LYCOMING CREEK TRIBUTARIES ATMOSPHERIC DEPOSITION TMDL

Lycoming County

Prepared for:

Pennsylvania Department of Environmental Protection

November 29, 2012

TABLE OF CONTENTS

TABLES

ATTACHMENTS

Lycoming Creek Watershed
Lycoming County, Pennsylvania

INTRODUCTION

This report presents the Total Maximum Daily Loads (TMDLs) developed for impaired segments in the Lycoming Creek Watershed (Attachment A). These are done to address the impairments noted on the 2010 Pennsylvania Section 303(d) list of impaired waters, required under the Clean Water Act. Lycoming Creek is listed as impaired for pH. All impairments result from atmospheric deposition.

Table 1. Integrated Water Quality Monitoring and Assessment Report Listed Segments

State Water Plan (SWP) Subbasin: 10A				
HUC: 02050206 – Lower West Branch Susquehanna				
Watershed – Lycoming Creek Watershed				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Atmospheric Deposition*	pH	56.40	HQ-CWF, MF	Aquatic Life

* Reference Attachment F for more details.

Location

The watershed is located on the U.S. Geological Survey 7.5 minute quadrangles of Liberty, Ralston, Grover, Gleason, Barbours, Bodines, Trout Run, White Pine, Salladasburg, Cogan Station, Montoursville-North, and Williamsport, Pennsylvania. The stream flows south from Brier Mountain to Williamsport, Pa., where it joins the West Branch Susquehanna River. Some of the major tributaries to Lycoming Creek include Grays Run, Pleasant Stream, Rock Run, Frozen Run, Red Run, Abbott Run, Mill Creek, Hoagland Run, Beauty's Run, Bottle Run, Wolf Run, Trout Run, Slacks Run, and Roaring Branch. The largest population centers in the watershed include Williamsport and Ralston, Pa. U.S. Highways 15 and 14 travel north and south through the majority of the watershed. Few township and Pennsylvania State Forestry roads provide access to Lycoming Creek and its tributaries.

Hydrology, Geology, and Land Use

The headwaters of Lycoming Creek begin on the south slopes of Brier Mountain just north of Ogdensburg, Pa. Lycoming Creek flows south to its confluence with West Branch Susquehanna River. The Lycoming Creek Watershed contains approximately 271.93 square miles and 521.58 stream miles. Lycoming Creek flows through the towns of Ralston and Williamsport, Pa.

The Lycoming Creek Watershed primarily lies within the Mountainous High Plateau Section of the Appalachian Plateau Province. A very small portion of the watershed to the north lies within the Glaciated Low Plateaus Section of the Appalachian Plateau Province, and portions of the watershed in the south lie within the Appalachian Mountain Section of Ridge and Valley Province. There is a vertical drop in the watershed of about 1,900 feet from its headwaters to the mouth. The average annual precipitation is 42 inches. The region is characterized by warm summers and long, cold winters. Temperatures change frequently and sometimes rapidly.

The watershed is dominated primarily by forested and developed land uses. Forested consists of 78 percent of the land use and is predominantly found throughout the Lycoming Creek Watershed. Agricultural accounts for approximately 18 percent and is concentrated near the mouth of Lycoming Creek. The remaining 4 percent consists of developed lands.

The Lycoming Creek Watershed is primarily interbedded sedimentary, which accounts for approximately 60 percent of the area. Sandstone comprises the remaining 40 percent of the area. The predominant soil associations in the watershed are the Wellsboro-Oquaga-Morris, Volusia-Mardin-Lordstown, and Oquaga-Lordstown-Wurtsboro. These three soils account for 70 percent of the Lycoming Creek Watershed.

Segments Addressed in this TMDL

Lycoming Creek is affected by pollution from atmospheric deposition. This pollution has caused low pH in the watershed. There are no NPDES permits in the watershed that would require a waste load allocation (WLA). The TMDLs will be expressed as long-term average loadings. Due to the nature and complexity of atmospheric deposition effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations.

Clean Water Act Requirements

Section 303(d) of the 1972 Clean Water Act requires states, territories, and authorized tribes to establish water quality standards. The water quality standards identify the uses for each waterbody and the scientific criteria needed to support that use. Uses can include designations for drinking water supply, contact recreation (swimming), and aquatic life support. Minimum goals set by the Clean Water Act require that all waters be “fishable” and “swimmable.”

Additionally, the federal Clean Water Act and the U.S. Environmental Protection Agency’s (USEPA) implementing regulations (40 CFR 130) require:

- States to develop lists (Section 303(d) lists) of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);

- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;

- States to submit the list of waters to USEPA every two years (April 1 of the even numbered years);

- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and

- USEPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Despite these requirements, states, territories, authorized tribes, and USEPA have not developed many TMDLs since 1972. Beginning in 1986, organizations in many states filed lawsuits against USEPA for failing to meet the TMDL requirements contained in the federal Clean Water Act and its implementing regulations. USEPA has entered into consent agreements with the plaintiffs in several states.

In the cases that have been settled to date, the consent agreements require USEPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., atmospheric deposition, implementation of nonpoint source Best Management Practices (BMPs), etc.).

Section 303(d) Listing Process

Prior to developing TMDLs for specific waterbodies, sufficient data must be available to assess which streams are impaired and should be on the Section 303(d) list. With guidance from USEPA, the states have developed methods for assessing the waters within their respective jurisdictions.

The primary method adopted by the Pennsylvania Department of Environmental Protection (PADEP) for evaluating waters changed between the publication of the 1996 and 1998 303(d) lists. Prior to 1998, data used to list streams were in a variety of formats, collected under differing protocols. Information also was gathered through the Section 305(b)[1] reporting process. For this TMDL, PADEP used the Unassessed Waters Protocol (UWP), a modification of the USEPA Rapid Bioassessment Protocol II (RPB-II), as the primary mechanism to assess Pennsylvania's waters. The UWP provides a more consistent approach to assessing Pennsylvania's streams.

The assessment method requires selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. A biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment can vary between sites. All the biological surveys include kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH (Attachment C), temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates are identified to the family level in the field.

After the survey is completed, the biologist determines the status of the stream segment. The decision is based on the performance of the segment using a series of biological metrics. If the

---

[1] Section 305(b) of the Clean Water Act requires a biannual description of the water quality of the waters of the state.

stream is determined to be impaired, the source and cause of the impairment are documented. An impaired stream must be placed on the state's 303(d) list with the documented source and cause. A TMDL must be developed for the stream segment. Each TMDL is for only one pollutant. If a stream segment is impaired by two pollutants, two TMDLs must be developed for that stream segment. In order for the process to be more effective, adjoining stream segments with the same source and cause listing are addressed collectively, and on a watershed basis.

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, basic processes or steps apply to all cases. They include:

1. Collect and summarize pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using USEPA-approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Begin public review and comment period on draft TMDL;
6. Submit final TMDL; and
7. Obtain USEPA approval of the TMDL.

This document will present the information used to develop the Lycoming Creek Watershed TMDL.

ACIDITY TMDL DETERMINATION

A two-step approach was used for the TMDL analysis of atmospheric deposition impaired stream segments. The first step uses a statistical method for determining the allowable instream concentration at the point of interest necessary to meet water quality standards. This is done at each point of interest (sample point) in the watershed. The second step is a mass balance of the loads as they pass through the watershed. Loads at these points are computed based on average annual flow.

The statistical analysis described below can be applied to situations where all of the pollutant loading is from nonpoint sources, as well as those where there are both point and nonpoint sources. The following defines point sources and nonpoint sources for the purposes of our evaluation. Point sources are defined as permitted discharges or a discharge that has a responsible party; nonpoint sources are any pollution sources that are not point sources. For situations where all of the impact is due to nonpoint sources, the equations shown below are applied using data for a point in the stream. The LA made at that point is for all of the watershed area that is above that point. For situations where there are point source impacts alone, or in combination with nonpoint sources, the evaluation uses the point source data and a mass balance is performed with the receiving water to determine the impact of the point source.

