Slate Lick Run Sediment TMDL
Clearfield Creek,
West Branch Susquehanna River

Cambria County, Pennsylvania

Prepared by:

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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TABLE OF CONTENTS

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Executive Summary

A Total Maximum Daily Load (TMDL) for sediment was developed to address impairments in the Slate Lick Run Watershed as noted in Pennsylvania's Integrated Water Quality Monitoring and Assessment Report (2010). Slate Lick Run is a tributary of Clearfield Creek and the greater West Branch Susquehanna River, Cambria County. The impairments were documented during biological surveys of the aquatic life present in the watershed (1998 and 2003). Excessive siltation resulting from agricultural activities has been identified as the cause of these impairments. Erosion from cropland and hay/pastureland in Slate Lick Run has also created habitat impairment due to sediment inundation. Because Pennsylvania does not currently have water quality criteria for sediment, a TMDL endpoint for sediment was identified using a reference watershed approach. Based on a comparison to a similar, unimpaired stream, North Witmer Run, the maximum sediment loading that should allow water quality objectives to be met in the sediment-impaired segments of Slate Lick Run. Allocation of the sediment TMDL is summarized below:

Table 1. Summary of TMDL for Slate Lick Run in lbs./yr. & lbs./day						
Summary of TMDL for Slate Lick Run (lbs./yr.)						
Pollutant	TMDL	WLA	MOS	LA	LNR	ALA
Sediment	3,118,654.8	31,308.3	311,865.5	2,775,481.0	98,600.0	2,676,881.0
Summary of TMDL for Slate Lick Run (lbs./day)						
Pollutant	TMDL	WLA	MOS	LA	LNR	ALA
Sediment	8,544.3	85.8	854.4	7,604.1	270.1	7,333.9

The Slate Lick Run Sediment TMDL is allocated to point and nonpoint sources, with 10% of the TMDL reserved explicitly as a margin of safety (MOS). The wasteload allocation (WLA) is that portion of the total load assigned to National Pollutant Discharge Elimination System (NPDES) permitted point source discharges. A search of the Pennsylvania Department of Environmental Protection's (Department) efacts permit database identified two point source discharges within the Slate Lick Run. The WLA was adjusted based on permit information. An additional allocation of 1% of the TMDL was incorporated into the WLA as a bulk reserve to take in account the dynamic nature of future permit activity. The load allocation (LA) is that portion of the total load assigned to nonpoint sources, all sources other than NPDES permitted point sources. Loads not reduced (LNR) are the portion of the LA associated with nonpoint sources other than agricultural (croplands, hay/pasture), transitional land, and stream bank and is equal to the sum of forested, wetland and low intensity development loadings. The adjusted load allocation (ALA) represents the remaining portion of the LA to be distributed among agricultural, transitional land and stream bank uses receiving load reductions. The TMDL developed for the sediment-impaired segments of Slate Lick Run established a reduction in the current sediment loading to 48.2%.

Introduction

Slate Lick Run is currently considered a Cold Water Fishery (CWF), (PA Code 25 § 93.9o), § 93.4b(a). The designation of CWF provides for the maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat. It is also designated as Migratory Fishery (MF) which provides the passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which move to or from flowing waters to complete their life cycle in other waters.

This Total Maximum Daily Load (TMDL) calculation has been prepared for all sediment-impaired segments in the Slate Lick Run Watershed (Figure 1.-2., Page 13-14, and Figure 5., Page 21). The headwaters are located near the town of St. Augustine, Clearfield Township, Cambria County. Slate Lick Run, including all its tributaries, make up approximately 40.21 stream miles downstream to the Glendale Lake, Prince Gallitzin State Park and ultimately to Clearfield Creek. The entire watershed basin is approximately 14 square miles (9,044 acres). Land use in this watershed is composed of forestland (55%), agriculture (39%), including croplands and hay/pasture, and other (6% low intensity development, wetland, and transition).

The watersheds are located in State Water Plan (SWP) Subbasin 08B and within Hydrologic Unit Code (HUC) 02050201- Upper West Branch Susquehanna. The Slate Lick Run Watershed is within the nutrient rich Piedmont physiographic province with an elevation range of over 2000 feet to less than 1460 feet. The generally, low gradient drainage amongst sloping hills with minimally vegetated agricultural areas creates excess runoff during precipitation events. The unsuccessful sediment transport consecutively downstream causes inundation of benthic habitat to the point of biological impairment. The TMDL was completed to address the impairments noted on the 2008 Pennsylvania 303(d) and Integrated Water Quality Monitoring and Assessment Report, required under the Clean Water Act, and covers the listed segments shown in Table 2 and Attachment C. The TMDL addresses siltation from croplands, hay/pasture lands, and transitional lands.

Table 2. Integrated Water Quality Monitoring and Assessment Report Listed Segments				
State Water Plan (SWP) Subbasin: 08B				
HUC: 02050201 – Upper West Branch Susquehanna				
Watershed – Slate Lick Run				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Agriculture	Siltation	40.21	CWF, MF	Aquatic Life

HUC = Hydrologic Unit Code
CWF = Cold Water Fishery, MF = Migratory Fishes
The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.
See Attachments C, "Pennsylvania Integrated Water Quality Monitoring and Assessment Report: Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL" for more information on the listings and listing process.

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 United States Environmental Protection Agency's (EPA) implementing regulations (40 CFR 130) require:

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

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

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

Pennsylvania Clean Streams Law Requirements and Agricultural Operations

All Pennsylvania farmers are subject to the water quality regulations authorized under the Pennsylvania Clean Streams Law, Title 25 Environmental Protection, and found within Chapters 91-93, 96, 102 and 105. These regulations include topics such as manure management, Concentrated Animal Operations (CAOs), Concentrated Animal Feeding Operations (CAFOs), Pollution Control and Prevention at Agricultural Operations, Water Quality Standards, Water Quality Standards Implementation, Erosion and Sediment Control Requirements, and Dam Safety and Waterway Management. To review these regulations, please refer to http://pacode.com/ or the Pennsylvania Water Quality Action Packet for Agriculture which is supplied by the County Conservation Districts. To find your County Conservation District's contact information, please refer to http://pacd.org/ or call any DEP office or the Pennsylvania Conservation Districts Headquarters at 717-238-7223.

Integrated Water Quality Monitoring and Assessment Report, List 5, 303(d), Listing Process

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be listed in the Integrated Water Quality Monitoring and Assessment Report. Prior to 2004 the impaired waters were found on the 303(d) List; from 2004 to present, the 303(d) List was incorporated into the Integrated Water Quality Monitoring and Assessment Report and found on List 5. Please see Table 3. below for a breakdown of the changes to listing documents and assessment methods through time.

With guidance from EPA, the states have developed methods for assessing the waters within their respective jurisdictions. From 1996-2006, the primary method adopted by the Pennsylvania Department of Environmental Protection for evaluating waters found on the 303(d) lists (1998-2002) or in the Integrated Water Quality Monitoring and Assessment Report (2004-2006) was the Statewide Surface Waters Assessment Protocol (SSWAP). SSWAP was a modification of the EPA Rapid Bioassessment Protocol II (RPB-II) and provided a more consistent approach to assessing Pennsylvania's streams.

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

The listings found in the Integrated Water Quality Monitoring and Assessment Reports from 2008 to present were derived based on the Instream Comprehensive Evaluation protocol (ICE). Like the SSWAP protocol that preceded the ICE protocol, the method requires selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. All the biological surveys include D-frame kicknet sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples are returned to the laboratory where the samples are then subsampled to obtain a benthic macroinvertebrate sample of 200 + or – 20% (160 to 240). The benthic macroinvertebrates in this subsample were then identified to the generic level. The ICE protocol is a modification of the EPA Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP.

After these surveys (SSWAP, 1998-2006 lists or ICE, 2008-present lists) were completed, the biologist determined the status of the stream segment. The decision was based on the performance of the segment using a series of biological metrics. If the stream segment was classified as impaired, it was then listed on the state's 303(d) List or presently the Integrated Water Quality Monitoring and Assessment Report with the source and cause documented.

Once a stream segment is listed as impaired, a TMDL must be developed for it. A TMDL addresses only one pollutant. If a stream segment is impaired by multiple pollutants, all of those pollutants receive separate and specific TMDLs within that stream segment. In order for the TMDL process to be most effective, adjoining stream segments with the same source and cause listing are addressed collectively on a watershed basis.

Table 3. Impairment Documentation and Assessment Chronology		
Listing Date	Listing Document	Assessment Method
1998	303(d) List	SSWAP
2002	303(d) List	SSWAP
2004	Integrated List	SSWAP
2006	Integrated List	SSWAP
2008-Present	Integrated List	ICE

Integrated List= Integrated Water Quality Monitoring and Assessment Report
SSWAP= Statewide Surface Waters Assessment Protocol
ICE= Instream Comprehensive Evaluation Protocol

Basic Steps for Determining a TMDL

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

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using EPA approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Submit draft report for public review and comments; and
6. EPA approval of the TMDL.

TMDL Elements (WLA, LA, MOS)

A TMDL equation consists of a wasteload allocation, load allocation and a margin of safety. The wasteload allocation (WLA) is the portion of the load assigned to point sources (National Pollutant Discharge Elimination System (NPDES) permitted discharges). The load allocation (LA) is the portion of the load assigned to nonpoint sources (non-permitted). The margin of safety (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).

Future TMDL Modifications

In the future, the Department may adjust the load and/or wasteload allocations in this TMDL to account for new information or circumstances that are developed or 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 load and wasteload allocation will only be made following an opportunity for public participation. A wasteload allocation 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 once the total changes exceed 1% 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 load allocations will be met. The Department will notify EPA 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 EPA 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 water quality standards (WQS).
- Non-attainment of WQS with implementation of the TMDL.
- Allocation transfers in trading programs.

Changes in TMDLs That May Not Require EPA Approval

- Total loading shift less than or equal to 1% 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.

TMDL Approach

The TMDL developed for the Slate Lick Run Watershed addresses sediment. Because neither Pennsylvania nor EPA has water quality criteria for sediment, a method was developed to determine water quality objectives for this pollutant that should result in the impaired stream segments attaining their designated uses. The method employed for this TMDL is termed the "Reference Watershed Approach".

Selection of the Reference Watershed

The reference watershed approach was used to estimate the appropriate sediment loading reduction necessary to restore healthy aquatic communities to the Slate Lick Run Watershed. This approach is based on selecting a non-impaired, or reference, watershed and estimating its current loading rates for the pollutants of interest. The objective of the process is to reduce loading rates of those pollutants identified as causing impairment to a level equivalent to or lower than the loading rates in the reference watershed. Achieving the appropriate load reductions should allow the return of a healthy biological community to affected stream segments.

First, there are three factors that should be considered when selecting a suitable reference watershed: impairment status, similarity of physical properties, and size of the watershed. A watershed that the Department has assessed and determined to be attaining water quality standards should be used as the reference. Second, a watershed that closely resembles the impaired watershed in physical properties such as land use/land cover, physiographic province, elevation, slope and geology should be chosen. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area.

