LITTLE SHAMOKIN CREEK SUBWATERSHED TMDL

Northumberland County

Prepared for:

Pennsylvania Department of Environmental Protection

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TMDL SUMMARIES

1. The impaired stream segments addressed by this Total Maximum Daily Load (TMDL) are located in Upper Augusta, Rockefeller, and Shamokin Townships in Northumberland County, Pennsylvania. The stream segments drain approximately 18.8 square miles as part of State Water Plan subbasin 6B. The aquatic life existing uses for Little Shamokin Creek, including its tributaries, are cold water fisheries and migratory fishes (25 Pa. Code Chapter 93).

2. Pennsylvania's 2008 303(d) list identified 16.44 miles within the Little Shamokin Creek Subwatershed as impaired by organic enrichment/low dissolved oxygen (D.O.) and sediment from agricultural land use practices. Organic enrichment is directly associated with livestock deposits in the stream resulting in accelerated oxygen uptake. Phosphorus was used as the surrogate pollutant in this analysis for organic enrichment and low dissolved oxygen listings. The 2008 listings are based on data collected in 2001 through the Pennsylvania Department of Environmental Protection's (PADEP's) Surface Water Monitoring Program. In order to ensure attainment and maintenance of water quality standards in the Little Shamokin Creek Subwatershed, mean annual loading for sediment will need to be limited 14,049.0797 pounds per day (lbs/day) and for phosphorus 12.0904 lbs/day.

   The major components of the Little Shamokin Creek Subwatershed TMDL are summarized below.

Little Shamokin Creek Subwatershed Components	**Total Phosphorus (lbs/day)**	**Sediment (lbs/day)**
TMDL (Total Maximum Daily Load)	12.0904	14,049.0797
WLA (Wasteload Allocation)	-	-
MOS (Margin of Safety)	1.2090	1,404.9080
LA (Load Allocation)	10.8814	12,644.1717

3. Mean annual sediment and phosphorus loadings are estimated at 23,170.1109 lbs/day and 15.1770 lbs/day, respectively. To meet the TMDL, the sediment and phosphorus loadings will require reductions of 45 percent and 28 percent, respectively.

4. There are no point sources addressed in these TMDL segments.

5. The adjusted load allocation (ALA) is the actual portion of the load allocation (LA) distributed among nonpoint sources receiving reductions, or sources that are considered controllable. Controllable sources receiving allocations are hay/pasture, cropland, developed lands, and streambanks. The sediment and phosphorus TMDL includes a nonpoint source ALA of 12,149.4868 lbs/day and 10.5900 lbs/day, respectively. Sediment and phosphorus loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Little Shamokin Creek Subwatershed TMDL are summarized below.

Little Shamokin Creek: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	**Allocated Loading (lbs/day)**	**Adjusted Load Allocation (lbs/day)**	**% Reduction**
Sediment	14,049.0797	12,149.4868	14
Phosphorus	12.0904	10.5900	12

6. Ten percent of the Little Shamokin Creek Subwatershed sediment and phosphorus TMDL was set-aside as a margin of safety (MOS). The 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. The MOS for the sediment and phosphorus TMDL are 1,404.9080 lbs/day and 1.2090 lbs/day, respectively.

7. The continuous simulation model used for developing the Little Shamokin Creek Subwatershed TMDL 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 accounts for seasonal variability.

WATERSHED BACKGROUND

The Little Shamokin Creek Watershed is approximately 29.2 square miles in area. The headwaters of Little Shamokin Creek are located inside the east-central portion of Northumberland County, a few miles north of Trevorton, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Sunbury and Trevorton, Pa. The stream flows west out of Irish Valley until Augustaville Church, where it turns north to its confluence with Shamokin Creek. The major tributaries to Little Shamokin Creek include Plum Creek and several unnamed tributaries (UNTs). Smaller towns include Augustaville, Resler, Wolfs Crossroads, Lantz, and Hamilton. State Route 890 travels north/south from Hamilton and the majority of the watershed. Numerous township roads provide access to the Little Shamokin Creek Watershed and its tributaries.

The TMDL watershed is located within the Appalachian Mountain Section of the Ridge and Valley physiographic province. The highest elevations are located in the south-eastern portion of the watershed area on Little Mountain. The total change in elevation in the watershed is approximately 960 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is interbedded sedimentary (90 percent), predominantly associated with the Hamilton Group, Irish Valley, and Buddy Run Members of the Catskill Formation (Figure 1). The remaining rock types found in the watershed are sandstone (10 percent), predominantly associated with the Trimmers Rock and Spechty Kopf Formations.

The Berks-Weikert-Bedington series is the predominant soil type in the TMDL watershed. This soil is listed as a shaly-silt-loam soil and is mostly associated in the lowlands of the watershed (Figure 2). Other dominant soils in the watershed consist of Leck Kill-Meckesville-Calvin and Hazleton-Dekalb-Buchanan.

Based on GIS datasets created in 2001, land use values were calculated for the TMDL watershed. Agriculture was the dominant land use at approximately 49 percent (Figure 3). Forested land uses account for approximately 43 percent of the watershed. Developed areas are 8 percent of the watershed, covering low-intensity residential and transitional. Riparian buffer zones are nearly nonexistent (Figure 4) in some of the agricultural lands. Livestock also have unlimited access to streambanks in certain parts of the watershed, resulting in streambank trampling and severe erosion. Some contiguous forested tracts remain in the watershed.

