MAHONING CREEK WATERSHED TMDL
Northumberland and Montour Counties

Prepared for:

Pennsylvania Department of Environmental Protection

April 30, 2011

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TMDL SUMMARIES

1. The impaired stream segments addressed by this Total Maximum Daily Load (TMDL) are located in Liberty, Valley, West Hemlock, Derry, Madison, Hemlock, Mahoning, and Montour Townships in Columbia and Montour Counties, Pennsylvania. The stream segments drain approximately 39.6 square miles as part of State Water Plan subbasin 5E. The aquatic life existing uses for Mahoning Creek, including its tributaries, are Warm Water Fishes (25 Pa. Code Chapter 93).

2. Pennsylvania's 2008 303(d) list identified 21.95 miles within the Mahoning Creek Watershed as impaired by organic enrichment, low dissolved oxygen, and sediment from agricultural and urban 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 listings were based on data collected in 1997 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 Mahoning Creek Watershed, mean annual loadings for sediment and phosphorus will need to be limited 20,364.6078 pounds per day (lbs/day) and 22.8377 lbs/day, respectively

   The major components of the Mahoning Creek Watershed TMDL are summarized below.

Mahoning Creek Watershed Components	**Sediment (lbs/day)**	**Phosphorus (lbs/day)**
TMDL (Total Maximum Daily Load)	22,751.4043	22.8377
WLA (Wasteload Allocation)	111.6561	-
MOS (Margin of Safety)	2,275.1404	2.2838
LA (Load Allocation)	20,364.6078	20.5539

3. Mean annual sediment and phosphorus loadings are estimated at 48,768.3419 lbs/day and 26.3570 lbs/day, respectively. To meet the TMDL, the sediment and phosphorus loadings will require reductions of 53 percent and 13 percent, respectively.

4. There are two point source addressed in these TMDL segments. The Valley Township Municipal Authority and Mooresburg Wastewater Treatment Plant discharge suspended solids, and is included in the wasteload allocation (WLA).

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 19,427.5667 lbs/day and 14.8714 lbs/day, respectively. Sediment and phosphorus loadings from all other sources, such as forested, wetlands, groundwater, and septic systems, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Mahoning Creek Watershed TMDL are summarized below.

Mahoning Creek: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	**Current Loading (lbs/day)**	**Adjusted Load Allocation (lbs/day)**	**% Reduction**
Sediment	20,746.2639	19,427.5667	6
Phosphorus	20.5539	14.8714	28

6. Ten percent of the Mahoning Creek Watershed sediment 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 is 2,275.1404 lbs/day and 2.2838 lbs/day, respectively.

7. The continuous simulation model used for developing the Mahoning Creek Watershed 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 Mahoning Creek Subwatershed is approximately 39.6 square miles in area. The headwaters of Mahoning Creek are located inside the eastern portion of Columbia County, a few miles north of Danville, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Danville, Millville, Riverside, and Washingtonville, Pa. The stream flows south to its confluence with the Susquehanna River. The major tributaries to Mahoning Creek include Kase Run, Mauses Creek, Sechler Run, and several unnamed tributaries (UNTs). Interstate 80 travels east and west through the central portion of the watershed. Numerous township roads provide access to the Mahoning Creek Subwatershed 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 eastern portion of the watershed. The total change in elevation in the watershed is approximately 800 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is sedimentary (95 percent), predominantly associated with the Trimmers Rock Formation, Hamilton Group, Wills Creek Formation, Bloomsburg/Mifflintown Formation, Clinton Group, Catskill Formation, and Onondaga/Old Port Formation (Figure 1). The remaining rock types found in the watershed are carbonate (5 percent combined), predominantly associated with the Keyser/Tonoloway Formation Undivided.

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 gently sloping plains and uplands of the watershed (Figure 2). Other dominant soils in the watershed consist of Clymer-Buchanan-Norwich, Leck Kill-Meckesville-Calvin, and Chenango-Pope-Holly.

Based on GIS datasets created in 2001, land use values were calculated for the TMDL watershed. Forested was the dominant land use at approximately 50 percent (Figure 3). Agricultural land uses account for approximately 38 percent of the watershed. Developed areas are 12 percent of the watershed, covering low-intensity residential and transitional. In small sections of the watershed, livestock also have unlimited access to streambanks, resulting in streambank trampling and severe erosion. Riparian buffer zones are being replanted by local groups (Figure 4) in some of the agricultural lands. Some contiguous forested tracts remain in the watershed.