Allowable loads are determined for each point of interest using Monte Carlo simulation. Monte Carlo simulation is an analytical method meant to imitate real-life systems, especially when other analyses are too mathematically complex or too difficult to reproduce. Monte Carlo simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distribution of the uncertain variables and using those values to populate a larger dataset. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk[2] by performing 5,000 iterations to determine the required percent reduction so that the water quality criteria, as defined in the *Pennsylvania Code, Title 25 Environmental Protection, Department of Environmental Protection, Chapter 93, Water Quality Standards,* will be met instream at least 99 percent of the time. For each iteration, the required percent reduction is:

PR = maximum {0, (1-Cc/Cd)} where (1)

PR = required percent reduction for the current iteration

Cc = criterion in milligrams per liter (mg/l)

Cd = randomly generated pollutant source concentration in mg/l based on the observed data

Cd = RiskLognorm(Mean, Standard Deviation) where (1a)
Mean = average observed concentration
Standard Deviation = standard deviation of observed data

The overall percent reduction required is the 99th percentile value of the probability distribution generated by the 5,000 iterations, so that the allowable long-term average (LTA) concentration is:

LTA = Mean * (1 – PR99) where (2)

LTA = allowable LTA source concentration in mg/l

Once the allowable concentration and load for each pollutant is determined, mass-balance accounting is performed starting at the top of the watershed and working down in sequence. This mass-balance or load tracking is explained below.

For pH TMDLs, acidity is compared to alkalinity. Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both in units of mg/l $CaCO_3$. Statistical procedures are applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between

---

[2] @Risk – Risk Analysis and Simulation Add-in for Microsoft Excel, Palisade Corporation, Newfield, NY, 1990-1997.

six and nine. This method negates the need to specifically compute the pH value, which for streams affected by low pH from atmospheric deposition may not be a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

Information for the TMDL analysis performed using the methodology described above is contained in the TMDLs by Segment section of this report.

TMDL Endpoints

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment of applicable water quality. An instream numeric endpoint therefore represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards.

Because of the nature of the pollution sources in the watershed, the TMDL's components makeup will be load allocations (LAs) that are specified above a point in the stream segment. All allocations will be specified as long-term average daily concentrations. These long-term average daily concentrations are expected to meet water quality criteria 99 percent of the time. Pa. Title 25 Chapter 96.3(c) specifies that the water quality standards must be met 99 percent of the time. Table 2 shows the water quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

Parameter	Criterion Value (mg/l)	Total Recoverable/Dissolved
pH *	6.0-9.0	N/A

*The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality.

TMDL Elements (LA, MOS)

A TMDL equation consists of a load allocation (LA) and a margin of safety (MOS). The LA is the portion of the load assigned to nonpoint sources. The MOS is applied to account for uncertainties in the computational process. The MOS may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Allocations Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each sampling point. The reduction schemes in Table 3 for each segment are based on the assumption that all upstream allocations are implemented and take into account all upstream reductions. Attachment D contains the TMDLs by segment analysis for each allocation point in a detailed discussion. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. An implicit MOS based on conservative assumptions in the analysis is included in the TMDL calculations.

The allowable long-term average concentration in each segment is calculated using Monte Carlo Simulation as described previously. The allowable load is then determined by multiplying the allowable concentration by the average flow and a conversion factor at each sample point. The allowable load is the TMDL at that point.

The LA at each point includes all loads entering the segment including those from upstream allocation points. The percent reduction is calculated to show the amount of load that needs to be reduced from nonpoint sources within a segment in order for water quality standards to be met at the point.

In some instances, instream processes, such as settling, are taking place within a stream segment. These processes are evidenced by a decrease in measured loading between consecutive sample points. It is appropriate to account for these losses when tracking upstream loading through a segment. The calculated upstream load lost within a segment is proportional to the difference in the measured loading between the sampling points.

Table 3. Lycoming Creek Watershed Summary Table

Parameter	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	NPS Load Reduction (lbs/day)	NPS % Reduction
LYC12 – Abbott Run Mouth						
Acidity (lbs/day)	156.85	156.85	-	-	0.00	0.0
LYC9 – Red Run Mouth						
Acidity (lbs/day)	1,465.92	732.96	-	-	732.96	50.0
LYC8 – Miners Run Mouth						
Acidity (lbs/day)	627.53	338.86	-	-	288.57	46.0
LYC7– Doe Run Mouth						
Acidity (lbs/day)	200.56	146.41	-	-	54.15	27.0
LYC6 – Hound Run Mouth						
Acidity (lbs/day)	675.41	439.02	-	-	236.39	35.0
LYC5 – Yellow Dog Run Mouth						
Acidity (lbs/day)	53.36	53.36	-	-	0.00	0.0
LYC4 – Frozen Run Mouth						
Acidity (lbs/day)	1,322.62	700.99	-	-	621.63	47.0
LYC3 – Mill Hollow Run Mouth						
Acidity (lbs/day)	14.79	14.79	-	-	0.00	0.0
LYC2 – Long Run (Pleasant Stream) Mouth						
Acidity (lbs/day)	18.92	18.92	-	-	0.00	0.0
LYC1 – Long Run (Grays Run) Mouth						
Acidity (lbs/day)	82.98	78.83	-	-	4.15	5.0

RECOMMENDATIONS

There are two challenges to consider when developing a strategy for implementing treatment in the Lycoming Creek Watershed. These two challenges include limited access and topography. The watershed has very limited access by vehicle into portions of the watershed. Of the sample sites in this project, all can be accessed by State Highway 14 or limited access private or forestry gravel roads. Of the access available, only the mouth of these tributaries are truly accessible by vehicle which creates a limitation on treatment locations in the watersheds.

Another challenge in the watershed is topography. The topography includes steeply incised valleys causing difficult access to portions of the streams. The condition of the roads listed above can be directly correlated with the steep terrain. Roads that are available to address treatment are cut into the mountainside and are very narrow. However, these steeply incised valleys have also helped produce the aesthetics of this watershed. The steep terrain formed by sandstone layers has provided the watershed with numerous plunge pools, some reaching 15 feet. Additionally, with a majority of the watersheds' acreage being located in Department of Conservation and Natural Resources Bureau of Forestry controlled lands, this provides a unique opportunity for partnership during restoration.

Given these variables, the selection of a treatment option that is less invasive and provides a minimal footprint is important. Options for the watershed include the implementation of vertical flow wetlands, high flow buffer channels, road liming, instream limestone sand dosing, and alkaline addition (lime dosing silos) treatment systems. Systems of these designs have proved to be very effective in treating episodic acidification from atmospheric deposition in many watersheds. However, when limited by access and topography, some of these systems become less chemically and cost-effective and require a larger construction footprint. The installation of lime dosing silos in the headwaters of selected tributaries could be the practice that meets all criteria listed above. However, every technique has a limitation. In the case of a lime dosing silo, yearly operational fees (i.e., alkaline material purchase) are necessary for success. Consequently, a best case scenario trust fund or a worst case scenario yearly fundraising effort must be accomplished. If this restoration option was pursued, it would be recommended that any project partners review any applicable state and federal requirements. Coordination with the Department of Conservation and Natural Resources/Pennsylvania Heritage Program should be completed to make sure the installation of this project is not harmful to endangered species. Other more economical options such road liming, instream limestone sand dosing, and high flow buffer channels will help increase alkalinity during precipitation increased flows with less cost up front. Ultimately these projects will also require maintenance to continue effectiveness.

