

# **WARRIORS MARK RUN SUBWATERSHED TMDL**

**Huntingdon and Centre Counties**

DRAFT

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 Halfmoon, Ferguson, and Warriors Mark Townships in Columbia and Montour Counties, Pennsylvania. The stream segments drain approximately 12.42 square miles as part of State Water Plan subbasin 11A. The aquatic life existing uses for Warriors Mark Run, including its tributaries, are High Quality-Cold Water Fishes (25 Pa. Code Chapter 93).
2. Pennsylvania's 2008 303(d) list identified 30.44 miles within the Warriors Mark Run Subwatershed as impaired by nutrients and sediment from agricultural land use practices. The listings were 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 Warriors Mark Run Subwatershed, mean annual loadings for sediment and phosphorus will need to be limited 9,655.8836 pounds per day (lbs/day) and 7.1478 lbs/day, respectively.

The major components of the Warriors Mark Run Subwatershed TMDL are summarized below.

<b>Warriors Mark Run Subwatershed Components</b>	<b>Sediment (lbs/day)</b>	<b>Phosphorus (lbs/day)</b>
TMDL (Total Maximum Daily Load)	9,655.8836	7.1478
WLA (Wasteload Allocation)	-	-
MOS (Margin of Safety)	965.5884	0.7148
LA (Load Allocation)	8,690.2952	6.4330

3. Mean annual sediment and phosphorus loadings are estimated at 26,714.9875 lbs/day and 18.0138 lbs/day, respectively. To meet the TMDL, the sediment and phosphorus loadings will require reductions of 64 percent and 60 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 8,508.5966 lbs/day and 4.2764 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 Warriors Mark Run Subwatershed TMDL are summarized below.

<b>Warriors Mark Run: Adjusted Load Allocations for Sources of Sediment and Phosphorus</b>			
<b>Pollutant</b>	<b>Current Loading (lbs/day)</b>	<b>Adjusted Load Allocation (lbs/day)</b>	<b>% Reduction</b>
<b>Sediment</b>	9,655.8836	8,508.5966	12
<b>Phosphorus</b>	7.1478	4.2764	40

6. Ten percent of the Warriors Mark Run Subwatershed 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 965.5884 lbs/day and 0.7148 lbs/day, respectively.
7. The continuous simulation model used for developing the Warriors Mark Run 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 Warriors Mark Run Subwatershed is approximately 12.42 square miles in area. The headwaters of Warriors Mark Run are located inside the southern portion of Centre County, a few miles southwest of Stormstown, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Port Matilda, Franklinville, and Tyrone, Pa. The stream flows south-southwest to its confluence with Spruce Creek. The major tributaries to Warriors Mark Run include several unnamed tributaries (UNTs). Smaller towns include Warriors Mark, Spring Mount, and Frogtown. State Routes 550 and 558 travel northeast/southwest, and State Route 45 travels north/south through the majority of the watershed. Numerous township roads provide access to the Warriors Mark Run 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 northern portion of the watershed. The total change in elevation in the watershed is approximately 775 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is carbonate (70 percent), predominantly associated with the Coburn, Bellefonte and Axemann, Gatesburg, and Warrior Formations (Figure 1). The remaining rock types found in the watershed are shale and sandstones (30 percent combined), predominantly associated with the Juniata, Bald Eagle, Reedsville, and Lower Gatesburg Formations.

The Hagerstown-Duffield-Clarksburg series is the predominant soil type in the TMDL watershed. This soil is listed as a silt-loam soil and is mostly associated in the rolling uplands of the watershed (Figure 2). Other dominant soils in the watershed consist of Morrison-Hazleton-Clymer and Hazleton-Dekalb-Buchanan series.

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.

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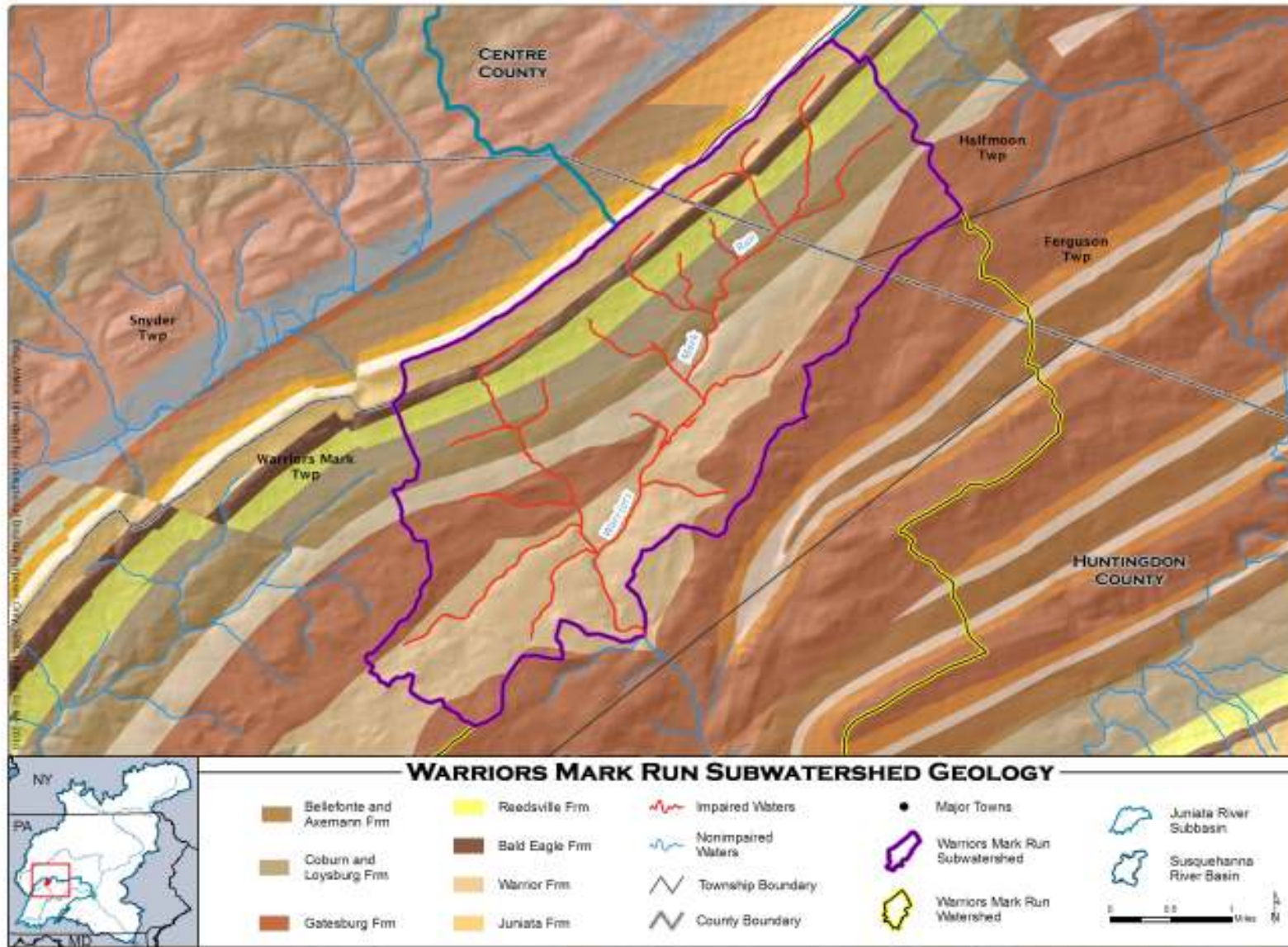