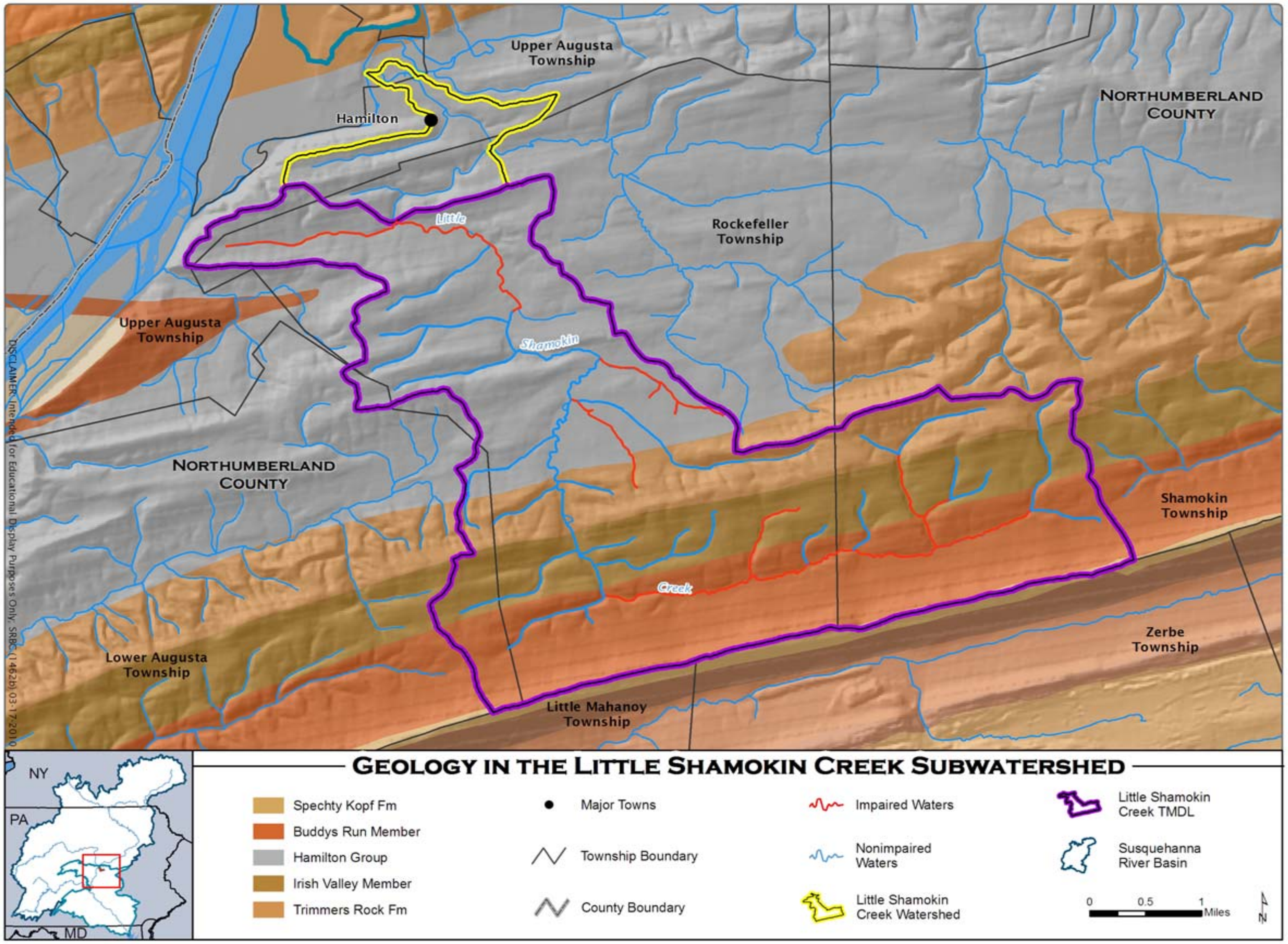

Figure 1. Geology Map of Little Shamokin Creek Subwatershed

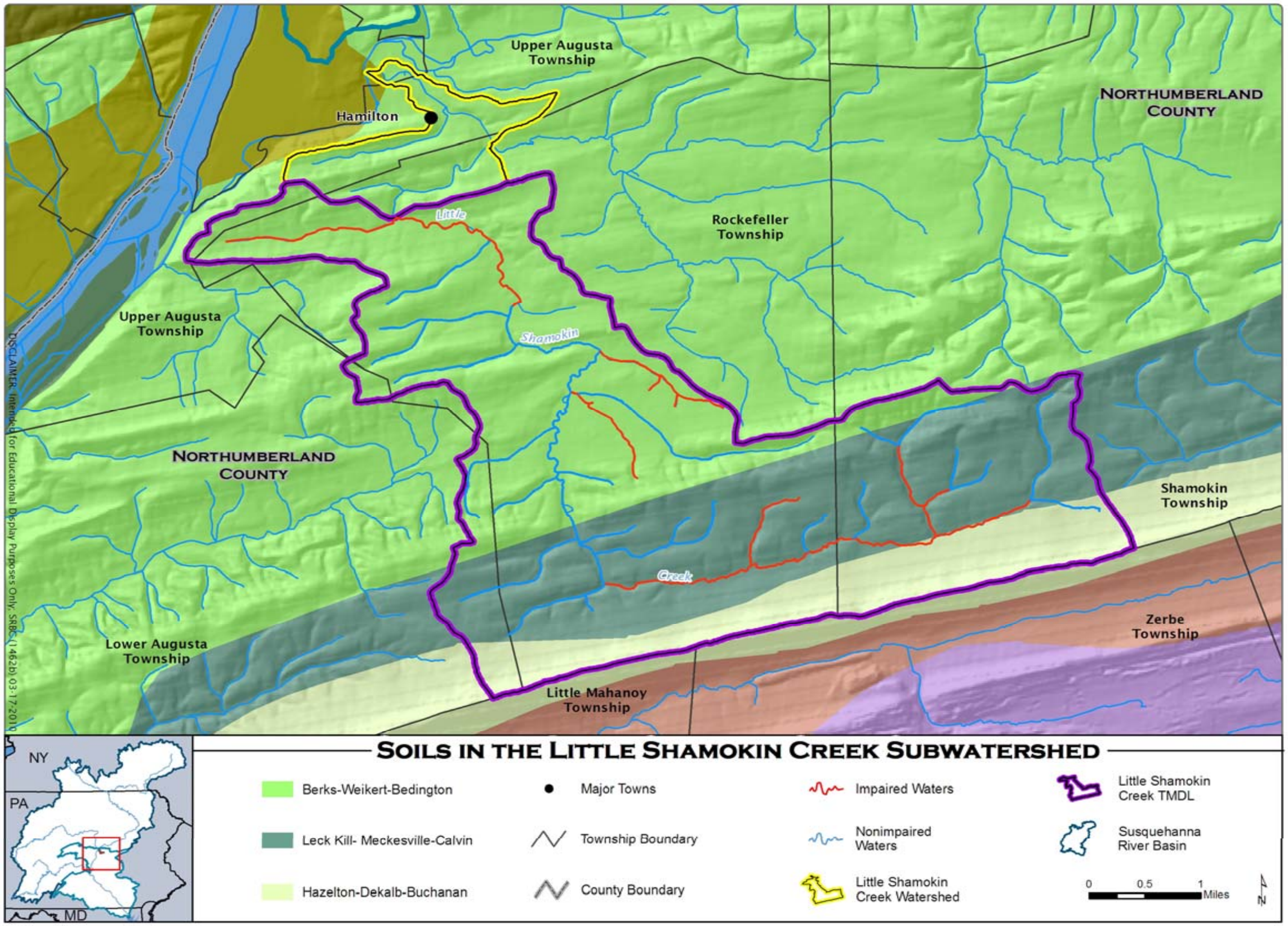

Figure 2. Soils Map of Little Shamokin Creek Subwatershed

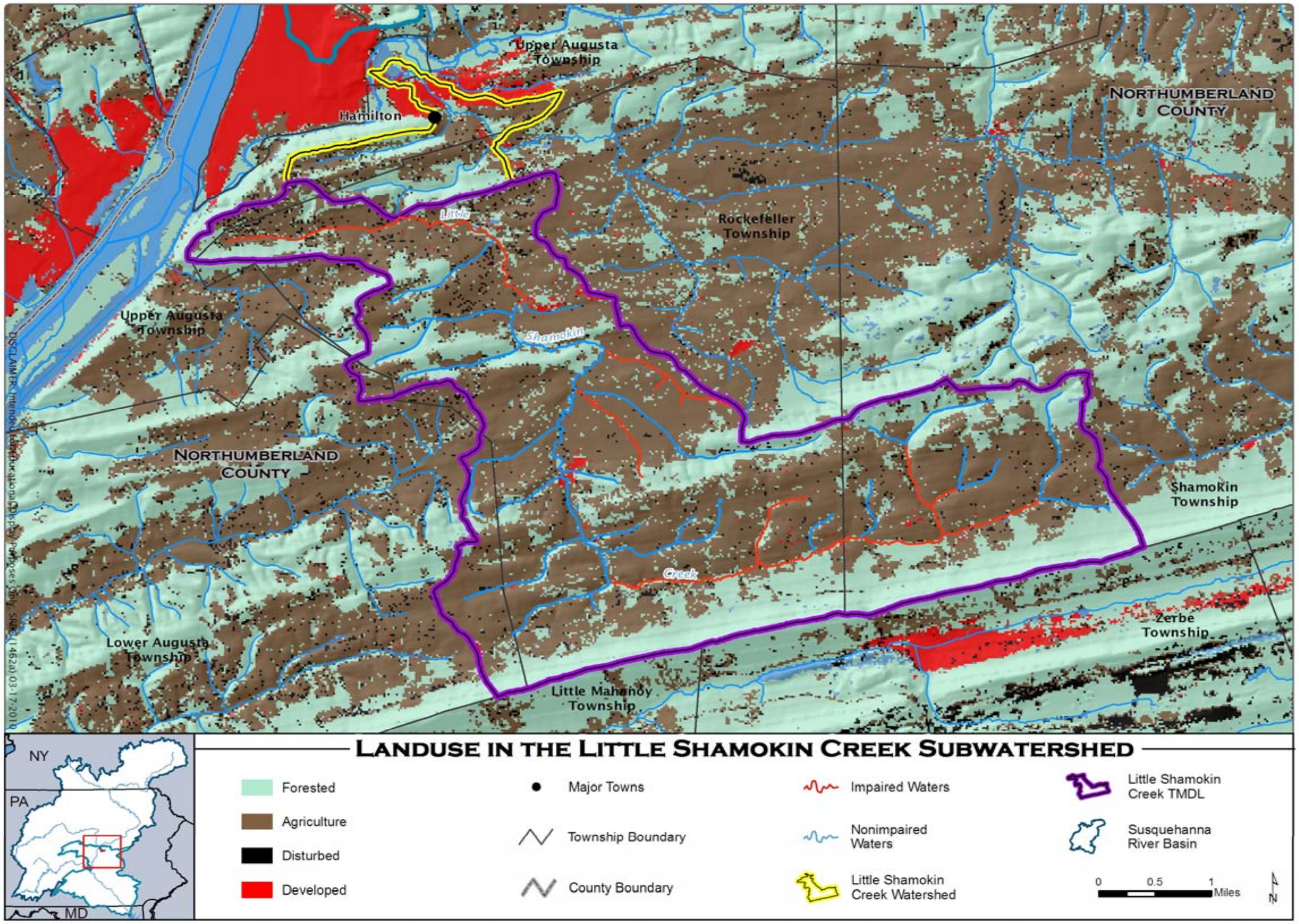

Figure 3. Land Use Map of Little Shamokin Subwatershed

Figure 4. Evidence of Lack of Riparian Vegetation and Streambank Erosion in the Little Shamokin Creek Subwatershed

Surface Water Quality

Pennsylvania's 2008 edition of the 303(d) list(s) identifie2 16.44 miles of the Little Shamokin Creek Subwatershed as impaired by organic enrichment, low dissolved oxygen, and siltation emanating from agricultural practices (Table 1).