Currently, active groups such as the Lycoming Creek Watershed Association (LCWA) and the Lycoming County Conservation District have focused on other impairments besides atmospheric deposition in the watershed. However, this TMDL coupled with a *Watershed Assessment Plan* or additional studies, could lead to several new opportunities for these groups to begin alkaline addition projects and restoring portions of the watershed.

Public Participation

A notice of availability for comments on the draft Lycoming Creek Tributaries TMDL was published in the Pa. Bulletin on *Date*, and *Company* newspaper on *Date*, to foster public comment on the allowable loads calculated. A public meeting was held on *Date*, at the *Location* to discuss the proposed TMDL. The public participation process (which ended on *Date*) was provided for the submittal of comments. Comments and responses are summarized in Attachment I.

Notice of final TMDL approval will be posted on the PADEP's web site.

Future TMDL Modifications

In the future, PADEP may adjust the load and/or WLAs in this TMDL to account for new information or circumstances that develop and are discovered during the implementation of the TMDL when a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment between the LA and WLA will only be made following an opportunity for public participation. A WLA adjustment will be made consistent and simultaneous with associated permit(s) revision(s)/reissuances (i.e., permits for revision/reissuance in association with a TMDL revision will be made available for public comment concurrent with the related TMDLs availability for public comment). New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information, and land use information. All changes in the TMDL will be tallied and compared to the original calculations. Once the total changes exceed 1 percent of the total original TMDL allowable load, the TMDL will be revised. The adjusted TMDL, including its LAs and WLAs, will be set at a level necessary to implement the applicable water quality standards (WQS), and any adjustment increasing a WLA will be supported by reasonable assurance demonstration that LAs will be met. PADEP will notify USEPA of any adjustments to the TMDL within 30 days of its adoption and will maintain current tracking mechanisms that contain accurate loading information for TMDL waters.

Changes in TMDLs That May Require USEPA Approval

- Increase in total load capacity.
- Transfer of load between point (WLA) and nonpoint (LA) sources.
- Modification of the margin of safety (MOS).
- Change in WQS.
- Non-attainment of WQS with implementation of the TMDL.
- Allocations in trading programs.

Changes in TMDLs That May Not Require USEPA Approval

- Total loading shift less than or equal to 1 percent of the total load.
- Increase of WLA results in greater LA reductions provided reasonable assurance of implementation is demonstrated (a compliance/implementation plan and schedule).

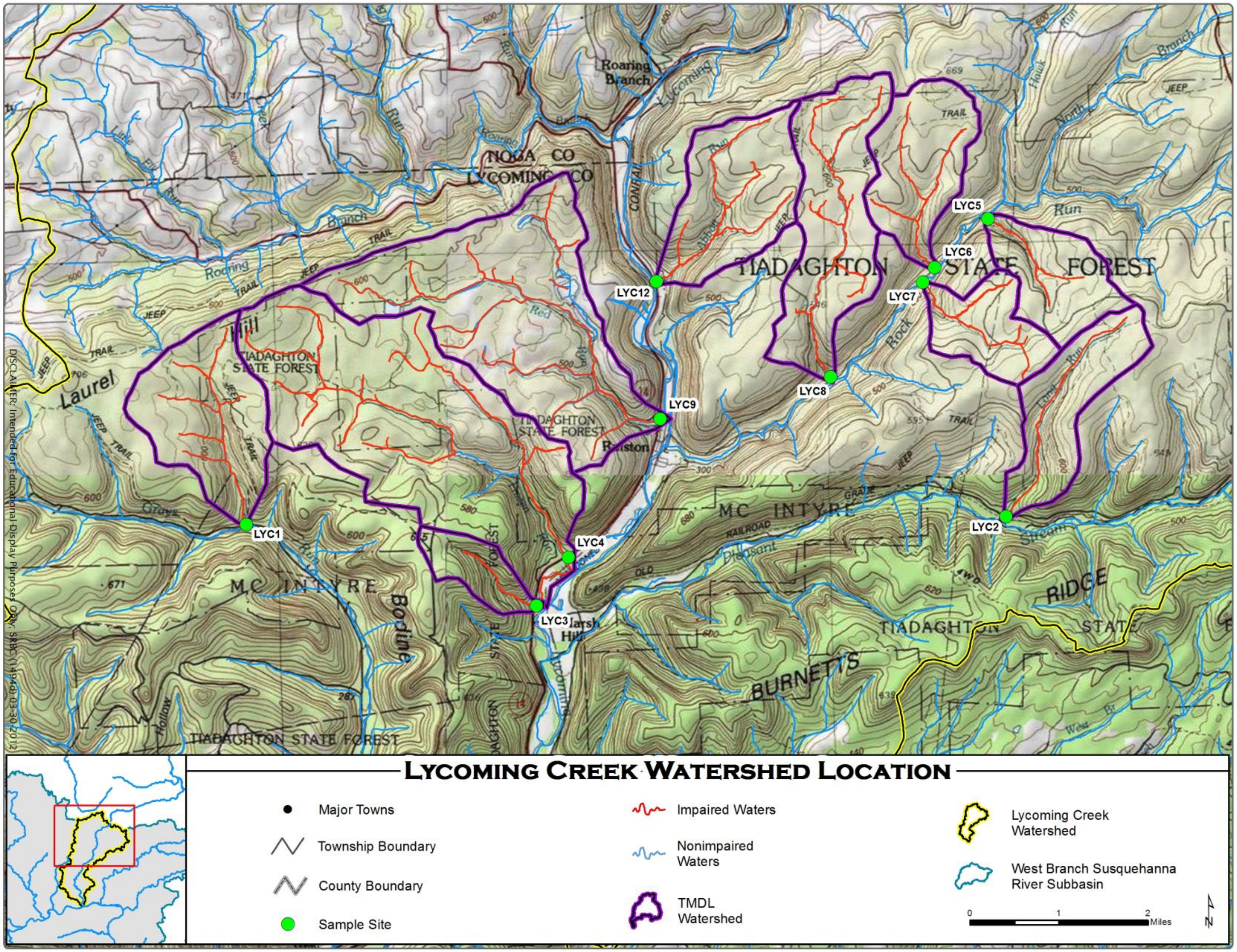
- Changes among WLAs with no other changes; TMDL public notice concurrent with permit public notice.
- Removal of a pollutant source that will not be reallocated.
- Reallocation between LAs.
- Changes in land use.

References

Commonwealth of Pennsylvania. 2005. Pennsylvania Code, Title 25. Environmental Protection, Department of Environmental Protection, Chapter 93. Water Quality Standards.

Attachment A

Lycoming Creek Watershed Map



Lycoming Creek Watershed Location

DISCLAIMER: Intended for Educational Display Purposes Only; SRBC (1494d) 03-30-2012

Attachment B

Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists and Integrated Report/List (2004, 2006)

The following are excerpts from the PADEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, 2002, 2004, and 2006 303(d) Lists and Integrated Report/List (2006). The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

In the 1996 Section 303(d) narrative, strategies were outlined for changes to the listing process. Suggestions included, but were not limited to, a migration to a Global Information System (GIS), improved monitoring and assessment, and greater public input.

The migration to a GIS was implemented prior to the development of the 1998 Section 303(d) list. As a result of additional sampling and the migration to the GIS some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

1. mileage differences due to recalculation of segment length by the GIS;
2. slight changes in source(s)/cause(s) due to new USEPA codes;
3. changes to source(s)/cause(s), and/or miles due to revised assessments;
4. corrections of misnamed streams or streams placed in inappropriate SWP subbasins; and
5. unnamed tributaries no longer identified as such and placed under the named watershed listing.

Prior to 1998, segment lengths were computed using a map wheel and calculator. The segment lengths listed on the 1998 Section 303(d) list were calculated automatically by the GIS (ArcInfo) using a constant projection and map units (meters) for each watershed. Segment lengths originally calculated by using a map wheel and those calculated by the GIS did not always match closely. This was the case even when physical identifiers (e.g., tributary confluence and road crossings) matching the original segment descriptions were used to define segments on digital quad maps. This occurred to some extent with all segments, but was most noticeable in segments with the greatest potential for human errors using a map wheel for calculating the original segment lengths (e.g., long stream segments or entire basins).

