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SUSQUEHANNA RIVER BASIN COMMISSION
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September 24, 2020

RECEIVED
SEP 25 2020
Independent Regulatory Review Commission

Environmental Quality Board
P.O. Box 8477
Harrisburg, PA 17105-8477

Re: Pennsylvania's Proposed Change to Water Quality Standard for Manganese

Dear Environmental Quality Board:

In accordance with the public notice published in the Pennsylvania Bulletin on July 25, 2020, the Susquehanna River Basin Commission (Commission) offers the enclosed comments related to the Pennsylvania Department of Environmental Protection's (PADEP's) proposed water quality standard (WQS) for manganese and implementation (50 PA Bulletin 3724). The Commission is a federal-interstate agency with a mission to enhance public welfare through comprehensive planning, water supply allocation, and management of the water resources of the Susquehanna River Basin.

COMMISSION'S KEY MESSAGES

1. The Commission staff supports the designation of manganese as a toxic substance.
2. The Commission staff supports the continued application of point-of-compliance for toxic substances to be the point-of-discharge.
3. The Commission staff encourages PADEP to adopt tiered restoration goals for watersheds impacted by legacy mining activities to acknowledge that a strict manganese numeric WQS is likely to create technical and financial hurdles as well as impede stakeholder willingness to assume liability focused on restoration efforts of unregulated/legacy mine discharges.
4. The Commission staff concludes that lowering the numeric manganese WQS will not necessarily improve source water quality in coalfield regions because manganese loads are dominated by unregulated, legacy discharges with no responsible party required to implement the proposed WQS.
5. The Commission staff encourages PADEP to detail implementation plans for the proposed WQS, including potential financial assistance, with specific emphasis on consequences for facilities that have assumed responsibility to treat acid mine drainage.

The Commission is grateful for the opportunity to comment on the proposed WQS for manganese. Detailed comments are included in the enclosure. Please direct questions, comments, or requests for additional supporting information to Andrew Gavin, Deputy Executive Director, at agavin@srbc.net.

Sincerely,

Andrew D. Dehoff
Executive Director

Enclosure

BACKGROUND

The existing regulatory objective for the discharge of manganese to surface water is to achieve an ***aesthetic-based criterion*** in finished PWS; i.e., the current regulatory objective is not to protect human health or any other statewide water use. For an authorized discharge source to comply with the current regulation, the manganese concentration in a waterway that receives the discharge must be lower than 1.0 mg/L ***at the location of a discharge to surface water***.

Pennsylvania's manganese WQS last underwent technical evaluation in the 1960s and at that time, evaluation was limited to consideration of aesthetic qualities (taste, odor, stain). Contemporary scientific research findings (refer to bibliography of literature reviewed by PADEP) conclude that manganese, at elevated levels, is a human neurotoxin, with particular sensitivity for exposure during fetal and early childhood development stages. Contemporary scientific findings also conclude that elevated manganese concentrations are harmful to aquatic life and, just as human population has uneven sensitivity to manganese exposure, so too does the aquatic community (Howe et. al., 2004). When a substance in sufficient quantity or concentration is determined to be harmful to humans, as required in PA Code 93.8a(a), PADEP must limit the concentration in waste discharges commensurate with all uses of the water resource.

In response to the Pennsylvania Legislature's October 2017 adoption of Section 1920-A of Act 40 pertaining to "water quality criteria for manganese," PADEP: (i) reviewed published scientific findings regarding human and ecological toxicity to manganese; (ii) determined from its technical literature review that manganese is a *toxic substance,* consistent with the definition contained in PA Code 93.1; and, (iii) followed United States Environmental Protection Agency (USEPA) guidelines for development of Ambient Water Quality Criteria[1] to calculate the currently-proposed manganese water quality criterion to be protective of human health. The proposed human health-based WQS for manganese is 0.3 mg/L. In addition to its revised numeric WQS, PADEP proposed two alternative points of compliance as: (a) all existing and planned surface water source PWS withdrawal locations; or, (b) all surface waters.

MAGNITUDE AND DISTRIBUTION OF MANGANESE IN THE COMMISSION'S WATER QUALITY DATABASE

For decades, the Commission has collected scientific data and evaluated water quality and biologic condition of the Susquehanna River Watershed's aquatic resources. The Commission's database is drawn upon to provide context for the proposed manganese WQS. From 2000 through 2019, the Commission collected and analyzed more than 11,650 individual surface water samples for manganese. The Commission's manganese data were obtained from approximately 1,500 unique locations throughout the Susquehanna River Watershed (Figures 1a and 1b are maps of sampled locations. Figures 2a and 2b are maps of surface water source PWS and locations for which manganese concentration was greater than 0.3 mg/L. Figure 3 is a chart showing the statistical frequency of manganese concentrations.)

[1] In deriving the numeric WQS for the protection of human health based on a dietary exposure model, USEPA guidelines use a *relative source contribution* value to account for non-dietary as well as certain dietary exposure sources outside the realm of the model's core framework. PADEP applied a relative source contribution value of 0.2 in the divisor of USEPA's dietary exposure model that effectively embeds an 80% uncertainty factor into Pennsylvania's proposed manganese WQS.