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

State Water Plan (SWP) Subbasin: 6B				
HUC: 02050301 – Lower Susquehanna-Penns				
Watershed – Little Shamokin Creek Watershed				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Agriculture*	Siltation	16.44	CWF, MF	Aquatic Life
Agriculture	Organic Enrichment/ Low D.O.	7.67	CWF, MF	Aquatic Life

* Please refer to Attachment H for more details.

In general, soil erosion is a major problem in the Little Shamokin Creek Subwatershed. Unrestricted access of livestock to streams results in trampled streambanks, excessive stream sedimentation, increased nutrient levels, and sparse streamside buffers and riparian vegetation. Large areas of row crops and use of conventional tillage, as well as unrestricted cattle access to streams, combine to leave the soil vulnerable to erosion. The resulting high sediment can make water unfit to drink, smother aquatic life and fish eggs, clog fish gills, and block sunlight into the creeks and rivers. Runoff from road construction also can be an additional, although temporary, source of stream sedimentation and increased nutrient levels.

APPROACH TO TMDL DEVELOPMENT

Pollutants & Sources

Nutrients and sediment have been identified as the pollutants causing designated use impairments in the Little Shamokin Creek Subwatershed TMDL, with the source(s) listed as agricultural. At present, there are no point source contributions within the segments addressed in this TMDL.

As stated in previous sections, the land use is dominantly agriculture. Pasture and croplands extend right up to the streambanks with little to no riparian buffer zones present. Livestock have unlimited access to streambanks throughout most of the watershed. Based on visual observations, streambank erosion is severe in most reaches of the streams.

TMDL Endpoints

In an effort to address the sediment and nutrients problem found in the Little Shamokin Creek Subwatershed, a TMDL was developed to establish loading limits for sediment and nutrients. The TMDL is intended to address sediment and nutrient impairments from developed land uses that were first identified in Pennsylvania's 2002 303(d) list, as well as other nonpoint sources such as agriculture. The decision to use phosphorus load reductions to address nutrient enrichment is based on an understanding of the relationship between nitrogen, phosphorus, and organic enrichment in stream systems. Elevated nutrient loads from human activities (nitrogen and phosphorus in particular) can lead to increased productivity of aquatic plants and other organisms, resulting in the degradation of water quality conditions through the depletion of dissolved oxygen in the water column (Novotny and Olem, 1994; Hem, 1983). In aquatic ecosystems, the quantities of trace elements are typically plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the limiting nutrient because its relative quantity affects the rate of production (growth) of aquatic biomass. If the limiting nutrient load to a waterbody can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control the eutrophication processes in waterbodies, emphasis is placed on the limiting nutrient. However, this is not always the case. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources, such as nitrates in groundwater.

In most freshwater systems, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of nitrogen to the amount of phosphorus is often used to make this determination (Thomann and Mueller, 1987). If the nitrogen/phosphorus (N/P) ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. For the Little Shamokin Creek Subwatershed, the average N/P ratio is approximately 17, which indicates that phosphorus is the limiting nutrient. Controlling the phosphorus loading to the Little Shamokin Creek Subwatershed will limit plant growth, thereby helping to eliminate use impairments currently being caused by excess nutrients.

Reference Watershed Approach

The TMDL developed for the Little Shamokin Creek Subwatershed addresses sediment and nutrients. Because neither Pennsylvania nor the U.S. Environmental Protection Agency (USEPA) has instream numerical water quality criteria for sediment and phosphorus, a method was developed to implement the applicable narrative criteria. The method for these types of TMDLs is termed the "Reference Watershed Approach." Meeting the water quality objectives specified for this TMDL will result in the impaired stream segment attaining its designated uses.

The Reference Watershed Approach compares two watersheds: one attaining its uses and one that is impaired based on biological assessments. Both watersheds ideally have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted for in the model. The objective of the process is to reduce the loading rate of pollutants in the impaired stream segment to a level equivalent to the loading rate in the nonimpaired, reference stream segment. This load reduction will result in conditions favorable to the return of a healthy biological community to the impaired stream segments.

Selection of the Reference Watershed

In general, three factors are considered when selecting a suitable reference watershed. The first factor is to use a watershed that the PADEP has assessed and determined to be attaining water quality standards. The second factor is to find a watershed that closely resembles the impaired watershed in physical properties such as land cover/land use, physiographic province, and geology/soils. Finally, the size of the reference watershed should be within 20-35 percent of the impaired watershed area. The search for a reference watershed for the Little Shamokin Creek Subwatershed to satisfy the above characteristics was done by means of a desktop screening using several GIS coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land cover/use grid, Pennsylvania's streams database, and geologic rock types.

Mugser Run was selected as the reference watershed for developing the Little Shamokin Creek Subwatershed TMDL. Mugser Run is located just west of Numidia, in Columbia County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 5E, a tributary to Roaring Creek, and protected uses include aquatic life and recreation. The tributary is currently designated as a High Quality Cold Water Fishery (25 Pa. Code Chapter 93). Based on PADEP assessments, Mugser Run is currently attaining its designated uses. The attainment of designated uses is based on sampling done by PADEP as part of its State Surface Water Assessment Program.

Drainage area, location, and other physical characteristics of the impaired segments of the Little Shamokin Creek Subwatershed were compared to the Mugser Run Watershed (Table 2). Agricultural land is the dominant land use category in the Little Shamokin Creek Subwatershed (49 percent) and Mugser Run (46 percent). The geology, soils, and precipitation in both are also similar (Table 2).