Migration to National Hydrography Data (NHD)

New to the 2006 report is use of the 1/24,000 National Hydrography Data (NHD) streams GIS layer. Up until 2006, PADEP relied upon its own internally developed stream layer. Subsequently, the United States Geologic Survey (USGS) developed 1/24,000 NHD streams layer for the Commonwealth based upon national geodatabase standards. In 2005, PADEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old PADEP stream assessment information to the improved NHD and the old PADEP streams layer was archived. Overall, this marked an improvement in the quality of the streams layer and made the stream assessment data compatible with national standards but it necessitated a change in the Integrated Listing format. The NHD is not attributed with the old PADEP five digit stream codes so segments can no longer be listed by stream code but rather only by stream name or a fixed combination of NHD fields known as reachcode and ComID. The NHD is aggregated by Hydrologic Unit Code (HUC) watersheds so HUCs rather than the old State Water Plan (SWP) watersheds are now used to group streams together. A more basic change was the shift in data management philosophy from one of “dynamic segmentation” to “fixed segments.” The dynamic segmentation records were proving too difficult to manage from an historical tracking perspective. The fixed segment methods will remedy that problem. The stream assessment data management has gone through many changes over the years as system requirements and software changed. It is hoped that with the shift to the NHD and Office of Information Technology’s (OIT’s) fulltime staff to manage and maintain SLIMS, the systems and formats will now remain stable over many Integrated Listing cycles.

Attachment C

Method for Addressing 303(d) Listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published by PADEP demonstrates that by plotting net alkalinity (alkalinity-acidity) vs. pH, the resulting pH value from a sample possessing a net alkalinity of zero is approximately equal to six (Figure C-1). Where net alkalinity is positive (greater than or equal to zero), the pH range is most commonly six to eight, which is within the USEPA's acceptable range of six to nine and meets Pennsylvania water quality criteria in Chapter 93.

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to standard statistics. Additionally, pH does not measure latent acidity. For this reason, and based on the above information, Pennsylvania is using the following approach to address the stream impairments noted on the 303(d) list due to pH. The concentration of acidity in a stream is at least partially chemically dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values, which would result from treatment of atmospheric deposition. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable. Therefore, the measured instream alkalinity at the point of evaluation in the stream will serve as the goal for reducing total acidity at that point. The methodology that is applied for alkalinity (and therefore pH) is the same as that used for other parameters such as aluminum that have numeric water quality criteria.

Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. The same statistical procedures that have been described for use in the evaluation of the metals is applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for atmospheric deposition waters is not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

Reference: *Rose, Arthur W. and Charles A. Cravotta, III, 1998. Geochemistry of Coal Mine Drainage. Chapter 1 in Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania. Pa. Dept. of Environmental Protection, Harrisburg, Pa.*

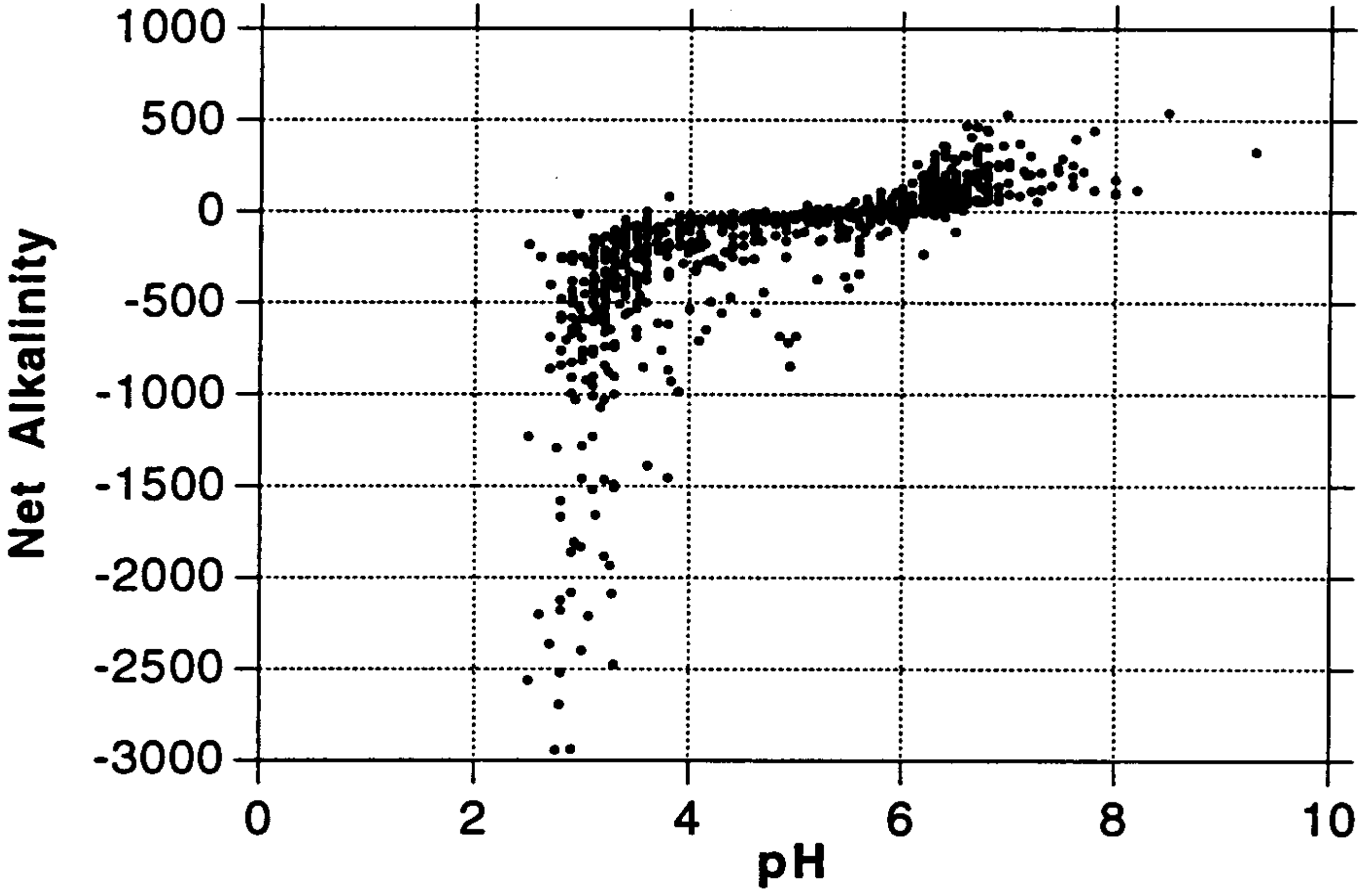


Figure C-1. Net Alkalinity vs. pH. Taken from Figure 1.2 Graph C, pages 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