These points summarize key facts with respect to the Commission's manganese data:

- **Manganese occurs throughout the Susquehanna River Watershed.** Manganese was detected (analytical detection limit: 0.01 mg/L) in approximately 90% of the samples and at more than 95% of the sampled locations.
- **For the overwhelming majority of streams and rivers in the watershed, manganese concentrations meet the proposed human health-based WQS.** In roughly 80% of both samples and locations, the concentration of manganese was less than 0.3 mg/L.
- **Parts of the Susquehanna River Watershed do not meet the proposed human health-based WQS.** For approximately 20% of locations sampled by the Commission, manganese concentrations were greater than 0.3 mg/L and for more than 10% of such locations, manganese concentrations were greater than 1.0 mg/L.
- **In general, streams, rivers, and their watersheds underlain by coalfields are at high likelihood <u>not</u> to meet the proposed manganese WQS.** More than 99% of locations for which manganese concentration was greater than 0.3 mg/L are underlain by coalfields and impacted by legacy mining due to acid mine discharge.
- **Currently, a subset of surface water source PWS withdrawal features occur in/near parts of the Susquehanna River Watershed that do not meet the proposed human health-based WQS.** Within such settings, the PWS withdrawal features are upstream of reaches where manganese >0.3 mg/L.

COALFIELDS AND ACID MINE DISCHARGE

Acid mine drainage, a metal-rich acidic solution that forms by oxidation of sulfur minerals, is a major environmental problem associated with mining and excavation activities in areas where certain common sulfur minerals are exposed to air and water. When pyrite (i.e., iron sulfide) contacts oxygen and water, a geochemical oxidation reaction produces sulfuric acid plus iron (Fe^{2+}). Naturally-occurring bacteria metabolize the freed iron by-product and in so doing, produce a highly reactive *different* form of iron (Fe^{3+}) that, in turn, accelerates the pyrite oxidation reaction. These biogeochemical reactions cascade with result that waters receiving such discharge rapidly become acidic (e.g., pH as low as 2 to 4 standard units). The acidity alone is highly toxic to many forms of aquatic life, but the acidic water reacts with other minerals to leach toxic forms and concentrations of a variety of metals. The mobility and biological availability of toxic metals, coupled with low pH waters, leads to severe and long-lasting impacts to aquatic diversity (RoyChowdhury et al., 2015).