Figure 1. Geology Map of Warriors Mark Run Subwatershed

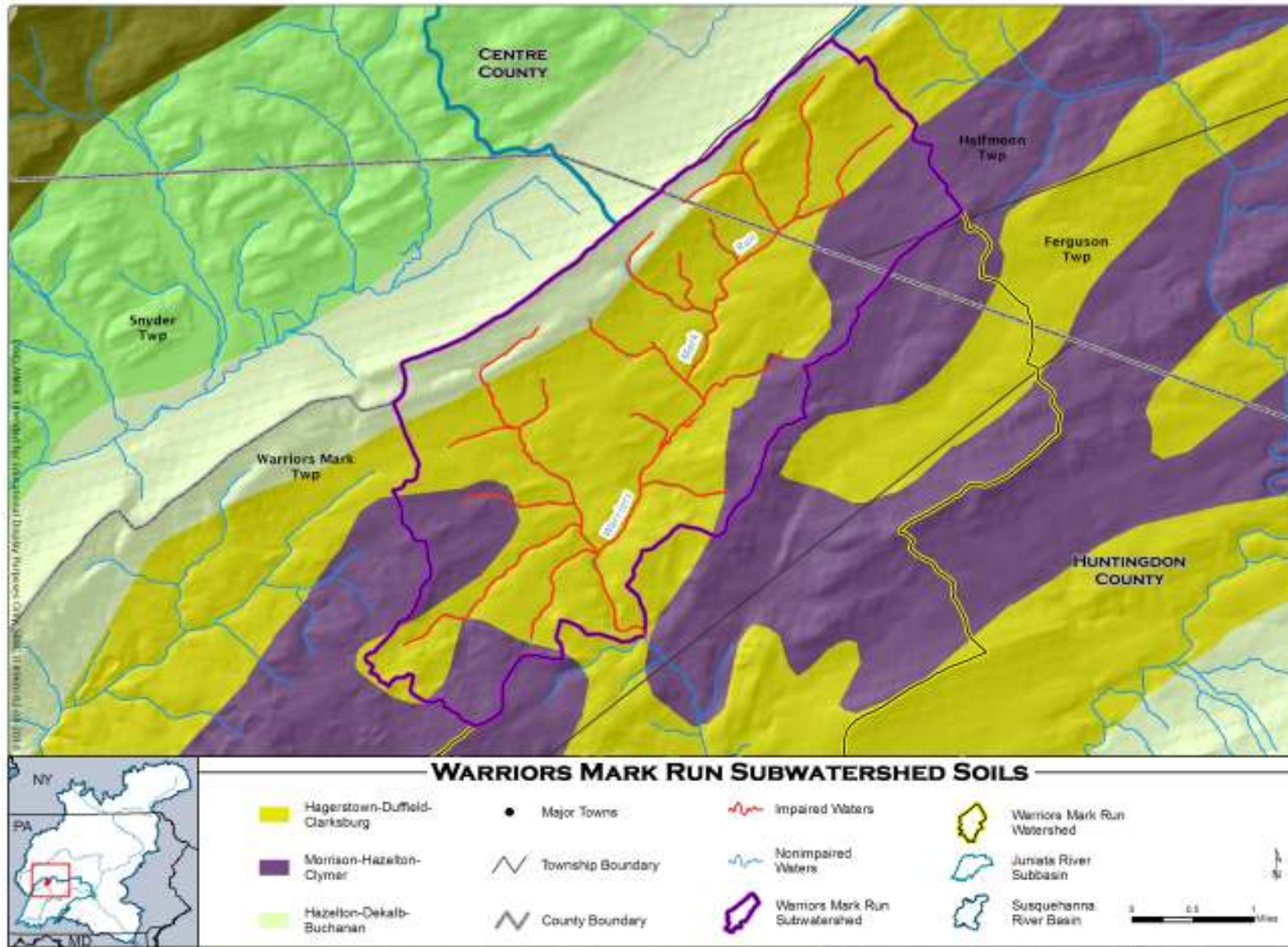


Figure 2. Soils Map of Warriors Mark Run Subwatershed

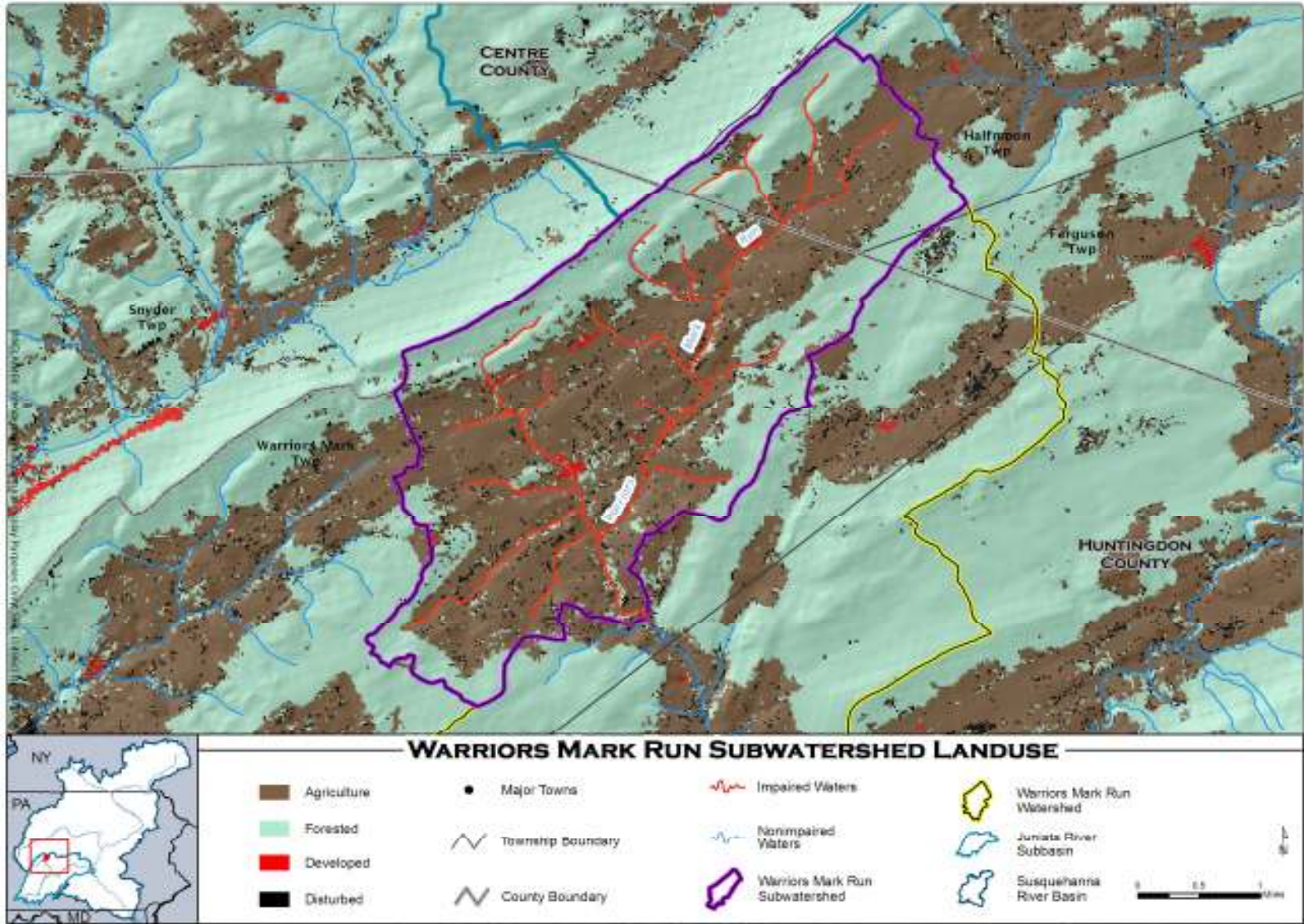


Figure 3. Land Use Map of Warriors Mark Run Subwatershed



***Figure 4. Evidence of Lack of Riparian Vegetation and Streambank Erosion in the Warriors Mark Run Subwatershed***

## Surface Water Quality

Pennsylvania's 2008 edition of the 303(d) list identified 30.44 miles of the Warriors Mark Run Subwatershed as impaired by nutrients and siltation emanating from agricultural practices (Table 1).

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

State Water Plan (SWP) Subbasin: 11A				
HUC: 02050302 – Upper Juniata				
Watershed – Warriors Mark Run				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Agriculture*	Siltation	15.22	CWF, MF	Aquatic Life
Agriculture	Nutrients	15.22	CWF, MF	Aquatic Life

\* Please see Attachment H for more details.

In general, soil erosion is a major problem in the Warriors Mark Run 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. Seasonal thunderstorms can cause the watershed to become excessively muddy for several days. 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 Warriors Mark Run Subwatershed, 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 Warriors Mark Run 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 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 Warriors Mark Run Subwatershed, the average N/P ratio is approximately 16, which indicates that phosphorus is the limiting nutrient. Controlling the phosphorus loading to the Warriors Mark Run 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 Warriors Mark Run 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 Warriors Mark Run 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.

Tea Creek was selected as the reference watershed for developing the Warriors Mark Run Subwatershed TMDL. Tea Creek is located just north of Reedsville, in Mifflin County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 12A, a tributary to Kishacoquillas 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, Tea 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 Warriors Mark Run Subwatershed were compared to the Tea Creek Watershed (Table 2). Agricultural land is a dominant land use category in the Warriors Mark Run Subwatershed (49 percent) and Tea Creek (46 percent). The geology, soils, and precipitation in both are also similar (Table 2).