The search for a reference watershed that would satisfy the above characteristics was done by means of a desktop screening using several GIS shapefiles, including a watershed layer, geologic formations layer, physiographic province layer, soils layer, Landsat-derived land cover/use grid, and the stream assessment information found on the Department's Instream Comprehensive Evaluation Protocol (ICE) GIS-based website. The suitability of the chosen watershed was confirmed through discussions with Department staff as well as through field verification of conditions.

North Witmer Run was selected as the reference watershed for developing the Slate Lick Run Watershed TMDL (Figure 1., page 13, Figure 3., Page 15, and Figure 46., page 43). North Witmer Run is also designated as a Cold Water and Migratory Fishery (CWF, MF). The watershed is located in the Piedmont physiographic province in State Water Plan (SWP) sub-basin 08B, HUC: 02050201 – Upper West Branch Susquehanna River. North Witmer Run is identified in ICE as attaining its designated aquatic life uses (CWF, MF). The attainment of designated uses is based on biological sampling done by the Department.

North Witmer Run was compared to the impaired Slate Lick Run and flow within Chest and Jordan Townships, Cambria County. Table 4., compares the respective impaired and reference watersheds in terms of size, location, and other physical characteristics.

Table 4. Comparison of Slate Lick R. (impaired) and North Witmer R. (reference)

	Slate Lick Run	North Witmer Run
Physiographic Province	Piedmont	Piedmont
Area (acres)	9,044	9,155
Land Use Distribution		
% Agriculture	39	37
% Forest	55	61
% Other	6	2
Dominant Soils: Group B	100	100
Surface Geology: Schist	100	100
Average Rainfall (in.)	46.12, 19 years	45.56, 19 years
Average Runoff (in.)	3.64, 19 years	2.87, 19 years

The analysis of value counts for each pixel of the Multi-Resolution Land Characterization (MRLC) grid revealed that land cover/use distributions in both watersheds are similar. Forest is the dominant land use in both watersheds. Slate Lick Run and North Wtimer Run lie within the Piedmont Upland Physiographic Province. Surface geology in the watershed consists mainly of metamorphic rocks called schists. This geology has little influence on the sediment loads to either watershed.

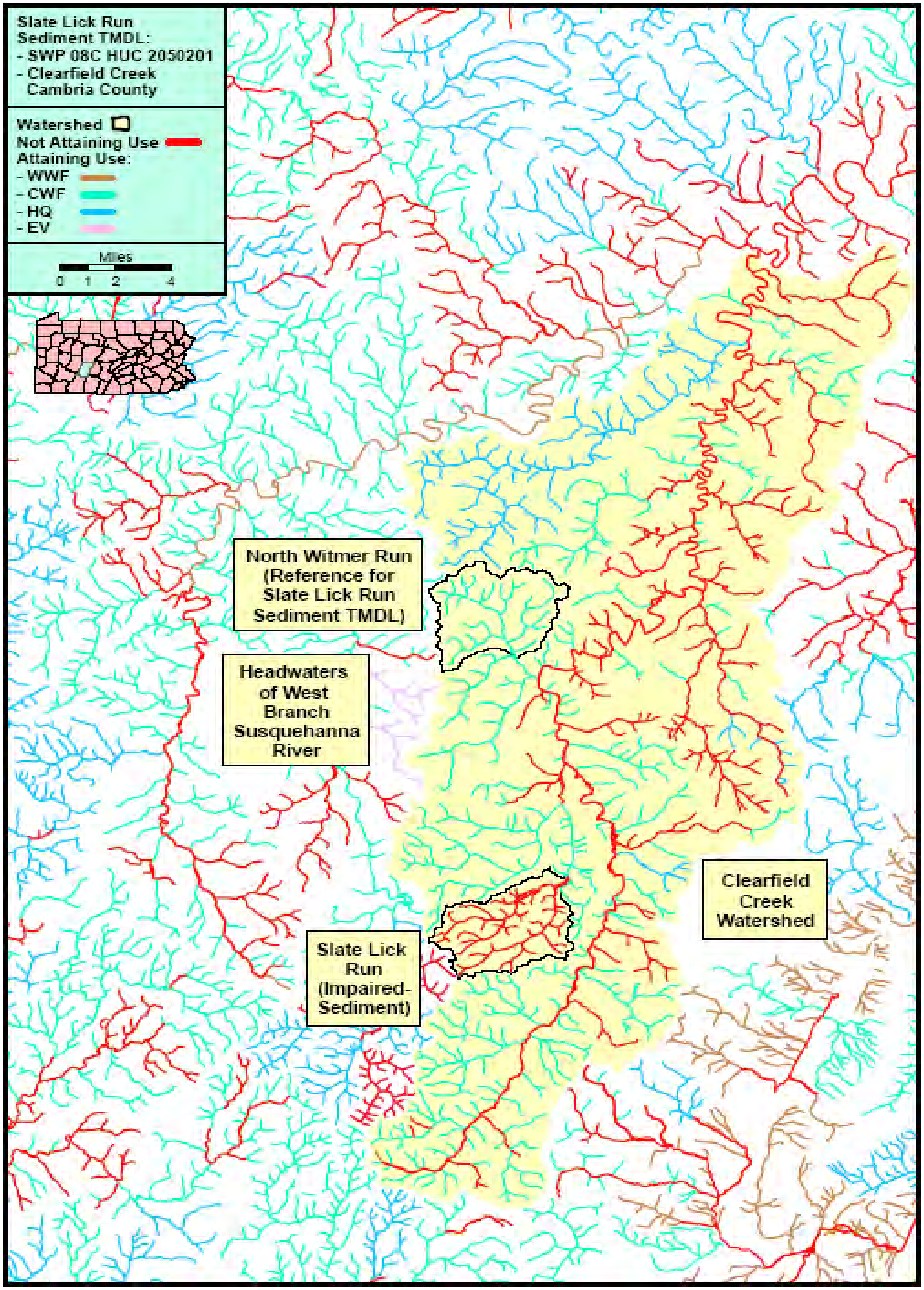


Figure 1. – Overview map of the Slate Lick Run Watershed impaired by sediment and its corresponding non-impaired, reference watershed North Witmer Run (tributaries to Clearfield Creek and the West Branch Susquehanna River, Cambria County)

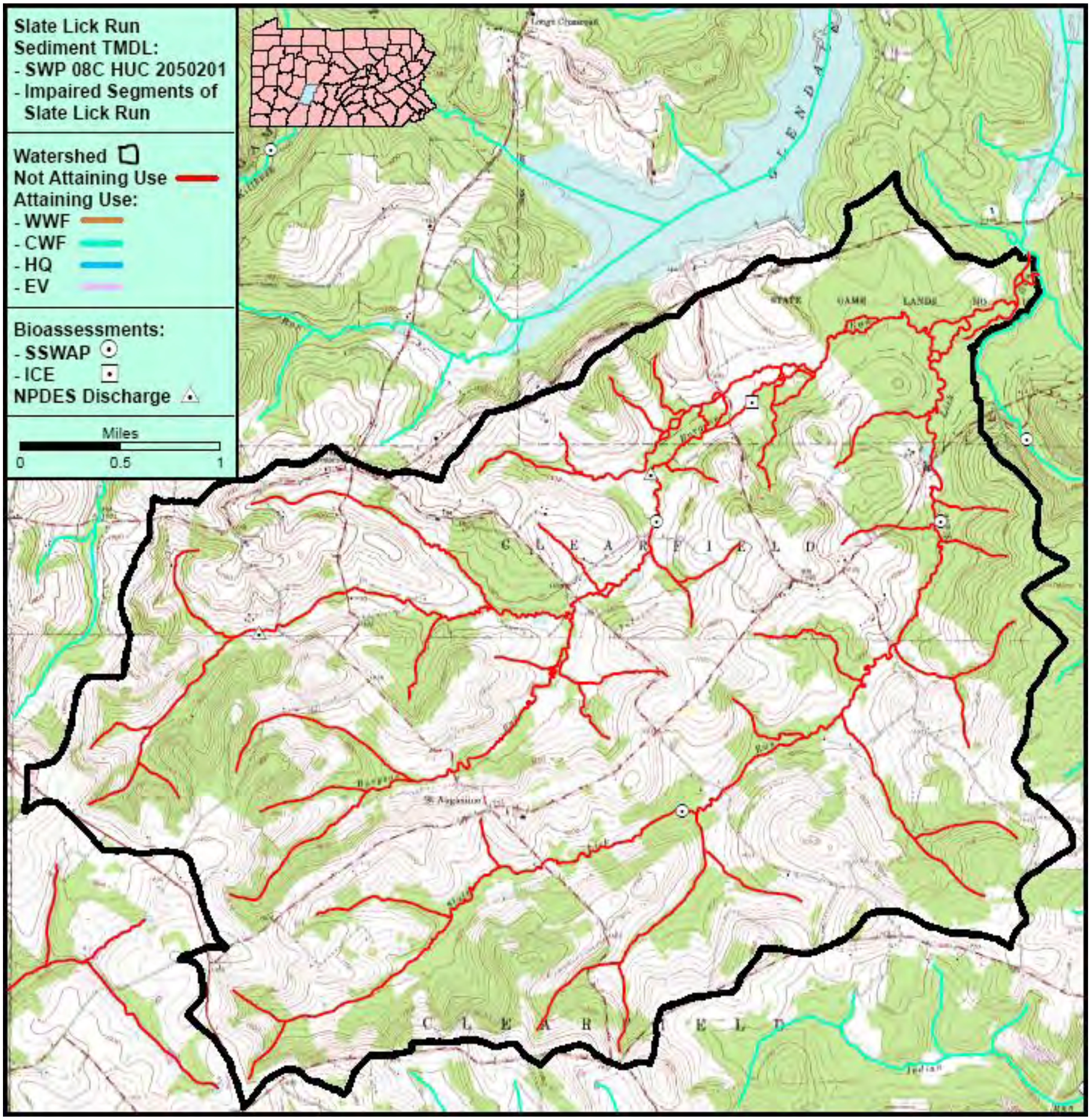


Figure 2. – Topography map of the Slate Lick Run (impaired)