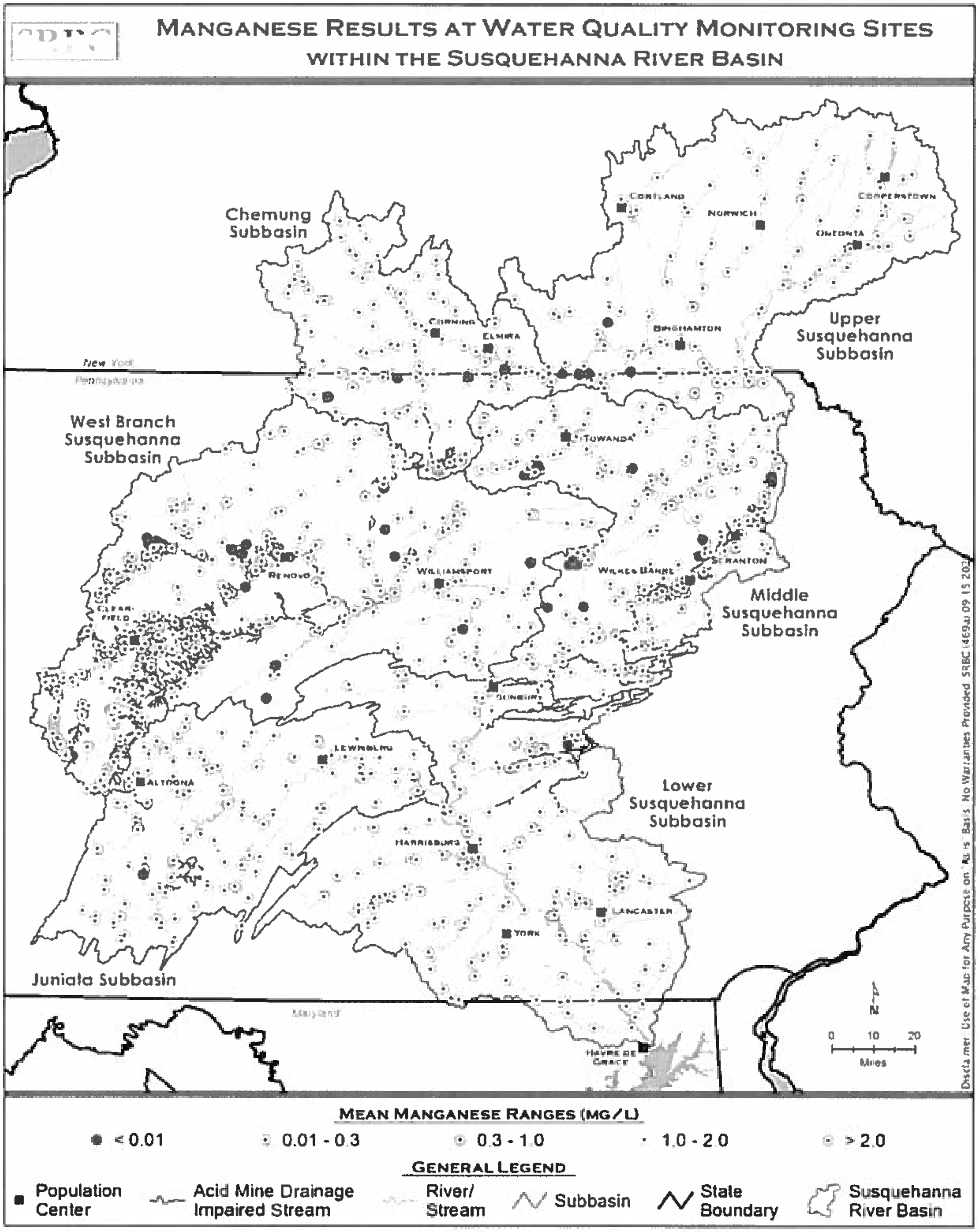

***Figure 1a. Map of Susquehanna River Basin with Approximately 1,500 Unique Manganese Sample Locations** (Colors correspond to manganese concentration. For locations sampled more than once, manganese concentration is the mean of all sample results. The laboratory detection limit was substituted in mean calculations for sample results reported as "Non Detect." Stream segments listed as impaired for aquatic life use due to acid mine drainage are shown in red.)*

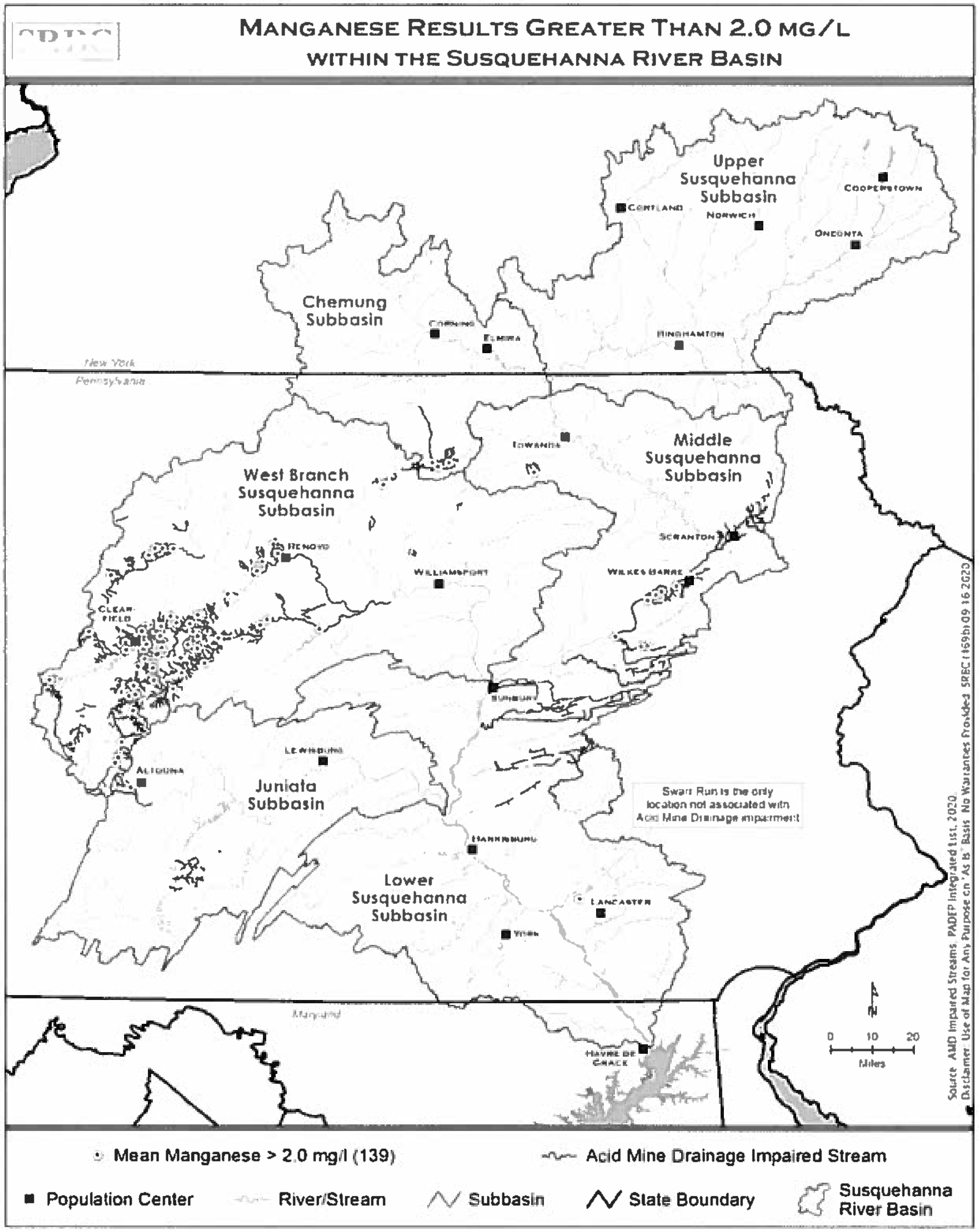

Figure 1b. Map of Susquehanna River Basin Showing Unique Sample Locations with Mean Manganese Concentration > 2.0 mg/L *(Stream segments listed as impaired for aquatic life use due to acid mine drainage are shown in red. Note that just one elevated manganese sample location, Swarr Run northwest of Lancaster, PA, occurred outside of known acid mine drainage impairment.)*