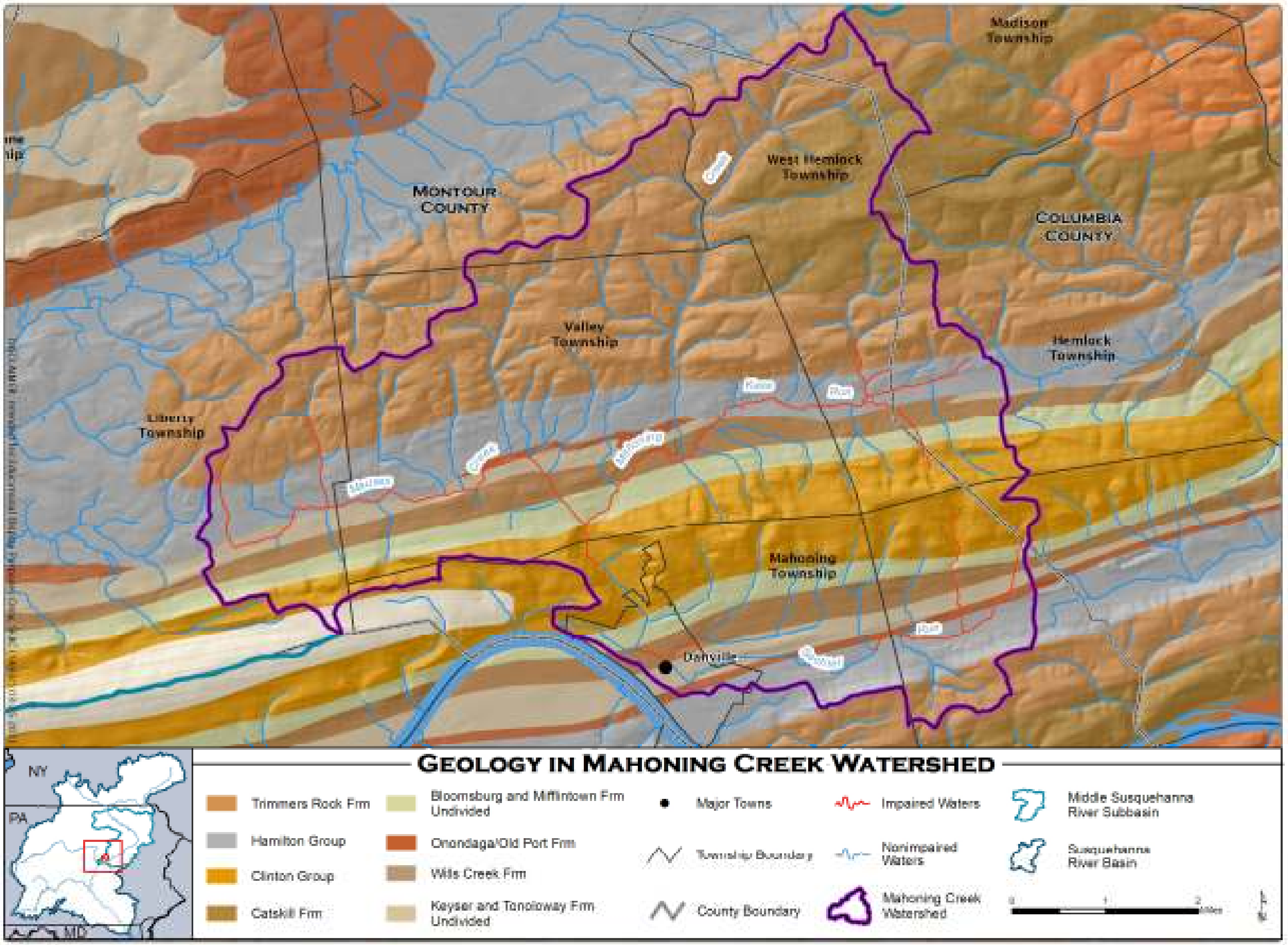


Figure 1. Geology Map of Mahoning Creek Watershed

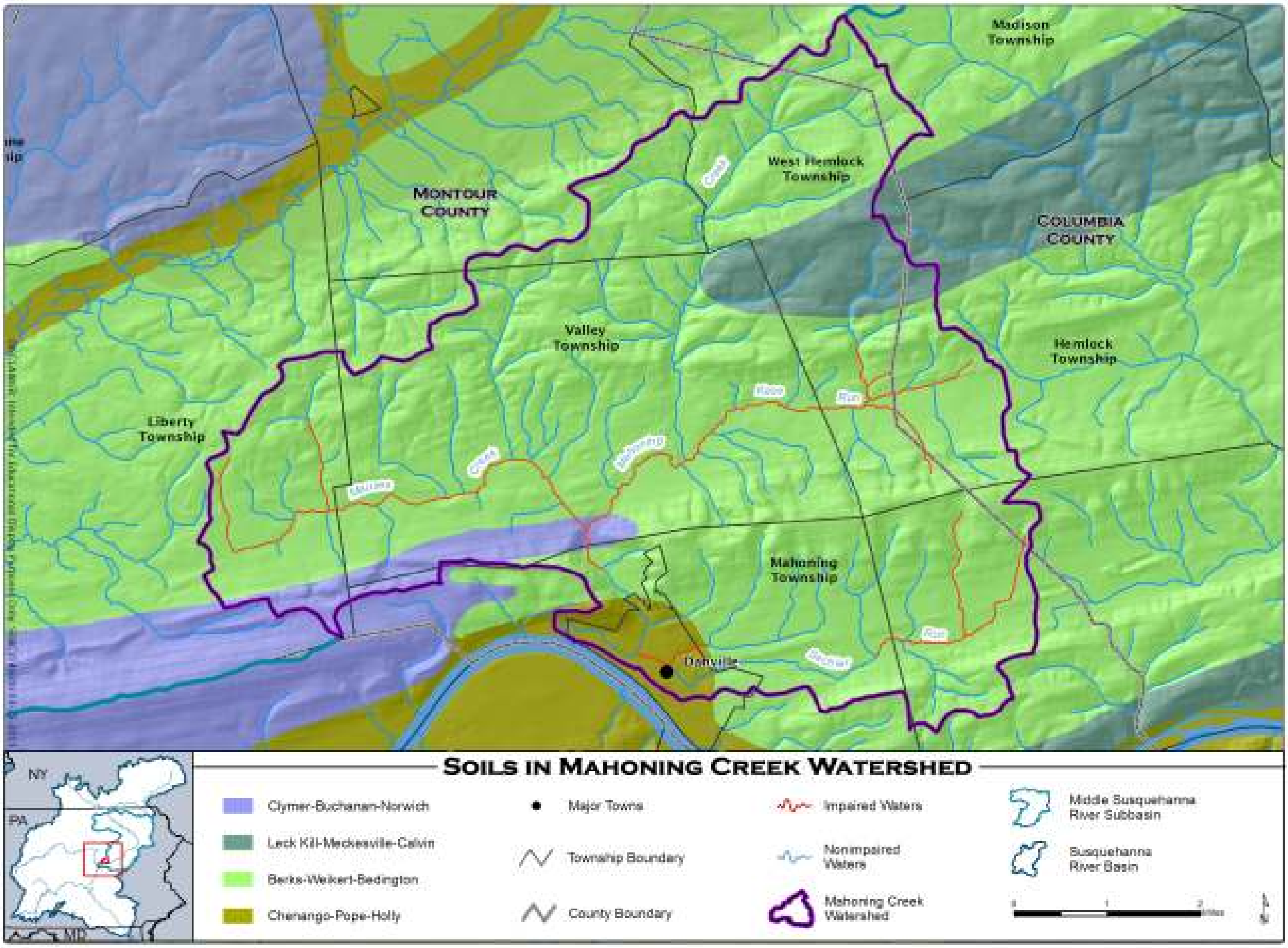


Figure 2. Soils Map of Mahoning Creek Watershed

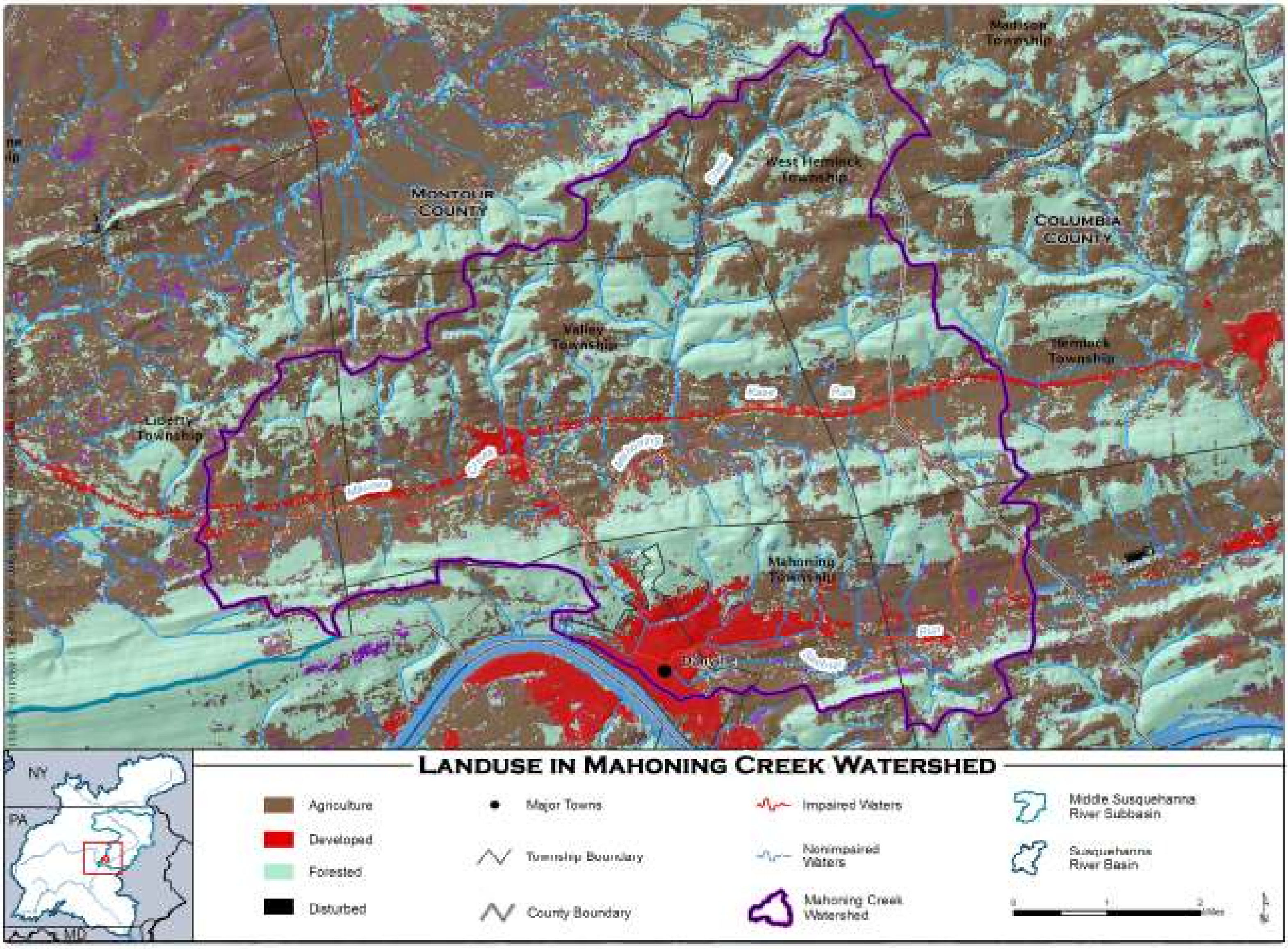


Figure 3. Land Use Map of Mahoning Creek Watershed

***Figure 4.	Evidence of Lack of Riparian Vegetation and Streambank Erosion in the Mahoning Creek Watershed***

Surface Water Quality

Pennsylvania's 2008 edition of the 303(d) list identified 21.95 miles of the Mahoning Creek Watershed as impaired by organic enrichment/low D.O. and siltation emanating from agricultural practices (Table 1).

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

State Water Plan (SWP) Subbasin: 5E				
HUC: 02050107 – Upper Susquehanna – Lackawanna				
Watershed – Mahoning Creek				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Agriculture*	Siltation	19.13	CWF, MF	Aquatic Life
Agriculture	Organic Enrichment/Low D.O.	1.07	CWF, MF	Aquatic Life
Urban Runoff/Storm Sewers	Siltation	1.75	CWF, MF	Aquatic Life

* Please see Attachment H for more details.

In general, soil erosion is a major problem in the Mahoning Creek Watershed. 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.

APPROACH TO TMDL DEVELOPMENT

Pollutants & Sources

Organic enrichment, low dissolved oxygen, and sediment have been identified as the pollutants causing designated use impairments in the Mahoning Creek Watershed, 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 Mahoning Creek Watershed, 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 1998 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 Mahoning Creek Watershed, the average N/P ratio is approximately 16, which indicates that phosphorus is the limiting nutrient. Controlling the phosphorus loading to the Mahoning Creek Watershed will limit plant growth, thereby helping to eliminate use impairments currently being caused by excess nutrients.

Reference Watershed Approach

The TMDL developed for the Mahoning Creek Watershed 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 Mahoning Creek Watershed 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.

Roaring Creek Subwatershed was selected as the reference watershed for developing the Mahoning Creek Watershed TMDL. Roaring Creek is located just south of Catawissa, in Columbia County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 5E, a tributary to the Susquehanna River, and protected uses include aquatic life and recreation. The tributary is currently designated as a Cold Water Fishery/Trout Stocking Fishery (25 Pa. Code Chapter 93). Based on PADEP assessments, Roaring Creek 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 Mahoning Creek Watershed were compared to the Roaring Creek Subwatershed (Table 2). Agricultural land is a dominant land use category in the Mahoning Creek Watershed (36 percent) and Roaring Creek (38 percent). The geology, soils, and precipitation in both are also similar (Table 2).

