from the renewal application and the DMR reports, Lead was remodeled and found to be well below its calculated WQBEL of 59.7 µg/l. The previous requirement for monitoring of Lead has been removed from this NPDES permit renewal.

A Reasonable Potential Analysis was performed in accordance with Pennsylvania's approved procedures for the following pollutants of concern: Aluminum, Barium, Boron, Cadmium, Copper, Dissolved Iron, Lead, Manganese, Mercury, Nickel, Osmotic Pressure, Selenium, Total Iron, and Zinc. Only an Osmotic Pressure limit was required for this renewal NPDES Permit.

Total Iron, Total Manganese, and Total Aluminum were modeled due to the 6/9/2009 TMDL for Little Toby Creek, which is affected by Abandoned Mine Drainage (AMD). The Brockway STP discharge concentrations for Total Iron, Total Manganese, and Total Aluminum are significantly lower than the water quality criteria standards. Therefore, no sampling will be added to this NPDES Permit.

The proposed discharge limitations are based on the following: BPT-40 CFR 133, except for Ammonia-Nitrogen, which is water quality based, and Fecal Coliform, pH, and Osmotic Pressure, which are based on Chapter 93.7. Flow is monitor only. The limits for TDS are water quality based on Chapter 95.10 based on the maximum values that were previously authorized to be discharged under NPDES Permit PA0028428, prior to the passage of Chapter 95.10 on August 21, 2010.

Based on Chapter 95.10 and the DEP guidance document, monitoring has been included for the following pollutants of concern: Chloride, Bromide, Total Barium, Total Strontium, Radium 226/228 (combined), Gross Alpha, and Total Uranium due to the acceptance of natural gas-related wastewater.

For Outfall: 001 Latitude: **41° 15' 13"** Longitude: **78° 47' 50"** River Mile Index: 10.62 Stream Code: 50229

which receives wastewater from: **municipal sanitary sewers serving Brockway Borough, Snyder Township, and Horton Township, and a maximum of 14,000 gpd of natural gas-related wastewaters.**

Discharges to: the **Little Toby Creek.**

Monthly average daily flow: **1.5** million gallons per day (MGD).

	Loadings (lbs/day)		Concentrations (mg/l)			Monitoring	
Parameters	Monthly Average	Weekly Average	Monthly Average	Weekly Average	Instant. Maximum	Measurement Frequency	Sample Type
Flow (MGD)	Report	Report Daily Max.				Continuous	Measured
pH	Within limits of 6.0 to 9.0 standard units at all times					Daily	Grab
$CBOD_5$	237	355	19	28.5	38	2/Week	24-Hr Comp.
Total Suspended Solids	375	562	30	45	60	2/Week	24-Hr Comp.
Fecal Coliform (05/01 – 09/30) (10/01 – 04/30)			Geo Mean 200 2,000		 1,000 10,000	 2/Week 2/Week	 Grab Grab
Ammonia-Nitrogen (05/01 – 10/31) (11/01 – 04/30)	 81 243		 6.5 19.5		 13.0 39.0	 2/Week 2/Week	 24-Hr Comp. 24-Hr Comp.
~~Total Dissolved Solids~~	~~17,574~~	29,143 ~~Daily~~ Max.	~~4,274~~		~~7,960~~	~~2/Month**~~	~~24-Hr Comp.~~
Osmotic Pressure (in mOs/kg)*			228		456	2/Month**	24-Hr Comp.
Total Barium	Report		Report		Report	2/Month**	24-Hr Comp.
Total Strontium	Report		Report		Report	2/Month**	24-Hr Comp.
Total Uranium (in µg/l)	Report		Report		Report	2/Month**	24-Hr Comp.
Chloride	Report		Report		Report	2/Month**	24-Hr Comp.
Bromide	Report		Report		Report	2/Month**	24-Hr Comp.
Gross Alpha (in pCi/L)			Report		Report	2/Month**	24-Hr Comp.
Radium 226/228 (in pCi/L)			Report		Report	2/Month**	24-Hr Comp.

Samples taken at the following location: Outfall 001, after UV disinfection and post aeration.

* - The US EPA has requested that upstream sampling of Osmotic Pressure be performed for the next NPDES Permit renewal to ensure that the background value used for modeling is representative (see Attachment 10). The DEP will have its Field Specialist sample for Osmotic Pressure upstream of the Brockway WWTP once the NPDES Permit renewal application is received.

** - Refer to Special Condition VI.

ADDENDUM - First Draft:

On August 3, 2009, Timothy Keister, Chairman of the Brockway Area Sewage Authority ("BASA"), forwarded comments pertaining to the Draft NPDES permit (see Attachment 1). A summary of these comments and the Department's responses follows:

Comment 1: We object to the inclusion of an effluent limit, and monitoring requirement, for copper at Outfall 001.

Response 1: After obtaining further sample data, Total Copper was remodeled and found to be no longer required.

Comment 2: We object to the inclusion of monitoring requirements for sulfate, chloride, and strontium at outfall 001. Our rate payers should not have to pay the cost for the Department wishing to collect some data on parameters which are already regulated by imposition of a dissolved solids effluent limitation.

In general, we object to imposition of any monitoring requirement which cannot be justified on the basis of being a controllable pollutant. As you may be aware, the increasingly stringent requirements on PADEP certified laboratories have driven the cost of analytical work up substantially, thus pointless monitoring is a burdensome expense.

Response 2: The inclusion of monitoring requirements for sulfate has been removed. The inclusion of monitoring requirements for chloride and strontium at Outfall 001 is a direct result of the Brockway WWTP accepting natural gas-related wastewaters. These parameters, as well as the others assigned as monitor and report, have been identified as pollutants of concern associated with treating natural gas-related wastewaters.

Sulfates, Chlorides, and Strontium are indeed controllable pollutants since they come from natural gas-related wastewaters. The monitoring requirements are therefore justified and are, in fact, due to the permittee's desire to accept and "treat" natural gas-related wastewaters.

The monitoring requirements for Sulfates have been removed in the fourth Draft NPDES Permit.

Comment 3: Given the dilution available at our discharge point, we believe that the 4,000 mg/l average, 10,000 mg/l maximum, effluent limits for dissolved solids are too low.

We would note and call your attention to the fact that the "TDS Strategy of April 2009" is not a regulation. The controlling regulation for control of TDS is the public water supply criteria of 500 mg/l dissolved solids. Accordingly, please provide your background data, calculations, and justification for imposition of such low dissolved solids effluent limitations for our technical review.

Response 3: The maximum should have actually been 6,000 mg/l. The 4,000 mg/l average is based on a recommended maximum TDS concentration in the biological reactor of the STP in order to prevent biological interference. This equates to a non-seasonal loading of 50,040 lbs/day of TDS at the permitted flow of 1.5 MGD for the Brockway STP.

However, with the passage of the new Chapter 95.10 regulations, the fourth Draft NPDES Permit will set the allowable monthly average TDS concentration in the effluent based on the average discharged value of 4,274 mg/l.

ADDENDUM - First Draft (continued):

On September 21, 2009, Jon M. Capacasa, Director of the Water Protection Division of Region III of the US EPA, forwarded a specific objection letter pertaining to the BASA Draft NPDES permit (see Attachment 2). In addition, the US EPA sent a separate letter dated September 21, 2009 to the DEP Central Office in Harrisburg, PA, reiterating their concerns on the methods used to develop several brine-related draft permits across Pennsylvania (see Attachment 3). A summary of the specific objections EPA stated on the BASA Permit, and the Department's responses, follows:

Comment 1: The development of "monthly" Q7-10 flows is inconsistent with the commonly accepted calculation approach of a Q7-10 flow and has not been the interpretation or approach used by PADEP to develop NPDES permits in the past. PADEP must reanalyze and document the far field requirements to include calculations based on the normal "annual" Q7-10 calculations.

Response 1: The Department has reanalyzed and documented the far field requirements for the BASA permit, to include calculations based on the normal "annual" Q7-10 calculations.

Comment 2: The EPA recommends that the permit include a numeric water quality based effluent limit (WQBEL) for Osmotic Pressure based on the existing Chapter 93 standard, which would take the place of the "near field" analysis of TDS.

Response 2: The Department will include a numeric water quality based effluent limit (WQBEL) for Osmotic Pressure in the re-draft permit, based on the existing Chapter 93 standard, in place of the "near field" analysis of TDS.

Comment 3: According to page 6, paragraph (2)(b)(i), of PADEP's April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges", POTWs currently accepting brine wastewaters through an approved permit must also be given a final TDS effluent limit currently proposed at 500 mg/l effective January 1, 2011.

Response 3: The April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges" is no longer in use. Instead, the revisions to Chapter 95 dated August 21, 2010, will be used to regulate facilities that accept brine wastewaters.

Comment 4: PADEP should contact EPA in situations where PADEP is recommending a POTW to develop a Pretreatment Program. With EPA's positive determination, the permit would need to include the proper language to develop the program. Brockway currently is not required to have a Pretreatment Program and the draft permit does not have language for Brockway to develop a program. In order for Brockway (or any other POTW that doesn't currently have a program) to be required to develop an approved program, the permit needs to include the proper permit language once EPA has made the determination that a program is needed.

Response 4: The Pennsylvania DEP will contact EPA in situations where PADEP is recommending that a POTW develops a Pretreatment Program. The Brine acceptance by Brockway has not caused any interference or pass through problems at the POTW. For Brockway, the DEP does not believe referring this case to EPA for a Pretreatment Program determination is necessary at this time.

ADDENDUM - Second Draft:

On February 28, 2011, Timothy Keister, Chairman of the Brockway Area Sewage Authority ("BASA"), forwarded comments pertaining to the second Draft NPDES permit (see Attachment 4). A summary of these comments and the Department's responses follows:

Comment 1: Brockway Area Sewerage Authority (BASA) objects to the inclusion of effluent monitoring and limits for the parameter of "osmotic pressure". This objection is based on the fact that osmotic pressure is not a generally recognized effluent monitoring parameter with standardized test methods, there is no USEPA approved procedure at 40 CFR 136. In addition, the wastewater pollutant to be monitored and controlled by osmotic pressure is already monitored, with effluent limits established, by the inclusion of monitoring and effluent limits for total dissolved solids. We cannot economically justify monitoring and regulation of one pollutant using two different parameters, one of which, osmotic pressure, is going to increase our monitoring costs.

The use of "osmotic pressure" as an effluent limitation is not acceptable due to the fact that this parameter is not defined by any generally recognized standard analytical method. Regardless of the water quality criteria given in Chapter 93, calculation of a permit effluent limitation based on a water quality criteria, which has no scientifically valid, recognized standard analytical method, is not acceptable to BASA. We would also point out that total dissolved solids essentially regulates the exact same parameter, using a generally recognized standard analytical method, and is as protective of the environment as the osmotic pressure water quality criteria.