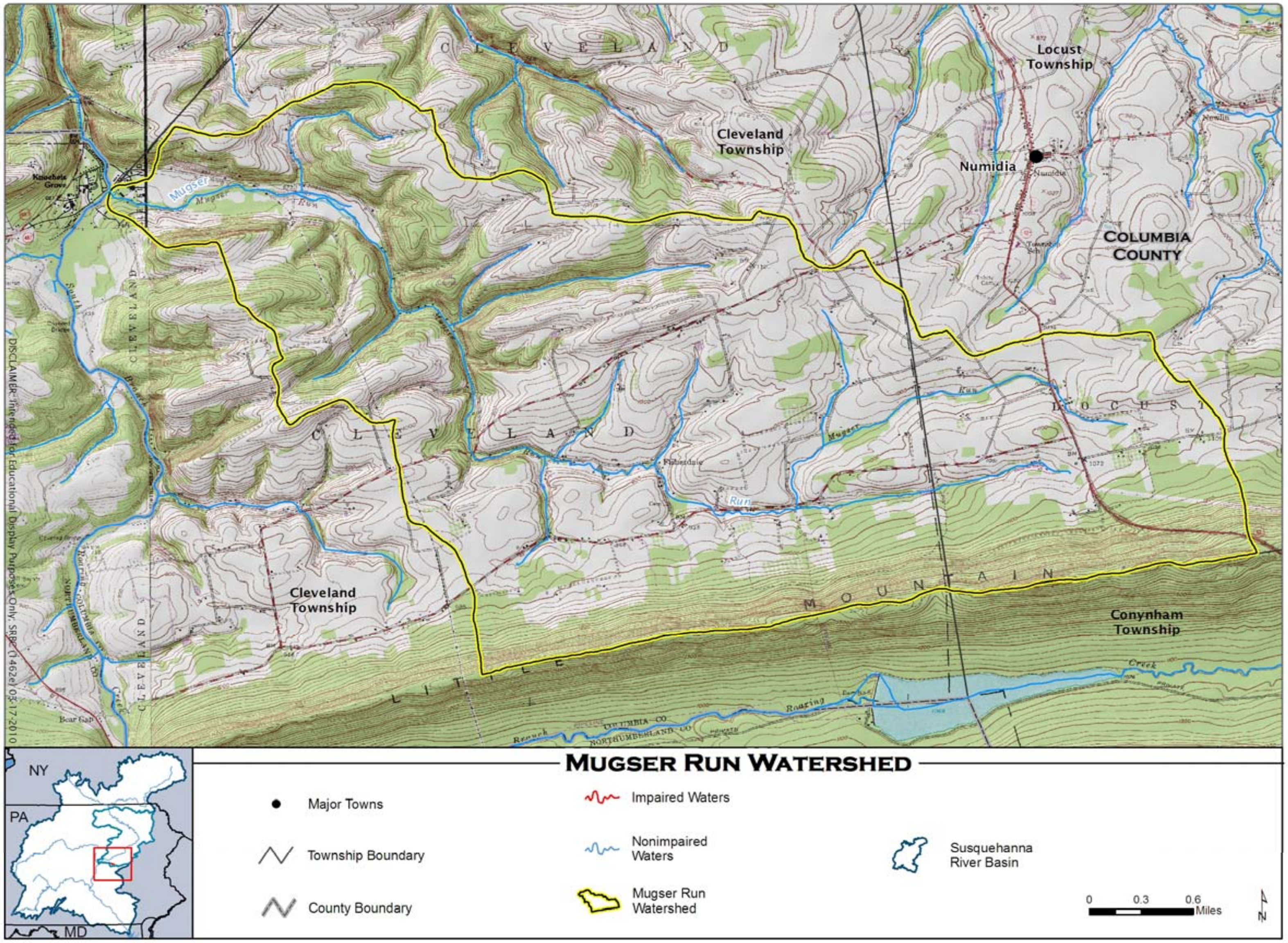

Figure 5. Location Map for Reference Watershed Mugser Run

Table 2. Comparison Between Little Shamokin Creek Subwatershed and Mugser Run Watershed

Attribute	Watershed	
	Little Shamokin Creek Subwatershed	**Mugser Run**
Physiographic Province	Appalachian Mountain Section: Ridge and Valley (100%)	Appalachian Mountain Section: Ridge and Valley (100%)
Area (mi^2)	17.2	11.9
Land Use	Agriculture (48.85%) Development (7.87%) Forested (43.28%)	Agriculture (45.73%) Development (3.94%) Forested (50.32%)
Geology	Hamilton Group (45%) Trimmers Rock Formation (15%) Irish Valley Member (15%) Buddys Run Member (20%) Spechty Kopf Formation (5%)	Trimmers Rock Formation (35%) Buddys Run Member (35%) Irish Valley Member (25%) Hamilton Group (5%)
Soils	Berks-Weikert-Bedington (65%) Leck Kill-Meckesville-Calvin (25%) Hazleton-Dekalb-Buchanan (10%)	Berks-Weikert-Bedington (40%) Leck Kill-Meckesville-Calvin (30%) Hazleton-Dekalb-Buchanan (30%)
Dominant HSG	Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Leck Kill-Meckesville-Calvin A (0%) B (43%) C (50%) D (7%) Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%)	Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Leck Kill-Meckesville-Calvin A (0%) B (43%) C (50%) D (7%) Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%)
K Factor	Berks-Weikert-Bedington (0.24) Leck Kill-Meckesville-Calvin (0.24) Hazleton-Dekalb-Buchanan (0.18)	Berks-Weikert-Bedington (0.24) Leck Kill-Meckesville-Calvin (0.24) Hazleton-Dekalb-Buchanan (0.18)
20-Yr. Ave. Rainfall (in)	44.5	44.5
20-Yr. Ave. Runoff (in)	0.23	0.22

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Little Shamokin Creek Subwatershed was developed using the ArcView Generalized Watershed Loading Function model (AVGWLF) as described in Attachment C. The AVGWLF model was used to establish existing loading conditions for the impaired segments of the Little Shamokin Creek Subwatershed and the Mugser Run reference watershed. All modeling inputs have been attached to this TMDL as Attachments D and E.

The AVGWLF model produced information on watershed size, land use, nutrients, and sediment loading. The sediment and nutrient loadings represent an annual average over a 17-year period, from 1976 to 1992, and for the Little Shamokin Creek Subwatershed and Mugser Run Watershed, respectively. This information was then used to calculate existing unit area loading rates for the two watersheds. Acreage, sediment and phosphorus loadings information for both the impaired watershed and the reference watershed are shown in Tables 3 and 4, respectively.

Table 3. Existing Sediment and Phosphorus Loads for the Little Shamokin Creek Subwatershed

		Phosphorus		Sediment	
Pollutant Source	**Acreage**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**
HAY/PAST	2,508.1	1.4181	0.0006	879.0137	0.3505
CROPLAND	2,861.5	10.8890	0.0038	17,581.0411	6.1440
FOREST	4,744.4	0.2911	0.0001	494.6301	0.1043
WETLAND	12.4	0.0003	0.0000	0.0548	0.0044
TRANSITION	27.2	0.1631	0.0060	276.1096	10.1511
LO_INT_DEV	837.7	0.1207	0.0001	661.2055	0.7893
Streambank	-	0.0721	-	3,278.0561	-
Groundwater	-	2.1727	-	-	-
Septic System	-	0.0500	-	-	-
TOTAL	10,991.3	15.1770	0.0014	23,170.1109	2.1080

Table 4. Existing Sediment and Phosphorus Loads for the Mugser Run Subwatershed

		Phosphorus		Sediment	
Pollutant Source	**Acreage**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**
HAY/PAST	1,784.1	0.9766	0.0005	510.1370	0.2859
CROPLAND	1,687.7	5.3279	0.0032	7,526.0822	4.4594
FOREST	3,810.4	0.3021	0.0001	483.7260	0.1269
WETLAND	9.9	0.0002	0.0000	0.0548	0.0055
TRANSITION	19.8	0.1570	0.0079	251.3425	12.6941
LO_INT_DEV	276.8	0.0399	0.0001	229.7534	0.8300
HI_INT_DEV	2.5	0.0044	0.0018	0.1096	0.0438
Streambank	-	0.0155	0.0000	702.1930	-
Groundwater	-	1.3967	-	-	-
Septic System	-	0.0450	-	-	-
TOTAL	7591.20	8.2653	0.0011	9,703.3985	1.2782

TMDLS

The targeted TMDL value for the Little Shamokin Creek Subwatershed was established based on current loading rates for sediment and phosphorus in the Mugser Run reference watershed. Biological assessments have determined that Mugser Run is currently attaining its designated uses. Reducing the loading rate of sediment and phosphorus in the Little Shamokin Creek Subwatershed to levels equivalent to those in the reference watershed will provide conditions favorable for the reversal of current use impairments.

Background Pollutant Conditions

There are two separate considerations of background pollutants within the context of this TMDL. First, there is the inherent assumption of the reference watershed approach that because of the similarities between the reference and impaired watershed, the background pollutant contributions will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed that are consistent with the loads from the reference watershed. Second, the AVGWLF model implicitly considers background pollutant contributions through the soil and the groundwater component of the model process.

Targeted TMDLs

The targeted TMDL value for sediment and phosphorus was determined by multiplying the total area of the Little Shamokin Creek Subwatershed (10,991.3 acres) by the appropriate unit-area loading rate for the Mugser Run reference watershed (Table 5). The existing mean annual loading of sediment and phosphorus to Little Shamokin Creek Subwatershed (23,170.1109 lbs/day and 15.1170 lbs/day, respectively) will need to be reduced by 39 percent and 20 percent, respectively, to meet the targeted TMDL of 14,049.0797 lbs/day and 12.0904 lbs/day, respectively.

Table 5. Targeted TMDL for the Little Shamokin Creek Subwatershed

Pollutant	Area (ac)	Unit Area Loading Rate Mugser Run Reference Watershed (lbs/ac/day)	Targeted TMDL for Little Shamokin Creek (lbs/day)
Sediment	10,991.3	1.2782	14,049.0797
Phosphorus	10,991.3	0.0011	12.0904

Targeted TMDL values were used as the basis for load allocations and reductions in the Little Shamokin Creek Subwatershed, 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)
ALA = Adjusted Load Allocation
LNR = Loads not Reduced

Margin of Safety

The 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 TMDLs for sediment and phosphorus were reserved as the

MOS. Using 10 percent of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of Little Shamokin Creek Subwatershed. The MOS used for the sediment and phosphorus TMDLs is shown below.

Little Shamokin Creek Subwatershed:

MOS (sediment) = 14,049.0797 lbs/day (TMDL) x 0.1 = 1,404.9080 lbs/day

MOS (phosphorus) = 12.0904 lbs/day (TMDL) x 0.1 = 1.2090 lbs/day

Adjusted Load Allocation

The 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 or LNR) from the LA. Sediment reductions were made to the hay/pasture, cropland, developed areas (sum of LO_INT_DEV, and TRANSITION), and streambanks. Those land uses/sources for which existing loads were not reduced (FOREST, WETLANDS, Groundwater, and Septic Systems) were carried through at their existing loading values (Table 6).