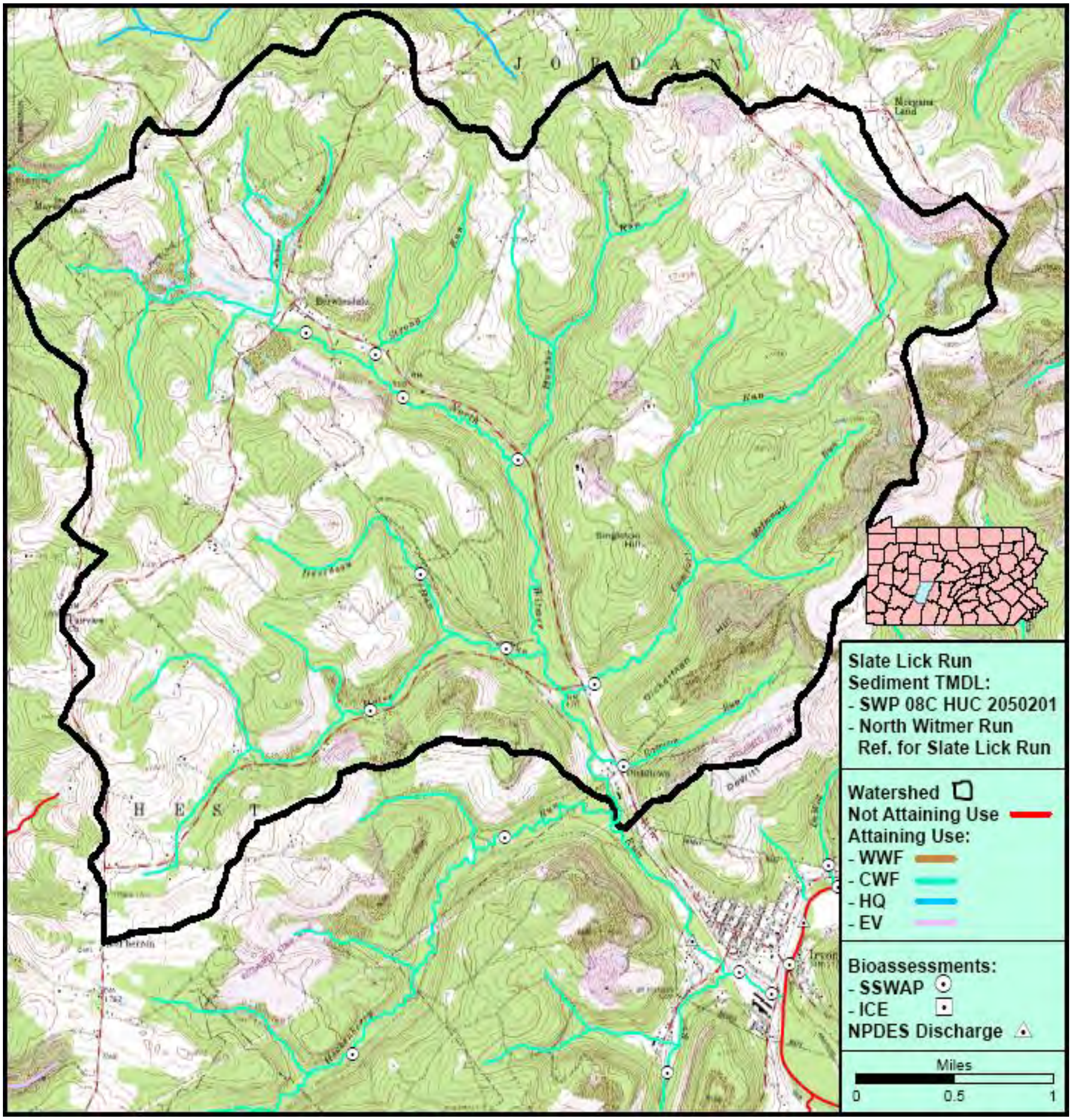


Figure 3. – Topography map of North Witmer Run (reference for Slate Lick Creek)

Hydrologic / Water Quality Modeling

Part 1. Model Overview & Data Compilation

The TMDL for this watershed was calculated using the ArcView Generalized Watershed Loading Function (AVGWLF) Interface for Windows, version 7.2.3. The remaining paragraphs in this section are excerpts from the GWLF User's Manual (Haith et al., 1992).

The core watershed simulation model for the AVGWLF software application is the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker. The original DOS version of the model was re-written in Visual Basic by Evans et al. (2002) to facilitate integration with ArcView, and tested extensively in the U.S. and elsewhere.

The GWLF model provides the ability to simulate runoff and sediment load from a watershed given variable-size source areas (i.e., agricultural, forested, and developed land). It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment loads based on the daily water balance accumulated to monthly values.

GWLF is considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each source area into a watershed total; in other words there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

With respect to the major processes simulated, GWLF models surface runoff using the Soil Conservation Service Curve Number, or SCS-CN, approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (i.e., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacity, which is based on average daily runoff, is then applied to the calculated erosion to determine sediment yield for each source area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values.

For execution, the model requires two separate input files containing transport and weather-related data. The transport (transport.dat) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The weather (weather.dat) file contains daily average temperature and total precipitation values for each year simulated.

Since its initial incorporation into AVGWLF, the GWLF model has been revised to include a number of routines and functions not found in the original model. For example, a significant revision in one of the earlier versions of AVGWLF was the inclusion of a streambank erosion routine. This routine is based on an approach often used in the field of geomorphology in which monthly streambank erosion is estimated by first calculating a watershed-specific lateral erosion rate (LER). After a value for LER has been computed, the total sediment load generated via streambank erosion is then calculated by multiplying the above erosion rate by the total length of streams in the watershed (in meters), the average streambank height (in meters), and the average soil bulk density (in kg/m3).

The inclusion of the various model enhancements mentioned above has necessitated the need for several more input files than required by the original GWLF model, including a "scenario" (*.scn) file, an animal data (animal.dat) file. Also, given all of the new and recent revisions to the model, it has been renamed "GWLF-E" to differentiate it from the original model.

As alluded to previously, the use of GIS software for deriving input data for watershed simulation models such as GWLF is becoming fairly standard practice due to the inherent advantages of using GIS for manipulating spatial data. In this case, a customized interface developed by Penn State University for ArcView GIS software (versions 3.2 or 3.3) is used to parameterize input data for the GWLF-E model. In utilizing this interface, the user is prompted to load required GIS files and to provide other information related to various "non-spatial" model parameters (e.g., beginning and end of the growing season; the months during which manure is spread on agricultural land, etc.). This information is subsequently used to automatically derive values for required model input parameters which are then written to the appropriate input files needed to execute the GWLF-E model. Also accessed through the interface are Excel-formatted weather files containing daily temperature and precipitation information. (In the version of AVGWLF used in Pennsylvania, a statewide weather database was developed that contains about twenty-five (25) years of temperature and precipitation data for seventy-eight (78) weather stations around the state). This information is used to create the necessary weather.dat input file for a given watershed simulation.

Part 2. GIS Based Derivation of Input Data

The primary sources of data for this analysis were geographic information system (GIS) formatted databases and shapefiles. In using the AVGWLF interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g. beginning and end of growing season, manure spreading period, etc.). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography and physiography; and includes location-specific default information such as cropping practices. Complete GWLF-formatted weather files are also included for the seventy-eight weather stations around the state.

Table 5. lists GIS datasets and shapefiles used for the Slate Lick Run Sediment TMDL calculations via AVGWLF and provides explanations of how they were used for development of the input files for the GWLF model.

Table 5. GIS Datasets	
DATASET	**DESCRIPTION**
county.shp	The county boundaries coverage lists data on conservation practices which provides C and P values in the Universal Soil Loss Equation (USLE).
padem	100 meter digital elevation model; this is used to calculate landslope and slope length.
palumrlc	A satellite image derived land cover grid which is classified into 15 different landcover categories. This dataset provides landcover loading rates for the different categories in the model.
physprov.shp	A shapefile of physiographic provinces. This is used in rainfall erosivity calculations.
smallsheds.shp	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
streams.shp	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
PAgeo	A shapefile of the surface geology used to compare watersheds of similar qualities.
weathersta.shp	Historical weather files for stations around Pennsylvania to simulate flow.
soils.shp	A shapefile providing soil characteristics data. This is used in multiple calculations.
zipcodes.shp	This shapefile provides animal density numbers used in the LER calculation.

In the GWLF model, the nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It is also affected by farming practices utilized in the area. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

Areal extent of different land use/cover categories: This is calculated directly from a GIS layer of land use/cover.

Curve number: This determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type, and is calculated directly using digital land use/cover and soils layers.

K factor: This factor relates to inherent soil erodibility, and affects the amount of soil erosion taking place on a given unit of land.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, the crops grown and the cultivation practices utilized largely control this factor. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.
P factor: This factor is directly related to the conservation practices utilized in agricultural areas. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment that is delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This relates to the amount of water that can be stored in the soil and affects runoff and infiltration. It is calculated using a digital soils layer.

Other less important factors that can affect sediment loads in a watershed are also included in the model.

The above parameter descriptions were taken from the *AVGWLF Version 7.1 Users Guide* (Evans et al., 2007).

Watershed Assessment and Modeling

The AVGWLF model was used to establish existing loading conditions for the sediment-impaired segments of Slate Lick Run Watershed and its corresponding non-impaired, reference watershed North Witmer Run. All AVGWLF data and outputs have been attached to this TMDL as Attachment B. Department staff visited the impaired and reference watershed to get a better understanding of existing conditions that might influence the AVGWLF model. General observations (see aerial maps and field photographs, pages 19-__), of the individual watershed characteristics of Slate Lick Run and North Witmer Run included:

Slate Lick Run (impaired)

- Minimally vegetated, cropland, sloping to stream
- Trees growing from unconsolidated banks
- Riparian and riverine wetland development
- Sediment inundation/biologically unproductive benthic habitat and pooling
- Pastureland sloping to minimally vegetated riparian zone
- Livestock trampled stream banks
- Banks vulnerable to sediment build up during low flow
- High prone erosion with slumping banks

North Witmer Run (reference)

- Forested riparian buffering, some sloping to stream
- Well-developed and variety riffle/run substrate
- Clear water and successful sediment transport downstream
- Biologically productive benthic habitat

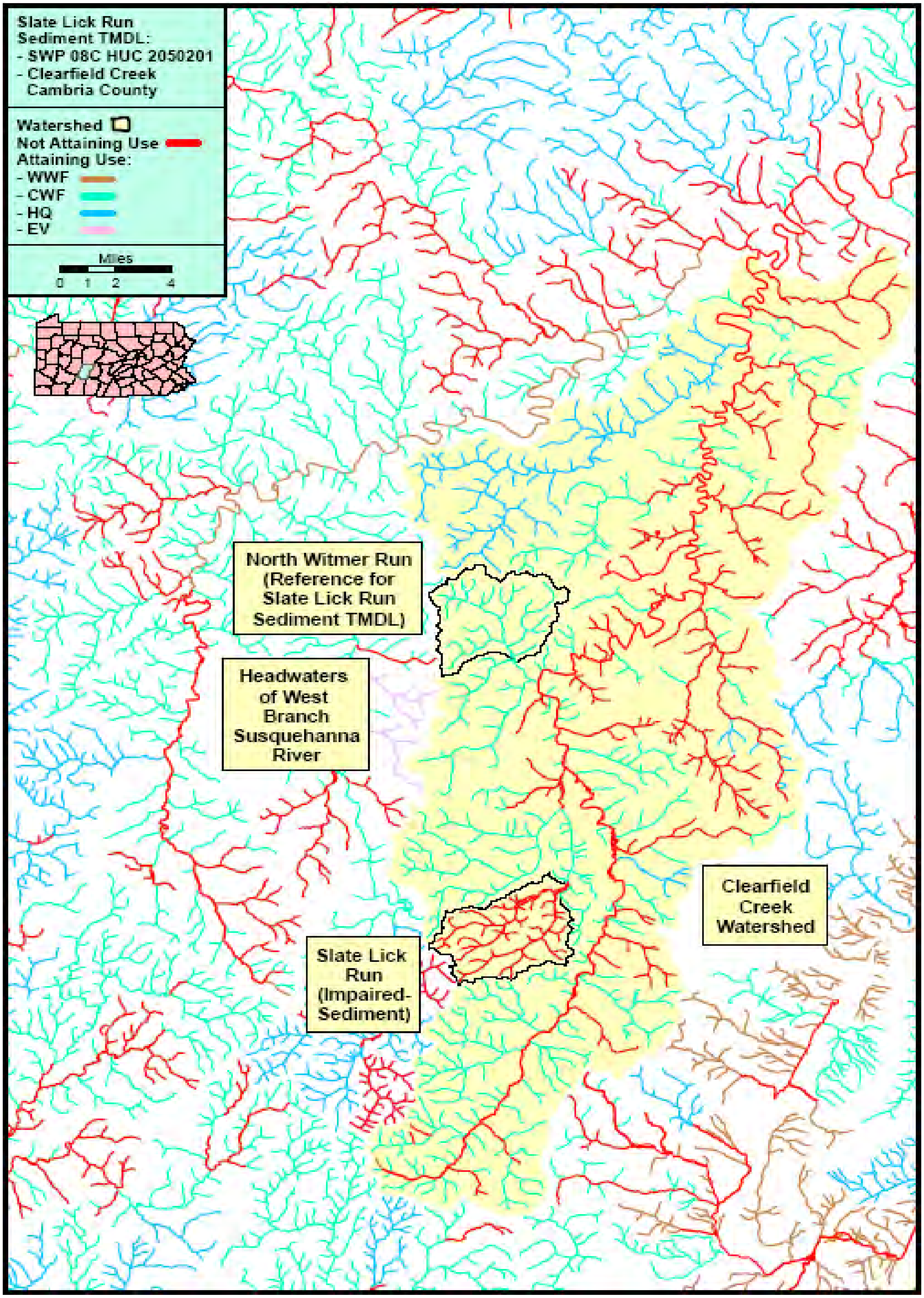
Based on field observations adjustments may be made to specific parameters used in the AVGWLF model. These adjustments were as follows:

Slate Lick Run

- No changes to the model were necessary for the Slate Lick Run.

North Witmer Run

- No changes to the model were necessary for the North Witmer Run.



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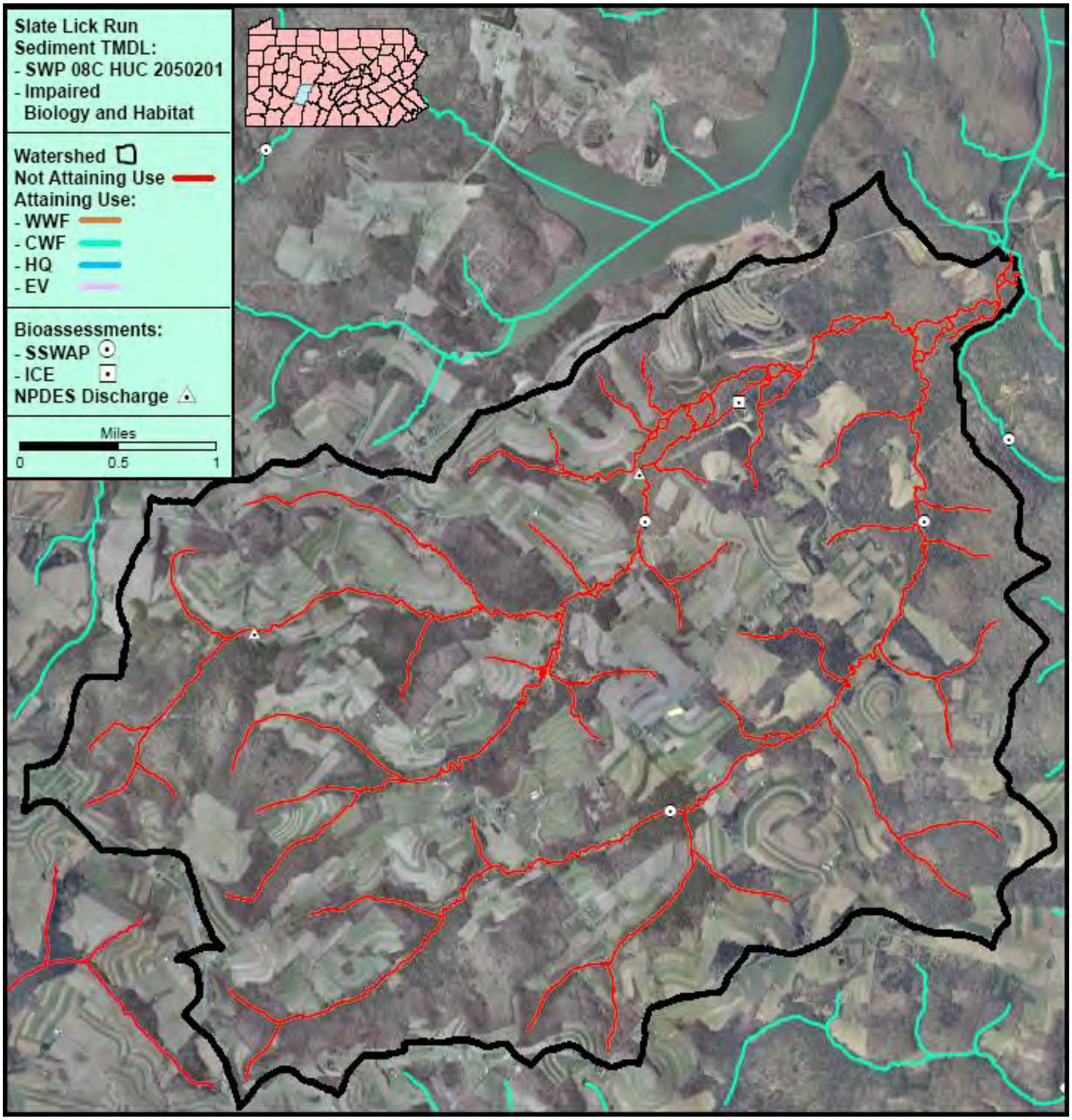

Figure 5. – Aerial map of the Slate Lick Run (impaired)

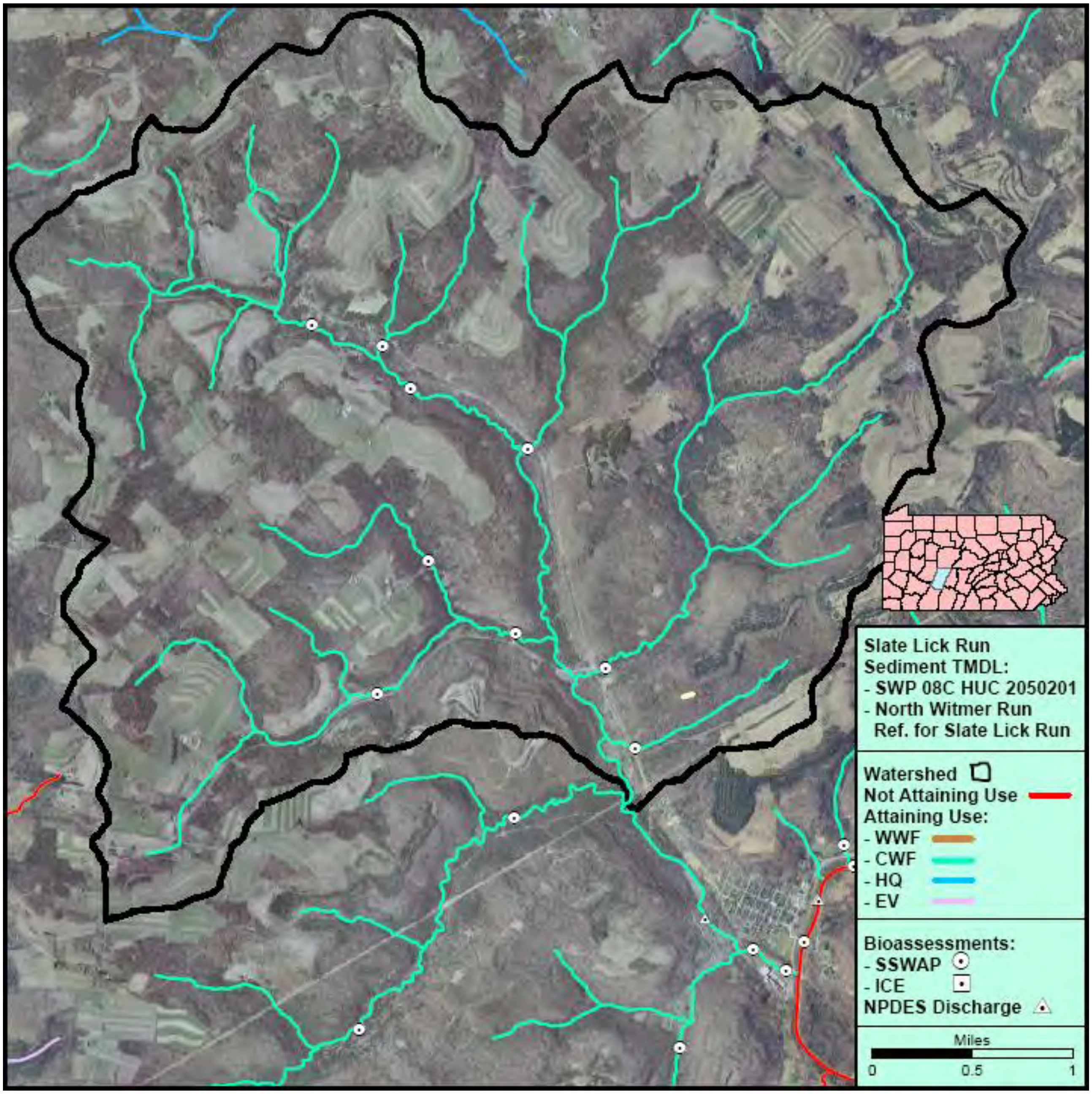

Figure 6. – Aerial map of North Witmer Run
(reference for Slate Lick Run)

Figure 7. – Minimally vegetated cropland sloping to right side bank, headwaters tributary to Burgoon Run (looking upstream)

Figure 8. – Willow and aspen growing from unconsolidated banks, headwaters tributary to Burgoon Run (looking upstream)

Figure 9. – Silty substrate with pooling,
headwaters tributary to Burgoon Run (looking downstream)

Figure 10. – Minimally vegetated cropland slope and willow/red osier dogwood wetland,
left side bank, headwaters tributary of Burgoon Run (looking downstream)

Figure 11. – Close-up view of minimally vegetated cropland slope,
left side bank, headwaters tributary of Burgoon Run (looking downstream)

Figure 12. – Minimally vegetated cropland slope,
right side bank, headwaters tributary of Burgoon Run (looking downstream)

Figure 13. – Further downstream the headwaters tributary of Burgoon Run meandering thru willow/locust wetland, minimally vegetated cropland slope (background), (looking upstream)

Figure 14. – Silty substrate with glide and pools,
further downstream the headwaters tributary of Burgoon Run, (looking upstream)

Figure 15. – Further downstream the headwaters tributary of Burgoon Run, minimally vegetated cropland slope in background, (looking downstream)

Figure 16. – Further downstream the headwaters tributary of Burgoon Run, meandering thru willow/locust wetland, (looking downstream)

Figure 17. – Pastureland sloping to the left side bank and minimal riparian zone, headwaters of Burgoon Run (looking upstream)