Attachment D

TMDLs By Segment

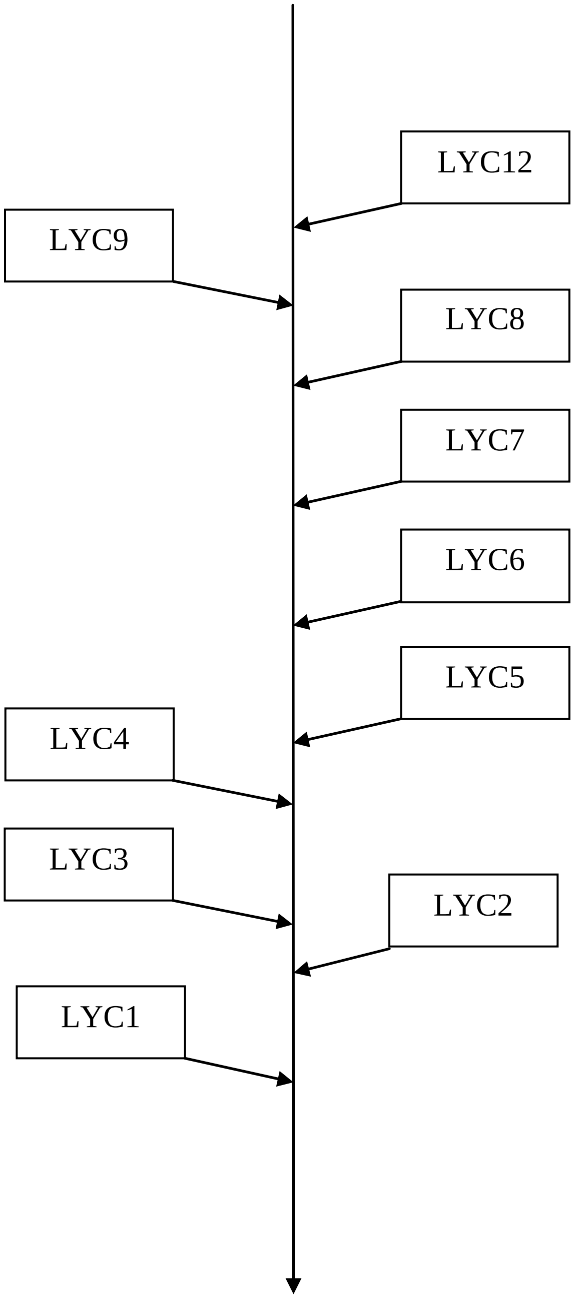
Lycoming Creek

The TMDL for Lycoming Creek consists of load allocations (LAs) to ten sampling sites in Lycoming Creek Watershed (LYC1, LYC2, LYC3, LYC4, LYC5, LYC6, LYC7, LYC8, LYC9, and LYC12). Sample datasets were collected in 2011. All sample points are shown on the maps in Attachment A as well as on the loading schematic presented on the following page. Lycoming Creek is listed on the 2010 303(d) List for pH from atmospheric deposition as the cause of the stream degradation. The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average instream concentration for acidity is determined at each sample point. These analyses are designed to produce a long-term average value that, when met, will be protective of the water quality criterion for that parameter 99 percent of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water quality criteria 99 percent of the time. The simulation was run assuming the dataset was lognormally distributed. Using the mean and the standard deviation of the dataset, 5,000 iterations of sampling were completed and compared against the water quality criterion for that parameter. For each sampling event, a percent reduction was calculated, if necessary, to meet water quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99 percent of the time. The mean value from this dataset represents that long-term daily average concentration that needs to be met to achieve water quality standards. Standard deviations in the existing concentration formula were given values of 1.6 to project a more accurate reduction and reflection of the current water quality conditions among the atmospheric deposition impaired streams addressed in the Lycoming Creek Tributaries TMDL.

Lycoming Creek Sampling Diagram

Arrows represent direction of flow, and diagram is not to scale.



LYC12: Abbott Run Mouth

Abbott Run is a tributary to Lycoming Creek and begins in the Tiadaghton State Forest, just north of Ralston, Pa. The sample point LYC12 is located upstream of the confluence with Lycoming Creek.

The TMDL for this section of Abbott Run consists of a LA to the watershed area above LYC12. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC12 (7.998 million gallons per day (MGD)). The LAs made at point LYC12 for this stream segment are presented in Table D1.

Table D1. TMDL Calculations at Point LYC12

Flow = 7.998 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	2.35	156.85	2.35	156.85
Alkalinity	11.35	757.55	-	-

Reductions at point LYC12 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC12 are shown in Table D2.

Table D2. Calculation of Load Reduction Necessary at Point LYC12

	Acidity (lbs/day)
Existing load at LYC12	156.85
Allowable load at LYC12	156.85
Load Reduction at LYC12	0.00
Percent reduction required at LYC12	0.0%

The TMDL for point LYC12 does not require a LA for acidity.

LYC9: Red Run Mouth

Red Run is a tributary to Lycoming Creek and begins on the south slopes of Laurel Hill, just north of Ralston, Pa. The sample point LYC9 is located upstream of the confluence with Lycoming Creek.

The TMDL for this section of Red Run consists of a LA to the watershed area above LYC9. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC9 (19.482 MGD). The LAs made at point LYC9 for this stream segment are presented in Table D3.

Table D3. TMDL Calculations at Point LYC9				
Flow = 19.482 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	9.02	1,465.92	4.51	732.96
Alkalinity	6.77	1,100.12	-	-

Reductions at point LYC9 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC9 are shown in Table D4.

Table D4. Calculation of Load Reduction Necessary at Point LYC9	
	Acidity (lbs/day)
Existing load at LYC9	1,465.92
Allowable load at LYC9	732.96
Load Reduction at LYC9	732.96
Percent reduction required at LYC9	50.0%

The TMDL for point LYC9 requires a LA for acidity.

LYC8: Miners Run Mouth

Miners Run is a tributary to Rock Run and begins in the Tiadaghton State Forest, just east of Ralston, Pa. The sample point LYC8 is located upstream of the confluence with Rock Run.

The TMDL for this section of Miners Run consists of a LA to the watershed area above LYC8. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC8 (9.322 MGD). The LAs made at point LYC8 for this stream segment are presented in Table D5.

Table D5. TMDL Calculations at Point LYC8				
Flow = 9.322 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	8.07	627.53	4.36	338.86
Alkalinity	6.83	531.58	-	-

Reductions at point LYC8 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC8 are shown in Table D6.

Table D6. Calculation of Load Reduction Necessary at Point LYC8	
	Acidity (lbs/day)
Existing load at LYC8	627.43
Allowable load at LYC8	338.86
Load Reduction at LYC8	288.57
Percent reduction required at LYC8	46.0%

The TMDL for point LYC8 requires a LA for acidity.

LYC7: Doe Run Mouth

Doe Run is a tributary to Rock Run and begins in the Tiadaghton State Forest, just east of Ralston, Pa. The sample point LYC7 is located upstream of the confluence with Rock Run.

The TMDL for this section of Doe Run consists of a LA to the watershed area above LYC7. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC7 (4.120 MGD). The LAs made at point LYC7 for this stream segment are presented in Table D7.

Table D7. TMDL Calculations at Point LYC7

Flow = 4.120 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	5.83	200.56	4.26	146.41
Alkalinity	7.77	267.03	-	-

Reductions at point LYC7 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC7 are shown in Table D8.

Table D8. Calculation of Load Reduction Necessary at Point LYC7

	Acidity (lbs/day)
Existing load at LYC7	200.56
Allowable load at LYC7	146.41
Load Reduction at LYC7	54.15
Percent reduction required at LYC7	27.0%

The TMDL for point LYC7 requires a LA for acidity.

LYC6: Hound Run Mouth

Hound Run is a tributary to Rock Run and begins in the Tiadaghton State Forest, just east of Ralston, Pa. The sample point LYC6 is located upstream of the confluence with Rock Run.

The TMDL for this section of Hound Run consists of a LA to the watershed area above LYC6. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC6 (10.791 MGD). The LAs made at point LYC6 for this stream segment are presented in Table D9.

Table D9. TMDL Calculations at Point LYC6

Flow = 10.791 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	7.50	675.41	4.88	439.02
Alkalinity	7.80	702.43	-	-

Reductions at point LYC6 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC6 are shown in Table D10.

Table D10. Calculation of Load Reduction Necessary at Point LYC6

	Acidity (lbs/day)
Existing load at LYC6	675.41
Allowable load at LYC6	439.02
Load Reduction at LYC6	236.39
Percent reduction required at LYC6	35.0%

The TMDL for point LYC6 requires a LA for acidity.