Table 6. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Little Shamokin Creek

	Phosphorus (lbs/day)	Sediment (lbs/day)
Load Allocation	10.8814	12,644.1717
Loads not Reduced	2.5141	494.6849
FOREST	0.2911	494.6301
WETLANDS	0.0003	0.0548
Groundwater	2.1727	0.0000
Septic Systems	0.0500	0.0000
Adjusted Load Allocation	8.3673	12,149.4868

TMDLs

The sediment and phosphorus TMDLs established for the Little Shamokin Creek Subwatershed consist of a LA, ALA, and MOS. The individual components of the TMDL are summarized in Table 7.

Table 7. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Little Shamokin Creek

Component	Phosphorus (lbs/day)	Sediment (lbs/day)
TMDL (Total Maximum Daily Load)	12.0904	14,049.0797
MOS (Margin of Safety)	1.2090	1,404.9080
LA (Load Allocation)	10.8814	12,644.1717
LNR (Loads not Reduced)	2.5141	494.6849
ALA (Adjusted Load Allocation)	8.3673	12,149.4868

CALCULATION OF SEDIMENT AND PHOSPHORUS LOAD REDUCTIONS

The ALA established in the previous section represents the annual total sediment and phosphorus load that is available for allocation between contributing sources in the Little Shamokin Creek Subwatershed. The ALAs for sediment and phosphorus were allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Little Shamokin Creek Subwatershed using the Equal Marginal Percent Reduction (EMPR) allocation method (Attachment F). The LA and EMPR procedures were performed using MS Excel, and results are presented in Attachment G.

In order to meet the sediment and phosphorus TMDL, the load currently emanating from controllable sources must be reduced (Table 7). This can be achieved through reductions in current sediment and phosphorus loadings from cropland, from hay/pasture, developed areas, and streambanks (Table 8).

Table 8. Sediment and Phosphorus Load Allocations and Reductions for Little Shamokin Creek Subwatershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	2,508.1	0.3505	0.2469	879.0137	619.3253	30
Cropland	2,861.5	6.1440	2.9915	17,581.0411	8,560.1443	51
Developed	864.9	1.0837	0.7636	937.3151	660.4026	30
Streambanks	-	-	-	3,278.0561	2,309.6147	30
Total	-	-	-	22,675.4260	12,149.4869	46
Phosphorus						
Hay/Pasture	2,508.1	0.0006	0.0005	1.4181	1.1700	17
Cropland	2,861.5	0.0038	0.0024	10.8890	6.9036	37
Developed	864.9	0.0003	0.0003	0.2838	0.2342	17
Streambanks	-	-	-	0.0721	0.0595	17
Total	-	-	-	12.6630	8.3673	34

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 and phosphorus loads based on the daily water balance accumulated to 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 and phosphorus to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

CONSIDERATION OF SEASONAL VARIATIONS

The continuous simulation model used for these analyses 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.

RECOMMENDATIONS FOR IMPLEMENTATION

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Little Shamokin Creek Subwatershed TMDL identifies the necessary overall load reductions for sediment and phosphorus currently causing use impairments and distributes those reduction goals to the appropriate nonpoint sources. Reaching the reduction goals established by this TMDL will only occur through Best Management Practices (BMPs). BMPs that would be helpful in lowering the amounts of sediment and phosphorus reaching Little Shamokin Creek include the following: streambank stabilization and fencing; riparian buffer strips; strip cropping; conservation tillage; stormwater retention wetlands; and heavy use area protection, among many others.

Active groups in the watershed include the Northumberland County Conservation District and the Little Shamokin Creek Watershed Association. Together they have implemented fish habitat structures which reduce erosion and increase quality/quantity of fish population. They have also purchased and installed “no-mow” zone signs to increase and encourage riparian consistency. Also, they have held three workshops which included focuses on riparian buffer uses, proper planting for riparian buffers, and fish populations.

The Natural Resources Conservation Service maintains a *National Handbook of Conservation Practices* (NHCP), which provides information on a variety of BMPs. The NHCP is available online at http://www.ncg.nrcs.usda.gov/nhcp_2.html. Many of the practices described in the handbook could be used in the Little Shamokin Creek Subwatershed to help limit sediment and phosphorus impairments. Determining the most appropriate BMPs, where they should be installed, and actually putting them into practice, will require the development and implementation of restoration plans. Development of any restoration plan will involve the gathering of site-specific information regarding current land uses and existing conservation practices. This type of assessment has been ongoing in the Little Shamokin Creek Subwatershed, and it is strongly encouraged to continue.

By developing a sediment and phosphorus TMDL for the Little Shamokin Creek Subwatershed, PADEP continues to support design and implementation of restoration plans to correct current use impairments. PADEP welcomes local efforts to support watershed restoration plans. For more information about this TMDL, interested parties should contact the appropriate watershed manager in PADEP's Northcentral Regional Office (570-327-3636).

PUBLIC PARTICIPATION

A notice of availability for comments on the draft Little Shamokin Creek Subwatershed TMDL was published in the Pa. Bulletin on June 5, 2010, and *The News Item* and *Standard Journal* newspapers on June 1, 2010, to foster public comment on the allowable loads calculated. A public meeting was held on June 17, 2010, at the Rockerfeller Township building to discuss the proposed TMDL. The public participation process (which ended on July 5, 2010) was provided for the submittal of comments. Comments and responses are summarized in Attachment I. There were no public comments received for this TMDL.

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

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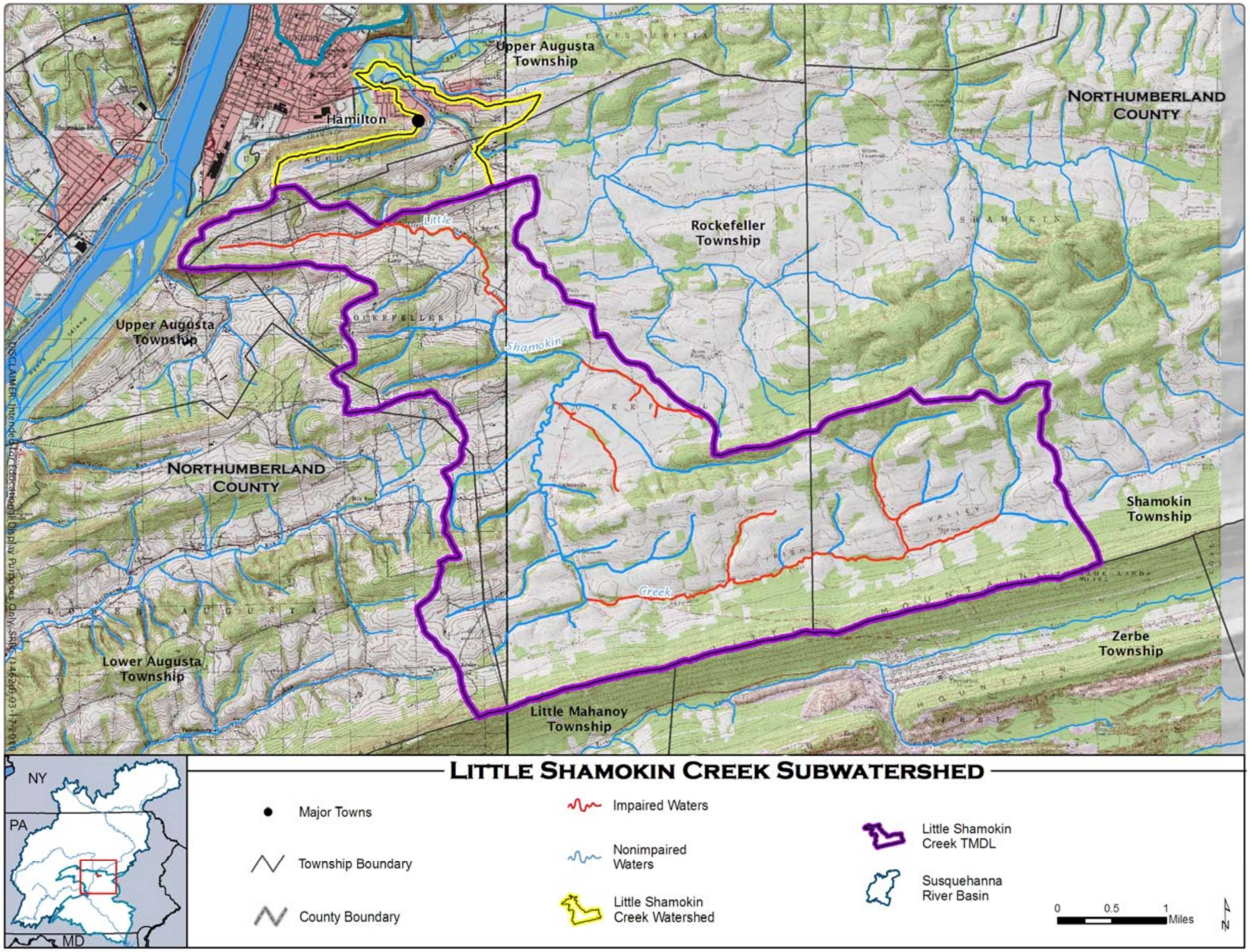
Attachment A