Response 1: Osmotic Pressure is required under Chapter 93. Furthermore, all facilities that accept natural gas-related wastewaters are now being required to sample for Osmotic Pressure by the US EPA to protect the "near field" stream concerns.

See the DEP Document number 391-2000-008 entitled "Interim Method for the Sampling and Analysis of Osmotic Pressure on Streams, Brines, and Industrial Dischargers". A copy of this document was added to the cover letter of the third draft NPDES Permit.

Comment 2: BASA objects to the inclusion of any monitoring for gross alpha, radium 226/228, and uranium. This objection is based on the fact that no significant amount of radiation has been reported in gas well production wastewaters in Pennsylvania. Our source of this information is the presentation made by researchers from Bucknell University, Lewisburg, PA, at the "The Science of Marcellus Shale" conference hosted by Lycoming College in Williamsport, PA, January 29, 2010.

Monitoring for unregulated parameters, which have been shown by competent researchers to not present a problem, is a waste of scarce BASA economic resources. We would request that PADEP provide any data to indicate that these parameters represent any concern as to pollution of the receiving stream.

Response 2: The inclusion of monitoring requirements for gross alpha, radium 226/228, and uranium at Outfall 001 is a direct result of the Brockway WWTP accepting natural gas-related wastewaters. These parameters, as well as the others assigned as monitor and report, have been identified as pollutants of concern associated with treating natural gas-related wastewaters.

Radioactivity is indeed a regulated parameter for the users of drinking water in the City of Clarion, since the water supply for the City of Clarion is downstream of the Permittee's discharge. The Department is requiring the parameters be monitored so data can be compiled to determine whether radioactivity is a concern or not.

ADDENDUM - Second Draft (continued):

Comment 3: BASA objects to the requirement that a "Radiation Protection Action Plan" be prepared. As pointed out in our objection to any monitoring for radioactives, the only study issued on this subject determined that radioactives are not a concern for gas well wastewaters. Again, BASA does not have the economic resources to waste on useless plan preparation.

We also note that the PADEP technical guidance document (385-2100-002), from which the suggestion to include such a plan was apparently taken, is still a draft document and in no way binding at the current time. In addition, please note that a guidance document is not law or regulation, the exact wording concerning inclusion of a "Radiation Protection Action Plan" is "should", not "shall", it is optional.

Response 3: The PADEP technical guidance document (385-2100-002) was made final on November 12, 2011. The Special Condition requiring a Radiation Protection Action Plan has been included in the NPDES Permit. The exact wording of the Special Condition is "shall", it is not optional.

Comment 4: Please provide the calculations used to determine the mass limits for total dissolved solids on the draft permit. BASA is concerned that we are NOT getting the mass loading for the permitted 14,000 gpd, but instead are being permitted at the loadings from the average and maximum brine flows of 8,782 and 1,520 gpd as provided to the PADEP in our letter of November 19, 2010. If the permitted 14,000 gpd is used our mass loadings would calculate as 17,585 lbs/day daily average and 29,161 lbs/day daily maximum.

Please note that the gas well wastewater accepted by BASA for treatment is production wastewater, not hydrofrac flowback, and is accepted from just a single firm, Dannic Energy, under contract. Further, please note that BASA has no "project consultant" on renewal of our NPDES permit, so please correct your fact sheet accordingly.

Response 4: BASA was indeed NOT getting the mass loading for the permitted 14,000 gpd, but instead was being permitted at the loadings from the average and maximum brine flows of 8,782 and 11,520 gpd as provided to the PADEP in the letter of November 19, 2010.

At the Permittee's request, and since the facility was permitted to receive up to 14,000 gpd of natural gas-related wastewater prior to the passage of Chapter 95.10, the Department has agreed that the permitted 14,000 gpd will be used to calculate your mass loadings. The new mass loadings for TDS will therefore be 150,519 mg/l x 0.014 MGD x 8.34 = 17,574 lbs/day daily average and 249,600 mg/l x 0.014 MGD x 8.34 = 29,143 lbs/day daily maximum.

The Project Consultant listed on the previous Fact Sheet has been removed at the Permittee's request.

ADDENDUM - Second Draft (continued):

On March 3, 2011, Robert S. Decker, P.E. of Nittany Engineering & Associates, LLC, forwarded comments pertaining to the second Draft NPDES permit (see Attachment 5). A summary of these comments and the Department's responses follows:

Comment 1: The mass loading limitations in the second draft NPDES Permit should be relaxed based on calculations provided (see the actual letter for calculations).

There should not be a 14,000 gpd limit on natural gas-related wastewaters accepted at the STP since that value was just a basis for initial calculations.

Response 1: The mass loading limitations have been relaxed slightly at the request of the Permittee (see Response 4 above).
No further relaxation is possible while still adhering to current regulations and policies in place.

There is already a 14,000 gpd limit on natural gas-related wastewaters accepted at the STP due to the fact that the only NPDES Permit amendment in place prior to the passage of Chapter 95.10 only approved the acceptance of up to 14,000 gpd. Higher volumes may be permitted, but those increased volumes would have to be treated to the levels stated in Chapter 95.10 for new or increased loadings. The most restrictive of which is probably the requirement that the TDS in the effluent be treated to a concentration of 500 mg/l.

ADDENDUM - Third Draft:

On June 9, 2011, Timothy Keister, Chairman of the Brockway Area Sewage Authority ("BASA"), forwarded comments pertaining to the third Draft NPDES permit (see Attachment 6). A summary of these comments and the Department's responses follows:

Comment 1: Brockway Area Sewerage Authority (BASA) objects to the inclusion of effluent monitoring and limits for the parameter of "osmotic pressure".

Response 1: Osmotic Pressure is required under Chapter 93, and is also being required by the US EPA to protect the "near field" stream concerns.

Comment 2: BASA objects to the inclusion of any monitoring for gross alpha, radium 226/228, and uranium.

Response 2: The inclusion of monitoring requirements for gross alpha, radium 226/228, and uranium at Outfall 001 is a direct result of the Brockway WWTP accepting natural gas-related wastewaters. These parameters, as well as the others assigned as monitor and report, have been identified as pollutants of concern associated with treating natural gas-related wastewaters.

Radioactivity is indeed a regulated parameter for the users of drinking water in the City of Clarion, since the water supply for the City of Clarion is downstream of the Permittee's discharge. The Department is requiring the parameters be monitored so data can be compiled to determine whether radioactivity is a concern or not.

Comment 3: BASA objects to the requirement that a "Radiation Protection Action Plan" be prepared.

Response 3: The condition requiring a Radiation Protection Action Plan will remain in the NPDES Permit. The exact wording of the Special Condition is "shall", it is not optional.

Comment 4: Please provide the calculations used to determine the mass limits for total dissolved solids on the draft permit. BASA is concerned that we are NOT getting the mass loading for the permitted 14,000 gpd, but instead are being permitted at the loadings from the average and maximum brine flows of 8,782 and 1,520 gpd as provided to the PADEP in our letter of November 19, 2010. If the permitted 14,000 gpd is used our mass loadings would calculate as 17,585 lbs/day daily average and 29,161 lbs/day daily maximum.

Response 4: BASA was indeed NOT getting the mass loading for the permitted 14,000 gpd, but instead was being permitted at the loadings from the average and maximum brine flows of 8,782 and 11,520 gpd as provided to the PADEP in the letter of November 19, 2010.

At the Permittee's request, and since the facility was permitted to receive up to 14,000 gpd of natural gas-related wastewater prior to the passage of Chapter 95.10, the Department has agreed that the permitted 14,000 gpd will be used to calculate your mass loadings. The new mass loadings for TDS will therefore be 150,519 mg/l x 0.014 MGD x 8.34 = 17,574 lbs/day daily average and 249,600 mg/l x 0.014 MGD x 8.34 = 29,143 lbs/day daily maximum.

Comment 5: We are requesting that the Department justify the inclusion of total alkalinity and sulfate in the permit.

Response 5: Total alkalinity and sulfate were added to the third draft in response to the US EPA's letter requesting that all POTWs that accept Marcellus wastewater monitor for numerous pollutants of concern including total alkalinity and sulfate.

Total alkalinity and sulfate are no longer required to be monitored with the fourth draft NPDES Permit.

ADDENDUM - Fourth Draft:

On February 29, 2012, Robert S. Decker, P.E. of Nittany Engineering & Associates, LLC, forwarded comments pertaining to the Fourth Draft NPDES permit (see Attachment 7). A summary of these comments and the Department's responses follows:

Comment 1: The TDS Limits have a mass loading limit and a concentration limit. Please eliminate the mass limit and only have the concentration limits of 4,274 mg/l Average Monthly and 7,960 mg/l Instantaneous Max.

Response 1: The mass loading limitations for TDS are required for this permit under Chapter 95.10 and will not be removed. The concentration limits will also remain as drafted.

Comment 2: For the implementation of the Radiation Protection Action Plan, we request the Department provide us with a reasonable implementation schedule to get in place within the permit, (i.e. permittee shall implement the Radiation Protection Action Plan within twelve (12) months from the issuance date of this permit).

Response 2: The NPDES Permit requires the Radiation Protection Action Plan to be submitted for approval within 180 days of permit issuance. The Radiation Protection Action Plan is to be implemented once it has been approved by the Department. No additional implementation schedule is necessary

Comment 3: We would like to have the option of reducing some of the monitoring requirements of some constituents that have been added to the permit due to the acceptance of gas wastewater and/or the frequency of those parameters if it is determined over the course of the first year that nothing of environmental significance has been identified as a concern as a special condition to the permit.

Response 3: A Special Condition has been added to allow the Permittee, after one (1) year of sampling, to submit a ~~summary of sampling data and a NPDES Permit Amendment application to request a reduction in~~ sampling frequency, and possibly a reduction in the sampling of some parameters, if the results of the sampling show that the parameters are not detectable, or of an extremely low concentration such that further monitoring would be deemed unnecessary by the Department.

In support of allowing the Permittee to request a sampling reduction after 1 year, the Department considered that: (1) several of these parameters don't have WQ criteria to compare against, (2) Brockway has already been sampling for these parameters pursuant to EPA's Section 308 letter, so there is already a wealth of data, and (3) allowing the Permittee wanted to know some end to the monitoring was in sight (see comment 3 above).

ADDENDUM - Fourth Draft:

On February 29, 2012, Ms. Rayza Santiago, Certified Legal Intern, and Ms. Emily A. Collins, Supervising Attorney, forwarded comments pertaining to the Fourth Draft NPDES permit (see Attachment 8). A summary of these comments and the Department's responses follows:

Comment 1: The Brockway WWTP accepts industrial wastewater without pretreatment and therefore should be subject to the effluent limitations of 40 CFR Part 437 for facilities that accept untreated industrial waste.