Figure 18. – Closer view of pastureland sloping to the left side bank, headwaters of Burgoon Run (looking upstream)

Figure 19. – Slumping right side bank, high prone erosion, and willow trees growing out of sediment hummocks, headwaters of Burgoon Run (looking upstream)

Figure 20. – Close up view of slumping right side bank and high prone erosion, headwaters of Burgoon Run (looking upstream)

Figure 21. – Active pastureland and tramped down banks,
headwaters of Burgoon Run (looking downstream)

Figure 22. – Close up view of tramped down bank and sediment build up,
headwaters of Burgoon Run (looking downstream)

Figure 23. – Minimal sediment transport and bank build up; riparian red osier wetlands, mid-stream and below confluence of headwaters of Burgoon Run (looking upstream)

Figure 24. – Sediment inundation and biologically unproductive substrate mid-stream and below confluence of headwaters of Burgoon Run (looking upstream)

Figure 25. – Minimally vegetated cropland (background) sloping to banks;
sediment accumulation on banks and in stream,
mid-stream and below confluence of headwaters of Burgoon Run (looking downstream)

Figure 26. – Sediment accumulation on banks and in-stream; riparian wetland
above the mouth of Burgoon Run and confluence with Slate Lick Run (looking upstream)


Figure 27. – Sediment accumulation on banks and in-stream; riparian wetland above the mouth of Burgoon Run and confluence with Slate Lick Run (looking downstream)

Figure 28. – Minimally vegetated cropland sloping to bank,
headwaters of Slate Lick Run (looking upstream)

Figure 29. – Headwaters of Slate Lick Run meandering thru red osier dogwood wetland
(looking upstream)

Figure 30. – Sediment inundation from unconsolidated and unvegetated banks, headwaters of Slate Lick Run (looking downstream)

Figure 31. – Cropland sloping down to banks; red osier dogwood wetland adjacent and in stream, headwaters of Slate Lick Run (looking downstream)

Figure 32. – Minimally vegetated cropland (background left) sloping down to small riparian zone of willow/red osier dogwood, mid-section of Slate Lick Run (looking upstream)

Figure 33. – Minimally vegetated cropland (background right) sloping down to small riparian zone of willow/red osier dogwood, mid-section of Slate Lick Run (looking downstream)

Figure 34. – Closer view of cropland (note cows) sloping down to right bank, mid-section of Slate Lick Run (looking downstream)

Figure 35. – Sediment inundation of a variety of substrate, mid-section of Slate Lick Run (looking downstream)

Figure 36. – Cropland (note farm) sloping down to banks; red osier dogwood wetland adjacent and in stream, mid-section of Slate Lick Run (looking downstream)

Figure 37. – Minimally vegetated cropland sloping down to slumping banks, further downstream, mid-section of Slate Lick Run (looking upstream)

Figure 38. – Sediment inundation and biologically unproductive substrate, further downstream, mid-section of Slate Lick Run (looking upstream)

Figure 39. – Minimally vegetated cropland sloping down to slumping to right bank, further downstream, mid-section of Slate Lick Run (looking downstream)

Figure 40. – Zoomed out view of minimally vegetated cropland sloping down to slumping to right bank, further downstream, mid-section of Slate Lick Run (looking downstream)

Figure 41. – Minimally vegetated cropland sloping down to slumping to left bank, further downstream, mid-section of Slate Lick Run (looking downstream)

Figure 42. – Minimally vegetated cropland sloping down to slumping banks,
above mouth of Slate Lick Run and confluence of Burgoon Run (looking upstream)

Figure 43. – Sediment inundation and biologically unproductive substrate,
above mouth of Slate Lick Run and confluence of Burgoon Run (looking upstream)

Figure 44. – Bank slumping and high prone area for erosion,
above mouth of Slate Lick Run and confluence of Burgoon Run (looking downstream)

Figure 45. – Open water and riparian wetlands, mouth of Slate Lick Run into Glendale Lake,
Prince Gallitzin State Park (looking downstream)

Figure 46. – Open water and riparian wetlands, mouth of Slate Lick Run into Glendale Lake (coming from upper right), Prince Gallitzin State Park (looking downstream)

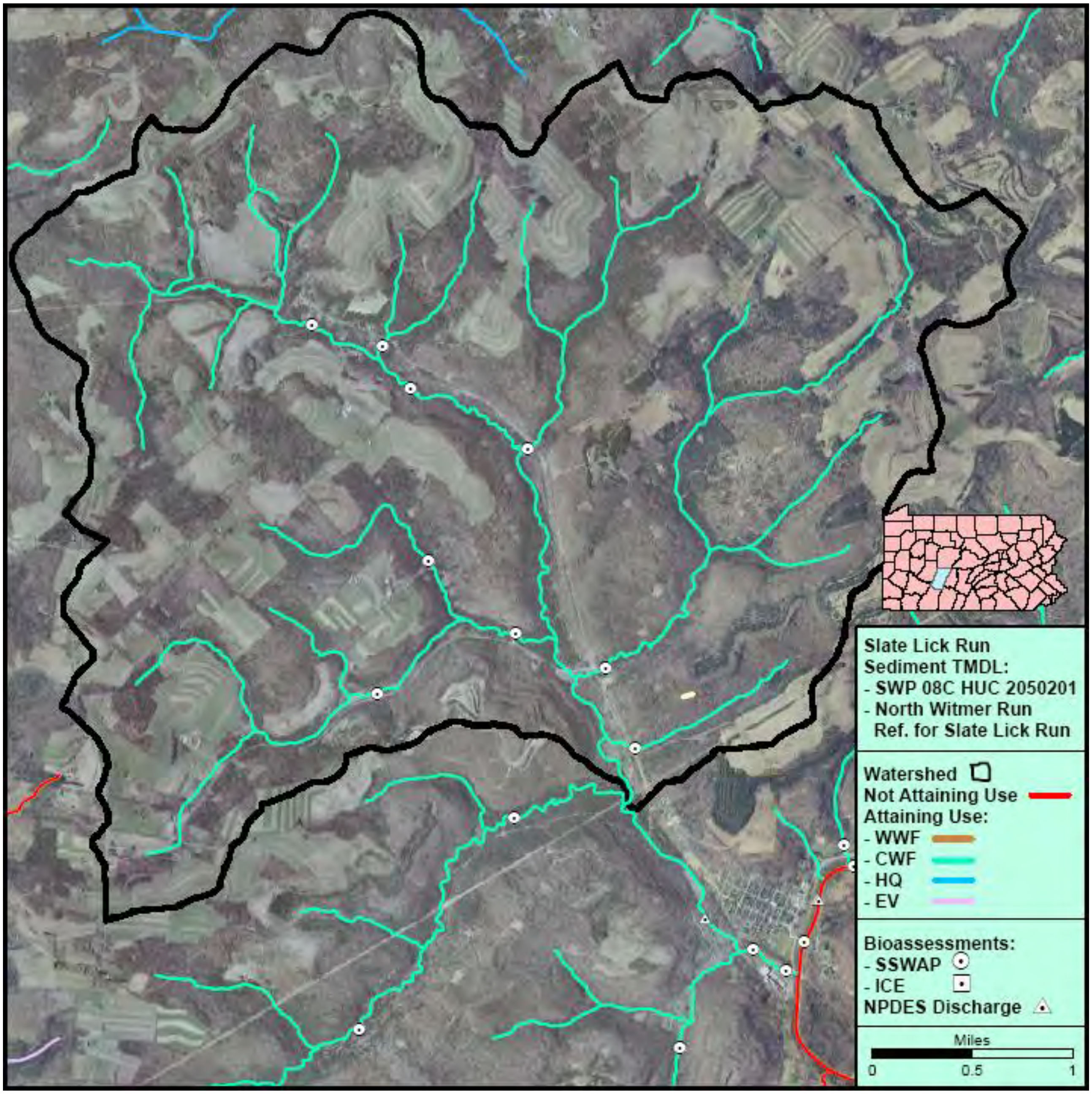

Figure 47. – Aerial map of North Witmer Run
(reference for Slate Lick Run)

Figure 48. – Well-developed riparian zone and riffle/run habitat, headwaters of North Witmer Run (looking upstream)

Figure 49. – Well-developed riparian zone and riffle/run habitat, headwaters of North Witmer Run (looking downstream)

Figure 50. – Well-developed riparian zone and riffle/run habitat, Strong Run, Tributary of North Witmer Run (looking upstream)

Figure 51. – Young aspen and cherry riparian zone and good sediment transport, Hunter Run, Tributary of North Witmer Run (looking upstream)

Figure 52. – Riparian zone of grasses and young forest, headwaters of Holes Run, tributary to North Witmer Run (looking upstream)

Figure 53. – Riparian zone of hemlock/aspen and stable banks, tributary of Holes Run, tributary to North Witmer Run (looking upstream)

Figure 54. – Riparian zone of hemlock and successful sediment transport, tributary of Holes Run, tributary to North Witmer Run (looking downstream)

Figure 55. – Clear water and well-developed benthic substrate, tributary of Holes Run, tributary to North Witmer Run

Figure 56. – Well-developed riparian zone of hemlock and riffle/run substrate, mouth of Holes Run, tributary to North Witmer Run (upstream upstream)

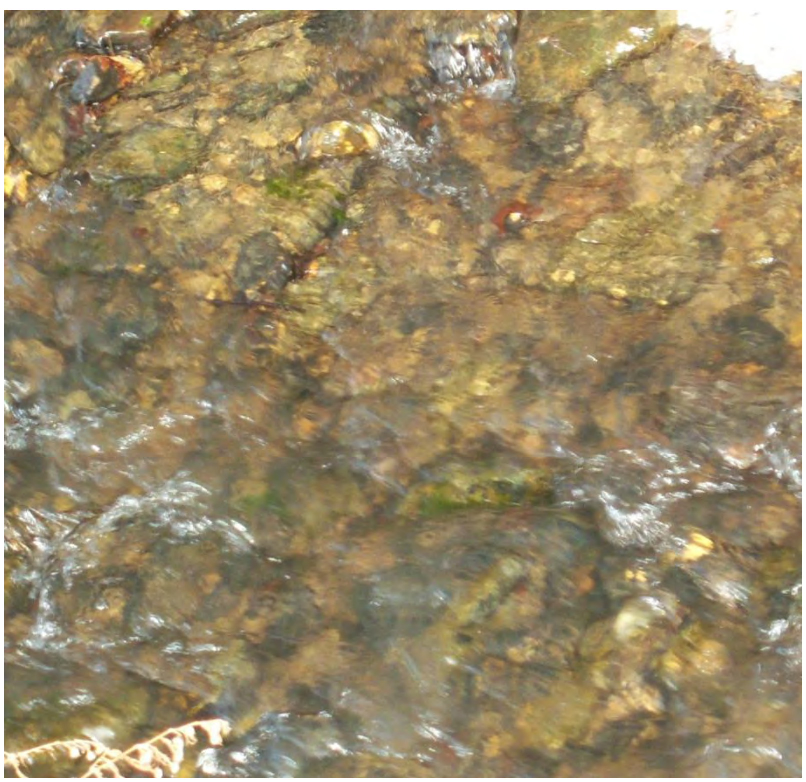

Figure 57. – Clear water and biologically productive benthic habitat, mouth of Holes Run, tributary to North Witmer Run