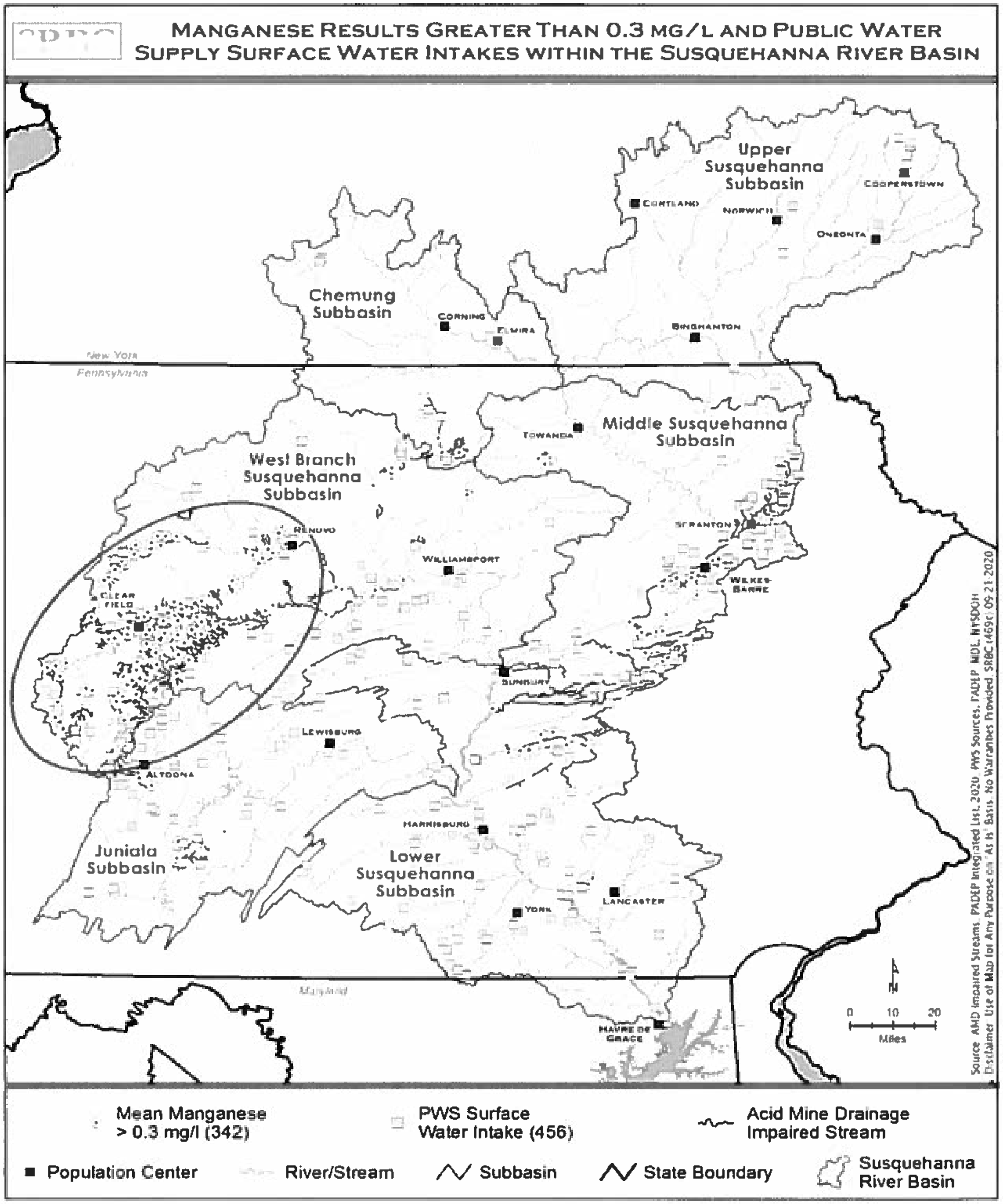

Figure 2a. Map of Susquehanna River Basin with Surface Water Source PWS and Locations for Which the Mean Manganese Concentration Was Greater Than the Proposed 0.3 mg/L WQS *(The oval covers Chest Creek, Clearfield Creek, Moshannon Creek, and portions of the Upper West Branch Susquehanna River – refer to Figure 2b for detailed view of PWS and manganese sample locations.)*