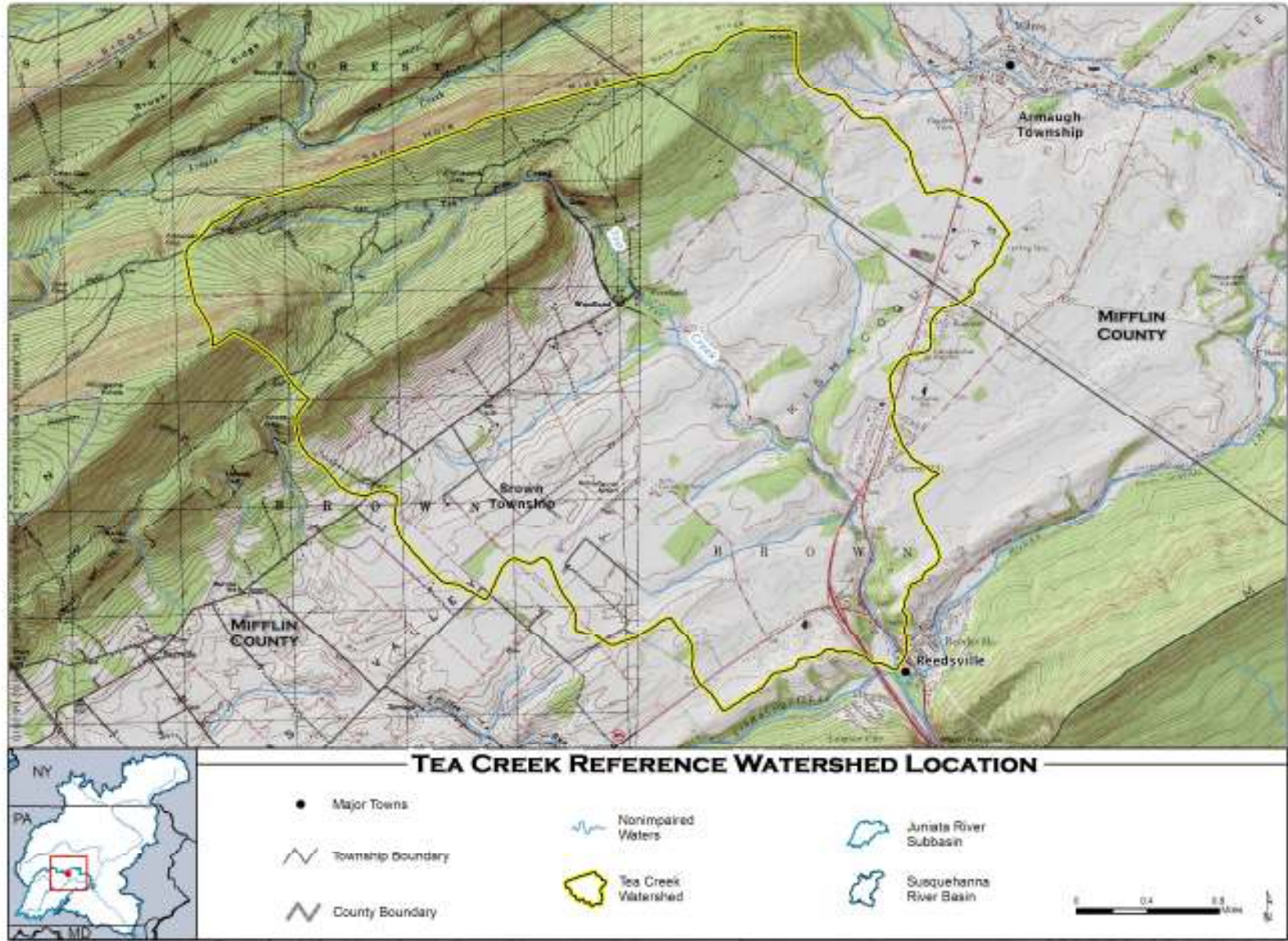


Figure 5. Location Map for Reference Watershed Tea Creek

**Table 2. Comparison Between Warriors Mark Run Subwatershed and Tea Creek Watershed**

Attribute	Watershed	
	Warriors Mark Run Subwatershed	Tea Creek
<b>Physiographic Province</b>	Appalachian Mountain Section: Ridge and Valley (100%)	Appalachian Mountain Section: Ridge and Valley (100%)
<b>Area (mi<sup>2</sup>)</b>	12.4	10.9
<b>Land Use</b>	Agriculture (49.13%) Development (7.81%) Forested (43.06%)	Agriculture (46.16%) Development (12.30%) Forested (41.54%)
<b>Geology</b>	Warrior Run Formation (20%) Gatesburg Formation (20%) Nittany and Stonehenge Formation (10%) Bellefonte and Axemann Formation (10%) Coburn and Loysburg Formation (10%) Reedsville Formation (10%) Juniata Formation (10%) Bald Eagle Formation (7%) Tuscarora Formation (3%)	Bellefonte Formation (25%) Juniata Formation (20%) Benner Formation (15%) Coburn Formation (15%) Reedsville Formation (10%) Bald Eagle Formation (10%) Axemann Formation (5%)
<b>Soils</b>	Hagerstown-Duffield-Clarksburg (65%) Morrison-Hazleton-Clymer (20%) Hazleton-Dekalb-Buchanan (15%)	Hagerstown-Duffield-Clarksburg (60%) Hazleton-Dekalb-Buchanan (30%) Berks-Weikert-Bedington (10%)
<b>Dominant HSG</b>	Hagerstown-Duffield-Clarksburg A (0%) B (36%) C (60%) D (2%)  Morrison-Hazleton-Clymer A (5%) B (82%) C (13%) D (0%)  Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%)	Hagerstown-Duffield-Clarksburg A (0%) B (36%) C (60%) D (2%)  Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%)  Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%)
<b>K Factor</b>	Hagerstown-Duffield-Clarksburg (0.32) Morrison-Hazleton-Clymer (0.20) Hazleton-Dekalb-Buchanan (0.18)	Hagerstown-Duffield-Clarksburg (0.32) Hazleton-Dekalb-Buchanan (0.18) Berks-Weikert-Bedington (0.24)
<b>20-Yr. Ave. Rainfall (in)</b>	38.7	38.7
<b>20-Yr. Ave. Runoff (in)</b>	0.19	0.19