Little Shamokin Creek Subwatershed Impaired Waters



Upper Augusta Township
Hamilton
Northumberland County
Rockefeller Township
Little
Shamokin
Creek
Upper Augusta Township
Northumberland County
Shamokin Township
Zerbe Township
Lower Augusta Township
Little Mahanoy Township
Little Shamokin Creek Subwatershed
NY
PA
MD
Major Towns
Township Boundary
County Boundary
Impaired Waters
Nonimpaired Waters
Little Shamokin Creek Watershed
Little Shamokin Creek TMDL
Susquehanna River Basin
0
0.5
1
Miles
N

Attachment B

Information Sheet for the Little Shamokin Creek Subwatershed TMDL

What is being proposed?
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Little Shamokin Creek Subwatershed.

Who is proposing the plans? Why?
The Pennsylvania Department of Environmental Protection (PADEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (USEPA) for review and approval as required by federal regulation. In 1995, USEPA was sued for not developing TMDLs when Pennsylvania failed to do so. PADEP has entered into an agreement with USEPA to develop TMDLs for certain specified waters over the next several years. This TMDL has been developed in compliance with the state/USEPA agreement.

What is a TMDL?
A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all the sources of the pollutant on that waterbody. A TMDL plan includes waste load allocations for point sources, load allocations for nonpoint sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to USEPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that USEPA must do so.

What is a water quality standard?
The Clean Water Act sets a national minimum goal that all waters be "fishable" and "swimmable." To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as "warm water fishes" or "recreation." States must assign a use or several uses to each of their waters. The second component relates to the instream conditions necessary to protect the designated use(s). These conditions or "criteria" are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the "designated use" and the "criteria" to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being met and the water is said to be in violation of water quality standards.

What is the purpose of the plans?
The Little Shamokin Creek Subwatershed is impaired due to sediment and phosphorus emanating from agricultural runoff and other nonpoint sources. The plans include a calculation of the loading for sediment and phosphorus that will correct the problem and meet water quality objectives.

Why was the Little Shamokin Creek Subwatershed selected for TMDL development?
In 2008, PADEP listed segments of the Little Shamokin Creek Subwatershed under Section 303(d) of the federal Clean Water Act as impaired due to causes linked to sediment and phosphorus.

What pollutants do these TMDLs address?
The proposed plans provide calculations of the stream's total capacity to accept sediment and phosphorus.

Where do the pollutants come from?
The sediment and phosphorus related impairments in the Little Shamokin Creek Subwatershed come from nonpoint sources of pollution, primarily overland runoff from developed areas and agricultural lands, as well as from streambank erosion.

How was the TMDL developed?
PADEP used a reference watershed approach to estimate the necessary loading reduction of sediment and phosphorus that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a nonimpaired watershed that has similar land use characteristics and determining the current loading rates for the pollutants of interest. This is done by modeling the loads that enter the stream, using precipitation and land use characteristic data. For this analysis, PADEP used the AVGWLF model (the Environmental Resources Research Institute of the Pennsylvania State University's Arcview-based version of the Generalized Watershed Loading Function model developed by Cornell University). This modeling process uses loading rates in the nonimpaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the nonimpaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvania nor USEPA has instream numerical water quality criteria for sediment and phosphorus.

How much pollution is too much?
The allowable amount of pollution in a waterbody varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a free flowing stream impacted by nonpoint source pollution loading of sediment and phosphorus, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all streamflow conditions. PADEP established the water quality objectives for sediment and phosphorus by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates for sediment and phosphorus in the impaired watershed to the current loading rates in the reference watershed will result in meeting the water quality objectives.

How will the loading limits be met?
Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions.

How can I get more information on the TMDL?
To request a copy of the full report, contact William Brown at (717) 783-2938 between 8:00 a.m. and 3:00 p.m., Monday through Friday. Mr. Brown also can be reached by mail at the Office of

Water Management, PADEP, Rachel Carson State Office Building, 400 Market Street, Harrisburg, PA 17105 or by e-mail at wbrown@state.pa.us.

How can I comment on the proposal?

You may provide e-mail or written comments postmarked no later than July 5, 2010 to the above address.

Attachment C

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Little Shamokin Creek Subwatershed was developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (nitrogen and phosphorus) loadings from the watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. 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 aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (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 (e.g., 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 conservation practices factor (P). A sediment delivery ratio based on watershed size, transport capacity, and average daily runoff is applied to the calculated erosion for determining sediment yield for each source area. Surface nutrient losses are determined by applying dissolved nitrogen and phosphorus coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges also can contribute to dissolved losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Subsurface losses are calculated using dissolved nitrogen and phosphorus coefficients for shallow groundwater contributions to stream nutrient loads, and the subsurface submodel only considers a single, lumped-parameter contributing 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. All of the equations used by the model can be viewed in GWLF Users Manual.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.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 nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were Geographic Information System (GIS) formatted databases. A specially designed interface was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function).

In using this 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 the growing season, the months during which manure is spread on agricultural land, and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT, NUTRIENT.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 background nitrogen and phosphorus concentrations and cropping practices. Complete GWLF-formatted weather files also are included for 80 weather stations around the state.

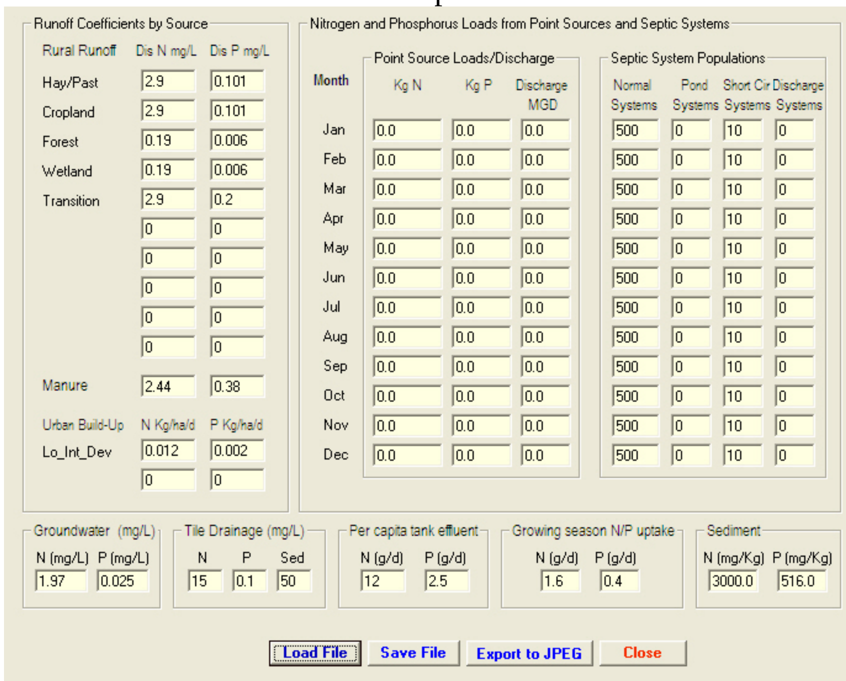
The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

GIS Data Sets	
DATASET	**DESCRIPTION**
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute *usew_sept* includes data on conventional systems, and *sew_other* provides data on short-circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships, and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. Used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different land cover categories. This dataset provides land cover loading rate for the different categories in the model.
Pasingle	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
Physprov	A shapefile of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set recession coefficient.
Pointsrc	Major point source discharges with permitted nitrogen and phosphorus loads.
Refwater	Shapefile of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorus loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
Statsgo	A shapefile of generalized soil boundaries. The attribute *mu_k* sets the k factor in the USLE. The attribute *mu_awc* is the unsaturated available capacity, and the *muhsg_dom* is used with land use cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in Pennsylvania's 305(b) report. Current status of assessed streams.
Surfgeol	A shapefile of the surface geology used to compare watersheds of similar qualities.
T9sheds	Data derived from a PADEP study conducted at PSU with N and P loads.
Zipcode	A coverage of animal densities. Attribute *aeu_acre* helps estimate N & P concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