Response 1: As a publicly-owned treatment works (POTW) the Brockway WWTP is not subject to 40 CFR Part 437. Brockway's acceptance of industrial wastewater does not subject it to 40 CFR Part 437. The natural gas-related industrial wastewater accepted by Brockway WWTP is pretreated by the Dannic Energy Corporation, which has an on-site pretreatment facility. The indirect discharges from the Dannic Energy facility to the Brockway WWTP is subject to the pretreatment requirements in 40 CFR Part 437, but the Department is not delegated to administer the pretreatment program, the US EPA is. The EPA is currently evaluating the Dannic Energy facility to determine whether any pretreatment requirements will be required (see Attachment 10).

Comment 2: There are no limits for Chlorides and no monitoring for Bromides.

Response 2: DEP agrees that bromide and chloride are potential threats to water quality standards, including protected uses such as potable water supply (PWS) and aquatic life-related uses. But this observation does not translate into the necessity for quantitative effluent limits. There must be reasonable potential for the pollutant loading from the permittee's facility to challenge those water quality standards. The Department has fully considered the potential threats to water quality of chloride and bromide when developing the permit conditions for the Brockway facility as discussed below.

Chloride

Chloride has an applicable water quality criterion in 25 Pa. Code Chapter 93 of 250 mg/L based on the need to protect the potable water supply use. As per 25 Pa. Code §96.3(d), the criterion for chloride is applicable only at a downstream point of water supply withdrawal. The nearest downstream PWS is located at the PA American Water Company on the Clarion River, more than 45 miles downstream of the Brockway WWTP discharge. Based on the information contained in the permittee's application, and also ambient water quality data, the permittee's facility is not capable of discharging sufficient chloride to challenge the water quality criterion for chloride at the PA American Water Company PWS, or at any other downstream PWS.

The Department recognizes the toxic effects of Chloride on aquatic life. Presently, the Department evaluates and controls the toxic effects of chloride indirectly through application of a water quality criterion for osmotic pressure. This renewed NPDES Permit for the Brockway WWTP will contain water quality based limits for osmotic pressure.

Sampling and reporting for chloride is also required in the permit. The Department has begun to track all larger sources of TDS to assure that sufficient data are available to anticipate and avoid potential problems with water quality due to aggregate loadings of TDS in watersheds. Chloride is potentially a major component of TDS and is now tracked in facilities with substantial chloride loadings.

Bromide

Bromide has low toxicity in the environment and there are no applicable water quality criteria in Pennsylvania. The Department is performing ongoing studies to quantify the concentrations and impact of bromide in our rivers and streams. Based on these studies, the Department has taken action to reduce the loadings of bromide to rivers and streams, primarily by reducing the discharge of treated natural gas wastewater. Many discharges have been eliminated. Others, such as Brockway, have been limited under

Response 2: (continued) the applicable provisions of 25 Pa. Code Chapter 95. Brockway's permit limits the Brockway WWTP to receiving and treating 14,000 gallons per day of natural gas wastewater from conventional shallow well sources.

In addition, a review of the downstream water supply sampling data shows no THM production as a result of the acceptance of natural gas-related wastewater at the Brockway WWTP. Since the quantity of wastewater is to remain the same, and the source of the natural gas-related wastewater cannot come from shale gas extraction (SGE) wells, there is very low potential for future THM production due to Bromide discharge as well.

A sampling and reporting requirement for Bromide has been added to this permit for bromide to help assure that the Department has the necessary data to quantify the loadings of bromide in surface waters, and take additional actions to further reduce those loadings if necessary.

Comment 3: On page three of the fact sheet, DEP does not state that the previously discharged concentrations [at the Brockway WWTP] were previously authorized under a permit that authorized the acceptance, treatment and discharge of TDS pursuant to Chapter 95.10(a)(1)(ii).

Response 3: The Brockway WWTP was authorized on 4/17/2007 through an NPDES Permit Amendment to accept up to 14,000 gallons per day (gpd) of natural gas-related wastewater. Pursuant to 25 Pa. Code §95.10(a)(1), this volume is not considered a new or expanding mass loading of TDS and Brockway WWTP is exempt from the treatment requirements. This is made clearer in the Final Fact Sheet.

ADDENDUM - Fourth Draft:

On March 14, 2012, Jon M. Capacasa, Director of the Water Protection Division of Region III of the US EPA, forwarded a letter to Mr. Kelly Burch, Director of the Northwest Regional Office of the DEP, to lift the objection that the EPA had placed on the Brockway NPDES Permit (see Attachment 9). A summary of the specific objections EPA stated on the BASA Permit, and the Department's responses, follows:

Comment 1: The assumed background level of 5 mOs/kg used for Osmotic Pressure should be verified with in-stream sampling in order to use in any subsequent WQBEL calculations for Osmotic Pressure.

The draft permit should be revised to specify that in-stream monitoring upstream of the discharge should be conducted for Osmotic Pressure and included with the next permit renewal application.

Response 1: The DEP will have its Field Specialist sample for Osmotic Pressure upstream of the Brockway WWTP once the NPDES Permit renewal application is received.

Attachment 1

Brockway Area Sewage Authority
70 Industrial Park Drive
Brockway, PA 15824

P 814-265-0830
F 814-265-0830
E basa@brockwaytv.com

August 3, 2009

SAM 8/5/2009
Mr. Stephen McCauley, EIT
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

RECEIVED
AUG 05 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

RE: NPDES PA 0028428
APS ID No. 494075
Brockway Borough, Jefferson County

Dear Mr. McCauley,

We have carefully reviewed the draft amended NPDES permit as supplied under your cover of June 18, 2009, and wish to provide the following specific comments.

1. We object to the inclusion of an effluent limit, and monitoring requirement, for copper at outfall 001. Our reasons for this objection are:

a) There are no known controllable sources of copper in the plant influent. Phoenix Sintered Metals, a potential copper source, operates with zero process water discharge.

b) The proposed effluent limits of 0.048 mg/l average, 0.096 mg/l maximum, are clearly at a level much below that needed to obtain the 1.0 mg/l specified by the USEPA for domestic water supplies and also lower than that needed for protection of aquatic life.

Bearing in mind that the Little Toby Creek is classified as a mild alkalinity, **hard water**, copper levels from 0.4 to as high as 1.25 mg/l have been reported as LC 50 values for rainbow trout. Accordingly, the proposed values cannot be justified for our discharge limit.

c) Previous monitoring data for our discharge, seven samples, shows an average value of 0.061 mg/l, which is above the proposed value. Bear in mind that during this data collection period we had no known sources of copper in our influent and that our plant is not designed for copper removal.

We will not accept an effluent limitation where compliance cannot be obtained using our existing new treatment plant, and the proposed copper effluent limit falls within that classification. We are requesting that you provide us with all the materials used to justify imposition of a copper effluent limit, including references.

2. We object to the inclusion of monitoring requirements for sulfate, chloride, and strontium on outfall 001. Our rate payers should not have to pay the cost for the Department wishing to collect some data on parameters which are already regulated by imposition of a dissolved solids effluent limitation.

In general, we object to imposition of any monitoring requirement which cannot be justified on the basis of being a controllable pollutant. As you may be aware, the increasingly stringent requirements on PADEP certified laboratories have driven the cost of analytical work up substantially, thus pointless monitoring is a burdensome expense.

3. Given the dilution available at our discharge point, we believe that the 4,000 mg/l average, 10,000 mg/l maximum, effluent limits for dissolved solids are too low.

We would note and call your attention to the fact that the "TDS Strategy of April 2009" is not a regulation. The controlling regulation for control of TDS is the public water supply criteria of 500 mg/l dissolved solids. Accordingly, please provide your background data, calculations, and justification for imposition of such low dissolved solids effluent limitations for our technical review.

I trust that these objections will be carefully reviewed and a reply provided prior to issue of a final permit. Please contact me directly with any questions or comments.

Sincerely,

Timothy Keister, CWT
Chairman

Attachment 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

RECEIVED
SEP 25 2009
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

SEP 21 2009

Mr. Kelly Burch, Director
Northwest Regional Office
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

Re: NPDES Permit No. PA0028428
Brockway WWTP
Brockway Borough, Jefferson County

Dear Mr. Burch:

The draft National Pollutant Discharge Elimination System (NPDES) permit renewal for the above-referenced facility was received by the U. S. Environmental Protection Agency (EPA) on June 23, 2009, for review pursuant to 40 CFR § 123.44 and the Memorandum of Agreement (MOA) between EPA and the Pennsylvania Department of Environmental Protection (PADEP). EPA issued a general objection/time extension letter on July 17, 2009. This letter is a specific objection to the issuance of the referenced permit based on 40 CFR § 123.44(c)(4) & (c)(8) and it is being submitted pursuant to 40 CFR § 123.44(b)(2) and Section III.A.2. of the MOA.

EPA's objection to the draft permit and identification of revisions needed for EPA to remove the objection are described below. Additional information is contained in the enclosed letter to Dana Aunkst dated September 21, 2009. The enclosed letter addresses several issues regarding the PADEP's calculations and assumptions in proposing effluent limitations for Total Dissolved Solids (TDS). Discussed below are the issues specific to the Brockway draft permit.

Monthly Q7-10 Calculations

Pennsylvania defines Q7-10 flow in the Commonwealth's Chapter 96 regulations as "The actual or estimated lowest 7 consecutive-day average flow that occurs once in 10 years for a stream with unregulated flow, or the estimated minimum flow for a stream with regulated flow." PADEP has argued that this definition does not prohibit the Department from looking at individual months to calculate 12 separate Q7-10 flows for the same waterbody. This monthly Q7-10 determination is being applied to the calculations for TDS effluent requirements to satisfy both the local water load (near field) and the far field in-stream analysis of meeting 500 mg/l at the point of the nearest drinking water intake.

Most of the water quality criteria established in the Commonwealth's regulations at Chapter 93, including TDS, was not derived as monthly values. The development of "monthly" Q7-10 flows is inconsistent with the commonly accepted calculation approach of a Q7-10 flow and has not been the interpretation or approach used by PADEP to develop NPDES permit limits in the past. Monthly Q7-10 flows do not appear to be the intent of the Chapter 96 definition. This is clearly not a typical approach for calculating a Q7-10 flow, and it leads to higher Q7-10 values that result in less stringent loads. EPA does not believe this to be a good precedent to set. NPDES permits are to be developed based on critical conditions and PADEP regulations / guidance use the Q7-10 as the critical condition to protect aquatic life.

Although the Brockway draft permit as currently written suggests that interference of the biological processes at the treatment plant yields a more stringent effluent limit than the near field or far field analysis, in order to resolve this portion of our objection, PADEP must reanalyze and document the far field requirements to include calculations based on the normal "annual" Q7-10 calculations. The permit then must be redrafted, if necessary, to include the more stringent requirement. For the near field analysis, please refer to the next section.