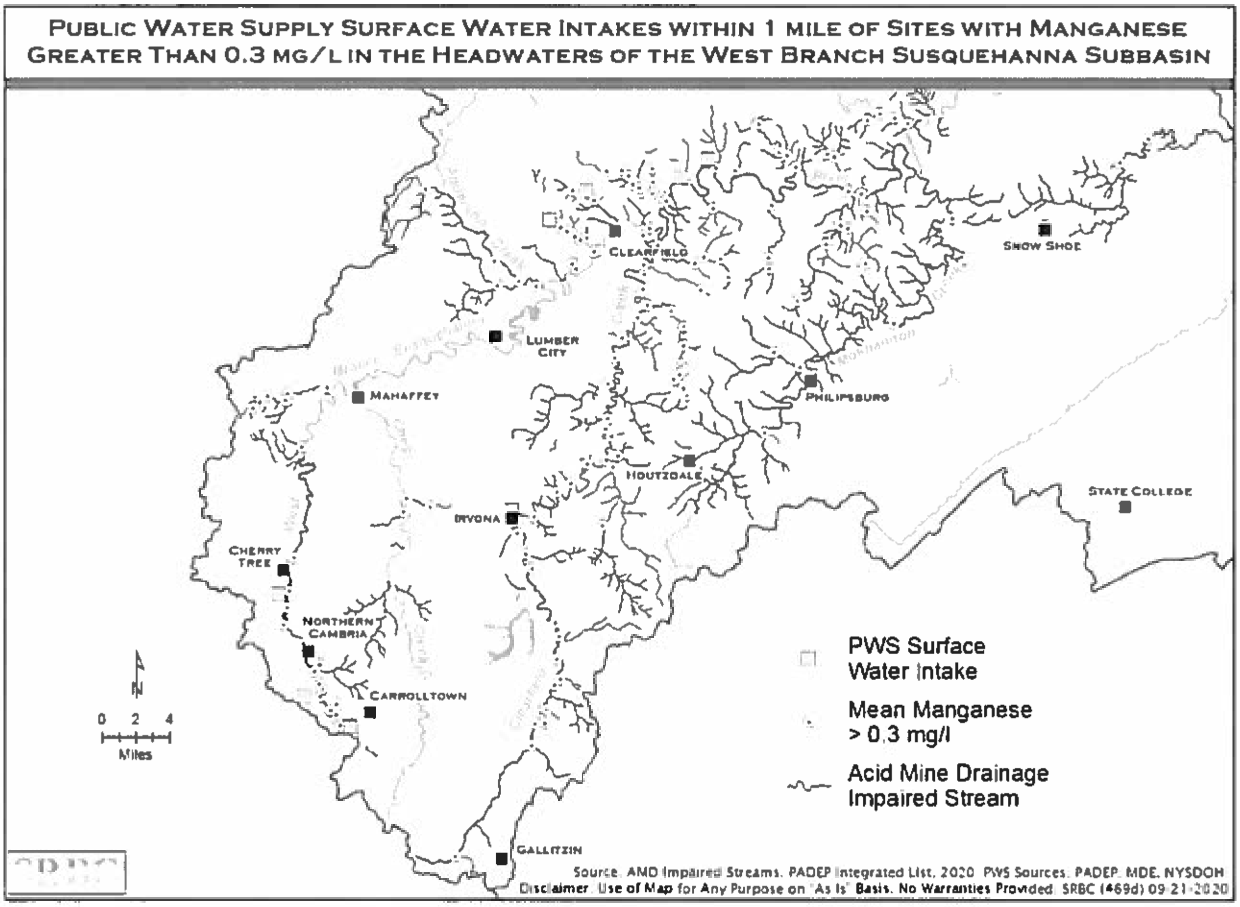

***Figure 2b. Headwaters (Chest Creek, Clearfield Creek, Moshannon Creek, and Parts of the Upper West Branch Susquehanna River) of the West Branch Susquehanna River Subbasin Showing Potable Water Supply Sources Located within 1-mile of a Commission Stream Sample Having Manganese > 0.3 mg/L** (Note that surface water source PWS withdrawals are situated upstream of sample locations with elevated manganese or the PWS withdrawals are located on tributaries prior to confluence with elevated manganese.)*