Attachment D

AVGWLF Model Inputs for the Little Shamokin Creek Subwatershed

Little Shamokin Creek Subwatershed Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.101
Cropland	2.9	0.101
Forest	0.19	0.006
Wetland	0.19	0.006
Transition	2.9	0.2
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
	0	0

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	500	0	10	0
Feb	0.0	0.0	0.0	500	0	10	0
Mar	0.0	0.0	0.0	500	0	10	0
Apr	0.0	0.0	0.0	500	0	10	0
May	0.0	0.0	0.0	500	0	10	0
Jun	0.0	0.0	0.0	500	0	10	0
Jul	0.0	0.0	0.0	500	0	10	0
Aug	0.0	0.0	0.0	500	0	10	0
Sep	0.0	0.0	0.0	500	0	10	0
Oct	0.0	0.0	0.0	500	0	10	0
Nov	0.0	0.0	0.0	500	0	10	0
Dec	0.0	0.0	0.0	500	0	10	0

Groundwater (mg/L) N (mg/L)	P (mg/L)	Tile Drainage (mg/L) N	P	Sed	Per capita tank effluent N (g/d)	P (g/d)	Growing season N/P uptake N (g/d)	P (g/d)	Sediment N (mg/Kg)	P (mg/Kg)
1.97	0.025	15	0.1	50	12	2.5	1.6	0.4	3000.0	516.0

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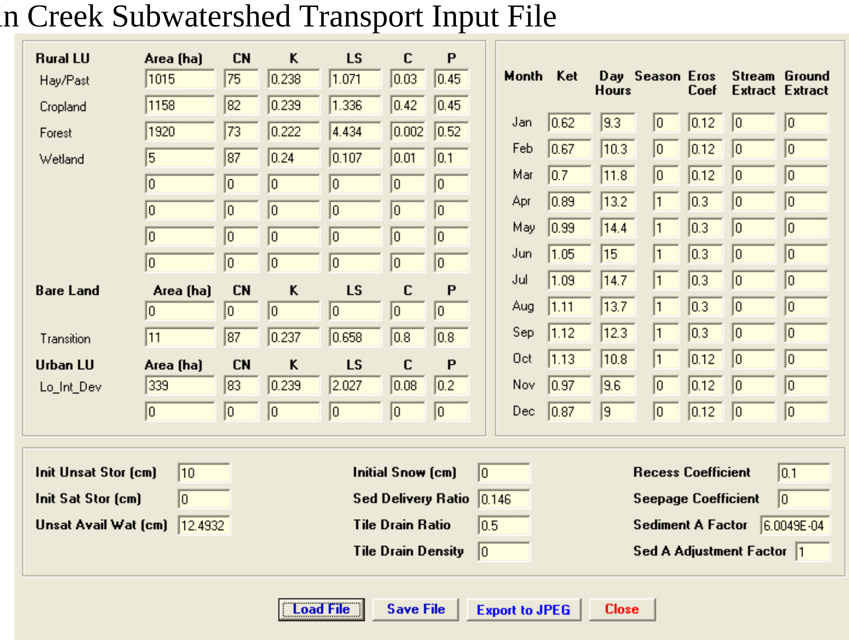
Little Shamokin Creek Subwatershed Transport Input File



Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1015	75	0.238	1.071	0.03	0.45
Cropland	1158	82	0.239	1.336	0.42	0.45
Forest	1920	73	0.222	4.434	0.002	0.52
Wetland	5	87	0.24	0.107	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	11	87	0.237	0.658	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	339	83	0.239	2.027	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.62	9.3	0	0.12	0	0
Feb	0.67	10.3	0	0.12	0	0
Mar	0.7	11.8	0	0.12	0	0
Apr	0.89	13.2	1	0.3	0	0
May	0.99	14.4	1	0.3	0	0
Jun	1.05	15	1	0.3	0	0
Jul	1.09	14.7	1	0.3	0	0
Aug	1.11	13.7	1	0.3	0	0
Sep	1.12	12.3	1	0.3	0	0
Oct	1.13	10.8	1	0.12	0	0
Nov	0.97	9.6	0	0.12	0	0
Dec	0.87	9	0	0.12	0	0

Init Unsat Stor (cm)	10	**Initial Snow (cm)**	0	**Recess Coefficient**	0.1
Init Sat Stor (cm)	0	**Sed Delivery Ratio**	0.146	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	12.4932	**Tile Drain Ratio**	0.5	**Sediment A Factor**	6.0049E-04
		Tile Drain Density	0	**Sed A Adjustment Factor**	1

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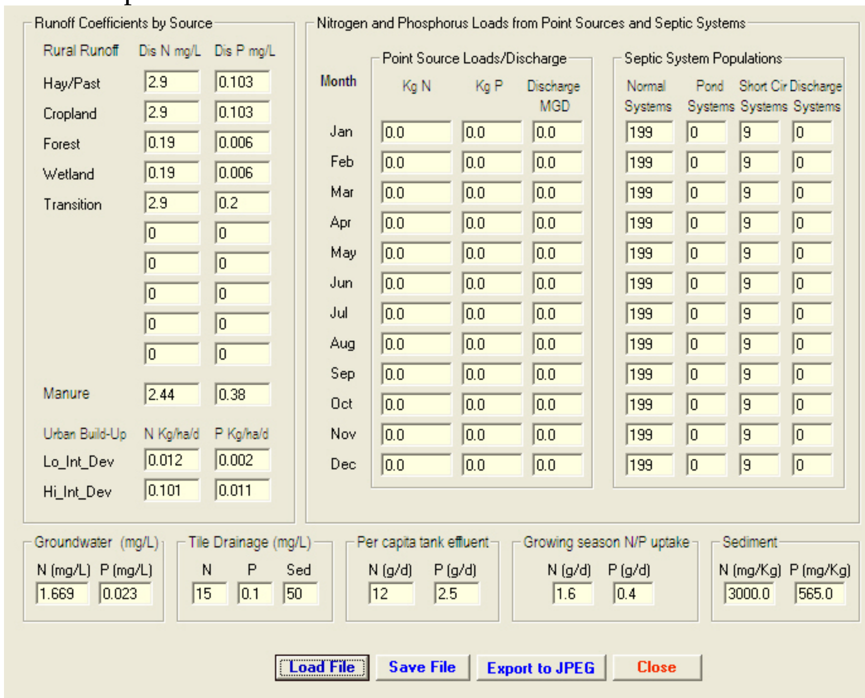
Attachment E

AVGWLF Model Inputs for the Mugser Run Reference Watershed

Mugser Run Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.103
Cropland	2.9	0.103
Forest	0.19	0.006
Wetland	0.19	0.006
Transition	2.9	0.2
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38

Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

	Point Source Loads/Discharge			Septic System Populations			
Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	199	0	9	0
Feb	0.0	0.0	0.0	199	0	9	0
Mar	0.0	0.0	0.0	199	0	9	0
Apr	0.0	0.0	0.0	199	0	9	0
May	0.0	0.0	0.0	199	0	9	0
Jun	0.0	0.0	0.0	199	0	9	0
Jul	0.0	0.0	0.0	199	0	9	0
Aug	0.0	0.0	0.0	199	0	9	0
Sep	0.0	0.0	0.0	199	0	9	0
Oct	0.0	0.0	0.0	199	0	9	0
Nov	0.0	0.0	0.0	199	0	9	0
Dec	0.0	0.0	0.0	199	0	9	0

Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N	P	Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
1.669	0.023	15	0.1	50	12	2.5	1.6	0.4	3000.0	565.0