Near Field TDS Analysis – 1,800 mg/l Instream

Based on the limited information available to EPA regarding the correlation between the Chapter 93 criteria for Osmotic Pressure (OP) of 50 mOs/kg and a TDS concentration of 1,800 mg/l, EPA recommends that the permit include a numeric water quality based effluent limit (WQBEL) for OP based on the existing Chapter 93 standard. This would take the place of the "near field" analysis of TDS and limit the discharge on water quality criteria that is applied at the point discharge.

Therefore, in order to resolve this portion of our objection, PADEP must include both 1) the more stringent TDS limits of the "far field" (based on an annual Q7-10 flow) or inhibition of the POTW treatment process and 2) the WQBEL for OP (also based on an annual Q7-10 flow).

Final TDS Limits

According to page 6, paragraph (2)(b)(i), of PADEP's April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges", POTWs currently accepting brine wastewaters through an approved permit must also be given a final TDS effluent limit currently proposed at 500 mg/l effective on January 1, 2011. The Brockway POTW was permitted to accept brine wastewater through a permit action in 2007. However, the draft permit renewal incorrectly assumes that POTWs currently approved under a permit to treat brine wastewater are exempt from complying with the final average monthly limit of 500 mg/l. As a result, the draft permit is currently written to allow the "interim period" TDS limits for the life of the permit. Interim period limits should only be effective until December 31, 2010.

Therefore, in order to resolve this issue, the draft permit must be corrected to include the final limit of 500 mg/l effective January 1, 2011.

I understand that a majority, if not all, of these issues need to be coordinated with your Central Office in Harrisburg. As these issues affect other NPDES facilities in the Commonwealth, we are sending a separate letter to PADEP Central Office (copy enclosed) in order to address these issues across the Commonwealth. In the meantime, the permit for Brockway should not be issued without written authorization from EPA.

If you have any questions, please contact me, or Brian P. Trulear of my staff at (215) 814-5723.

Sincerely,

Jon M. Capacasa, Director
Water Protection Division

Enclosure

cc: Ron Furlan, PADEP Central Office
Ricardo Gilson, PADEP Northwest Office
~~David Balog, PADEP Northwest Office~~
✓Stephen McCauley, PADEP Northwest Office
Timothy Keister, Brockway Area Sewage Authority

Attachment 3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Mr. Dana Aunkst, Director
Bureau of Water Standards and Facility Regulation
Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
400 Market Street
Harrisburg, PA 17105-2063

SEP 21 2009

Dear Mr. Aunkst,

On May 28, 2009, EPA Region 3 sent permit review comments to the Pensylvania Department of Environmental Protection (PADEP) Northcentral Regional Office regarding the draft TerrAqua Resource Management NPDES permit (PA0233650). Included in these comments were concerns we had on the development of proposed effluent limits for Total Dissolved Solids (TDS). Subsequently, EPA Region 3 has notified the PADEP Northwest Regional Office of our objections to the draft permits for Brockway (PA0028428) and New Castle (PA0027511), and we have notified the Northeast Regional Office of our objections to the draft permits for Wyoming Valley (PA0026107) and North Branch Processing (PA0065269). These permits used the same procedures and assumptions to develop TDS effluent limits as were used in the TerrAqua draft permit.

On August 11, 2009, my staff had the opportunity to meet with Ron Furlan, John Wetherell, and Tom Starosta of your staff to discuss these TDS issues. Together with additional information provided by your office after the meeting, this opportunity allowed EPA to acquire a better perspective of PADEP's methods for developing proposed TDS limits. As a result, our concerns have been reduced to the following issues.

Monthly Q7-10 Calculations

Pennsylvania defines Q7-10 flow in the Commonwealth's Chapter 96 regulations as "The actual or estimated lowest 7 consecutive-day average flow that occurs once in 10 years for a stream with unregulated flow, or the estimated minimum flow for a stream with regulated flow." This definition is being applied to the calculations for TDS effluent limits in the above PADEP developed draft permits with the argument that this definition does not prohibit the Department from looking at individual months to calculate 12 separate Q7-10 flows for the same waterbody.

Most of the water quality criteria established in the Commonwealth's regulations at Chapter 93, including TDS, was not derived as monthly values. The development of "monthly" Q7-10 flows is inconsistent with the commonly accepted calculation approach of a Q7-10 flow and has not been the interpretation or approach used by PADEP to develop NPDES permit limits in the past. Monthly Q7-10 flows do not appear to be the intent of the Chapter 96 definition. This is clearly not a typical approach for calculating a Q7-10 flow, and this approach generates higher Q7-10 values that could result in less stringent permit limits. EPA does not believe this to be a good precedent to set. NPDES permits are to be written based on critical conditions and PADEP regulations / guidance use the Q7-10 as the critical condition to protect aquatic life.

Therefore, in order to resolve this portion of our objections, PADEP must reanalyze / redraft the above mentioned permits to include calculations based on the normal "annual" Q7-10 calculations.

Near Field TDS Analysis – 1,800 mg/l Instream

Based on the limited information available to EPA regarding the correlation between the Chapter 93 criteria for Osmotic Pressure (OP) of 50 mOs/kg and a TDS concentration of 1,800 mg/l, combined with the fact that the "far field" requirement of 500 mg/l TDS at potable water intakes yields the more stringent effluent limit than the "near field" analysis in all but one (Brockway) of the above draft permits, EPA recommends that these permits include a numeric water quality based effluent limit (WQBEL) for OP based on the existing Chapter 93 standard. This would take the place of the "near field" analysis of TDS and limit the discharge on water quality criteria that is applied at the point discharge.

Therefore, in order to resolve this portion of our objections to these draft permits, PADEP must include both 1) the more stringent TDS limits of the "far field" (based on an annual Q7-10 flow) or inhibition of the POTW treatment process and 2) the WQBEL for OP (also based on an annual Q7-10 flow).

Final TDS Limits

According to page 6, paragraph (2)(b)(i), of PADEP's April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges", POTWs currently accepting brine wastewaters through an approved permit must also be given a final TDS effluent limit currently proposed at 500 mg/l effective on January 1, 2011. The Brockway POTW was permitted to accept brine wastewater through a permit action in 2007. It is unclear if or when the New Castle POTW was approved to accept brine wastewater under a previous permit. However, the draft permit renewals for both Brockway and New Castle incorrectly assume that POTWs currently approved under a permit to treat brine wastewater are exempt from complying with the final average monthly limit of 500 mg/l. As a result, these two draft permits are currently written to allow the "interim period" TDS limits for the life of the permit. Interim period limits should only be effective until December 31, 2010.

Therefore, in order to resolve this issue, the draft permit for Brockway and New Castle must be corrected to include the final limit of 500 mg/l effective January 1, 2011.

In addition, the following is being provided not as part of our objections, but as a comment.

Pretreatment Program

According to page 6, paragraph (2)(b)(iii), of PADEP's April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges", POTWs are required to obtain EPA approval of a Pretreatment Program. Since PADEP is not authorized to implement pretreatment, EPA would have to make the determination that a program is needed [see 40 CFR 403.8(a)]. PADEP should contact EPA in situations where PADEP is recommending a POTW to develop a Pretreatment Program. With EPA's positive determination, the permit would need to include the proper language to develop the program. Brockway currently is not required to have a Pretreatment Program and the draft permit does not have language for Brockway to develop a program. In order for Brockway (or any other POTW that doesn't currently have a program) to be required to develop an approved program, the permit needs to include the proper permit language once EPA has made the determination that a program is needed.

Please note that this letter is not meant to be an approval or disapproval of PADEP's April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges". Instead, we have been reviewing these permits for support that they are protective of aquatic life and human health consistent with the Commonwealth's water quality standards.

We recognize all the effort you and your staff have and continue to put into developing procedures to implement TDS requirements in NPDES permits. We believe the above changes will result in increased protection of receiving waters during the interim period, prior to the Department's planned development of applicable TDS effluent standards.

In conclusion, it is our understanding from your staff that PADEP will consider these comments and will propose revisions to the five (5) draft permits mentioned above. Once these revisions are received by EPA, they will be reviewed for conformance with the above. Our objections to these permits would be lifted if we concur with the revised draft permits. In addition, all future draft permits that propose to treat high TDS wastewaters will also incorporate these recommendations.

If you have any questions, please contact me or have your staff contact Mr. Brian Trulear at (215) 814-5723.

Sincerely,

for Jon M. Capacasa, ~~Director~~
Water Protection Division

cc: Ron Furlan, PADEP Central Office
Kelly Burch, Northwest Regional Office
David Balog, Northwest Regional Office
Kate Crowley, Northeast Regional Office
Mike Brunamonti, Northeast Regional Office

Attachment 4

Brockway Area Sewage Authority
70 Industrial Park Drive
Brockway, PA 15824

P 814-265-0830
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E basa@brockwaytv.com

February 28, 2011

SM 3/4/2011

Mr. Stephen McCauley, EIT
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

RE: NPDES PA 0028428
APS ID No. 494075
Brockway Borough, Jefferson County

Dear Mr. McCauley,

We have carefully reviewed the second draft of the renewal NPDES permit, and supporting information, provided under your cover letter of February 4, 2011. We wish to provide the following specific comments concerning various provisions and conditions on the draft as follows.

1. Brockway Area Sewerage Authority (BASA) objects to the inclusion of effluent monitoring and limits for the parameter of "osmotic pressure". This objection is based on the fact that osmotic pressure is not a generally recognized effluent monitoring parameter ~~with standardized test methods, there is no USEPA-approved procedure at 40 CFR 136.~~ In addition, the wastewater pollutant to be monitored and controlled by osmotic pressure is already monitored, with effluent limits established, by the inclusion of monitoring and effluent limits for total dissolved solids. We cannot economically justify monitoring and regulation of one pollutant using two different parameters, one of which, osmotic pressure, is going to increase our monitoring costs.

The use of "osmotic pressure" as an effluent limitation is not acceptable due to the fact that this parameter is not defined by any generally recognized standard analytical method. Regardless of the water quality criteria given in Chapter 93, calculation of a permit effluent limitation based on a water quality criteria, which has no scientifically valid, recognized standard analytical method, is not acceptable to BASA. We would also point out that total dissolved solids essentially regulates the exact same parameter, using a generally recognized standard analytical method, and is as protective of the environment as the osmotic pressure water quality criteria.

2. BASA objects to the inclusion of any monitoring for gross alpha, radium 226/228, and uranium. This objection is based on the fact that no significant amount of radiation has been reported in gas well production wastewaters in Pennsylvania. Our source of this information is the presentation made by researchers from Bucknell University, Lewisburg, PA, at the "The Science of Marcellus Shale" conference hosted by Lycoming College in Williamsport, PA, January 29, 2010.