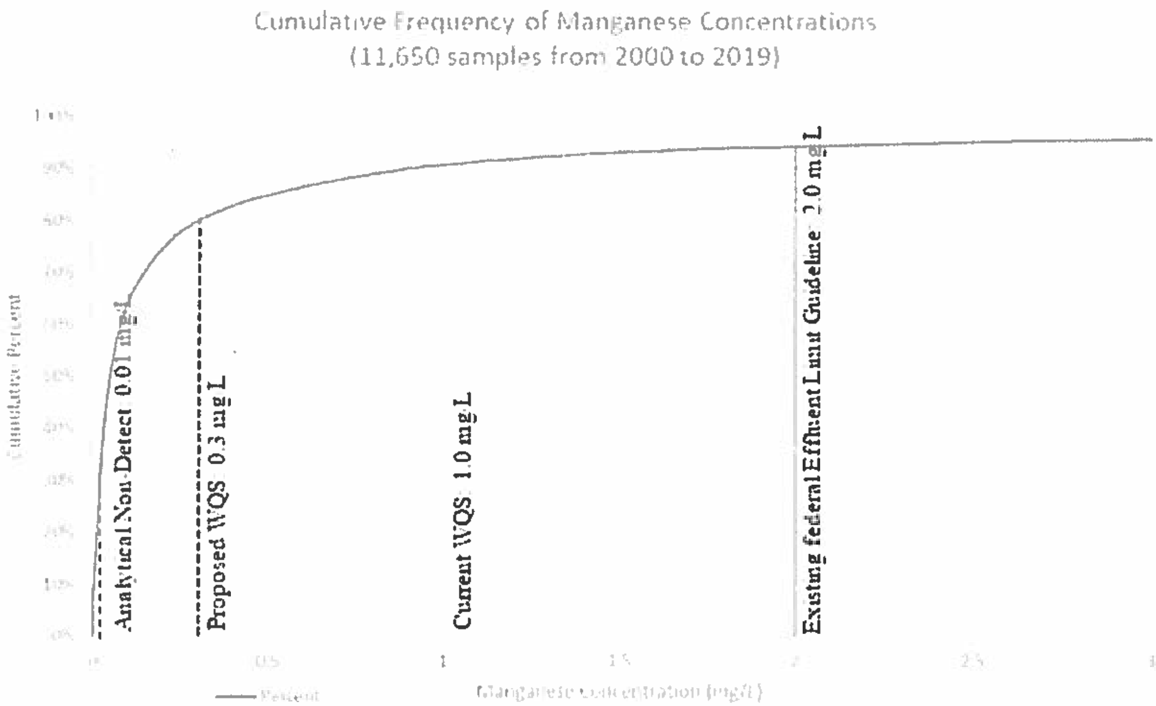

***Figure 3. Cumulative Frequency of Manganese Concentrations for 11,562 Samples Collected from 2000 to 2019 in the Susquehanna River Basin** (For reference, manganese concentrations that correspond to the: (i) analytical non-detect level; (ii) proposed human health-based WQS; (iii) existing PWS-based WQS; and, (iv) federal Effluent Limit Guideline as 30-day average for specific (active) coal mining operations are shown.)*

CO-OCCURRENCE OF MANGANESE WITH OTHER SUBSTANCES OF WATER QUALITY CONCERN

The Commission's water quality data also demonstrate that, in addition to a propensity for elevated manganese, streams, rivers, and their watersheds that are underlain by coalfields also tend to have high concentrations of hydrogen (pH), aluminum, iron, sulfate, and total dissolved solids. The Commission's database has more than 400 locations for which manganese concentration was above 0.3 mg/L. In locations where manganese was above the proposed WQS, aluminum concentration also was above its corresponding WQS of 0.75 mg/L at more than 60% and iron concentration was above its WQS of 1.5 mg/L at more than 40% of such locations. For nearly 289 (78%) of the 401 locations for which manganese concentration was greater than 0.3 mg/L, the vast majority of which occur in coalfield regions, either or both aluminum and iron also were above corresponding aquatic life-based WQS.

In contrast to aluminum and iron, sulfate does not have a Pennsylvania or federal WQS based on human health or aquatic life use, yet the concentrations of manganese and sulfate are strongly and positively associated in the Commission's database and as the concentration of one increases, so too does the other as shown by Figure 4.

The co-occurrence of substances has significant implications for toxicity including: (i) geochemical interactions that alter, by enhancing or diminishing, the rate of biological uptake from the environment; (ii) mechanisms that control the flux of substances within metabolic pathways; and, (iii) processes that activate specific enzymes toward detoxification or promotion of harmful effects.

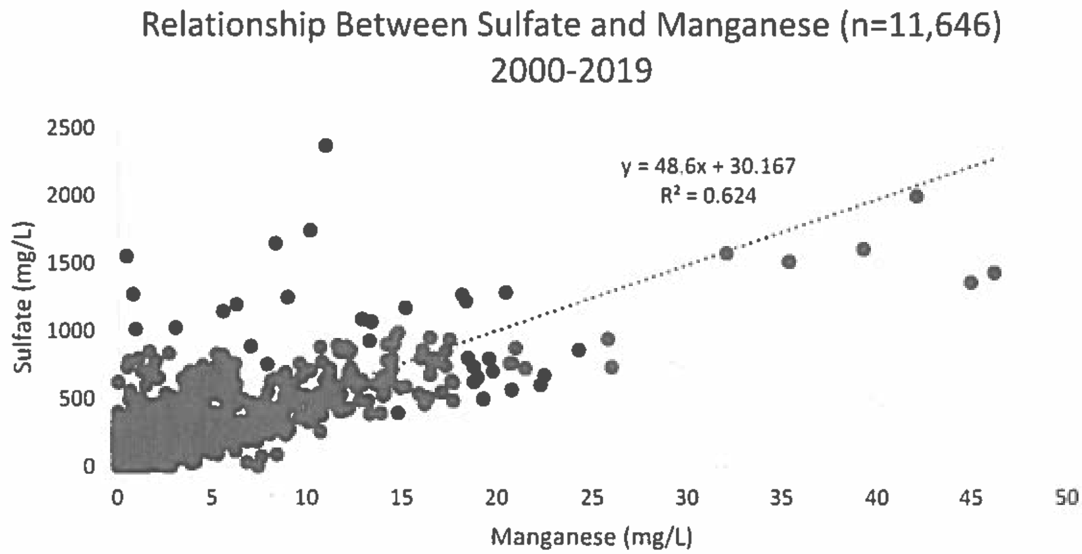

***Figure 4. Manganese and Sulfate Concentrations for 11,646 Samples Collected from 2000 to 2019 in the Susquehanna River Watershed** (A positive linear trend is shown as dashed line with the corresponding equation and a coefficient of determination (R^2) value of 62%.)*