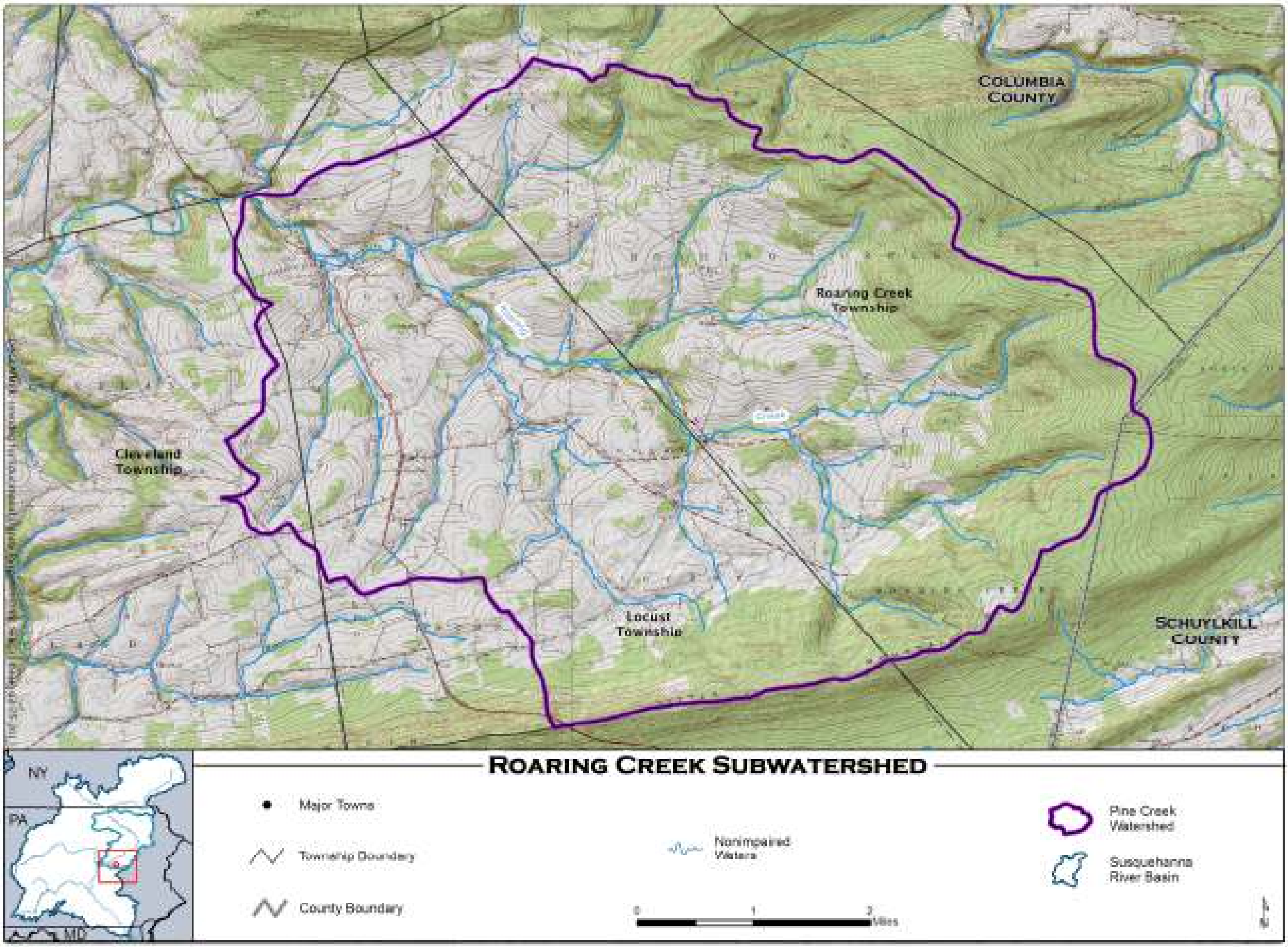


Figure 5. Location Map for Reference Watershed Roaring Creek

Table 2.   Comparison Between Mahoning Creek Watershed and Roaring Creek Subwatershed

Attribute	Watershed	
	Mahoning Creek Watershed	**Roaring Creek Subwatershed**
Physiographic Province	Appalachian Mountain Section: Ridge and Valley (100%)	Appalachian Mountain Section: Ridge and Valley (100%)
Area (mi^2)	39.6	31.6
Land Use	Agriculture (36.47%) Development (16.38%) Forested (47.15%)	Agriculture (38.37%) Development (4.20%) Forested (57.43%)
Geology	Trimmers Rock Formation (50%) Clinton Group (15%) Hamilton Group (10%) Bloomsburg/Mifflintown Formation (8%) Keyser/Tonoloway Formation (5%) Wills Creek Formation (5%) Catskill Formation (5%) Onondaga/Old Port Formation (2%)	Buddys Run Member/Catskill Formation (60%) Irish Valley Member/Catskill Formation (30%) Trimmers Rock Formation (8%) Spechty Kopf Formation (2%)
Soils	Berks-Weikert-Alvira (90%) Leck Kill-Meckesville-Calvin (5%) Clymer-Buchanan-Norwich (3%) Chenango-Pope-Hilly (2%)	Leck Kill-Meckesville-Calvin (50%) Hazleton-Dekalb-Buchanan (25%) Watson-Buchanan-Leck Kill (10%) Berks-Weikert-Bedington (5%)
Dominant HSG	Berks-Weikert-Alvira A (2%) B (18%) C (58%) D (22%) Leck Kill-Meckesville-Calvin A (0%) B (43%) C (50%) D (7%) Clymer-Buchanan-Norwich A (0%) B (54%) C (30%) D (16%) Chenango-Pope-Holly A (26%) B (37%) C (20%) D (17%)	Leck Kill-Meckesville-Calvin A (0%) B (43%) C (50%) D (7%) Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%) Watson-Buchanan-Leck Kill A (0%) B (18%) C (76%) D (6%) Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%)
K Factor	Berks-Weikert-Alvira (0.24) Leck Kill-Meckesville-Calvin (0.24) Clymer-Buchanan-Norwich (0.20) Chenango-Pope-Hilly (0.30)	Leck Kill-Meckesville-Calvin (0.24) Hazleton-Dekalb-Buchanan (0.18) Watson-Buchanan-Leck Kill (0.29 Berks-Weikert-Bedington (0.24)
20-Yr. Ave. Rainfall (in)	39.3	39.3
20-Yr. Ave. Runoff (in)	0.23	0.22

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Mahoning Creek Watershed 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 Mahoning Creek Watershed and the Roaring Creek reference watershed. All modeling inputs have been attached to this TMDL as Attachments D and E. SRBC staff visited the watershed in winter 2010 and spring 2011. The field visits were conducted to get a better understanding of existing conditions that might influence the AVGWLF model. General observations of the individual watershed characteristics include:

<u>**Mahoning Creek Watershed**</u>

- Reset P factor for cropland (0.45) and hay/pasture (0.45) land uses to 0.32 and 0.32, respectively, while forested (0.52) and wetlands (0.10) remained unchanged. These changes were made to account for the presence of riparian buffer zones, streambank fencing, and stable streambanks.
- Reset C factor for cropland (0.42) and hay/pasture (0.03) land uses to 0.30 and 0.02, respectively, while forested (0.002) and wetlands (0.01) remained unchanged. These changes were made to account for the presence of general management practices such as no-till farming and increased presence of erosion through lack vegetative cover.