LYC5: Yellow Dog Run Mouth

Yellow Dog Run is a tributary to Rock Run and begins in the Tiadaghton State Forest, just east of Ralston, Pa. The sample point LYC5 is located upstream of the confluence with Rock Run.

The TMDL for this section of Yellow Dog Run consists of a LA to the watershed area above LYC5. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC5 (6.503 MGD). The LAs made at point LYC5 for this stream segment are presented in Table D13.

Table D13. TMDL Calculations at Point LYC5

Flow = 6.503 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	0.98	53.36	0.98	53.36
Alkalinity	10.48	568.87	-	-

Reductions at point LYC5 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC5 are shown in Table D14.

Table D14. Calculation of Load Reduction Necessary at Point LYC5	
	Acidity (lbs/day)
Existing load at LYC5	53.36
Allowable load at LYC5	53.36
Load Reduction at LYC5	0.00
Percent reduction required at LYC5	0.0%

The TMDL for point LYC5 does not require a LA for acidity.

LYC4: Frozen Run Mouth

Frozen Run is a tributary to Lycoming Creek and begins on the south slopes of Laurel Hill, just west of Ralston, Pa. The sample point LYC4 is located upstream of the confluence with Lycoming Creek.

The TMDL for this section of Frozen Run consists of a LA to the watershed area above LYC4. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC4 (16.173 MGD). The LAs made at point LYC4 for this stream segment are presented in Table D15.

Table D15. TMDL Calculations at Point LYC4				
Flow = 16.173 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	9.80	1,322.62	5.19	700.99
Alkalinity	7.60	1,025.71	-	-

Reductions at point LYC4 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC4 are shown in Table D16.

Table D16. Calculation of Load Reduction Necessary at Point LYC4	
	Acidity (lbs/day)
Existing load at LYC4	1,322.62
Allowable load at LYC4	700.99
Load Reduction at LYC4	621.63
Percent reduction required at LYC4	47.0%

The TMDL for point LYC4 requires a LA for acidity.

LYC3: Mill Hollow Run Mouth

Mill Hollow Run is a tributary to Lycoming Creek and begins on the east slopes of Bodine Mountain, just south of Ralston, Pa. The sample point LYC3 is located upstream of the confluence with Lycoming Creek.

The TMDL for this section of Mill Hollow Run consists of a LA to the watershed area above LYC3. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC3 (1.715 MGD). The LAs made at point LYC3 for this stream segment are presented in Table D17.

Table D17. TMDL Calculations at Point LYC3

Flow = 1.715 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	1.03	14.79	1.03	14.79
Alkalinity	12.20	174.60	-	-

Reductions at point LYC3 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC3 are shown in Table D18.

Table D18. Calculation of Load Reduction Necessary at Point LYC3

	Acidity (lbs/day)
Existing load at LYC3	14.79
Allowable load at LYC3	14.79
Load Reduction at LYC3	0.00
Percent reduction required at LYC3	0.0%

The TMDL for point LYC3 does not require a LA for acidity.

LYC2: Long Run (Pleasant Stream) Mouth

Long Run is a tributary to Pleasant Stream and begins on the east slopes of Sullivan Mountain, just south of Ralston, Pa. The sample point LYC2 is located upstream of the confluence with Pleasant Stream.

The TMDL for this section of Long Run consists of a LA to the watershed area above LYC2. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC2 (3.239 MGD). The LAs made at point LYC2 for this stream segment are presented in Table D19.

Table D19. TMDL Calculations at Point LYC2

Flow = 3.239 MGD	*Measured Sample Data*		*Allowable*	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	0.70	18.92	0.70	18.92
Alkalinity	9.13	246.86	-	-

Reductions at point LYC2 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC2 are shown in Table D20.

Table D20. Calculation of Load Reduction Necessary at Point LYC2	
	Acidity (lbs/day)
Existing load at LYC2	18.92
Allowable load at LYC2	18.92
Load Reduction at LYC2	0.00
Percent reduction required at LYC2	0.0%

The TMDL for point LYC2 does not require a LA for acidity.

LYC1: Long Run (Grays Run) Mouth

Long Run is a tributary to Grays Run and begins on the south slopes of Laurel Hill, just west of Ralston, Pa. The sample point LYC1 is located upstream of the confluence with Grays Run.

The TMDL for this section of Long Run consists of a LA to the watershed area above LYC1. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point LYC1 (5.474 MGD). The LAs made at point LYC1 for this stream segment are presented in Table D21.

Table D21. TMDL Calculations at Point LYC1				
Flow = 5.474 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Acidity	1.82	82.98	1.73	78.83
Alkalinity	7.57	345.64	-	-

Reductions at point LYC1 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point LYC1 are shown in Table D22.

Table D22. Calculation of Load Reduction Necessary at Point LYC1	
	Acidity (lbs/day)
Existing load at LYC1	82.98
Allowable load at LYC1	78.83
Load Reduction at LYC1	4.15
Percent reduction required at LYC1	5.0%

The TMDL for point LYC2 requires a LA for acidity.

Margin of Safety (MOS)

An implicit MOS was used in these TMDLs derived from the Monte Carlo statistical analysis employing the @Risk software. Pa. Title 25 Chapter 96.3(c) states that water quality criteria must be met at least 99 percent of the time. All of the @Risk analyses results surpass the minimum 99 percent level of protection. Other MOS used for this TMDL analyses are:

- Effluent variability plays a major role in determining the average value that will meet water quality criteria over the long term. The value that provides this variability in our analysis is the standard deviation of the dataset. The simulation results are based on this variability and the existing stream conditions (an uncontrolled system). The general assumption can be made that a controlled system (one that is controlling and stabilizing the pollution load) would be less variable than an uncontrolled system. This implicitly builds in a MOS.

- An additional MOS is that the calculations were performed using a daily iron average, instead of the 30-day average.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent all seasons.

Critical Conditions

The reductions specified in this TMDL apply at all flow conditions. A critical flow condition could not be identified from the data used for this analysis.