AQUATIC COMMUNITY IN CONJUNCTION WITH MANGANESE DATA

The Commission's scientific data include more than 1,400 records, from more than 375 unique locations, that paired manganese concentration with benthic macroinvertebrate community index of biotic integrity score. The index of biotic integrity score is a composite value, from 0 to 100, that combines multiple indicators of ecological condition. In general, a biotic integrity score of 53 is the threshold below which PADEP determines that a stream is impaired for aquatic life use; increasing scores indicate the aquatic community more closely resembles undisturbed, natural conditions. Figure 5 shows the distribution of manganese concentrations according to either impaired or non-impaired status for aquatic life use. Green symbols represent statistical outliers in manganese concentration for each group; i.e., outliers are the values that differ significantly from the group overall. As depicted on the left side of Figure 5, the impaired group shows a trail of manganese outliers that extends well above the group's primary range. In contrast, outliers for the non-impaired group are clustered close to the group's core range. The right side of Figure 5 depicts the same data, but emphasizes manganese concentrations below 1.0 mg/L – here, the rectangles represent each group's main manganese range.

Taken together, each group's core manganese range and relative spread for outliers indicate that higher levels of manganese are associated with greater likelihood for aquatic life-based impairment. Note that for both the impaired and non-impaired groups, the core manganese concentration range is below the proposed WQS of 0.3 mg/L. Note also that each group includes manganese outlier concentrations higher than the proposed manganese WQS, although the non-impaired group contains just two locations slightly above 1.0 mg/L, whereas the impaired group includes more than a dozen locations above the federal Effluent Limit Guideline for certain active coal operations of 2.0 mg/L. And note as well that correlation between manganese level (or any single substance measured in water) and aquatic life use impairment alone does not mean manganese caused impairment. Finally, it is important to note that different species show different sensitivity to the same substance, a principle known as *species sensitivity distribution*.

In the Commission's data, the composite biotic integrity score weakly corresponds to manganese concentration overall. However, for manganese concentrations above the proposed WQS of 0.3 mg/L, various analyses of benthic macroinvertebrate community data uniformly demonstrate that significant differences in the details of community structure correspond to both the current and proposed manganese WQS.

Multiple tests consistently show benthic macroinvertebrate communities differ significantly statistically according to the following groups:

i. Manganese < 0.3 mg/L;
ii. 0.3 mg/L > Manganese > 1.0 mg/L; and,
iii. Manganese > 1.0 mg/L.

The benthic macroinvertebrate community associated with the lowest manganese concentration group consistently has the most types of organisms (highest richness), similar population spread among organisms (highest diversity), and the largest overall abundance. The higher manganese concentration groups have certain benthic macroinvertebrate community members that occur in the lowest manganese concentration group and both groups share similar taxa, but abundance declines as manganese concentration increases. In some but not all cases, sensitive taxa, specifically sensitive mayflies, show the most rapid decline as manganese concentration increases. In contrast, some taxa of net-spinning caddisflies and well-known acid-tolerant stoneflies are less impacted by increasing manganese concentrations.

More study is needed to identify and refine acid- and metals-sensitive and especially manganese-sensitive taxa, but the Commission's dataset supports literature findings (Buchwalter et al., 2017; Cain et al., 2004; Clements et al., 2013; Dittman and Buchwalter, 2010) for species sensitivity distribution and for heightened sensitivity by particular taxa to elevated metals (i.e., manganese, aluminum, iron) concentrations. Importantly, as the right side of Figure 5 illustrates, streams with manganese concentrations between 0.3 and 1.0 mg/L may exhibit overall biotic integrity scores commensurate with aquatic life use attainment and as discussed previously, at its higher concentration range, manganese also tends to co-occur with high concentrations for a suite of other substances.