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 Mahoning Creek Watershed and Roaring Creek Subwatershed, respectively. This information was then used to calculate existing unit area loading rates for the two watersheds. Acreage and sediment loading 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 Mahoning Creek Watershed

		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	5,379.5	3.4225	0.0006	1,564.8219	0.2909
CROPLAND	3,874.6	15.5946	0.0040	19,396.7123	5.0061
FOREST	11,957.4	0.7040	0.0001	936.9863	0.0784
WETLAND	7.4	0.0002	0.0000	0.0548	0.0074
TURF GRASS	192.7	0.0776	0.0004	48.9315	0.2539
UNPAVED_RD	22.2	0.0739	0.0033	87.0137	3.9195
TRANSITION	93.9	0.1677	0.0018	147.3425	1.5691
LO_INT_DEV	3,674.5	0.5296	0.0001	1,609.6986	0.4381
HI_INT_DEV	173.0	0.2594	0.0015	16.1644	0.0934
Streambank	-	0.5492	-	24,960.6159	-
Groundwater	-	4.9033	-	-	-
Septic System	-	0.0750	-	-	-
TOTAL	25,375.2	26.3570	0.0010	48,768.3419	1.9219

Table 4. Existing Sediment and Phosphorus Loads for Roaring Creek Subwatershed

Pollutant Source	Acreage	Phosphorus		Sediment	
		Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)	Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)
HAY/PAST	3,971.0	2.2937	0.0006	782.6849	0.1971
CROPLAND	3,790.6	11.3130	0.0030	12,769.0411	3.3686
FOREST	11,584.3	0.6560	0.0001	856.1644	0.739
WETLANDS	32.1	0.0008	0.0000	0.0548	0.0017
UNPAVED_RD	24.7	0.0681	0.0028	74.3562	3.0104
TRANSITION	51.9	0.0646	0.0012	37.9726	0.7316
LO_INT_DEV	773.4	0.1115	0.0001	94.5753	0.1223
Streambank	-	0.0775	-	3,521.5585	-
Groundwater	-	3.5600	-	-	-
Septic System	-	0.1150	-	-	-
TOTAL	20,228.0	18.2601	0.0009	18,136.4078	0.8966

TMDLS

The targeted TMDL value for the Mahoning Creek Watershed was established based on current loading rates for sediment and phosphorus in the Roaring Creek reference watershed. Biological assessments have determined that Roaring Creek is currently attaining its designated uses.

Reducing the loading rate of sediment and phosphorus in the Mahoning Creek Watershed 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 Mahoning Creek Watershed (25,375.2 acres) by the appropriate unit-area loading rate for the Roaring Creek reference watershed (Table 5). The existing mean annual loading of sediment and phosphorus to Mahoning Creek Watershed (48,768.3419 lbs/day and 26.3570 lbs/day, respectively) will need to be reduced by 53 and 13 percent, respectively, to meet the targeted TMDL of 22,751.4043 lbs/day and 22.8377 lbs/day, respectively.

Table 5. Targeted TMDL for Mahoning Creek Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Roaring Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Mahoning Creek (lbs/day)
Sediment	25,375.2	0.8966	22,751.4043
Phosphorus	25,375.2	0.0009	22.8377

Targeted TMDL values were used as the basis for load allocations and reductions in the Mahoning Creek Watershed, 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

Waste Load Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Reviewing the PADEP's permitting files identified one point source discharge for sediment and phosphorus in the watershed.

The Valley Township Municipal Authority discharges treated sewage effluent into the streams covered by this TMDL, permit numbers PA0029068. The instantaneous maximums for suspended solids is 60.0 mg/L, respectively, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Valley Township Municipal Authority is 0.21 mgd (million gallons per day). Based on the instantaneous maximums for this facility, the potential for sediment loads if the Valley Township Municipal Authority capacities were fully utilized is 105.1470 lbs/day, respectively. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The Mooresburg Wastewater Treatment Plant discharges treated sewage effluent into the streams covered by this TMDL, permit numbers PA0209261. The instantaneous maximums for suspended solids is 60.0 mg/L, respectively, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Mooresburg Wastewater Treatment Plant is 0.013 mgd (million gallons per day). Based on the instantaneous maximums for this facility, the potential for sediment loads if the Mooresburg Wastewater Treatment Plant capacities were fully utilized is 6.5091 lbs/day, respectively. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

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 TMDL 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 Mahoning Creek Watershed. The MOS used for the sediment and phosphorus TMDL is shown below.

Mahoning Creek Watershed:
MOS (sediment) = 22,751.4043 lbs/day (TMDL) x 0.1 = 2,275.1404 lbs/day
MOS (phosphorus) = 22.8377 lbs/day (TMDL) x 0.1 = 2.2838 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 and phosphorus 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 Mahoning Creek

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	20,364.6078	20.5539
Loads not Reduced	937.0411	5.6825
FOREST	936.9863	0.7040
WETLANDS	0.0548	0.0002
Groundwater	-	4.9033
Septic Systems	-	0.0750
Adjusted Load Allocation	19,427.5667	14.8714

TMDLs

The sediment TMDL established for the Mahoning Creek Watershed consists 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 Mahoning Creek

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	22,751.4043	22.8377
MOS (Margin of Safety)	2,275.1404	2.2838
WLA (Waste Load Allocation)	111.6561	-
LA (Load Allocation)	20,364.6078	20.5539
LNR (Loads not Reduced)	937.0411	5.6825
ALA (Adjusted Load Allocation)	19,427.5667	14.8714

CALCULATION OF SEDIMENT LOAD REDUCTIONS

The ALA established in the previous section represents the annual total sediment and phosphorus loads that are available for allocation between contributing sources in the Mahoning Creek Watershed. The ALA for sediment and phosphorus was allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Mahoning Creek Watershed 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 Mahoning Creek Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	5,379.5	0.2909	0.1336	1,564.8219	718.7219	54
Cropland	3,784.6	5.1252	2.3540	19,396.7123	8,908.9007	54
Developed	4,156.3	0.4593	0.2110	1,909.1507	876.8720	54
Streambanks	-	-	-	24,960.6159	8,923.0721	64
Total				47,831.3008	19,427.5667	59
Phosphorus						
Hay/Pasture	5,379.5	0.0006	0.0005	3.4225	2.5511	25
Cropland	3,784.6	0.0041	0.0029	15.5946	11.0849	29
Developed	4,156.3	0.0003	0.0002	1.1082	0.8260	25
Streambanks	-	-	-	0.5492	0.4094	25
Total				20.6745	14.8714	28

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 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 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 Mahoning Creek Watershed 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 Mahoning 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.