Attachment E

Water Quality Data Used in TMDL Calculations

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	pH (lab)	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
LYC 1	1/26/2011	9:30	1.846	828.485	-0.60	7.80	6.10	14.33	5.73	26.90	0.00
LYC 1	6/13/2011	11:30	3.475	1559.580	1.20	6.80	5.70	9.06	5.56	24.60	12.00
LYC 1	8/15/2011	8:37	0.755	338.844	4.10	7.80	6.20	7.40	5.43	11.10	15.90
LYC 1	9/7/2011	8:30	35.857	16092.622	8.00	7.60	5.60	8.54	5.19	15.90	14.40
LYC 1	11/15/2011	7:30	6.531	2931.113	8.40	7.60	6.00	11.02	5.22	35.00	8.50
LYC 1	4/23/2012	8:45	2.355	1056.924	-10.20	7.80	6.10	12.13	6.52	24.30	5.10
Average			**8.470**	**3801.261**	**1.82**	**7.57**	**5.95**	**10.41**	**5.61**	**22.97**	**9.32**
Standard Dev.			**13.561**	**6086.328**	**6.89**	**0.39**	**0.24**	**2.57**	**0.49**	**8.43**	**6.03**
LYC 2	1/26/2011	11:00	1.188	533.174	-2.00	10.00	6.60	14.10	6.46	25.50	0.10
LYC 2	6/13/2011	12:30	1.904	854.515	3.40	10.00	6.60	8.71	6.50	22.10	13.10
LYC 2	8/15/2011	9:44	0.467	209.590	12.00	8.20	5.60	7.38	6.35	10.90	16.50
LYC 2	9/7/2011	10:00	20.637	9261.886	-5.40	8.80	6.60	8.64	5.30	13.00	14.80
LYC 2	11/15/2011	8:30	2.263	1015.634	2.00	8.20	6.40	11.02	6.50	33.90	8.60
LYC 2	4/23/2012	10:15	3.611	1620.617	-5.80	9.60	6.60	11.71	6.92	22.50	5.20
Average			**5.012**	**2249.236**	**0.70**	**9.13**	**6.40**	**10.26**	**6.34**	**21.32**	**9.72**
Standard Dev.			**7.728**	**3468.269**	**6.68**	**0.85**	**0.40**	**2.48**	**0.54**	**8.43**	**6.28**
LYC 3	1/26/2011	10:45:00	DRY	-	-	-	-	-	-	-	-
LYC 3	6/13/2011	10:00	0.009	4.039	-3.00	12.40	6.30	5.35	6.20	39.20	14.50
LYC 3	8/15/2011	15:00	0.001	0.449	-6.80	19.00	6.90	7.00	6.35	10.70	16.80
LYC 3	9/7/2011	17:00	13.635	6119.388	6.80	9.20	6.60	8.65	6.37	16.20	15.20
LYC 3	11/15/2011	13:40	0.077	34.558	15.60	9.40	6.70	11.04	6.13	37.50	8.60
LYC 3	4/23/2012	13:15	0.454	203.755	-7.80	11.20	6.80	10.90	6.24	31.00	7.80
LYC 3	9/18/2012	13:00	1.746	783.605	1.4000	12.0000	7.00	9.77	5.95	37.00	14.85
Average			**2.654**	**1190.966**	**1.03**	**12.20**	**6.72**	**8.79**	**6.21**	**28.60**	**12.96**
Standard Dev.			**5.421**	**2432.829**	**8.96**	**3.58**	**0.25**	**2.26**	**0.16**	**12.18**	**3.78**
LYC 4	1/26/2011	10:00	2.832	1271.002	2.60	7.80	5.90	14.09	5.48	14.60	0.00
LYC 4	6/13/2011	9:30	3.612	1621.066	3.40	6.80	5.60	8.63	5.38	24.60	13.20
LYC 4	8/15/2011	14:30	1.586	711.797	6.00	8.20	5.90	7.58	5.51	10.90	17.60
LYC 4	9/7/2011	16:30	127.499	57221.551	37.00	7.40	4.80	8.75	4.39	20.50	15.00
LYC 4	11/15/2011	13:17	8.986	4032.917	12.60	7.60	5.90	11.02	5.27	34.30	8.80
LYC 4	4/23/2012	12:45	5.633	2528.090	11.760	6.897	4.725	11.95	5.56	22.70	5.90
Average			**25.025**	**11231.070**	**12.23**	**7.45**	**5.47**	**10.34**	**5.27**	**21.27**	**10.08**
Standard Dev.			**50.269**	**22560.540**	**12.83**	**0.54**	**0.56**	**2.46**	**0.44**	**8.19**	**6.50**

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	pH (lab)	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
LYC 5	1/26/2011	12:30	0.291	130.601	-2.00	10.40	6.70	13.77	6.54	26.00	0.10
LYC 5	6/13/2011	15:00	0.519	232.927	-1.80	9.00	6.50	8.57	6.55	23.10	13.60
LYC 5	8/15/2011	11:00	0.129	57.895	-0.20	12.60	6.70	7.03	6.41	12.50	15.80
LYC 5	9/7/2011	11:15	53.1479	23852.778	9.30	8.10	5.70	8.64	5.15	13.40	14.30
LYC 5	11/15/2011	9:00	1.613	723.914	6.00	10.20	6.80	11.18	5.30	22.60	8.00
LYC 5	9/18/2012	10:00	4.670	2095.8960	-5.4	12.6	7.00	9.92	7.17	35.00	13.63
Average			**10.062**	**4515.669**	**0.98**	**10.48**	**6.57**	**9.85**	**6.19**	**22.10**	**10.91**
Standard Dev.			**21.176**	**9503.672**	**5.53**	**1.84**	**0.45**	**2.37**	**0.79**	**8.38**	**5.92**
LYC 6	1/26/2011	14:00	0.521	233.825	-1.20	8.20	6.10	13.99	5.33	25.30	0.30
LYC 6	6/13/2011	16:30	0.748	335.702	3.20	7.20	5.80	7.91	5.57	18.20	14.10
LYC 6	8/15/2011	12:30	0.128	57.446	7.00	9.20	6.40	6.94	5.98	11.30	16.10
LYC 6	9/7/2011	13:00	88.809	39857.479	13.40	7.20	5.10	8.66	4.60	16.20	14.70
LYC 6	11/15/2011	11:00	2.788	1251.254	10.20	6.80	5.90	11.00	5.45	32.90	8.60
LYC 6	9/18/2012	11:45	7.194	3228.667	12.40	8.20	6.30	9.86	5.70	29.00	14.40
Average			**16.698**	**7494.062**	**7.50**	**7.80**	**5.93**	**9.73**	**5.44**	**22.15**	**11.37**
Standard Dev.			**35.424**	**15898.512**	**5.67**	**0.89**	**0.47**	**2.53**	**0.47**	**8.26**	**6.01**
LYC 7	1/26/2011	13:00	0.215	96.492	-1.20	9.40	6.40	13.36	6.00	23.90	0.50
LYC 7	6/13/2011	15:41	0.236	105.917	1.80	6.20	5.10	8.32	4.80	22.30	14.10
LYC 7	8/15/2011	12:00	0.019	8.527	1.40	10.40	6.30	6.03	5.51	11.10	15.60
LYC 7	9/7/2011	12:15	32.47	14572.536	12.60	6.80	4.80	8.58	4.31	17.70	14.90
LYC 7	11/15/2011	9:30	1.484	666.019	9.40	6.40	5.50	11.16	4.94	33.70	8.00
LYC 7	9/18/2012	11:00	3.827	1717.558	11.00	7.40	5.80	9.99	4.74	27.00	13.74
Average			**6.375**	**2861.175**	**5.83**	**7.77**	**5.65**	**9.57**	**5.05**	**22.62**	**11.14**
Standard Dev.			**12.864**	**5773.302**	**5.841**	**1.732**	**0.641**	**2.535**	**0.605**	**7.754**	**5.876**
LYC 8	1/26/2011	14:30	0.703	315.506	1.20	7.60	5.40	14.14	4.95	16.50	0.10
LYC 8	6/13/2011	17:00	1.253	562.346	4.40	6.20	4.90	8.18	4.76	24.00	14.40
LYC 8	8/15/2011	13:00	0.342	153.490	9.20	7.00	5.30	7.51	4.63	14.20	17.10
LYC 8	9/7/2011	13:30	72.797	32671.294	12.40	6.40	4.60	8.68	4.21	21.70	15.00
LYC 8	11/15/2011	11:30	3.856	1730.573	13.20	6.60	5.20	10.93	4.84	37.10	9.10
LYC 8	9/18/2012	12:15	7.595	3408.636	8.00	7.20	5.50	9.81	4.57	37.00	14.85
Average			**14.424**	**6473.641**	**8.067**	**6.833**	**5.150**	**9.875**	**4.660**	**25.083**	**11.758**
Standard Dev.			**28.725**	**12892.000**	**4.626**	**0.528**	**0.339**	**2.417**	**0.260**	**9.911**	**6.302**