Figure 58. – Rooted steep banks and successful sediment transport,
mouth of Comfort Run, tributary to North Witmer Run (looking upstream)

Figure 59. – Clear water and biologically productive benthic habitat,
mouth of Comfort Run, tributary to North Witmer Run

The AVGWLF model produced area information and sediment loading based on land use (Table 6. for impaired segments and Table 7. for reference segments)

Table 6. Existing Loading Values for Slate Lick Run (impaired)			
Source	Area (ac)	Sediment (lbs)	Unit Area Load (lbs/ac/yr)
HAY/PAST	1,665.5	357,200.0	214.5
CROPLAND	1,870.6	3,678,400.0	1,966.4
FOREST	4,966.8	33,600.0	6.8
WETLAND	116.1	200.0	1.7
TRANSITION	9.9	38,800.0	3,919.2
LO_INT_DEV	415.1	64,800.0	156.1
STREAM BANK		1,092,400.0	
POINT SOURCE DISCHARGES		121.8	
Total	9,044.0	5,265,521.8	582.2

Table 7. Existing Loading Values for the North Witmer Run (reference)			
Source	Area (ac)	Sediment (lbs)	Unit Area Load (lbs/ac/yr)
HAY/PAST	2,345.0	569,800.0	243.0
CROPLAND	1,035.4	2,024,000.0	1,954.8
FOREST	5,579.6	50,400.0	9.0
WETLAND	17.3	0.0	0.0
TRANSITION	7.4	21,600.0	2,918.9
LO_INT_DEV	170.5	10,200.0	59.8
STREAM BANK		481,000.0	
Total	9,155.2	3,157,000.0	344.8

For Tables 6 and 7 the "stream bank" sediment loads are calculated by AVGWLF's stream bank routine. This routine uses stream bank (linear) miles rather than area.

Development of Sediment TMDL

The target TMDL value for the sediment-impaired segments of Slate Lick Run Watershed.was established based on current loading rates for sediment in the corresponding reference watershed of North Witmer Run. Reducing the loading rates of sediment in the headwaters of the Slate Lick Creek Watershed to levels equal to, or less than, the reference watershed should allow for the reversal of current use impairments and maintain its CWF and MF value.

As described in the previous section, sediment loading rates were computed for the reference watersheds using the AVGWLF model. The target TMDL value for sediment was determined by multiplying the unit area loading rates for the reference watershed by the total watershed area of impaired segments (Table 8).

Table 8. TMDL Values for Slate Lick Run				
Pollutant	Loading Rate in Reference (lb/ac-yr)	Total Area Impaired Watershed (ac)	Target TMDL Value (lb/yr)	Target TMDL Value (lb/day)
Sediment	344.8	9,044.0	3,118,654.8	8,544.3

The target TMDL value was then used as the basis for load allocations and reductions in Slate Lick Run, using the following two equations:

1. TMDL = WLA + LA + MOS
2. LA = ALA + LNR

where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (Point Sources)
LA = Load Allocation (Nonpoint Sources)
MOS = Margin of Safety
ALA = Adjusted Load Allocation
LNR = Loads Not Reduced

Waste Load Allocation

The waste load allocation (WLA) portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. A search of the Pennsylvania Department of Environmental Protection's (Department) efacts permit database identified two NPDES point source discharges within the Slate Lick Run Watershed. An additional allocation of 1% of the TMDL (3,118,654.8 lbs./yr.) was incorporated as a bulk reserve (31,186.5 lbs./yr.) for the dynamic nature of future permit activity.

The WLA was adjusted based on permit information for two NPDES permits, PAG046107 and PAG046148, which are single family units covered under PAG #4 (Single Family Residences). The WLA for NPDES permit number PAG046107 is derived from the permit limit of a total suspended solids (TSS) concentration of 10 mg/L (monthly average) and the design flow for 0.002 million gallons per day (mgd). The WLA for NPDES permit number PAG046148 is derived from the permit limit of a total suspended solids (TSS) concentration of 10 mg/L (monthly average) and the design flow for 0.002 million gallons per day (mgd). The WLA sum of the two point sources was adjusted at 121.8 lbs./yr. These permitted facilities along with the bulk reserve account for a waste load allocation for sediment loading at 31,308.3 lbs./yr. (Table 9).

WLA= Flow (mgd) * mg/L (monthly average)* 8.34 (conversion factor) * 365= TSS lbs./yr.

= 0.002 mgd Flow * 10 mg/L monthly average concentration* 8.34* 365= 60.88 TSS lbs./yr.

+

= 0.002 mgd Flow * 10 mg/L monthly average concentration* 8.34* 365= 60.88 TSS lbs./yr.

WLA= 121.8 lbs./yr. (WLA for NPDES permits)

WLA= 121.8 lbs./yr. (WLA for NPDES permits) + 31,186.5 lbs./yr. (1% Bulk Reserve)

WLA= 31,308.3 lbs./yr.

Margin of Safety

The margin of safety (MOS) is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment was reserved as the MOS.

Using 10% of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of Slate Lick Run. The MOS used for the sediment TMDL was set at 311,865.5 lbs./yr. for the watershed.

<u>Slate Lick Run:</u>
MOS = 3,118,654.8 lbs./yr. (TMDL) * 0.1 = 311,865.5 lbs./yr.
or
MOS = 8,544.3 lbs./day (TMDL) * 0.1 = 854.4 lbs./day

Load Allocation

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. The LA for sediment was computed by subtracting the MOS value and the WLA from the TMDL value. The LA for sediment was 2,775,481.0 lbs./yr for Slate Lick Run.

<u>Slate Lick Run:</u>
LA = 3,118,654.8 lbs./yr. (TMDL) – 311,865.5 lbs./yr. (MOS) – 31,308.3 lbs./yr. (WLA)= 2,775,481.0 lbs./yr.
or
LA = 8,544.3 lbs./day (TMDL) – 854.4 lbs./day (MOS) – 85.8 lbs./day (WLA)= 7,604.1 lbs./day

Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced (LNR)) from the LA. While the Slate Lick Run Sediment TMDL was developed to address impairments caused by agricultural activities, including pastureland and cropland, transitional land and stream banks were also considered a contributor to the sediment load in the watershed. Land uses/source loads not reduced (LNR) were carried through at their existing loading values (Table 9).

Table 9. Load Allocations, Loads Not Reduced and Adjusted Load Allocations (Slate Lick Run)

	Sediment (lbs./yr.)	Sediment (lbs./day)
Load Allocation	2,775,481.0	7,604.1
Loads Not Reduced:	98,600.0	270.1
Forest	33,600.0	92.1
Wetland	200.0	0
Low Intensity Development	64,800.0	177.5
Adjusted Load Allocation	2,676,881.0	7,333.9

TMDL Summary

The sediment TMDL established for the Slate Lick Run Watershed consists of a Load Allocation (LA) and a Margin of Safety (MOS). The individual components of the Slate Lick Run Watershed TMDL are summarized in Table 10.

Table 10. TMDL Components for Slate Lick Run		
Component	Sediment (lbs./yr.)	Sediment (lbs./day)
TMDL (Total Maximum Daily Load)	3,118,654.8	8,544.3
WLA (Waste Load Allocation)	31,308.3	85.8
MOS (Margin of Safety)	311,865.5	854.4
LA (Load Allocation)	2,775,481.0	7,604.1
LNR Loads Not Reduced)	98,600.0	270.1
ALA (Adjusted Load Allocation)	2,676,881.0	7,333.9

Calculation of Sediment Load Reductions

The adjusted load allocation established in the previous section represents the sediment load that is available for allocation between hay/pasture, cropland, transitional lands and stream banks in the Slate Lick Run Watershed. Data needed for load reduction analyses, including land use distribution, were obtained by GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method, Attachment B, was used to distribute the ALA between the three land use types and stream banks. The process is summarized below:

1. Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR. For this evaluation Cropland was in excess of the adjusted load allocation (ALA).

2. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the total allocable load. If the allocable load is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed. For this evaluation the allocable load was exceeded. The equal percent reduction, i.e., the ALA divided by the summation of the baselines, worked out to a 53.2% reduction for cropland and a 35.7% reduction for hay/pastureland, transitional, and associated stream banks.

Tables 11. (Annual Values) and 12. (Daily Values) contain the results of the EMPR for hay/pasture, cropland, transitional land and stream banks in Slate Lick Run. The load allocation for each land use is shown along with the percent reduction of current loads necessary to reach the targeted LA.

Table 11. Sediment Load Allocations/Reductions for Land Uses and Stream Banks in the Slate Lick Run (Annual Values)						
		Current Loading	Allowable Loading	Current Load	Load Allocation	
Land Use	Acres	(lbs./acre/yr.)	(lbs./acre/yr.)	(lbs./yr.)	(lbs./yr.)	% Reduction
Cropland	1,870.6	1,966.4	919.7	3,678,400.0	1,720,338.1	53.2
Hay/Pasture	1,665.5	214.5	137.8	357,200.0	229,560.0	35.7
Transitional Land	9.9	3,919.2	2,518.7	38,800.0	24,935.4	35.7
Stream bank				1,092,400.0	702,047.4	35.7

Table 12. Sediment Load Allocations/Reductions for Land Uses and Stream Banks in the Slate Lick Run (Daily Values)						
		Current Loading	Allowable Loading	Current Load	Load Allocation	
Land Use	Acres	(lbs./acre/dy)	(lbs./acre/dy)	(lbs./day)	(lbs./day)	% Reduction
Cropland	1,870.6	5.4	2.5	10,077.8	4,713.2	53.2
Hay/Pasture	1,665.5	0.6	0.4	978.6	629.0	35.7
Transitional Land	9.9	10.7	6.9	106.3	68.3	35.7
Stream bank				2,992.9	1,923.4	35.7

Consideration of Critical Conditions

The AVGWLF model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment loads, based on daily water balance accumulated in monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

Consideration of Background Contributions

The AVGWLF model accounts for all landuses within the watershed and their respective contributions to the sediment load. The only background sources of sediment within the watershed would be from forested areas. There are no additional "upstream" sources of sediment to this watershed. The remaining landuses are anthropogenic sources of sediment to the watershed, thus will not be considered background.

Recommendations

Sediment reduction in the TMDL is allocated to nonpoint sources in the watershed including: agricultural activities, transitional lands and stream banks. Implementation of best management practices (BMPs) in these affected areas are called for according to this TMDL document. The proper implementation of these BMPs should achieve the loading reduction goals established in the TMDL.

From an agricultural perspective, reductions in the amount of sediment reaching the streams in the watershed can be made through the right combination of BMPs including, but not limited to: establishment of cover crops, strip cropping, residue management, no till, crop rotation, contour farming, terracing, stabilizing heavy use areas and proper management of storm water. Vegetated or forested buffers are acceptable BMPs to intercept any runoff from farm fields. For the pasturing of farm animals and animal heavy use areas, acceptable BMPs may include: manure storage, rotational grazing, livestock exclusion fencing and forested riparian buffers. Some of these BMPs were observed in the sediment-impaired, Slate Lick Run Watershed; however, they were more extensively used in the unimpaired, reference watershed of North Witmer Run, with forested riparian buffers being the predominant BMP in use. Since both watersheds have a considerable amount of agricultural activities, it is apparent that the greater use of BMPs, especially forested riparian buffers, in the reference watershed has contributed to its ability to maintain its attainment status as a Cold Waters and Migratory Fishery (CWF, MF) stream.