## Watershed Assessment and Modeling

The TMDL for the impaired segments of the Warriors Mark Run 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 Warriors Mark Run Subwatershed and the Tea 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:

### Warriors Mark Run Subwatershed

- Reset P factor for cropland (0.45) and hay/pasture (0.45) land uses to 0.79 and 0.79, respectively, while forested (0.45) and wetlands (0.10) remained unchanged. These changes were made to account for the lack of riparian buffer zones, streambank fencing, and stable streambanks.
- Reset C factor for cropland (0.42) and hay/pasture (0.03) land uses to 0.79 and 0.05, respectively, while forested (0.002) and wetlands (0.01) remained unchanged. These changes were made to account for the lack 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 20-year period, from 1975 to 1994, and for the Warriors Mark Run Subwatershed and Tea Creek Watershed, 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 Warriors Mark Run 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	1,971.9	2.7273	0.0014	3,595.4521	1.8233
CROPLAND	1,929.9	13.0073	0.0067	21,184.2740	10.9769
FOREST	3,412.5	0.1213	0.0000	181.6438	0.0532
WETLAND	7.4	0.0001	0.0000	0.0548	0.0074
UNPAVED_RD	2.5	0.0032	0.0013	2.7397	1.0959
LO_INT_DEV	617.8	0.0861	0.0001	241.3151	0.3906
Streambank	-	0.0332	-	1,509.5080	-
Groundwater	-	2.0202	-	-	-
Septic System	-	0.0150	-	-	-
<b>TOTAL</b>	<b>7942.0</b>	<b>18.0137</b>	<b>0.0023</b>	<b>26,714.9875</b>	<b>3.3638</b>

**Table 4. Existing Sediment and Phosphorus Loads for Tea Creek Watershed**

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	1,863.2	1.1716	0.0006	1,097.3151	0.5889
CROPLAND	1,346.7	3.6446	0.0027	5,604.2740	4.1615
FOREST	2,888.7	0.1982	0.0001	359.5616	0.1245
UNPAVED_RD	2.5	0.0038	0.0015	4.2192	1.6877
LO_INT_DEV	847.6	0.1206	0.0001	189.3699	0.2234
HI_INT_DEV	4.9	0.0090	0.0018	0.3836	0.0783
Streambank	-	0.0264	-	1,199.0717	-
Groundwater	-	1.2390	-	-	-
Septic System	-	0.1200	-	-	-
<b>TOTAL</b>	6953.6	6.5332	0.0009	8,454.1951	1.2158

### TMDLS

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

Reducing the loading rate of sediment and phosphorus in the Warriors Mark Run 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 Warriors Mark Run Subwatershed (7,942.0 acres) by the appropriate unit-area loading rate for the Tea Creek reference watershed (Table 5). The existing mean annual loading of sediment and phosphorus to Warriors Mark Run Subwatershed (26,714.9875 lbs/day and 18.0137 lbs/day, respectively) will need to be reduced by 64 and 60 percent, respectively, to meet the targeted TMDL of 9,655.8836 lbs/day and 7.1478 lbs/day, respectively.

**Table 5. Targeted TMDL for Warriors Mark Run Subwatershed**

<b>Pollutant</b>	<b>Area (ac)</b>	<b>Unit Area Loading Rate Tea Creek Reference Watershed (lbs/ac/day)</b>	<b>Targeted TMDL for Warriors Mark Run (lbs/day)</b>
<b>Sediment</b>	7,942.0	1.2158	9,655.8836
<b>Phosphorus</b>	7,942.0	0.0009	7.1478

Targeted TMDL values were used as the basis for load allocations and reductions in the Warriors Mark Run 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 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 Warriors Mark Run Subwatershed. The MOS used for the sediment and phosphorus TMDL is shown below.

Warriors Mark Run Subwatershed:

$$MOS \text{ (sediment)} = 9,655.8836 \text{ lbs/day (TMDL)} \times 0.1 = 965.5884 \text{ lbs/day}$$

$$MOS \text{ (phosphorus)} = 7.1478 \text{ lbs/day (TMDL)} \times 0.1 = 0.7148 \text{ lbs/day}$$

### **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 Warriors Mark Run**

<b>Component</b>	<b>Sediment (lbs/day)</b>	<b>Phosphorus (lbs/day)</b>
<b>Load Allocation</b>	8,690.2952	6.4330
<b>Loads not Reduced</b>	181.6986	2.1566
<b>FOREST</b>	181.6438	0.1213
<b>WETLANDS</b>	0.0548	0.0001
<b>Groundwater</b>	-	2.0202
<b>Septic Systems</b>	-	0.0150
<b>Adjusted Load Allocation</b>	8,508.5966	4.2764

### **TMDLs**

The sediment and phosphorus TMDL established for the Warriors Mark Run Subwatershed 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 Warriors Mark Run**

<b>Component</b>	<b>Sediment (lbs/day)</b>	<b>Phosphorus (lbs/day)</b>
<b>TMDL (Total Maximum Daily Load)</b>	9,655.8836	7.1478
<b>MOS (Margin of Safety)</b>	965.5884	0.7148
<b>LA (Load Allocation)</b>	8,690.2952	6.4330
<b>LNR (Loads not Reduced)</b>	181.6986	2.1566
<b>ALA (Adjusted Load Allocation)</b>	8,508.5966	4.2764