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	pH (lab)	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
LYC 9	1/26/2011	9:30	1.705	765.204	5.00	7.40	5.00	14.21	4.70	37.60	0.00
LYC 9	6/13/2011	9:00	2.984	1339.219	6.20	6.20	4.80	8.47	4.78	64.40	13.20
LYC 9	8/15/2011	14:00	0.968	434.438	11.40	6.60	4.80	7.12	4.64	34.40	17.30
LYC 9	9/7/2011	16:00	162.998	73153.502	15.00	6.60	4.80	8.50	4.33	29.70	15.90
LYC 9	11/15/2011	12:30	6.027	2704.918	14.90	6.60	5.00	10.91	4.74	52.30	8.77
LYC 9	4/23/2012	12:15	6.191	2778.521	1.60	7.20	5.30	11.80	5.02	30.90	5.50
Average			**30.146**	**13529.300**	**9.02**	**6.77**	**4.95**	**10.17**	**4.70**	**41.55**	**10.11**
Standard Dev.			**65.120**	**29225.974**	**5.57**	**0.45**	**0.20**	**2.63**	**0.22**	**13.84**	**6.63**
LYC 12	1/26/2011	16:45	DRY	-	-	-	-	-	-	-	-
LYC 12	6/13/2011	17:35	0.064	28.723	0.60	6.80	6.00	8.58	5.78	22.20	15.80
LYC 12	8/15/2011	13:30	0.006	2.693	-6.80	24.00	6.90	6.49	6.99	37.10	16.90
LYC 12	9/7/2011	15:00	48.955	21971.004	5.80	7.20	5.20	8.61	4.71	15.10	15.00
LYC 12	11/15/2011	12:00	0.478	214.526	9.80	7.40	6.10	11.10	5.15	32.10	8.50
LYC 12	4/23/2012	12:00	DRY	-	-	-	-	-	-	-	-
LYC 12	9/18/2012	13:45	DRY	-	-	-	-	-	-	-	-
Average			**12.376**	**5554.237**	**2.35**	**11.35**	**6.05**	**8.70**	**5.66**	**26.63**	**14.05**
Standard Dev.			**24.387**	**10944.918**	**7.17**	**8.44**	**0.70**	**1.89**	**0.99**	**9.87**	**3.78**

Attachment F

Lycoming Creek Watershed Impaired Segment Listings for Atmospheric Deposition

Table F1. List of Impaired Stream Segments in Lycoming Creek Watershed

Segment ID	Year Listed	Stream Name	HUC	Source	Cause	Miles
4001	2004	Abbott Run	02050206	Atmospheric Deposition	pH	2.82
4001	2004	UNT 66907335 to Abbott Run	02050206	Atmospheric Deposition	pH	0.78
4001	2004	UNT 66907513 to Abbott Run	02050206	Atmospheric Deposition	pH	1.19
4001	2004	UNT 66907699 to Abbott Run	02050206	Atmospheric Deposition	pH	0.54
4357	2004	Doe Run	02050206	Atmospheric Deposition	pH	1.7
4357	2004	UNT 66907749 to Doe Run	02050206	Atmospheric Deposition	pH	0.15
4357	2004	UNT 66907679 to Doe Run	02050206	Atmospheric Deposition	pH	0.83
4357	2004	UNT 66907757 to Doe Run	02050206	Atmospheric Deposition	pH	0.50
4671	2004	Frozen Run	02050206	Atmospheric Deposition	pH	1.66
4695	2004	Frozen Run	02050206	Atmospheric Deposition	pH	2.03
4676	2004	UNT 66908535 to Frozen Run	02050206	Atmospheric Deposition	pH	0.14
4671	2004	UNT 66908657 to Frozen Run	02050206	Atmospheric Deposition	pH	1.08
4671	2004	UNT 66908803 to Frozen Run	02050206	Atmospheric Deposition	pH	0.71
4671	2004	UNT 66908913 to Frozen Run	02050206	Atmospheric Deposition	pH	0.43
4676	2004	UNT 66908991 to Frozen Run	02050206	Atmospheric Deposition	pH	0.60
4698	2004	UNT 66909037 to Frozen Run	02050206	Atmospheric Deposition	pH	0.14
4671	2004	UNT 66908809 to Frozen Run	02050206	Atmospheric Deposition	pH	1.84
4676	2004	UNT 66909031 to Frozen Run	02050206	Atmospheric Deposition	pH	2.48
4698	2004	UNT 66909067 to Frozen Run	02050206	Atmospheric Deposition	pH	1.15
4671	2004	UNT 66909073 to Frozen Run	02050206	Atmospheric Deposition	pH	0.62
5172	2004	UNT 66908917 to Grays Run	02050206	Atmospheric Deposition	pH	0.49
5172	2004	UNT 66909001 to Grays Run	02050206	Atmospheric Deposition	pH	0.35
5172	2004	UNT 66909027 to Grays Run	02050206	Atmospheric Deposition	pH	0.76
5172	2004	UNT 66909133 to Grays Run	02050206	Atmospheric Deposition	pH	0.54
5172	2004	UNT 66909215 to	02050206	Atmospheric	pH	0.51

Segment ID	Year Listed	Stream Name	HUC	Source	Cause	Miles
		Grays Run		Deposition		
5172	2004	UNT 66909401 to Grays Run	02050206	Atmospheric Deposition	pH	2.43
4134	2004	Hound Run	02050206	Atmospheric Deposition	pH	1.91
4134	2004	UNT 66907085 to Hound Run	02050206	Atmospheric Deposition	pH	1.26
4134	2004	UNT 66907191 to Hound Run	02050206	Atmospheric Deposition	pH	0.61
5446	2004	Long Run	02050206	Atmospheric Deposition	pH	2.95
4695	2004	Mill Hollow Run	02050206	Atmospheric Deposition	pH	1.21
4075	2004	Miners Run	02050206	Atmospheric Deposition	pH	4.05
4075	2004	UNT 66907261 to Miners Run	02050206	Atmospheric Deposition	pH	0.19
4075	2004	UNT 66906943 to Miners Run	02050206	Atmospheric Deposition	pH	1.13
4075	2004	UNT 66907203 to Miners Run	02050206	Atmospheric Deposition	pH	0.19
4075	2004	UNT 66907295 to Miners Run	02050206	Atmospheric Deposition	pH	0.52
4075	2004	UNT 66907591 to Miners Run	02050206	Atmospheric Deposition	pH	0.74
4075	2004	UNT 66907857 to Miners Run	02050206	Atmospheric Deposition	pH	0.22
5091	2004	Red Run	02050206	Atmospheric Deposition	pH	5.03
14155	2004	UNT 66907593 to Red Run	02050206	Atmospheric Deposition	pH	0.19
14155	2004	UNT 66907737 to Red Run	02050206	Atmospheric Deposition	pH	0.27
5091	2004	UNT 66908007 to Red Run	02050206	Atmospheric Deposition	pH	0.26
5091	2004	UNT 66908383 to Red Run	02050206	Atmospheric Deposition	pH	0.55
5091	2004	UNT 66908459 to Red Run	02050206	Atmospheric Deposition	pH	0.19
5091	2004	UNT 66908499 to Red Run	02050206	Atmospheric Deposition	pH	0.11
5091	2004	UNT 66908043 to Red Run	02050206	Atmospheric Deposition	pH	0.49
5091	2004	UNT 66908049 to Red Run	02050206	Atmospheric Deposition	pH	0.18
5091	2004	UNT 66908159 to Red Run	02050206	Atmospheric Deposition	pH	1.29
5091	2004	UNT 66908233 to Red Run	02050206	Atmospheric Deposition	pH	0.42
5091	2004	UNT 66908299 to Red Run	02050206	Atmospheric Deposition	pH	1.03

Segment ID	Year Listed	Stream Name	HUC	Source	Cause	Miles
5091	2004	UNT 66908495 to Red Run	02050206	Atmospheric Deposition	pH	1.54
5091	2004	UNT 66908749 to Red Run	02050206	Atmospheric Deposition	pH	0.75
5091	2004	UNT 66908939 to Red Run	02050206	Atmospheric Deposition	pH	0.67
4112	2004	Yellow Dog Run	02050206	Atmospheric Deposition	pH	1.40
4112	2004	UNT 66907349 to Yellow Dog Run	02050206	Atmospheric Deposition	pH	0.58

Attachment G

Comment and Response

No official comments were received for this TMDL.