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 Mahoning Creek Watershed 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 Mahoning Creek Watershed, and it is strongly encouraged to continue.

By developing a sediment and phosphorus TMDL for the Mahoning Creek Watershed, 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 Mahoning Creek Watershed TMDL was published in the Pa. Bulletin on April 30, 2011, and *The Press Enterprise* and *Standard Journal* newspaper on April 27, 2011, to foster public comment on the allowable loads calculated. A public meeting was held on May 4, 2011, at the Mahoning Township building to discuss the proposed TMDL. The public participation process (which ended on May 30, 2011) was provided for the submittal of comments. Comments and responses are summarized in Attachment H.

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

REFERENCES

Commonwealth of Pennsylvania. 2001. Pennsylvania Code. Title 25 Environmental Protection. Department of Environmental Protection. Chapter 93. Water Quality Standards. Harrisburg, Pa.

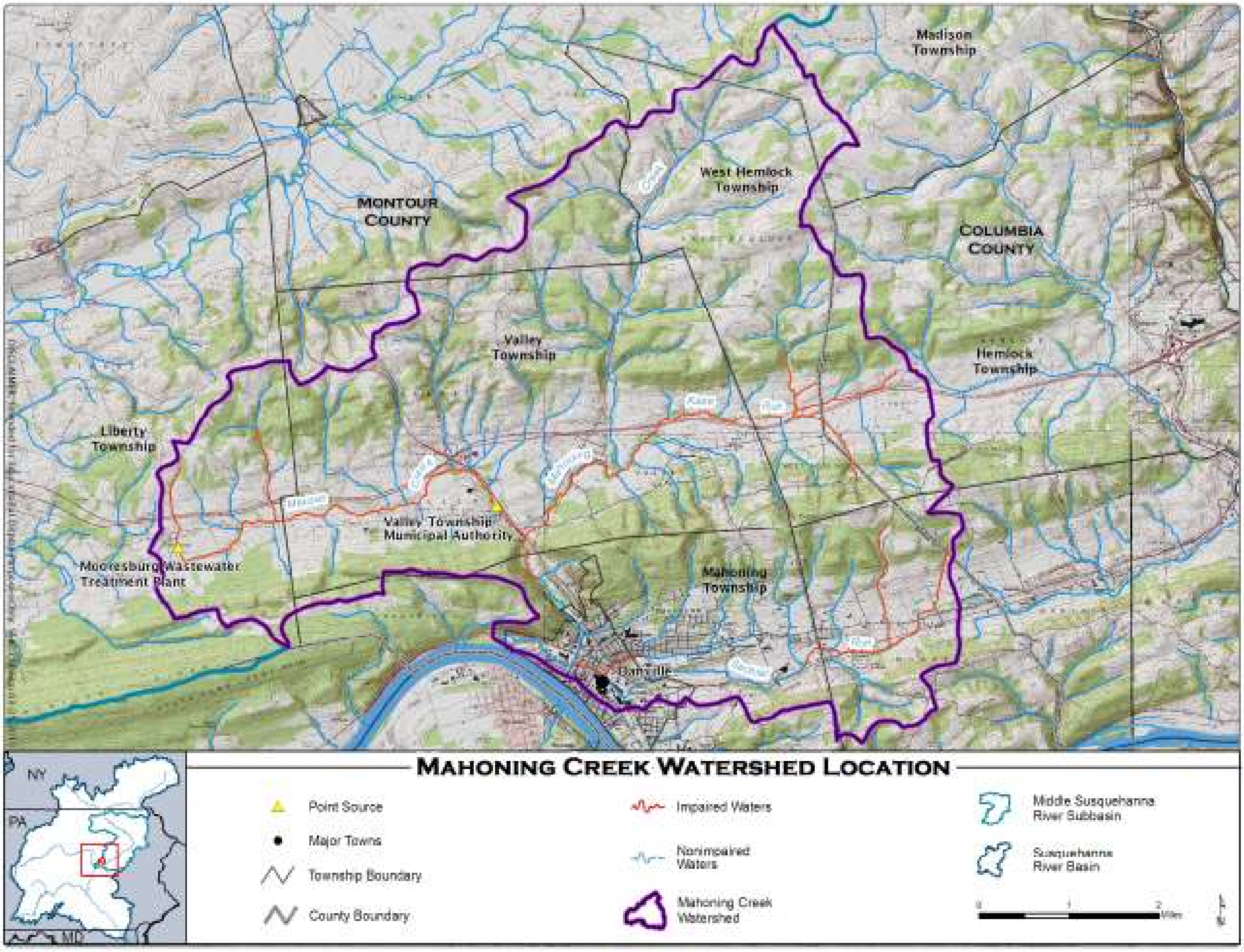
Hem, J.D. 1983. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water Supply Paper 1473.

Novotny, V. and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, N.Y.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, N.Y.

Attachment A

Mahoning Creek Watershed Impaired Waters


Madison Township
West Hemlock Township
MONTOUR COUNTY
COLUMBIA COUNTY
Valley Township
Hemlock Township
Liberty Township
Valley Township Municipal Authority
Mooresburg Wastewater Treatment Plant
Mahoning Township
Danville
NY
PA
MD
MAHONING CREEK WATERSHED LOCATION
Point Source
Major Towns
Township Boundary
County Boundary
Impaired Waters
Nonimpaired Waters
Mahoning Creek Watershed
Middle Susquehanna River Subbasin
Susquehanna River Basin
0
1
2
Miles

Attachment B

Information Sheet for the Mahoning Creek Watershed TMDL

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

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 Mahoning Creek Watershed is impaired due to sediment and phosphorus emanating from agricultural runoff. The plans include a calculation of the loading for sediment that will correct the problem and meet water quality objectives.