Monitoring for unregulated parameters, which have been shown by competent researchers to not present a problem, is a waste of scarce BASA economic resources. We would request that PADEP provide any data to indicate that these parameters represent any concern as to pollution of the receiving stream.

3. BASA objects to the requirement that a "Radiation Protection Action Plan" be prepared. As pointed out in our objection to any monitoring for radioactives, the only study issued on this subject determined that radioactives are not a concern for gas well wastewaters. Again, BASA does not have the economic resources to waste on useless plan preparation.

We also note that the PADEP technical guidance document (385-2100-002), from which the suggestion to include such a plan was apparently taken, is still a draft document and in no way binding at the current time. In addition, please note that a guidance document is not law or regulation, the exact wording concerning inclusion of a "Radiation Protection Action Plan" is "should", not "shall", it is optional.

4. Please provide the calculations used to determine the mass limits for total dissolved solids on the draft permit. BASA is concerned that we are NOT getting the mass loading for the permitted 14,000 gpd, but instead are being permitted at the loadings from the average and maximum brine flows of average 8,782 and 11,520 gpd as provided to the PADEP in our letter of November 19, 2010. If the permitted 14,000 gpd is used our mass loadings would calculate as 17,585 lb/day daily average and 29,161 lb/day daily maximum.

Please note that the gas well wastewater accepted by BASA for treatment is production wastewater, not hydrofrac flowback, and is accepted from just a single firm, Dannic Energy, under contract. Further, please note that BASA has no "project consultant" on renewal of our NPDES permit, so please correct your fact sheet accordingly.

We will provide the PADEP with the data used to determine the values reported to the PADEP in our letter dated November 19, 2010.

I trust that these comments will be carefully reviewed and a reply provided prior to issue of a final permit. Please contact me directly with any questions or comments.

Sincerely,

Timothy Keister

Timothy Keister, CWT
BASA Chairman

Attachment 5

NITTANY ENGINEERING & ASSOCIATES, LLC

Suite 1
2836 Earlystown Road
Centre Hall, Pennsylvania 16828

Tel: (814) 364-2262
Fax: (814) 364-2266
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RECEIVED
MAR 07 2011
Environmental Protection
Northwest Regional Office

March 3, 2011

Mr. Stephen McCauley, EIT SM 3/7/2011
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

Reference: NPDES PA 0028428
APS ID No. 494075
Brockway Borough, Jefferson County

Dear Mr. McCauley,

On Behalf of the Brockway Area Sewage Authority Board I am addressing the second draft of the NPDES Permit for your consideration. I understand Tim Keister, Chairman of BASA also submitted you comment on this matter, and this is in addition.

I have been asked by the Board to specifically address the concerns of limiting the volume of natural gas-related wastewater and proposed mass loading.

Assuming the influent waters to the POTW contain 500 mg/L TDS, using historical data, we calculated the average TDS of the brine coming into the POTW to be 179,270.75 mg/L or 1.49 lbs/gal and the maximum to be 333,383.42 mg/L or 2.78 lb/gal. Just simply multiplying the average TDS and 14,000 GPD you get an average TDS loading of 20,860 lbs and adding 1,982 lbs (for average plant flow minus brine flow at 500 mg/L) the total is 22,842 lbs TDS. The maximum is 38,920 lbs plus 1,982 lbs for normal plant influent gives 40,902 lbs. We are requesting these values be used as they are the true historic values the plant has received.

Also, there is not a current permit limit for the amount of brine that can be discharges to the plant, and the 14,000 gpd was used as a basis for initial calculations. We are requesting that there should not be an influent volume limit to the amount of natural gas-related wastewater and follow an accurate means of limiting this wastestream utilizing the mass loading we are requesting above.

In summery, please revise the draft to increase the TDS mass limit based on this actual historical amounts the plant has been treating as shown above and the elimination of any influent gallon amount limit.

Should you have any questions or concerns, please do not hesitate to contact me.

Sincerely,

Robert S. Decker, PE
President

rdecker@nittanyengineering.com

cc: BASA
NEA File #011-011

Attachment 6

Brockway Area Sewage Authority
70 Industrial Park Drive
Brockway, PA 15824

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June 9, 2010

Mr. Stephen McCauley, EIT
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

RECEIVED
JUN 13 2011
Environmental Protection
Northwest Regional Office

RE: NPDES PA 0028428
APS ID No. 494075
Brockway Borough, Jefferson County

Dear Mr. McCauley,

We have carefully reviewed the third draft of the renewal NPDES permit, and supporting information, provided under your cover letter of March 17, 2011. We would like you to consider the following comments concerning various provisions and conditions on the draft as follows. Please also be informed that we reserve the right to appeal any provision or condition on the issued permit to the Environmental Hearing Board for adjudication.

1. Brockway Area Sewerage Authority (BASA) objects to the inclusion of effluent monitoring and limits for the parameter of "osmotic pressure". This objection is based on the fact that osmotic pressure is not a generally recognized effluent monitoring parameter with standardized test methods; we could find no USEPA approved procedure at 40 CFR 136. In addition, the PADEP Document 391-2000-008 provided with your cover letter specifically notes that it is an "Interim Method", "not an adjudication or regulation", and its application is at "administrative discretion".

The wastewater pollutant to be monitored and controlled by osmotic pressure is already monitored, with effluent limits established, by the inclusion of monitoring and effluent limits for total dissolved solids. We cannot economically justify monitoring and regulation of one pollutant using two different parameters, one of which, osmotic pressure, is going to increase our monitoring costs. I would also point out that total dissolved solids is a widely used monitoring parameter and that most laboratories are both equipped and experienced in running the test for a typical charge of $10.00 to $15.00. In contrast, many laboratories are not equipped with the specialized test unit required to run osmotic pressure. These single parameter units typically cost $7,000 to $10,000 and can only be used for this specific test, in contrast to the total dissolved solids equipment which is general use laboratory equipment.

The use of "osmotic pressure" as an effluent limitation is not acceptable due to the fact that this parameter is not defined by any generally recognized standard analytical method. Regardless of the water quality criteria given in Chapter 93, calculation of a permit effluent limitation based on a water quality criteria, which has no scientifically valid, recognized standard analytical method, is not acceptable to BASA. We would also point out that total dissolved solids, which is in the draft permit as an effluent standard on a mass basis, regulates the exact same environmental affect, using a generally recognized standard analytical method, and is as protective of the environment as the osmotic pressure water quality criteria. So, the Department is requested to use its "administrative discretion" and remove osmotic pressure from the draft permit.

2. BASA objects to the inclusion of any monitoring for gross alpha, radium 226/228, and uranium. This objection is based on the fact that no significant amount of radiation has been reported in gas well production wastewaters in Pennsylvania. Our source of this information is the presentation made by researchers from Bucknell University, Lewisburg, PA, at the "The Science of Marcellus Shale" conference hosted by Lycoming College in Williamsport, PA, January 29, 2010.

Monitoring for unregulated parameters, which have been shown by competent researchers to not present a problem, is a waste of scarce BASA economic resources. We had requested that the Department provide any data to indicate that these parameters represent any concern as to pollution of the receiving stream in the comments submitted on the last draft permit application. We have not seen any reply to our request and thus conclude the Department has no factual basis for requiring BASA to monitor for these three parameters. In addition, very few laboratories in the country are certified for radiochemical analysis and one we contacted indicated a cost of about $200+ per sample for the three parameters on the draft permit. At two samples per month, that totals $4,800 just for the analysis, not counting in anything for the sampling and shipping costs. Our typical residential sewer charge is $49.00/month, so that is equal to about 98 months of sewer service billings!

3. BASA objects to the requirement that a "Radiation Protection Action Plan" be prepared. As pointed out in our objection to any monitoring for radioactives, the only study published on this subject determined that radioactives are not a concern for gas well wastewaters.

Review of the cited Guidance Document for a Radiation Protection Action Plan, Appendix D., shows it to be designed for a solid waste facility, not a POTW. We cannot understand why the Department has made the permit statement "-- is required due to the high concentrations of TDS in the effluent resulting from the acceptance of natural gas-related wastewaters". **To our knowledge, there is absolutely no connection between high levels of TDS and the presence of radiation.**

One study has been done on treatment of Marcellus hydrofracture flowback wastewater which produced two solid waste sludges, "barium" and "calcium". These two sludges, representing a substantial concentration of any radioactives present in the untreated wastewater, were analyzed with the following results obtained.

Barium sludge: Uranium: 30.8 pCi/g
Radium 226/228: 557.1 pCi/g
Calcium sludge: Uranium: 0.142 pCi/g
Radium 226/228: below detection limit

These amounts of concentrated radioactives are insignificant and indicate no need for a Radiation Protection Action Plan for the BASA facility. In addition, the permit strictly limits the maximum amount of gas production wastewater which can be processed, which limits the potential for radioactives in the plant effluent.

A preliminary evaluation of the Appendix D requirements shows that the cost to BASA for such an inappropriate plan would be in excess of $150,000. Simply put, BASA does not have the economic resources to expend on such an unnecessary plan.

In addition, please note that a guidance document is not law or regulation, the exact wording concerning inclusion of a "Radiation Protection Action Plan" is "should", not "shall", it is optional.

4. Please provide the calculations used to determine the mass limits for total dissolved solids on the draft permit. BASA is concerned that we are NOT getting the mass loading for the permitted 14,000 gpd, but instead are being permitted at the loadings from the average and maximum brine flows of average 8,782 and 11,520 gpd as provided to the PADEP in our letter of November 19, 2010. If the permitted 14,000 gpd is used our mass loadings would calculate as 17,585 lb/day daily average and 29,161 lb/day daily maximum.

Please note that the gas well wastewater accepted by BASA for treatment is production wastewater, not hydrofrac flowback, and is accepted from just a single firm, Dannic Energy, under contract.

5. We note the addition of total alkalinity and sulfate to the required monitoring and reporting portion of the permit. These are not typical monitoring requirements for a POTW and we are requesting that the Department justify their inclusion in the permit.

Please note that gas well production water does not contain any substantial amount of sulfate, generally less than 50 mg/l, while the receiving stream, Little Toby Creek, has a substantial sulfate loading due to abandoned coal mine acid discharges.

Again, since the Department requires that all analytical work be performed by costly PADEP certified laboratories, BASA objects to any additional monitoring requirements that have no technical justification on the basis of excess cost.

6. As barium, strontium, bromide, and chloride are known constituents of gas well production wastewaters, we have no objection to inclusion of these parameters on the permit.

The data used to determine the values reported to the PADEP in our letter dated November 19, 2010, have been sent to the Department by e-mail.