### **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 Warriors Mark Run Subwatershed. The ALA for sediment and phosphorus was allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Warriors Mark Run 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 Warriors Mark Run Subwatershed**

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
<b>Sediment</b>						
Hay/Pasture	1,971.9	1.5694	0.9998	3,094.7945	1,971.5820	36
Cropland	1,929.9	8.0440	2.8087	15,524.0548	5,420.5201	65
Developed	620.3	0.3918	0.2496	243.0548	154.8414	36
Streambanks	-	-	-	1,509.5080	961.6531	36
Total				2,0371.4121	8,508.5966	58
<b>Phosphorus</b>						
Hay/Pasture	1,971.9	0.0012	0.0008	2.4500	1.5298	38
Cropland	1,929.9	0.0051	0.0014	9.8716	2.6702	73
Developed	620.3	0.0001	0.0001	0.0893	0.0558	38
Streambanks	-	-	-	0.0332	0.0207	38
Total				12.4441	4.2764	66

### 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 Warriors Mark Run 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 Warriors Mark Run 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 Juniata College Department of Geology (<http://departments.juniata.edu/geology/sprucecreek/spruceindex.htm>). Since 2002, Juniata College has been measuring chemical and biological of the Spruce Creek Watershed. Approximately 10 sampling sites from this project have been dedicated to measuring nutrient impacts in the Warriors Mark Watershed. Macroinvertebrates, nitrogen, phosphorus, total dissolved solids, turbidity and flow are among some of the measurements recorded for this project. Numerous research reports have been produced thanks to the efforts Juniata College has undertaken to maintain this sampling program. Other groups include the Spruce Creek Watershed Association who has partnered with agencies such as the Huntindon County Conservation District and Penn State University with educational efforts in the watershed.

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.nrcg.nrcs.usda.gov/nhcp\\_2.html](http://www.nrcg.nrcs.usda.gov/nhcp_2.html). Many of the practices described in the handbook could be used in the Warriors Mark Run 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 Warriors Mark Run Subwatershed, and it is strongly encouraged to continue.

By developing a sediment and phosphorus TMDL for the Warriors Mark Run 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 Warriors Mark Run Subwatershed TMDL was published in the Pa. Bulletin on April 30, 2011, and *The Altoona Mirror and The Daily Herald* newspaper on May 5, 2011, to foster public comment on the allowable loads calculated. A public meeting was held on May 12, 2011, at the Warriors Mark-Franklin Fire Hall 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

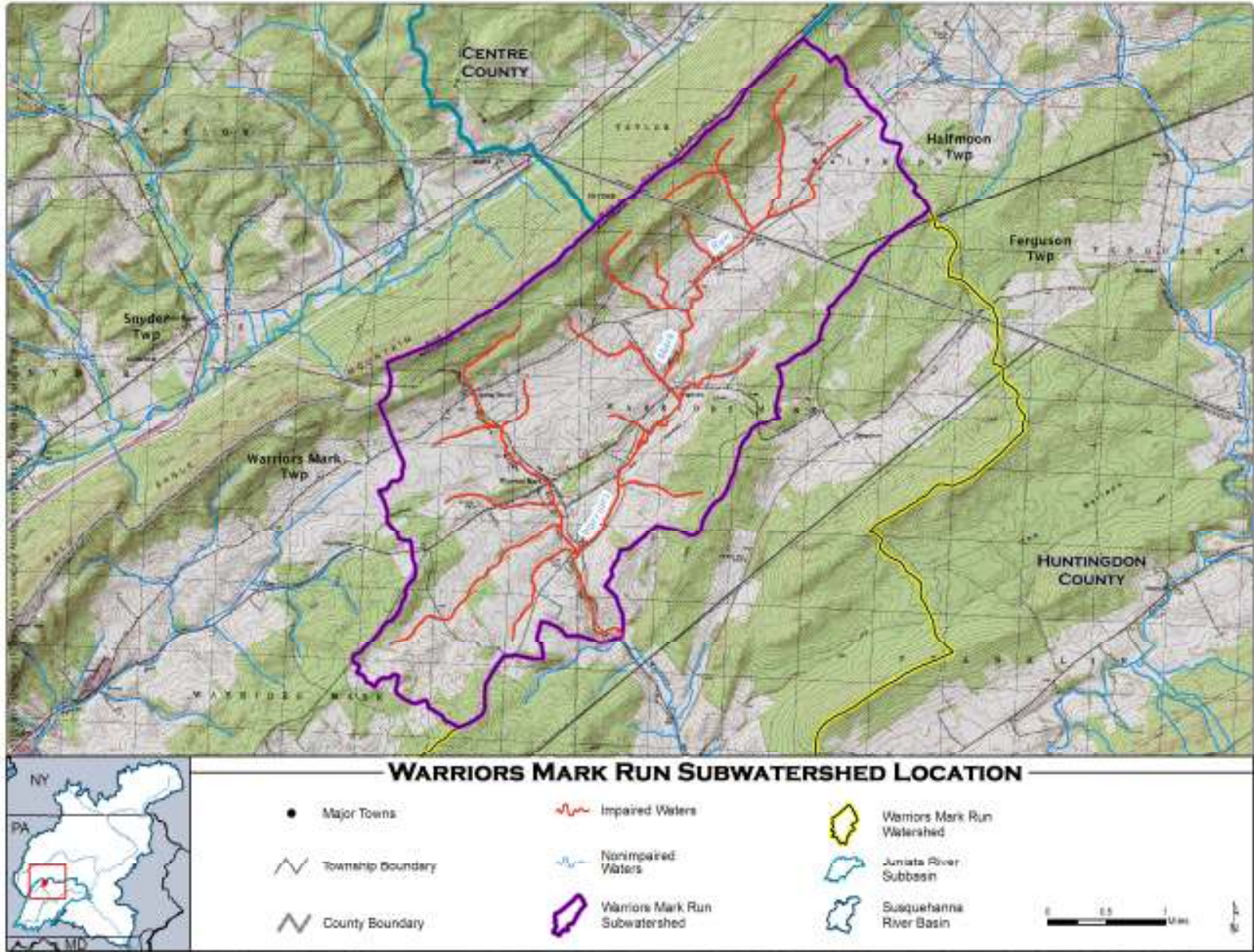
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# **Attachment A**