Why was the Mahoning Creek Watershed selected for TMDL development?
In 2008, PADEP listed segments of the Mahoning Creek Watershed 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 Mahoning Creek Watershed 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 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.

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, 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 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 May 30, 2011 to the above address.

Attachment C

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Mahoning Creek Watershed 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.

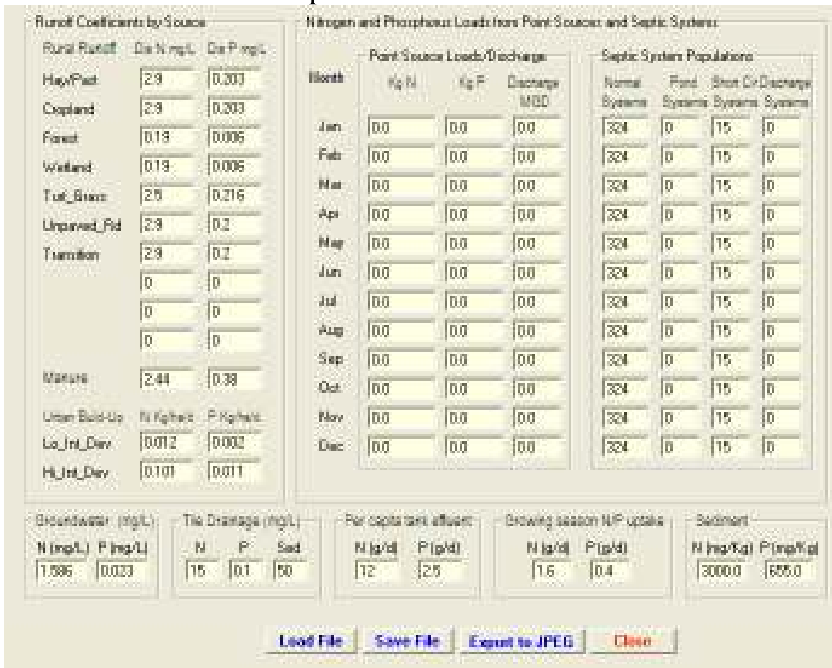
The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

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 Mahoning Creek Watershed

Mahoning Creek Watershed Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.203
Cropland	2.9	0.203
Forest	0.19	0.006
Wetland	0.19	0.006
Turf_Grass	2.5	0.216
Unpaved_Rd	2.9	0.2
Transition	2.9	0.2
	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

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	324	0	15	0
Feb	0.0	0.0	0.0	324	0	15	0
Mar	0.0	0.0	0.0	324	0	15	0
Apr	0.0	0.0	0.0	324	0	15	0
May	0.0	0.0	0.0	324	0	15	0
Jun	0.0	0.0	0.0	324	0	15	0
Jul	0.0	0.0	0.0	324	0	15	0
Aug	0.0	0.0	0.0	324	0	15	0
Sep	0.0	0.0	0.0	324	0	15	0
Oct	0.0	0.0	0.0	324	0	15	0
Nov	0.0	0.0	0.0	324	0	15	0
Dec	0.0	0.0	0.0	324	0	15	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)
1.586	0.023	15	0.1	50	12	2.5	1.6	0.4	3000.0	655.0

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Mahoning Creek Watershed Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	2177	75	0.24	2.403	0.02	0.32
Cropland	1568	82	0.24	2.757	0.3	0.32
Forest	4838	73	0.238	4.017	0.002	0.52
Wetland	3	87	0.25	0.22	0.01	0.1
Turf_Grass	78	71	0.24	0.839	0.08	0.2
	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**
Unpaved_Rd	9	87	0.24	2.089	0.1	1
Transition	38	87	0.243	1.024	0.1	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	1487	83	0.245	1.419	0.08	0.2
Hi_Int_Dev	70	90	0.284	0.261	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.65	9.4	0	0.12	0	0
Feb	0.7	10.3	0	0.12	0	0
Mar	0.73	11.8	0	0.12	0	0
Apr	0.89	13.2	1	0.3	0	0
May	0.98	14.4	1	0.3	0	0
Jun	1.04	14.9	1	0.3	0	0
Jul	1.07	14.6	1	0.3	0	0
Aug	1.08	13.7	1	0.3	0	0
Sep	1.09	12.2	1	0.3	0	0
Oct	1.1	10.8	1	0.12	0	0
Nov	0.96	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	0.113	Seepage Coefficient	0
Unsat Avail Wat (cm)	10.1511	Tile Drain Ratio	0.5	Sediment A Factor	1.0289E-03
		Tile Drain Density	0	Sed A Adjustment Factor	1

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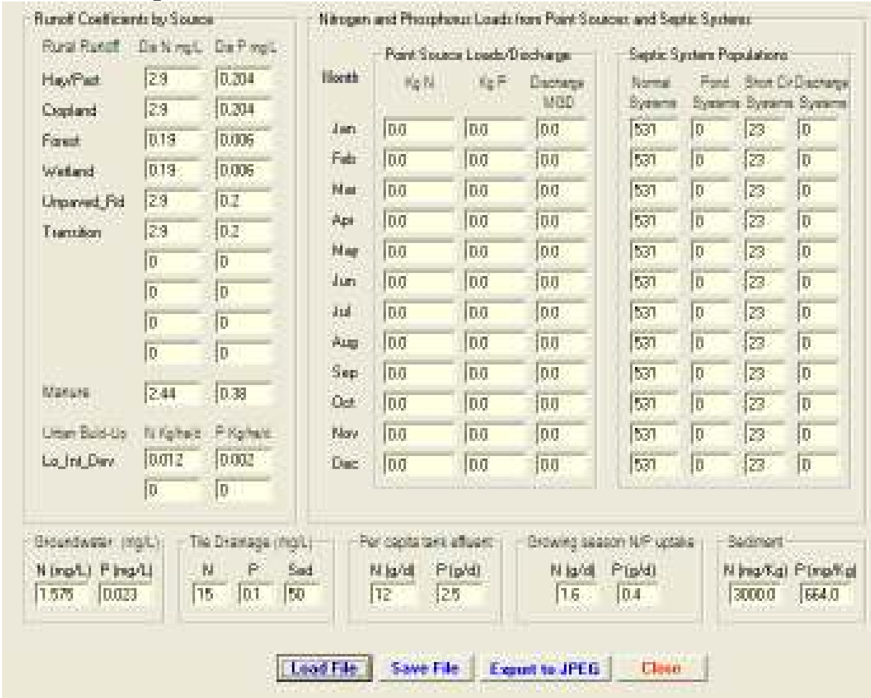
Attachment E