Stream banks contribute to the sediment load in Slate Lick Run. Stream bank stabilization projects would be acceptable BMPs for the eroded stream banks in the area. However, the establishment of forested riparian buffers is the most economical and effective BMP at providing stream bank stabilization and protection of the banks from freeze/thaw erosion and scouring flows. Forested riparian buffers are also essential to maintaining the biologically rich yet sensitive CWF and MF habitat. Forested riparian buffers also provide important natural and durable connectivity of land and water. This connectivity is necessary to provide cover, nesting and nursery sites, shade and stable temperatures, and viable substrate for aquatic organisms of all layers of the food web protected under the CWF and MF use designation.

Important to TMDLs, established forested riparian buffers act as nutrient and sediment sinks. This is because the highly active and concentrated biological communities they maintain will assimilate and remove nutrients and sediment from the water column instead of allowing them to pass downstream, thus forested riparian buffers work directly toward attaining the goals of the TMDL by reducing pollutant loads. These forested riparian buffers also provide the essential conditions necessary to meet the CWF and MF designated uses of the waterway. Forested riparian buffers also provide critical habitat to rare and sensitive amphibious and terrestrial organisms as well as migratory species. While forested riparian buffers are considered the most effective BMP, other possibilities for attaining the desired reductions may exist for the agricultural usages, as well as for the stream banks.

For both the agricultural landuses, further ground truthing should be performed in order to assess both the extent of existing BMPs, and to determine the most cost effective and environmentally protective combination of BMPs required for meeting the sediment reductions outlined in this report. A combined effort involving key personnel from the regional DEP office, the Cambria County Conservation District, Susquehanna River Basin Commission (SRBC) and other state and local agencies and/or watershed groups would be the most effective in accomplishing any ground truthing exercises. Development of a more detailed watershed implementation plan is recommended.

Public Participation

Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* on August 25, 2012 to foster public comment on the allowable loads calculated.

Literature Cited

Haith, D. A.; Mandel, R.; Wu, R. S. for Cornell University *Generalized Watershed Loading Functions Version 2.0 User's Manual*; Ithaca, NY, 1992.

Evans, B. M.; Lehning, D. W.; Corradini, K. J. for The Pennsylvania State University *AVGWLF Version 7.1 Users Guide*; University Park, PA, 2007

Attachment A
Equal Marginal Percent Reduction Method

Equal Marginal Percent Reduction (EMPR) (An Allocation Strategy)

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The load allocation and EMPR procedures were performed using a MS Excel spreadsheet. The 5 major steps identified in the spreadsheet are summarized below:

Step 1: Calculation of the TMDL based on impaired watershed size and unit area loading rate of reference watershed.

Step 2: Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

Step 3: Actual EMPR Process:

a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.

b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

Step 4: Calculation of total loading rate of all sources receiving reductions.

Step 5: Summary of existing loads, final load allocations, and % reduction for each pollutant source.

1	TMDL				2	Adjusted LA = TMDL total load - ((MOS) - loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					2676881.0	2676881.0					
	3118654.8											
3		Annual				Recheck	% reduction	Load			Allowable	%
		Avg. Load	Load Sum	Check	Initial Adjust	Adjust	allocation	Reduction	Initial LA	Acres	Loading Rate	Reduction
	CROPLAND	3678400.0	5166800.0	bad	2676881.0		0.6	956542.8	1720338.1	1870.6	919.7	53.2%
	HAY/PASTURE	357200.0		good	357200.0	1488400.0	0.1	127640.0	229560.0	1665.5	137.8	35.7%
	TRANSITIONAL	38800.0		good	38800.0		0.0	13864.6	24935.4	9.9	2518.7	35.7%
	STREAMBANK	1092400.0		good	1092400.0		0.3	390352.6	702047.4			35.7%
					4165281.0		1.0		2676881.0			
4	All Ag. Loading Rate	556.92										
			Allowable		Current	Current						
		Acres	loading rate	Final LA	Loading Rate	Load	% Red.			CURRENT LOAD	FINAL LA	
5	CROPLAND	1870.6	919.7	1720338.1	1966.4	3678400.0	53.2%		CROPLAND	3,678,400	1,720,338	
	HAY/PASTURE	1665.5	137.8	229560.0	214.5	357200.0	35.7%		HAY/PASTURE	357,200	229,560	
	TRANSITIONAL	9.9	2518.7	24935.4	3919.2	38800.0	35.7%		TRANSITIONAL	38,800	24,935	
	STREAMBANK			702047.4		1092400.0	35.7%		STREAMBANK	1,092,400	702,047	
				2676881.0		5166800.0	48.2%					

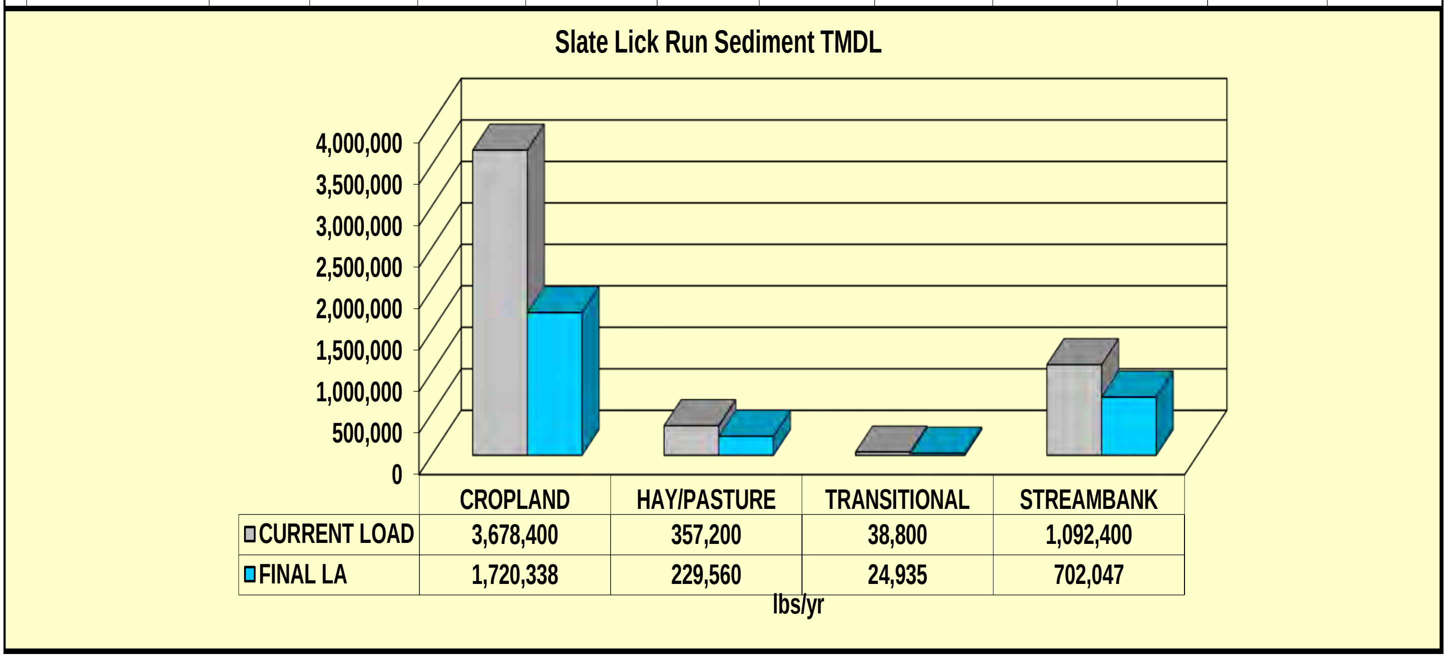

Table A1. Equal Marginal Percent Reduction calculations for Slate Lick Run

Attachment B
AVGWLF Generated Data Tables

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	674	75	0.31	1.537	0.03	0.45
Cropland	757	82	0.309	1.01	0.42	0.45
Forest	2010	73	0.303	0.744	0.002	0.45
Wetland	47	87	0.32	0.214	0.01	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
Transition	4	87	0.313	0.586	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	168	83	0.312	0.938	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.62	9.4	0	0.08	0	0
Feb	0.67	10.4	0	0.08	0	0
Mar	0.7	11.8	0	0.08	0	0
Apr	0.72	13.2	0	0.26	0	0
May	0.89	14.4	1	0.26	0	0
Jun	0.99	14.9	1	0.26	0	0
Jul	1.05	14.6	1	0.26	0	0
Aug	1.08	13.6	1	0.26	0	0
Sep	1.1	12.2	1	0.08	0	0
Oct	0.95	10.8	0	0.08	0	0
Nov	0.86	9.6	0	0.08	0	0
Dec	0.81	9.1	0	0.08	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.153	Seepage Coefficient	0
Unsat Avail Wat (cm)	16.6618	Tile Drain Ratio	0.5	Sediment A Factor	4.2191E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

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Table B1. GWLF model data inputs for the Slate Lick Run

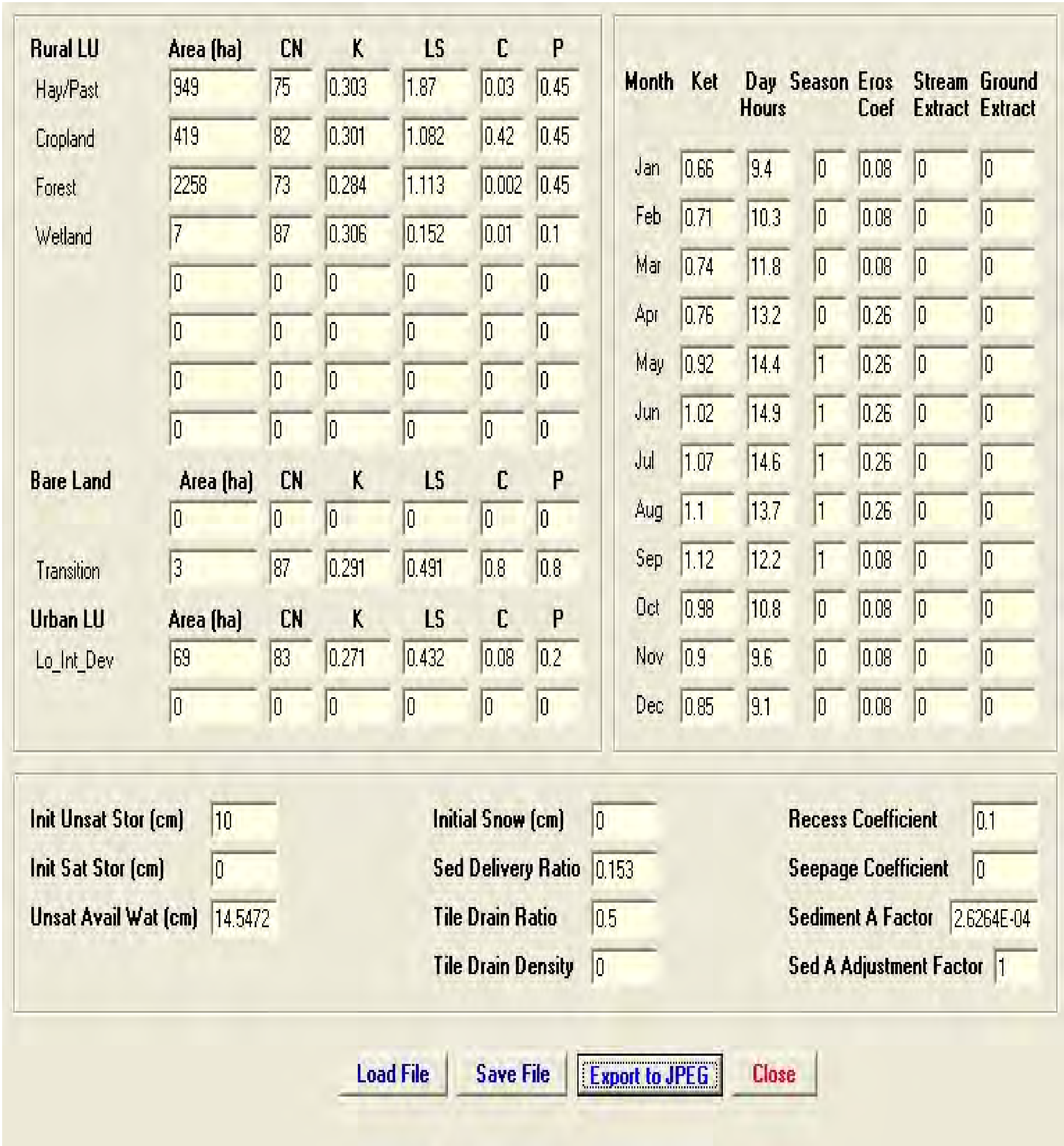
GWLF Total Loads for file: SlateLickRun-0