I trust that these comments will be carefully reviewed and a reply provided prior to issue of a final permit. Please contact me directly with any questions or comments.

Sincerely,

Timothy Keister

Timothy Keister, CWT
BASA Chairman

cc: Sam Smith
Joe Scarnati
Tom Corbett

Attachment 7

NITTANY ENGINEERING & ASSOCIATES, LLC

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RECEIVED
FEB 08 2012
Environmental Protection
Northwest Regional Office

January 27, 2012

SM 2/8/2012

Mr. Stephen McCauley, EIT
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, PA 16335-3481

REFERENCE: NPDES PA 0028428, RENEWAL FOURTH DRAFT
APS ID NO. 494075
BROCKWAY BOROUGH, JEFFERSON COUNTY

Dear Mr. McCauley:

On Behalf of the Brockway Area Sewage Authority Board, I wanted to thank you for your and the Department of Environmental Protection (Department) input and consideration for all of our comments on the pending NPDES renewal. I am addressing the fourth draft of the NPDES Permit for your final consideration.

Our comments are as follows:

1. The new proposed limits for TDS have both a mass loading limit and a concentration limit. Our overall concern on having both limits is that one could be within the limit while the other could be exceeded, pending flow conditions. We are not sure how this can be effectively regulated going forward. Please consider our request to eliminate the mass limit of TDS and only have the concentration limits of 4,274 mg/l Average Monthly and 7,960 mg/l Instantaneous Max.

2. For the implementation of the Radiation Protection Action Plan, we request the Department provide us with a reasonable implementation schedule to get in place within the permit, (i.e. permittee shall implement the Radiation Protection Action Plan within twelve (12) months from the issuance date of this permit).

3. We would like to have the option of reducing some of the monitoring requirements of some constituents that have been added to the permit due to acceptance of gas wastewater and/or the frequency of those parameters if it is determined over the course of the first year that nothing of environmental significance has been identified as a concern as a special condition to the permit. We would only petition for this if it can be determined mutually with the Department that the constituent being monitored is at a level that will not be a concern moving forward.

Thanks again for your consideration of our comments. Should you have any questions or concerns, please do not hesitate to contact me.

Sincerely,

Robert S. Decker, PE
President

rdecker@nittanyengineering.com

cc: BASA
NEA File #12-011

D. Moorhead (emailed)
~~D. Batoy~~ PCB
File

University of Pittsburgh

School of Law
Environmental Law Clinic

(Use this address for U.S. Mail)
P.O. Box 7226
Pittsburgh, PA 15213-0221

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210 South Bouquet Street
Pittsburgh, PA 15260
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February 6, 2012

RECEIVED
FEB 08 2012
Environmental Protection
Northwest Regional Office

Department of Environmental Protection, Meadville Office
Office of Water Quality
230 Chestnut Street
Meadville, Pennsylvania 16335-3481
Attn: John Holden

Re: Ridgway Borough STP (PA0023213), Brockway Area WWTP (PA0028428)

Dear Mr. Holden:

I am writing on behalf my client, Clean Water Action, to request a 15-day extension under 25 Pa. Code section 92a.82(d) for the public comment period for two facilities: (1) Ridgway Borough STP (PA0023213), and (2) Brockway Area WWTP (PA0028428). These permits were both noticed in the January 14, 2012, edition of the *Pennsylvania Bulletin*.

Please respond to the address or e-mail below:

Emily A. Collins, Esq., eac50@pitt.edu
Rayza Santiago, rrs38@pitt.edu
Neil Bakshi, neb28@pitt.edu
University of Pittsburgh
School of Law – Environmental Law Clinic
P.O. Box 7226
Pittsburgh, PA 15213-0221

Sincerely,

Emily A. Collins
Supervising Attorney

Rayza Santiago
Certified Legal Intern

Neil Bakshi
Certified Legal Intern

EAC

McCauley, Stephen

From: Balog, David
Sent: Monday, February 13, 2012 1:14 PM
To: eac50@pitt.edu; rrs38@pitt.edu; neb28@pitt.edu
Cc: Hutchinson, Robert; McCauley, Stephen; Holden, John
Subject: response to your letter of February 6, 2012

Attn: Emily A. Collins, Rayza Santiago, Neil Bakshi

This email responds to your February 6, 2012 letter, written on behalf of your client Clean Water Action, to John Holden, P.E., Clean Water Program Manager, of our office. Your letter requests we extend the public comment period for an additional 15 days, for both the Ridgway Borough STP NPDES renewal (PA0023213), and Brockway Area WWTP NPDES renewal (PA0028428). This request is pursuant to 25 Pa Code §92a.82(d). Notice of both permit renewals was published in the *Pa. Bulletin* on January 14, 2012.

We are granting your request. You now have until February 29, 2012 to submit any written comments on these permits for our consideration. Please contact me with any questions on this email response.

David G. Balog, P.E. | Environmental Engineering Manager
PA Department of Environmental Protection
Northwest Regional Office – Clean Water Program
230 Chestnut Street Meadville, PA 16335
Phone: 814-332-6328| Fax: 814-332-6121
www.depweb.state.pa.us

Attachment 8

PB File

University of Pittsburgh

School of Law
Environmental Law Clinic

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February 29, 2012

RECEIVED
MAR 02 2012
Environmental Protection
Northwest Regional Office

Mr. John Holden JH
Director, Clean Water Program
Pennsylvania Department of Environmental Protection
Northwest Regional Office
230 Chestnut Street
Meadville, Pennsylvania 16335

Re: ***Comments on NPDES Permit Renewal for Brockway Area WWTP (PA0028428)***

Dear Mr. Holden,

On behalf of our client, Clean Water Action, thank you for allowing us to comment on the recent National Pollutant Discharge Elimination System ("NPDES") permit renewal application for Brockway Area Sewer Authority ("Brockway") noticed on January 14, 2012. Many existing facilities in Pennsylvania are now accepting wastewaters associated shale gas drilling operations. The Pennsylvania Department of Environmental Protection ("PADEP") has begun to see permit renewal applications for these existing facilities, and we urge the PADEP to consider these permits carefully to ensure that proper effluent limits are imposed.

Our client believes that the current permit does not impose adequate limits on pollutants commonly found in shale gas extraction wastewater. Specifically, the proposed National Pollutant Discharge Elimination System ("NPDES") permit for Brockway does not impose limits for chloride, barium or bromide, and allows for the discharge of very high concentrations of Total Dissolved Solids ("TDS"). We urge the PADEP to review the renewal permit application for the Brockway facility to ensure that the most stringent of the three available effluent limitations – technology-based, water quality-based, or Pennsylvania's Chapter 95 standards – are imposed.

I. Factual Background

The drastic increase in the extraction of natural gas, especially shale gas, has prompted numerous facilities in areas of Pennsylvania, Ohio, and West Virginia to begin accepting natural gas-related wastewaters. Many of these facilities, however, are not equipped with the technology required to adequately treat shale gas wastewater. As a result, many of the pollutants found in this natural gas wastewater are being discharged into local water bodies.

The EPA and PADEP have both realized this problem, and have taken initial steps to remedy the situation. In mid-2011, the PADEP asked local drilling operators to cease sending their drilling wastewater to POTWs and CWTs that did not have the technology capable of effectively treating this wastewater before discharging.[1] Among the facilities listed in the letter were the Brockway Area Sewer Authority and the Ridgway Borough.[2] Driller operators were asked to stop all deliveries of wastewater from natural gas drilling operations to these facilities because they are not equipped to handle wastewaters effectively. The next step, as outlined in that same letter, is to deal with each NPDES permit renewal request from the facilities listed as they come in to limit the concentrations of natural gas-related wastewater substances.

The EPA has also taken the initiative in attempting to mandate facilities like Brockway to stop accepting natural gas-related wastewaters. In September of 2011, the EPA Region III office sent a Request for Information ("RFI") to Brockway with an attached certification page requiring the signature of a Brockway official. The certificate required that Brockway immediately discontinue the acceptance of natural gas-related wastewaters until the proper steps were taken to ensure compliance with the applicable Clean Water Act provisions.[3]

We urge the PADEP, on behalf of our client, to take a hard look at the proposed effluent limits for the Brockway permit renewal to ensure that the acceptance of natural gas-related wastewaters at the Brockway facility do not result in the discharge of high levels of pollutants in the waterways of Pennsylvania.

II. Comments

Brockway is currently requesting a NPDES permit renewal that includes high limitations for TDS – very common in shale gas extraction operations – and mere "monitor-and-report" requirements for several other substances found in these wastewaters like chloride, barium, and strontium.[4] The PADEP, under law, is required to impose effluent limitations on each and every facility discharging pollutants into waterways of Pennsylvania. These limitations can fit into three general categories: technology-based effluent limits, water quality-based effluent limits, and Chapter 95 effluent limits. The most stringent of the three limits are to be imposed on facilities applying for a NPDES permit.

a. The Brockway facility is accepting industrial wastewater without pretreatment. Therefore, Part 437 effluent limitations should apply.

The Brockway facility is accepting trucked-in industrial wastewater from multiple off-site operations without pretreatment and so, therefore, should be subject to the technology-based effluent limitations listed in 40 C.F.R. § 437 ("Part 437"). Under Part 437, facilities that "treat

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[1] PADEP Letter to EPA, July 26, 2011, *available at* http://www.epa.gov/region03/marcellus_shale/pdf/letter-padep-to-epa7-26-11.pdf.
[2] *Id.*
[3] EPA Letter to Brockway, September 30, 2011, *available at* http://www.epa.gov/region03/marcellus_shale/pdf/resource-ext-orders/brockway.pdf.
[4] 42 Pa.B. 207.

any hazardous or non-hazardous industrial wastes, hazardous or non-hazardous industrial wastewater, and/or used material received from off-site" are considered "Centralized Waste Treatment" ("CWT") facilities.[5]

The EPA announced in late 2011 that they plan to develop an Effluent Limitation Guideline (ELG), which is used by states to impose technology-based effluent limitations on dischargers, for both coalbed methane development wastewater and shale gas development wastewater.[6] EPA took public comment on the proposed schedule for finalizing those ELGs (coalbed methane ELG in 2013; shale gas ELG in 2014).[7] For the time being, EPA has endorsed the use of the Centralized Wastewater Treatment ELG for treatment facilities accepting shale gas wastewater.[8] The Part 437 ELGs are separated into four categories: A (Metals Treatment and Recovery), B (Oils Treatment and Recovery), C (Organics Treatment and Recovery), and D (Multiple Wastestreams). The Brockway facility aims not only to treat their traditional waste – sewage – but also wastewater from natural gas-related drilling operations.[9] Because the facility is planning on receiving multiple types of wastes, and because the facility is outfitted only for the treatment of sewage and not for the treatment of multiple different wastestreams, we believe that the Brockway facility should be subject to the provisions of Part 437.