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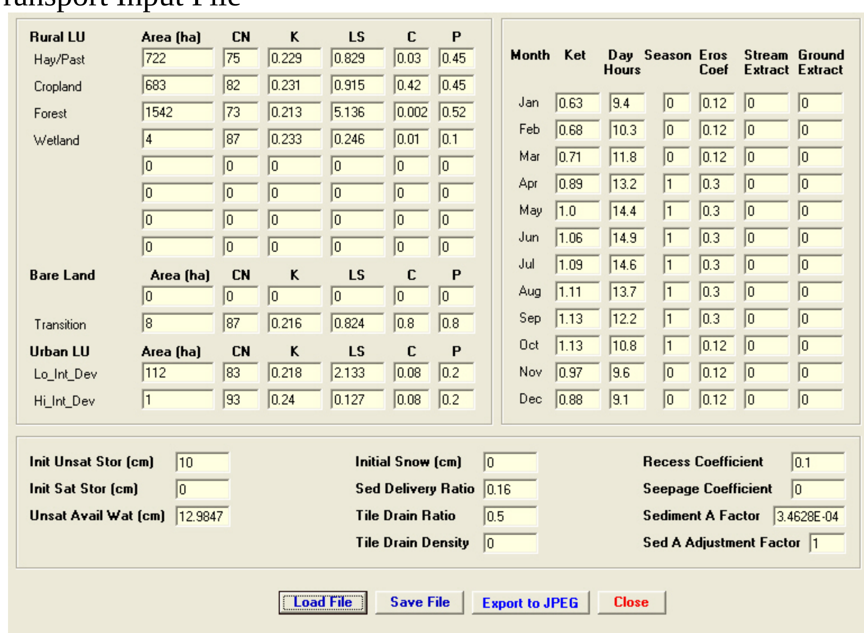
Mugser Run Transport Input File



Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	722	75	0.229	0.829	0.03	0.45
Cropland	683	82	0.231	0.915	0.42	0.45
Forest	1542	73	0.213	5.136	0.002	0.52
Wetland	4	87	0.233	0.246	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	8	87	0.216	0.824	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	112	83	0.218	2.133	0.08	0.2
Hi_Int_Dev	1	93	0.24	0.127	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.63	9.4	0	0.12	0	0
Feb	0.68	10.3	0	0.12	0	0
Mar	0.71	11.8	0	0.12	0	0
Apr	0.89	13.2	1	0.3	0	0
May	1.0	14.4	1	0.3	0	0
Jun	1.06	14.9	1	0.3	0	0
Jul	1.09	14.6	1	0.3	0	0
Aug	1.11	13.7	1	0.3	0	0
Sep	1.13	12.2	1	0.3	0	0
Oct	1.13	10.8	1	0.12	0	0
Nov	0.97	9.6	0	0.12	0	0
Dec	0.88	9.1	0	0.12	0	0

Init Unsat Stor (cm)	10	**Initial Snow (cm)**	0	**Recess Coefficient**	0.1
Init Sat Stor (cm)	0	**Sed Delivery Ratio**	0.16	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	12.9847	**Tile Drain Ratio**	0.5	**Sediment A Factor**	3.4628E-04
		Tile Drain Density	0	**Sed A Adjustment Factor**	1

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Attachment F

Equal Marginal Percent Reduction Method

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 the MS Excel and results are presented in Attachment G. The five major steps identified in the spreadsheet are summarized below:

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

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

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 the 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.

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

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

Attachment G

Equal Marginal Percent Reduction Calculations for the Little Shamokin Creek Subwatershed TMDL

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					12149.4868	12149					
	14049.0797											
	SEDIMENT LOADING											
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
	Hay/Past.	879.0137	22675.426	good	879	ADJUST	0.05	259.688	619.325	2508.10	0.247	30%
	Cropland	17581.0411		bad	12149	5094	0.70	3589.343	8560.144	2861.50	2.991	51%
	Developed	937.3151		good	937		0.05	276.913	660.403	864.90	0.764	30%
	Streambank	3278.0561		good	3278		0.19	968.441	2309.615			30%
	Total	22675.4260			17243.87169		1.00		12149.487			
Step 4:	All Ag. Loading Rate	1.71										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	2508.10	0.2469	619.3253	0.3505	879.0137	30%					
	Final Cropland LA	2861.50	2.9915	8560.1443	6.1440	17581.0411	51%					
	Developed	864.90	0.7636	660.4026	1.0837	937.3151	30%					
	Streambank			2309.6147		3278.0561	30%					
	Total			12149.4868		22675.4260	46%					

Little Shamokin

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					8.3673	8					
	12.0904											
	PHOSPHORUS LOADING											
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
	Hay/Past.	1.4181	12.663	good	1	ADJUST	0.14	0.248	1.170	2508.10	0.000	17%
	Cropland	10.8890		bad	8	2	0.83	1.464	6.904	2861.50	0.002	37%
	Developed	0.2838		good	0		0.03	0.050	0.234	864.90	0.000	17%
	Streambank	0.0721		good	0		0.01	0.013	0.059			17%
	Total	12.663			10.141287		1.00		8.367			
Step 4:	All Ag. Loading Rate	0.00										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	2508.10	0.0005	1.1700	0.0006	1.4181	17%					
	Final Cropland LA	2861.50	0.0024	6.9036	0.0038	10.8890	37%					
	Developed	864.90	0.0003	0.2342	0.0003	0.2838	17%					
	Streambank			0.0595		0.0721	17%					
	Total			8.3673		12.6630	34%					
	Little Shamokin											

Attachment H

Little Shamokin Creek Subwatershed Impaired Segment Listings

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

Hydrologic Unit Code: 02050301 - Lower Susquehanna-Penns

Little Shamokin Creek
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1732) - 0.85 miles; 1 Segment(s)*			
Grazing Related Agric	Organic Enrichment/Low D.O.	2002	2015
Grazing Related Agric	Siltation	2002	2015
Aquatic Life (1777) - 0.96 miles; 1 Segment(s)*			
Grazing Related Agric	Organic Enrichment/Low D.O.	2002	2015
Grazing Related Agric	Siltation	2002	2015
Aquatic Life (1787) - 2.62 miles; 3 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	2002	2015
Agriculture	Siltation	2002	2015
Aquatic Life (1804) - 2.04 miles; 5 Segment(s)*			
Agriculture	Siltation	2002	2015

Little Shamokin Creek (Unt 18515)
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1876) - 1.62 miles; 2 Segment(s)*			
Agriculture	Siltation	2002	2015

Little Shamokin Creek (Unt 18521)
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1798) - 1.30 miles; 3 Segment(s)*			
Agriculture	Siltation	2002	2015

Little Shamokin Creek (Unt 18522)
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1798) - 0.18 miles; 2 Segment(s)*			
Agriculture	Siltation	2002	2015

Little Shamokin Creek (Unt 18523)
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1798) - 0.12 miles; 2 Segment(s)*			
Agriculture	Siltation	2002	2015

Little Shamokin Creek (Unt 18524)
HUC: 02050301

Use Designation / Source	Cause	Date Listed	TMDL Date
Aquatic Life (1797) - 2.44 miles; 2 Segment(s)*			
Agriculture	Siltation	2002	2015

*Segments are defined as individual COM IDs.

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Little Shamokin Creek (Unt 18525)			
HUC: 02050301			
Aquatic Life (1798) - 1.07 miles; 4 Segment(s)*			
Agriculture	Siltation	2002	2015
Little Shamokin Creek (Unt 18536)			
HUC: 02050301			
Aquatic Life (1733) - 0.93 miles; 3 Segment(s)*			
Grazing Related Agric	Organic Enrichment/Low D.O.	2002	2015
Grazing Related Agric	Siltation	2002	2015
Little Shamokin Creek (Unt 18539)			
HUC: 02050301			
Aquatic Life (1732) - 1.01 miles; 2 Segment(s)*			
Grazing Related Agric	Organic Enrichment/Low D.O.	2002	2015
Grazing Related Agric	Siltation	2002	2015
Little Shamokin Creek (Unt 18540)			
HUC: 02050301			
Aquatic Life (1732) - 0.29 miles; 1 Segment(s)*			
Grazing Related Agric	Organic Enrichment/Low D.O.	2002	2015
Grazing Related Agric	Siltation	2002	2015

Report Summary

Watershed Summary

	Stream Miles	Assessment Units	Segments (COMIDs)
Watershed Characteristics	37.86	8	89

Impairment Summary

Source	Cause	Miles	Assessment Units	Segments (COMIDs)
Agriculture	Organic Enrichment/Low D.O.	2.62	1	3
Agriculture	Siltation	11.47	5	26
Grazing Related Agric	Organic Enrichment/Low D.O.	4.04	3	8
Grazing Related Agric	Siltation	4.04	3	8
		15.50 **	**8** **	**34** **

**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.

*Segments are defined as individual COM IDs.

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

Use Designation Summary

	Miles	Assessment Units	Segments (COMIDs)
Aquatic Life	15.50	8	34

Attachment I

Comment & Response Document for the Little Shamokin Creek Subwatershed TMDL

No official comments were received for this TMDL.