Period of analysis: 23 years from 1975 to 1997

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dis N	Total N	Dis P	Total P
Hay/Past	1665.5	3.2	1167.3	178.6	3085.3	4156.9	362.7	452.0
Cropland	1870.6	5.6	12020.8	1839.2	6142.0	17177.1	703.9	1623.5
Forest	4966.8	2.7	109.8	16.8	580.0	680.7	18.3	26.7
Wetland	116.1	8.6	0.9	0.1	43.2	44.0	1.4	1.4
Transition	9.9	8.6	126.5	19.4	56.2	172.3	3.9	13.6
Lo_Int_Dev	415.1	6.1	211.9	32.4	0.0	228.3	0.0	30.4
Farm Animals						0.0		0.0
Tile Drainage				0.0		0.0		0.0
Stream Bank				546.2		54.6		24.0
Groundwater					59329.7	59329.7	906.7	906.7
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					181.5	181.5	30.1	30.1
Totals	9044.0	3.60	13637.1	2632.7	69417.8	82025.1	2027.0	3108.5

Go Back | Pathogen Loads | Export to JPEG | Print | Close

Table B2. GWLF model data outputs for Slate Lick Run



Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	949	75	0.303	1.87	0.03	0.45
Cropland	419	82	0.301	1.082	0.42	0.45
Forest	2258	73	0.284	1.113	0.002	0.45
Wetland	7	87	0.306	0.152	0.01	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
Transition	3	87	0.291	0.491	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	69	83	0.271	0.432	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.66	9.4	0	0.08	0	0
Feb	0.71	10.3	0	0.08	0	0
Mar	0.74	11.8	0	0.08	0	0
Apr	0.76	13.2	0	0.26	0	0
May	0.92	14.4	1	0.26	0	0
Jun	1.02	14.9	1	0.26	0	0
Jul	1.07	14.6	1	0.26	0	0
Aug	1.1	13.7	1	0.26	0	0
Sep	1.12	12.2	1	0.08	0	0
Oct	0.98	10.8	0	0.08	0	0
Nov	0.9	9.6	0	0.08	0	0
Dec	0.85	9.1	0	0.08	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.153	Seepage Coefficient	0
Unsat Avail Wat (cm)	14.5472	Tile Drain Ratio	0.5	Sediment A Factor	2.6264E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

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Table B3. GWLF model data inputs for North Witmer Run (reference for Slate Lick Run)

GWLF Total Loads for file: NorthWitmerRun-0

Period of analysis: 19 years from 1975 to 1993

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dis N	Total N	Dis P	Total P
Hay/Past	2345.0	2.8	1862.2	284.9	3859.7	5569.2	433.8	584.3
Cropland	1035.4	5.1	6614.7	1012.0	3098.7	9171.0	341.2	875.6
Forest	5579.6	2.4	164.9	25.2	569.4	720.8	18.0	31.3
Wetland	17.3	8.0	0.1	0.0	5.9	6.0	0.2	0.2
Transition	7.4	8.0	70.4	10.8	38.7	103.4	2.7	8.4
Lo_Int_Dev	170.5	5.6	33.2	5.1	0.0	92.4	0.0	12.3
Farm Animals						0.0		0.0
Tile Drainage				0.0		0.0		0.0
Stream Bank				240.5		24.1		10.6
Groundwater					34605.5	34605.5	752.8	752.8
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					185.2	185.2	30.1	30.1
Totals	9155.2	2.90	8745.4	1578.5	42363.2	50477.4	1578.7	2305.4

Go Back | Pathogen Loads | Export to JPEG | Print | Close

Table B4. GWLF model data outputs for North Witmer Run (reference for Slate Lick Run)

Attachment C
Pennsylvania Integrated Water Quality Monitoring and Assessment Report: Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date

Hydrologic Unit Code: 02050201 - Upper West Branch Susquehanna

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Burgoon Run HUC: 02050201			
Aquatic Life (5357) - 6.74 miles; 20 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26397) HUC: 02050201			
Aquatic Life (5357) - 0.85 miles; 3 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26398) HUC: 02050201			
Aquatic Life (5357) - 1.94 miles; 12 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26399) HUC: 02050201			
Aquatic Life (5357) - 0.42 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26400) HUC: 02050201			
Aquatic Life (5357) - 0.41 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26401) HUC: 02050201			
Aquatic Life (5357) - 0.27 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26402) HUC: 02050201			
Aquatic Life (5357) - 0.30 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26403) HUC: 02050201			
Aquatic Life (5357) - 0.59 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26404) HUC: 02050201			
Aquatic Life (5357) - 0.25 miles; 1 Segment(s)*			

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Burgoon Run (Unt 26404) HUC: 02050201			
Aquatic Life (5357) - 0.25 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26405) HUC: 02050201			
Aquatic Life (5357) - 0.57 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26406) HUC: 02050201			
Aquatic Life (5357) - 3.25 miles; 8 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26407) HUC: 02050201			
Aquatic Life (5357) - 1.52 miles; 4 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26408) HUC: 02050201			
Aquatic Life (5357) - 0.47 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26409) HUC: 02050201			
Aquatic Life (5357) - 0.68 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26410) HUC: 02050201			
Aquatic Life (5357) - 0.37 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26411) HUC: 02050201			
Aquatic Life (5357) - 0.28 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26412) HUC: 02050201			
Aquatic Life (5357) - 0.73 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Burgoon Run (Unt 26413) HUC: 02050201			
Aquatic Life (5357) - 0.37 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26414) HUC: 02050201			
Aquatic Life (5357) - 0.28 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Burgoon Run (Unt 26415) HUC: 02050201			
Aquatic Life (5357) - 1.14 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run HUC: 02050201			
Aquatic Life (5357) - 7.71 miles; 18 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26417) HUC: 02050201			
Aquatic Life (5357) - 0.64 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26418) HUC: 02050201			
Aquatic Life (5357) - 0.39 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26419) HUC: 02050201			
Aquatic Life (5357) - 0.52 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26420) HUC: 02050201			
Aquatic Life (5357) - 0.35 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26421) HUC: 02050201			
Aquatic Life (5357) - 0.72 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Slate Lick Run (Unt 26422) HUC: 02050201			
Aquatic Life (5357) - 0.46 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26423) HUC: 02050201			
Aquatic Life (5357) - 0.73 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26424) HUC: 02050201			
Aquatic Life (5357) - 1.20 miles; 8 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26425) HUC: 02050201			
Aquatic Life (5357) - 0.56 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26426) HUC: 02050201			
Aquatic Life (5357) - 0.50 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26427) HUC: 02050201			
Aquatic Life (5357) - 1.96 miles; 4 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26428) HUC: 02050201			
Aquatic Life (5357) - 0.57 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26430) HUC: 02050201			
Aquatic Life (5357) - 0.27 miles; 2 Segment(s)*			
Agriculture	Siltation	2004	2017
Slate Lick Run (Unt 26431) HUC: 02050201			
Aquatic Life (5357) - 0.73 miles; 1 Segment(s)*			
Agriculture	Siltation	2004	2017

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
zz Unknown NHD Name: 02050201002552 HUC: 02050201			
Aquatic Life (13655) - 0.23 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002556 HUC: 02050201			
Aquatic Life (13655) - 0.23 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002558 HUC: 02050201			
Aquatic Life (13655) - 0.07 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002567 HUC: 02050201			
Aquatic Life (13655) - 0.06 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002572 HUC: 02050201			
Aquatic Life (13655) - 0.27 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002574 HUC: 02050201			
Aquatic Life (13655) - 0.08 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002579 HUC: 02050201			
Aquatic Life (13655) - 0.19 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002582 HUC: 02050201			
Aquatic Life (13655) - 0.18 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021
zz Unknown NHD Name: 02050201002583 HUC: 02050201			
Aquatic Life (13655) - 0.09 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
zz Unknown NHD Name: 02050201002588 HUC: 02050201			
Aquatic Life (13655) - 0.08 miles; 1 Segment(s)*			
Agriculture	Siltation	2008	2021

Report Summary

Watershed Summary

	Stream Miles	Assessment Units	Segments (COMIDs)
Watershed Characteristics	40.18	2	123

Impairment Summary

Source	Cause	Miles	Assessment Units	Segments (COMIDs)
Agriculture	Siltation	40.21	2	122
		40.21 **	**2****	**122 ****

**Totals reflect actual miles of impaired stream. Each stream segment may have multiple impairments (different sources or causes contributing to the impairment), so the sum of individual impairment numbers may not add up to the totals shown.

Use Designation Summary

	Miles	Assessment Units	Segments (COMIDs)
Aquatic Life	40.21	2	122

*Segments are defined as individual COM IDs.

Attachment D
Excerpts Justifying Changes between the 1998-2002 Section 303(d) Lists and the 2004 to present Integrated Water Quality Monitoring and Assessment Reports

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996-2002 303(d) Lists and the 2004 to present Integrated Water Quality Monitoring and Assessment Reports. 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 EPA 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 the Department 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, DEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old DEP stream assessment information to the improved NHD and the old DEP 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 DEP 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 mange 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 OIT's (Office of Information Technology) fulltime staff to manage and maintain SLIMS the systems and formats will now remain stable over many Integrated Listing cycles.

Attachment F
Comment and Response

No public comments were submitted for the Slate Lick Run Sediment TMDL.