The PADEP should utilize the Part 437 ELG as a basis for the development of technology-based effluent limitations for the Brockway facility because Brockway has proposed to accept multiple wastestreams via untreated trucked wastewater rather than accepting pretreated indirect discharges. To require the Brockway facility – who has made it clear that they intend to accept wastewaters from multiple industrial sources without pretreatment – to limit the discharge of barium and other pollutants associated with natural gas drilling is necessary because the Brockway facility meets the applicability requirements of Part 437.[10]

Alternatively, if the PADEP does not consider the Brockway facility to meet the applicability requirements of Part 437 as a CWT facility, then the Department should provide a clear basis for concluding that trucked wastewater without any pretreatment will avoid the threat of interference or pass-through at a POTW.[11] For instance, "the high salt concentrations are detrimental to . . . [POTW] digesters" in many instances.[12] Also, certain concentrations of dissolved metals, as well as pH, can increase the risk of treatment process inhibition,[13] and

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[5] 40 C.F.R. § 437.1 ("General Applicability).

[6] 76 F.R. 66286 (Oct. 26, 2011).

[7] *Id.*

[8] Water Quality Protection Report, Shallenberger Construction, Inc., Ronco Industrial Wastewater Treatment Facility, NPDES PA0253723-A1, Masontown Borough, Fayette County, January 4, 2011, page 6.

[9] This is explicit and implied from Brockway's NPDES permit renewal notice in the P.A. Bulletin.

[10] 40 C.F.R. § 437.1.

[11] 40 C.F.R. § 403.3(k) & (p) (2011).

[12] WEST VIRGINIA RESEARCH INSTITUTE, ZERO DISCHARGE WATER MANAGEMENT FOR HORIZONTAL SHALE GAS DEVELOPMENT: TECHNOLOGY STATUS ASSESSMENT, at 2, *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/ENVreports/FE0001466_TSA.pdf.

[13] U.S. ENVTL. PROT. AGENCY, GUIDANCE MANUAL FOR PREVENTING INTERFERENCE AT POTWS, at 10-13, 20 (1987); *see also* Don Hopey, *What Can Be Done with Wastewater?; Rapid Expansion of Gas Drilling Has Led to Problems with Disposal, Contamination*, PITTSBURGH POST-GAZETTE, Oct. 4, 2009 ("The U.S. Environmental Protection Agency warns against . . . [accepting oil and gas wastewater] because the sewage plants aren't equipped

consequently, increase the threat of interference or pass-through.[14] Furthermore, during the process of drafting the permit for the Ridgway facility, DEP staff themselves expressed concern over the fact that chlorides can interfere with sewage treatment at certain concentrations.[15] An internal DEP e-mail states that, at 4,000 mg/L, chlorides will start to interfere with the biological processes that STPs such as Ridgway rely on to treat their waste.[16] Without a pretreatment program crafted according to Clean Water Act requirements, Brockway risks inhibiting the treatment processes at its facility through its acceptance of oil and gas wastewater, especially because neither the trucked wastewater nor the Brockway facility has the capability to treat for TDS, chlorides, and other dissolved metals. Furthermore, any necessary local limits cannot be developed without proper consideration being given to the impacts of each pollutant present in industrial wastewater accepted at the Brockway facility for the purposes of analyzing the possibility of interference or pass-through.

b. Water quality-based effluent limitations.

DEP did not model the impacts of critical pollutants of concern in determining water quality-based effluent limits for the Brockway facility.

i. <u>Brockway's Summary of Receiving Stream Data.</u>

Brockway's draft permit does not provide an effluent limit for chloride and fails to require even reporting of any bromide discharge concentrations. As two substances that are both harmful and typically found in coalbed methane and shale gas drilling wastewater, DEP should analyze the water quality impacts of those pollutants on Little Toby Creek. In Brockway's Summary of Receiving Stream Data, submitted along with their NPDES permit renewal application, both sulfates and chlorides are listed as substances that do not require limits, as they are unlikely to cause harm to water supplies located downstream.[17] However, not only are discharges of high concentrations of those pollutants likely to cause negative effects on aquatic life and surrounding wildlife ecosystems, but chlorides in high concentrations are considered to be a toxic and should therefore limited, even if the nearest water supply intake is 40 miles downstream of the facility.[18]

Additionally, even though bromide has been recognized as a pollutant of concern for gas development wastewaters,[19] bromides are not reported in the NPDES permit renewal application

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to remove TDS or any of the chemicals the water may contain. *Of even more concern, TDS can disrupt the plants' treatment of ordinary sewage by killing organisms that are needed to treat human waste.*") (emphasis added).

[14] 40 C.F.R. § 403.3(k) & (p); U.S. ENVTL. PROT. AGENCY, GUIDANCE MANUAL FOR PREVENTING INTERFERENCE AT POTWS, at 6-10, 23-25 (Table 2-4).

[15] Internal E-mail by Thomas P. Starosta to Robert Hutchinson, et. al (Apr. 8, 2011 at 3:54 PM).

[16] *Id.*

[17] Brockway Area Sewer Authority, Summary of Receiving Stream Data, December 21, 2011.

[18] 25 Pa. Code § 16.11 ("These guidelines cover the Federal Clean Water Act section 307(a) priority pollutants and other toxic substances which the Department determines to be of concern due to their verified presence in wastewater discharges."). *See also* 40 Pa.B. 2264, May 1, 2010. http://www.pabulletin.com/secure/data/vol40/40-18/771.html ("Elevated levels of chloride are toxic to aquatic life in freshwater environments.").

[19] 39 Pa.B. 6469 (November 2009 proposal by the Pennsylvania Environmental Quality Board to amend Chapter 95 of the Pennsylvania Code to include "new effluent standards for new sources of wastewaters containing high Total

at all. Since they are a major part of discharges from natural gas-relating operations, and since they are already affecting Potable Water Supply uses of several Western Pennsylvania waterways,[20] the PADEP should analyze the potential impacts of bromide concentrations present in Brockway's proposed effluent. As described in detail below, even when water quality criteria do not exist for specific pollutants, the PADEP is obligated to protect existing uses of waterways.[21]

ii. Chloride: toxics at toxic levels.

The Clean Water Act prohibits the discharge of toxics in toxic amounts.[22] Since the PADEP has recognized in the past that chlorides found in discharges are considered toxic to aquatic life when found in high concentrations,[23] the PADEP should work to limit the discharge of chlorides. The Pennsylvania Clean Streams Law also limits the discharge of any substance "resulting in pollution" to any surface waters of the Commonwealth of Pennsylvania.[24] The word "pollution" is defined in the statute and is given a very broad meaning, but the main goal of the provision is to prohibit the discharge of "harmful, detrimental or injurious" substances into surface waters.[25] Chloride in high concentrations is toxic and falls within this prohibition.

As it currently stands, Brockway contends that they are not subject to the Chapter 93 Potable Water Supply water quality standards because the distance between the facility outfall and the nearest public water supply intake is over 60 miles downstream. Generally, their claim is that there is enough area to allow for significant dilution of certain substances normally limited by Chapter 93's water quality standards to invoke the standards. Contrary to that contention, though, toxic substances are not dependent on these intake locations – toxic substances are limited based solely on discharge amounts. As a result, chlorides should be evaluated separately by the PADEP to determine adequate limits to ensure the protection of "indigenous aquatic communities."[26] We strongly encourage the PADEP carefully examine the potential impact to aquatic life of high chloride discharges to Little Toby Creek.

Dissolved Solids (TDS) concentrations" (what is now 25 Pa. Code § 95.10. "A study conducted by the Environmental Protection Agency (EPA), the Department and the Allegheny County Health Department (ACHD) also identified bromides as a key parameter of concern in these waters.").

[20] *See* Hopey, Don. Bromide: a concern with drilling wastewater. PITTSBURGH POST-GAZETTE. March 13, 2011. http://www.post-gazette.com/pg/11072/1131660-113.stm.

[21] 25 Pa. Code § 93.4.

[22] 33 U.S.C. § 1251(a)(3) (2012) ("It is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited.").

[23] 40 Pa.B. 2264, May 1, 2010. http://www.pabulletin.com/secure/data/vol40/40-18/771.html.

[24] 35 P.S. § 691.401 (2011).

[25] 35 P.S. § 691.1 (2011) ("'Pollution' shall be construed to mean contamination of any waters of the Commonwealth such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, municipal, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life, including but not limited to such contamination by alteration of the physical, chemical or biological properties of such waters, or change in temperature, taste, color or odor thereof, or the discharge of any liquid, gaseous, radioactive, solid or other substances into such waters." It should be noted that the PADEP is entrusted with the responsibility of determining what is "pollution.").

[26] *Id.*

iii. Anti-degradation: bromide.

Brockway not only has no effluent limits for the discharge of bromide, but they also did not disclose that their wastewater influent will contain any concentration of bromide. This is especially surprising since Brockway expressly stated their intention to accept natural gas-related wastewaters and wastewaters from those natural gas drilling activities very often contain high concentrations of bromide.[27] This lack of water quality based standards combined with the sharp and dramatic increase in natural gas drilling operations in Pennsylvania in recent years has created a dire situation for the Commonwealth's waterways and water supplies.[28]

A study conducted by Stanley States at the Pittsburgh Water and Sewer Authority ("PWSA") illustrates just how dangerous this situation has become. Very high levels of brominated trihalomethanes – which are formed when bromide from source water reacts with chemicals in sewage treatment plants – have been found in water bodies in Western Pennsylvania.[29] The conclusion of the study is that the source of bromides is natural gas drilling operations, specifically Marcellus Shale.[30] That means that improperly treated wastewater is contributing to the high levels of bromide (in the form of brominated trihalomethanes) in the City of Pittsburgh's drinking water supply.

Although Pennsylvania has not developed a water quality criterion for bromide, Chapter 93.4a of the Pennsylvania code states the following with regard to the protection against degradation of waters in Pennsylvania: "Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected."[31] The uses given to the receiving stream in this case, Little Toby Creek, are all statewide uses and Cold Water Fishes ("CWF").[32] Since the PADEP has indicated that Little Toby Creek has attained all the uses listed in Chapter 93.4, Table 2 plus CWF, those uses must be maintained and protected.

As there is no current water quality based standard for bromide, but the law requires protection of "existing uses," including potable water supply uses, of waterways, it is necessary to develop limits for the discharge of bromide into the waters of the Commonwealth. Waterways across the state and especially in Western Pennsylvania are experiencing degradation and impairment of potable water supply uses due to bromide concentrations.[33] Since the PADEP is obligated under chapter 93.4a to maintain the "level of water quality necessary to protect the

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[27] *See* PADEP Letter to SM ENERGY CO. July 11, 2011, *available at* http://www.epa.gov/region03/marcellus_shale/pdf/letter-padep-to-epa7-26-11.pdf.