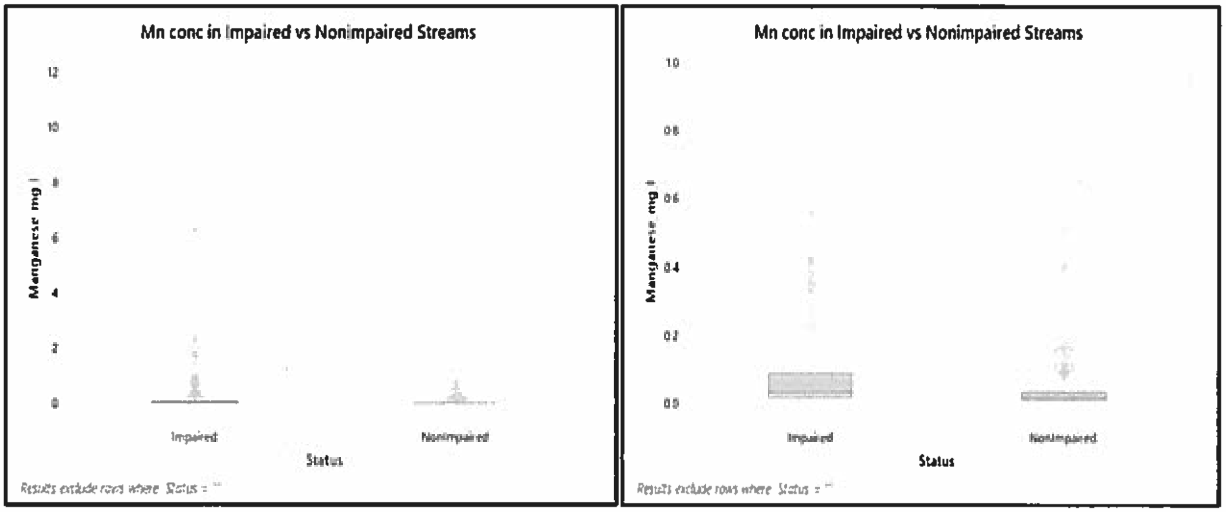

***Figure 5. Box-whisker Plots for the Distribution of Manganese Concentrations Grouped as Impaired or Non-impaired for Aquatic Life Use According to Index of Biotic Integrity Score** (Left side depicts the full range of manganese concentrations; right side emphasizes manganese concentration less than 1.0 mg/L. Green symbols are outliers that differ statistically from the group's primary range. The primary (or interquartile) range is shown by blue line (left) and rectangle (right).)*

DISCUSSION

1. ***The Commission staff supports the designation of manganese as a toxic substance.*** We concur with the body of contemporary scientific evidence that finds manganese, despite its essential role in human physiology, is a neurotoxin during sensitive human life stages when exposure level exceeds metabolic requirements. The Commission staff also concurs with scientific evidence that concludes manganese is toxic to aquatic life.

2. ***The Commission staff supports the point-of-compliance for toxic substances to be the point-of-discharge.*** We see no other way to protect all statewide water uses.

3. ***The Commission staff supports consideration for restoration/remediation activities with regulated manganese discharges in watersheds impacted by legacy mining activities.*** In the Susquehanna River Watershed, manganese loadings primarily are due to, and associated with, legacy mining activities. And as demonstrated herein, in coalfield settings, streams frequently have manganese and a suite of other substances at elevated concentrations whether or not regulated discharges occur. The Commission is concerned that compliance/enforcement of numeric WQS for manganese in such settings, especially for discharges related to treatment of acid mine drainage, will slow, stop, or even roll-back progress with stakeholder-based restoration initiatives that are reversing generations-long damage to aquatic resources.

   The federal Surface Mining Control and Reclamation Act trust lacks adequate funding to fully restore lands and streams impacted by legacy mining activities in the Commonwealth–construction costs to restore abandoned mine land alone is estimated at

$5B (Bradley, 2019). For context, Pennsylvania received $560M from the federal Abandoned Mine Land trust fund between 2006–2019 and $1.3B overall since 1980[2]. While considerable abandoned mine land reclamation progress has been made in recent decades across Pennsylvania, substantial legacy mining impacts persist; PADEP cites more than 5,500 miles of acid mine drainage-impaired streams[3] and more than 287,000 acres of abandoned mine land in Pennsylvania, equivalent to approximately 10% of the Commonwealth's land area (Bradley, 2019).

Acknowledging the disparity between available funding and need, PADEP (2016) developed a two-tier approach based on the level of biological restoration that can reasonably be achieved, when prioritizing and allocating federal trust funds to repair legacy mining damage. PADEP's goal for *Upper Tier* restoration is to reach full biological attainment for aquatic life use and remove the targeted stream or stream segment from PADEP's Impaired Waters List. PADEP's goal for the *Lower Tier* is a lesser level of biological recovery that focuses primarily on the attainment of a recreational fishery. Despite incomplete biological attainment, PADEP (Bradley, 2019) states that every mile of acid mine drainage-impacted stream that can be improved to support a trout-stocked fishery (i.e., a Lower Tier restoration goal) is capable of generating more than $100,000 annually for local economies.

The Commission recommends that watersheds impacted by legacy mining activities be afforded incentives to facilitate restoration, even where restoration outcomes may plateau at levels below full aquatic life use attainment. Acid mine drainage-impacted streams are chemically complex in ways that challenge operators to meet current WQS, yet despite the challenges, numerous projects have been implemented across the Commonwealth that have restored fish and other aquatic life substantially and in ways consistent with PADEP's *Lower Tier* restoration target. Compliance with a strict manganese numeric WQS is likely to create technical and financial hurdles as well as impede stakeholder willingness to assume liability that focuses restoration efforts on unregulated/legacy mine discharges.

4. ***The Commission staff concludes that lowering the numeric manganese WQS will not necessarily improve source water quality in coalfield regions because manganese loads are dominated by unregulated, legacy discharges with no responsible party required to implement the proposed WQS.*** Moreover, PWS already must comply with the federal Secondary Maximum Contaminant Level for manganese (0.05 mg/L) in finished water; therefore, lowering the numeric manganese WQS will not improve source water quality.

5. ***The Commission staff encourages PADEP to detail implementation plans for the proposed WQS, including potential financial assistance, with specific emphasis on consequences for facilities that have assumed responsibility to treat acid mine***

[2] In addition to abandoned mine land reclamation and acid mine drainage treatment, trust funds also pay for water supply infrastructure.

[3] According to PADEP's *Integrated Reports* for 2018 and 2020, at least 100 miles of acid mine drainage-impairments have been reversed since 2016.

drainage. Few existing acid mine drainage treatment operations, especially passive treatment facilities, have ready-access to funding to design and implement retro-fitted features capable of reducing manganese concentration. Even fewer facilities have ready-access to additional land if expanded treatment area is necessary.

Specific components regarding the Commission's data and analyses referenced herein are available upon request.

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