AVGWLF Model Inputs for the Roaring Creek Reference Watershed

Roaring Creek Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.204
Cropland	2.9	0.204
Forest	0.19	0.006
Wetland	0.19	0.006
Unpaved_Rd	2.9	0.2
Transition	2.9	0.2
	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	531	0	23	0
Feb	0.0	0.0	0.0	531	0	23	0
Mar	0.0	0.0	0.0	531	0	23	0
Apr	0.0	0.0	0.0	531	0	23	0
May	0.0	0.0	0.0	531	0	23	0
Jun	0.0	0.0	0.0	531	0	23	0
Jul	0.0	0.0	0.0	531	0	23	0
Aug	0.0	0.0	0.0	531	0	23	0
Sep	0.0	0.0	0.0	531	0	23	0
Oct	0.0	0.0	0.0	531	0	23	0
Nov	0.0	0.0	0.0	531	0	23	0
Dec	0.0	0.0	0.0	531	0	23	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)
1.575	0.023	15	0.1	50	12	2.5	1.6	0.4	3000.0	664.0

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Roaring Creek Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1607	75	0.245	0.706	0.03	0.45
Cropland	1534	82	0.245	0.862	0.42	0.45
Forest	4688	73	0.226	3.726	0.002	0.52
Wetland	13	87	0.239	0.101	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**
Unpaved_Rd	10	87	0.234	1.523	0.1	1
Transition	21	87	0.243	0.446	0.1	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	313	83	0.243	0.373	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	0.12	0	0
Feb	0.67	10.3	0	0.12	0	0
Mar	0.7	11.8	0	0.12	0	0
Apr	0.88	13.2	1	0.3	0	0
May	0.99	14.4	1	0.3	0	0
Jun	1.05	14.9	1	0.3	0	0
Jul	1.08	14.6	1	0.3	0	0
Aug	1.1	13.7	1	0.3	0	0
Sep	1.11	12.2	1	0.3	0	0
Oct	1.12	10.8	1	0.12	0	0
Nov	0.96	9.6	0	0.12	0	0
Dec	0.87	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**	0.121	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	15.545	**Tile Drain Ratio**	0.5	**Sediment A Factor**	3.7970E-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 Mahoning Creek Watershed TMDL

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable	
	Load = loading rate in ref. * Acres in Impaired					19539.2228	19539
	22751.4043						

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.	1564.8219	47831.3008	good	1565	ADJUST	0.04	843.872	720.950	5379.50	0.134	54%
	Cropland	19396.7123		good	19397	22871	0.46	10460.199	8936.513	3784.60	2.361	54%
	Developed	1909.1507		good	1909		0.05	1029.561	879.590	4156.30	0.212	54%
	Streambank	24960.6159		bad	19539		0.46	10537.052	9002.171			64%
	Total	47831.3008			42409.90769		1.00		19539.223			

Step 4:	All Ag. Loading Rate	1.05

Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.
	Final Hay/Past. LA	5379.50	0.1340	720.9495	0.2909	1564.8219	54%
	Final Cropland LA	3784.60	2.3613	8936.5128	5.1252	19396.7123	54%
	Developed	4156.30	0.2116	879.5898	0.4593	1909.1507	54%
	Streambank			9002.1707		24960.6159	64%
	Total			19539.2228		47831.3008	59%

Mahoning Creek

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
	Load = loading rate in ref. * Acres in Impaired					14.8714	15						
		22.8377											

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.	3.4225	20.6745	good	3	ADJUST	0.17	0.871	2.551	5379.50	0.000	25%
	Cropland	15.5946		bad	15	5	0.75	3.786	11.085	3784.60	0.003	29%
	Developed	1.1082		good	1		0.06	0.282	0.826	4156.30	0.000	25%
	Streambank	0.5492		good	1		0.03	0.140	0.409			25%
	Total	20.675			19.951312		1.00		14.871			

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	5379.50	0.0005	2.5511	0.0006	3.4225	25%
	Final Cropland LA	3784.60	0.0029	11.0849	0.0041	15.5946	29%
	Developed	4156.30	0.0002	0.8260	0.0003	1.1082	25%
	Streambank			0.4094		0.5492	25%
	Total			14.8714		20.6745	28%

Mahoning Creek

Attachment H

Mahoning Creek Impaired Segment Listings

Table 1. List of Impaired Stream Segments in Mahoning Creek Watershed

Segment ID	Year Listed	Stream Name	HUC	Source	Cause	Miles
4774	2004	Mahoning Creek	02050107	Agriculture, Urban Runoff/Storm Sewers	Siltation	0.56
4807	2004	Mahoning Creek	02050107	Agriculture	Siltation	1.74
3881	2004	Mauses Creek	02050107	Agriculture	Siltation	3.15
4759	2004	Mauses Creek	02050107	Agriculture	Siltation	1.63
4774	2004	Mauses Creek	02050107	Agriculture, Urban Runoff/Storm Sewers	Siltation	1.19
3873	2004	Mauses Creek	02050107	Agriculture	Organic Enrichment/Low D.O.	1.07
4724	2004	Kase Run	02050107	Agriculture	Siltation	0.54
4754	2004	Kase Run	02050107	Agriculture	Siltation	2.71
4820	2004	Kase Run (UNT 27365)	02050107	Agriculture	Siltation	1.21
4754	2004	Kase Run (UNT 27366)	02050107	Agriculture	Siltation	1.29
4754	2004	Kase Run (UNT 27370)	02050107	Agriculture	Siltation	0.29
4724	2004	Kase Run (UNT 27373)	02050107	Agriculture	Siltation	0.54
4754	2004	Kase Run (UNT 27373)	02050107	Agriculture	Siltation	0.14
4944	2004	Sechler Run	02050107	Agriculture	Siltation	2.62
4945	2004	Sechler Run (UNT 27405)	02050107	Agriculture	Siltation	1.52

Attachment I

Comment & Response Document for the Mahoning Creek Watershed TMDL