[28] See *supra*, note 17; *see also* Hopey, Don. Bromide levels in Monongahela River rose in 2010, remain high. PITTSBURGH POST-GAZETTE. November 4, 2011. http://www.post-gazette.com/pg/11308/1187389-113.stm; *and* Hopey, Don & Hamill, Sean D. Pa.: Marcellus wastewater shouldn't go to treatment plants. PITTSBURGH POST-GAZETTE. April 19, 2011. http://www.post-gazette.com/pg/11109/1140412-100-0.stm.

[29] States, Stanley, et al. Bromide in the Allegheny River and THMS is Pittsburgh Drinking Water: A Link with Marcellus Shale Drilling.

[30] *Id.*

[31] 25 Pa. Code § 93.4a(b).

[32] 25 Pa. Code § 93.9r. The term "statewide uses" refers to the uses listed in Table 2 of Chapter 93.4. These apply to all surface waters of Pennsylvania unless otherwise noted in Chapter 93.9. Statewide uses include: Warm Water Fishes, Potable Water Supply, Industrial Water Supply, Livestock Water Supply, Irrigation, Boating, Fishing, Water Contact Sports, and Esthetics.

[33] See *supra*, note 25.

existing uses" of a waterway, the PADEP must take steps to ensure that the water supply is not further impacted by high concentrations of bromide. The PADEP should evaluate bromide concentrations in the Brockway facility's proposed discharge to determine if effluent limits or permit conditions are necessary to protect the existing uses of Little Toby Creek and downstream existing uses.

c. ***The PADEP did not describe why it used "maximum values discharged" rather than previously authorized TDS loads in determining the TDS limits based on Chapter 95.***

In August of 2010, a new section was added to Title 25 of the Pennsylvania Code dealing with new and expanding mass loadings of TDS.[34] Chapter 95 of Title 25 deals specifically with new and expanding sources of TDS and implements strict standards for those facilities that discharge high levels of TDS. Because this is a new section, some facilities have fallen through the administrative "cracks" left by the Chapter 95's list of exemptions, including, allegedly, the Brockway facility in Jefferson County.[35] We ask that the PADEP please provide us with their explanation as to why the Brockway is considered exempt from the effluent limits in Chapter 95.10 in their response to comments.

Chapter 95.10 specifically targets facilities and operators discharging high levels of TDS. These standards, unlike the technology-based standards and water-quality standards imposed at the federal level, enforce "end-of-pipe" standards for facilities discharging wastewaters from natural gas drilling operations, regardless of the technology available or the assimilative capacity of the receiving water body. Chapter 95.10 imposes these standards for facilities specifically for discharges of TDS, but also includes other chemicals related to natural gas drilling operations.[36] However, some facilities are exempt from these standards, as they were authorized to discharge prior to the enactment of the new standards.[37] Hence, only facilities with "new and expanding" mass loadings of TDS are subject to chapter 95 standards.

On page 3 of the Fact Sheet for the Brockway facility's draft NPDES permit, DEP states that "[t]he limits for TDS are water quality based on Chapter 95.10 based on the maximum values discharged prior to the passage of Chapter 95.10 on August 21, 2010." However, DEP does not state the previously discharged TDS concentrations were "previously authorized" under a permit that authorized the "acceptance, treatment and discharge of TDS" pursuant to Chapter 95.10(a)(1)(ii). DEP should determine whether a previous authorization existed for acceptance, treatment and discharge of TDS under Brockway's prior NPDES permit. Once that determination is made, DEP should describe the concentration (or mass loading) that was previously authorized and the net increase in TDS mass loading in their response to comments.

[34] 25 Pa. Code § 95.10.
[35] PADEP Letter to EPA, July 26, 2011, available at http://www.epa.gov/region03/marcellus_shale/pdf/letter-padep-to-epa7-26-11.pdf (PADEP asking EPA to consider promulgation of ELGs for shale gas wastewater; PADEP stating that they will look at individual NPDES permit renewal applications from 15 facilities accepting shale gas wastewater under the Chapter 95.10 exemption to determine whether "more stringent limitations and conditions are needed.").
[36] 25 Pa. Code § 95.10(b)(3).
[37] 25 Pa. Code § 95.10(a).

III. Conclusion

The PADEP is charged with administering NPDES permits for facilities discharging pollutants into waters within the Commonwealth of Pennsylvania. Brockway's current permit application fails to list adequate TDS effluent limits and does not have chloride or bromide limits at all. These substances are common to natural gas-related wastewaters, and would likely not be eliminated by their treatment processes prior to discharge in Little Toby Creek. We believe the PADEP should reexamine the effluent limits imposed on the Brockway facility to ensure that these substances are not discharged in high concentrations.

Sincerely,

Rayza Santiago
Certified Legal Intern

Emily A. Collins
Supervising Attorney

Attachment 9

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

RECEIVED
MAR 19 2012
Environmental Protection
Northwest Regional Office

Mr. Kelly Burch, Director
Northwest Regional Office
Pennsylvania Department of Environmental Protection
230 Chestnut Street
Meadville, Pennsylvania 16335-3481

MAR 14 2012

Re: NPDES Permit No. PA0028428
Brockway WWTP
Brockway Borough, Jefferson County

Dear Mr. Burch:

On September 21, 2009, the U.S. Environmental Protection Agency (EPA) objected to the draft National Pollutant Discharge Elimination System (NPDES) permit renewal for the above-referenced facility which was received by the EPA on June 23, 2009. The draft permit was submitted to EPA for review pursuant to 40 CFR § 123.44 and the Memorandum of Agreement (MOA) between EPA and the Pennsylvania Department of Environmental Protection (PADEP). The comments we raised in our specific objection letter, as described below, have been addressed through subsequent revised draft permits, the most recent being dated December 30, 2011.

Monthly Q7-10 Calculations

PADEP had used a monthly Q7-10 determination to analyze TDS effluent requirements. The development of "monthly" Q7-10 flows is inconsistent with the commonly accepted calculation approach of a Q7-10 flow and has not been the interpretation or approach used by PADEP to develop NPDES permit limits in the past. Monthly Q7-10 flows do not appear to be the intent of the Chapter 96 definition. NPDES permits are to be developed based on critical conditions and PADEP regulations / guidance use the Q7-10 as the critical condition to protect aquatic life. Subsequent draft permits for the Brockway WWTP, including the December 30, 2011, revision, have now used the proper annual Q7-10 calculations to analyze TDS.

Near Field TDS Analysis – 1,800 mg/l Instream

Based on the limited information available to EPA regarding the correlation between the Chapter 93 criteria for Osmotic Pressure (OP) of 50 mOs/kg and a TDS concentration of 1,800 mg/l, EPA recommended that the permit include a numeric water quality based effluent limit (WQBEL) for OP based on the existing Chapter 93 standard. This would take the place of the "near field" analysis of TDS and limit the discharge on water quality criteria that is applied at the point of discharge. The current revised draft permit does contain a calculated WQBEL for OP utilizing the annual Q7-10 and an assumed background level of 5 mOs/kg. This assumed background level should be verified with in-stream sampling in order to use in any subsequent WQBEL calculations for OP. We note that the draft permit documentation did provide in-stream data on TDS (which could be translated into an approximate value for OP) in the Clarion River @ Clarksburg, but since the Little Toby Creek is AMD impaired, the levels of OP may not be similar. The draft permit should be revised to specify that in-stream monitoring upstream of the discharge should be conducted for OP and included with the next permit renewal application.

Final TDS Limits

At the time of the June 2009 draft permit, PADEP used an April 11, 2009 "Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges" which stated that POTWs currently accepting brine wastewaters through an approved permit must also be given a final TDS effluent limit currently proposed at 500 mg/l effective on January 1, 2011. Since that time, PADEP no longer uses the April 11, 2009 strategy and the Commonwealth has promulgated Chapter 95.10 regulations to address new and expanded sources of high TDS discharges. Since the Brockway WWTP was permitted to accept brine wastewater through a permit action in 2007, it has been determined by PADEP to be exempt from the PA Chapter 95.10 requirement to meet the new/expanded facility effluent limit of 500 mg/l TDS. In addition, the latest draft permit contains language that would institute the Chapter 95.10 requirements should Brockway receive brine wastewaters in excess of the approved 14,000 gal/day.

By this letter, EPA hereby lifts the specific objection to the above referenced draft permit. Prior to finalizing this permit, we do ask that PADEP include a permit condition to address the need for collecting in-stream OP background data as discussed above. We appreciate the hard work from your staff in addressing all of our concerns for this permit. If you have any questions, please contact me, or Brian P. Trulear of my staff at (215) 814-5723.

Sincerely,

Jon M. Capacasa, Director
Water Protection Division

cc: Ron Furlan, PADEP Central Office
Sean Furjanic, PADEP Central Office
John Holden, PADEP Northwest Office
David Balog, PADEP Northwest Office
Stephen McCauley, PADEP Northwest Office
Timothy Keister, Brockway Area Sewage Authority

Attachment 10

Balog, David

From: Brian Trulear <Trulear.Brian@epamail.epa.gov>
Sent: Thursday, April 26, 2012 9:33 AM
To: Balog, David
Subject: Fw: Brockway

FYI

----- Forwarded by Brian Trulear/R3/USEPA/US on 04/26/2012 09:32 AM -----

From: John Lovell/R3/USEPA/US
To: Brian Trulear/R3/USEPA/US@EPA
Date: 04/25/2012 03:32 PM
Subject: Brockway

I looked at the Brockway permit application and don't think we should require a pretreatment program. They are only authorized to accept 14,000 gpd of brine and the criteria for any discharge to be an SIU is >25,000 gpd. Since the permit does not authorize them to accept anything that would meet the criteria for an SIU and our regs only establish significant requirements for SIUs, requiring a pretreatment program would not impose a lot in the way of requirements for them to further regulate the discharges. In addition, the permit application shows their effluent levels of TDS to be around 300 mg/l while the draft NPDES permit seems to establish an instantaneous maximum limit of 10,000 mg/l. The permit application does list a number of industrial users, although most of them are listed as discharging only sanitary waste. There are 2 small users that appear to be subject to categorical standards that discharge process waste (glass manufacturer - 6400 gpd and inorganic chemical manufacturer - 34 gpd), but there is no indication that any of the IUs is causing any problems. I can add the two potential CIUs to the list of IUs for us to follow-up on.

So the bottom line is that I don't think that the time and resources spent approving a pretreatment program (both for them and for us) accomplishes anything significantly more than the NPDES permit does by itself and we don't need to require a pretreatment program..

John Lovell
Pretreatment Coordinator
EPA Region 3
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215-814-5790
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