## **Warriors Mark Run Subwatershed Impaired Waters**

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# **Attachment B**

## **Information Sheet for the Warriors Mark Run Subwatershed TMDL**

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***What is being proposed?***

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Warriors Mark Run 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 Warriors Mark Run Subwatershed 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 Warriors Mark Run Subwatershed selected for TMDL development?***

In 2008, PADEP listed segments of the Warriors Mark Run 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 Warriors Mark Run 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 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](mailto: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.

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# **Attachment C**

## **AVGWLF Model Overview & GIS-Based Derivation of Input Data**

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The TMDL for the Warriors Mark Run 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 AVGWF (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, AVGWF 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.

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

# **Attachment D**

## **AVGWLF Model Inputs for the Warriors Mark Run Subwatershed**

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## Warriors Mark Run Subwatershed Nutrient Input File

Rural Runoff Coefficients by Source

Rural Runoff	Da N mg/L	Da P mg/L
Hay/Past	2.9	0.183
Cropland	2.9	0.183
Forest	0.19	0.006
Wetland	0.19	0.006
Unpaved_Rd	2.9	0.2
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Sub-Up	N kg/ha P kg/ha	
Lo_Int_Dev	0.012	0.002
	0	0

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	kg N	kg P	Discharge MGD	Normal Systems	Point Systems	Shoreline Discharge	Other Discharge
Jan	0.0	0.0	0.0	171	0	0	0
Feb	0.0	0.0	0.0	171	0	0	0
Mar	0.0	0.0	0.0	171	0	0	0
Apr	0.0	0.0	0.0	171	0	0	0
May	0.0	0.0	0.0	171	0	0	0
Jun	0.0	0.0	0.0	171	0	0	0
Jul	0.0	0.0	0.0	171	0	0	0
Aug	0.0	0.0	0.0	171	0	0	0
Sep	0.0	0.0	0.0	171	0	0	0
Oct	0.0	0.0	0.0	171	0	0	0
Nov	0.0	0.0	0.0	171	0	0	0
Dec	0.0	0.0	0.0	171	0	0	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)
3.385 0.034	15 0.1 50	12 2.5	1.6 0.4	3000 0 754 0

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## Warriors Mark Run Subwatershed Transport Input File

Rural LU	Area (ha)	CM	K	LS	C	P
Hay/Past	798	75	0.303	1.788	0.05	0.79
Cropland	781	82	0.297	0.742	0.74	0.79
Forest	1381	75	0.253	2.743	0.002	0.45
Wetland	3	80	0.252	0.32	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
	0	0	0	0	0	0
	0	0	0	0	0	0

Bare Land	Area (ha)	CM	K	LS	C	P
Unpaved_Rd	1	87	0.279	0.467	0.1	1
	0	0	0	0	0	0

Urban LU	Area (ha)	CM	K	LS	C	P
Lo_Int_Dev	250	83	0.282	1.016	0.08	0.2
	0	0	0	0	0	0

Month	Kel	Day Hours	Season	Ess Cost	Stream Extract	Ground Extract
Jan	0.63	9.4	0	0.12	0	0
Feb	0.69	10.3	0	0.12	0	0
Mar	0.71	11.8	0	0.12	0	0
Apr	0.9	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	1.1	14.7	1	0.3	0	0
Aug	1.12	13.7	1	0.3	0	0
Sep	1.13	12.2	1	0.3	0	0
Oct	1.14	10.8	1	0.12	0	0
Nov	0.98	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	0.158	Seepage Coefficient	0
Unsat Avail Wat (cm)	23.4038	Tile Drain Ratio	0.5	Sediment A Factor	5.6932E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

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# **Attachment E**

## **AVGWLF Model Inputs for the Tea Creek Reference Watershed**

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## Tea Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Da N mg/L	Da P mg/L	Point Source Loads/Discharge			Septic System Populations				
			Month	kg N	kg P	Discharge MSD	Normal Systems	Point Systems	Shon Cr Systems	Discharge Systems
Hay/Past	2.9	0.174	Jan	0.0	0.0	0.0	124	0	24	0
Cropland	2.9	0.174	Feb	0.0	0.0	0.0	124	0	24	0
Forest	0.19	0.006	Mar	0.0	0.0	0.0	124	0	24	0
Unpaved_Rd	2.9	0.2	Apr	0.0	0.0	0.0	124	0	24	0
	0	0	May	0.0	0.0	0.0	124	0	24	0
	0	0	Jun	0.0	0.0	0.0	124	0	24	0
	0	0	Jul	0.0	0.0	0.0	124	0	24	0
	0	0	Aug	0.0	0.0	0.0	124	0	24	0
	0	0	Sep	0.0	0.0	0.0	124	0	24	0
	0	0	Oct	0.0	0.0	0.0	124	0	24	0
Manure	2.44	0.38	Nov	0.0	0.0	0.0	124	0	24	0
Urban Sub-Ur	N kg/ha/d	P kg/ha/d	Dec	0.0	0.0	0.0	124	0	24	0
La_Int_Dev	0.012	0.002								
Hi_Int_Dev	0.101	0.011								

Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season NP 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)
2.29	0.027	15	0.1	50	12	2.5	1.6	0.4	3000.0	500.0

## Tea Creek Transport Input File

Rural LID	Area (ha)	CN	K	LS	C	P	Month	Kel	Day	Season Hours	Extr Cool	Stream Extract	Ground Extract
Hay/Past	754	75	0.289	1.981	0.03	0.45	Jan	0.66	9.4	0	0.12	0	0
Cropland	545	82	0.304	0.647	0.42	0.52	Feb	0.72	10.3	0	0.12	0	0
Forest	1168	73	0.216	5.723	0.032	0.52	Mar	0.75	11.8	0	0.12	0	0
	0	0	0	0	0	0	Apr	0.91	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.01	14.4	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.07	14.9	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.1	14.7	1	0.3	0	0
Bare Land	Area (ha) <td>CN <td>K <td>LS <td>C <td>P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td> </td></td></td></td></td>	CN <td>K <td>LS <td>C <td>P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td> </td></td></td></td>	K <td>LS <td>C <td>P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td> </td></td></td>	LS <td>C <td>P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td> </td></td>	C <td>P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td> </td>	P <td>Aug</td> <td>1.12</td> <td>13.7</td> <td>1</td> <td>0.3</td> <td>0</td> <td>0</td>	Aug	1.12	13.7	1	0.3	0	0
Unpaved_Rd	1	87	0.253	0.67	0.1	1	Sep	1.13	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.14	10.8	1	0.12	0	0
Urban LID	Area (ha) <td>CN <td>K <td>LS <td>C <td>P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td> </td></td></td></td></td>	CN <td>K <td>LS <td>C <td>P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td> </td></td></td></td>	K <td>LS <td>C <td>P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td> </td></td></td>	LS <td>C <td>P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td> </td></td>	C <td>P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td> </td>	P <td>Nov</td> <td>0.99</td> <td>9.6</td> <td>0</td> <td>0.12</td> <td>0</td> <td>0</td>	Nov	0.99	9.6	0	0.12	0	0
La_Int_Dev	343	89	0.312	0.452	0.08	0.2	Dec	0.91	8.1	0	0.12	0	0
Hi_Int_Dev	2	93	0.32	0.149	0.08	0.2							

Init Urnsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.163	Seepage Coefficient	0
Urnsat Avail Wat (cm)	20.3796	Tile Drain Ratio	0.5	Sediment A Factor	R:9339E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

# **Attachment F**

## **Equal Marginal Percent Reduction Method**

DRAFT

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 Warriors Mark Run Subwatershed TMDL**

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<b>Step 1:</b> TMDL Total Load													<b>Step 2:</b> Adjusted LA = (TMDL total load - MOS) - uncontrollable				
Load = loading rate in ref. * Acres in Impaired													4.2764		4		
7.1478																	
<b>PHOSPHORUS LOADING</b>																	
<b>Step 3:</b>		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction					
		Hay/Past.	2.4500	12.4441	good	2	ADJUST	0.36	0.920	1530	1971.90	0.001	38%				
		Cropland	9.8716		bad	4		0.62	1.606	2.670	1929.90	0.001	73%				
		Developed	0.0893		good	0		0.01	0.034	0.056	620.30	0.000	38%				
		Streambank	0.0332		good	0		0.00	0.012	0.021			38%				
		Total	12.444			6.84892		1.00		4.276							
<b>Step 4:</b> All Ag. Loading Rate		0.00															
<b>Step 5:</b>		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.										
		Final Hay/Past. LA	1971.90	0.0008	1.5298	0.0012	2.4500	38%									
		Final Cropland LA	1929.90	0.0014	2.6702	0.0051	9.8716	73%									
		Developed	620.30	0.0001	0.0558	0.0001	0.0893	38%									
		Streambank			0.0207		0.0332	38%									
		Total			4.2764		12.4441	66%									
<b>Warriors Mark Run</b>																	

# **Attachment H**

## **Warriors Mark Run Subwatershed Impaired Segment Listings**

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**Table H1. List of Impaired Stream Segments in Warriors Mark Run Subwatershed**

<b>Segment ID</b>	<b>Year Listed</b>	<b>Stream Name</b>	<b>HUC</b>	<b>Source</b>	<b>Cause</b>	<b>Miles</b>
278	2002	Warriors Mark Run	02050302	Agriculture	Nutrients and Siltation	1.03
278	2002	Warriors Mark Run (Right Branch)	02050302	Agriculture	Nutrients and Siltation	5.37
278	2002	Warriors Mark Run (Right Branch) (UNT 15698)	02050302	Agriculture	Nutrients and Siltation	0.75
278	2002	Warriors Mark Run (Right Branch) (UNT 15699)	02050302	Agriculture	Nutrients and Siltation	0.57
278	2002	Warriors Mark Run (Right Branch) (UNT 15700)	02050302	Agriculture	Nutrients and Siltation	0.17
278	2002	Warriors Mark Run (Right Branch) (UNT 15701)	02050302	Agriculture	Nutrients and Siltation	0.91
278	2002	Warriors Mark Run (Right Branch) (UNT 15702)	02050302	Agriculture	Nutrients and Siltation	1.14
278	2002	Warriors Mark Run (Right Branch) (UNT 15703)	02050302	Agriculture	Nutrients and Siltation	0.09
278	2002	Warriors Mark Run (Right Branch) (UNT 15704)	02050302	Agriculture	Nutrients and Siltation	1.28
278	2002	Warriors Mark Run (Right Branch) (UNT 15705)	02050302	Agriculture	Nutrients and Siltation	0.57
278	2002	Warriors Mark Run (Right Branch) (UNT 15706)	02050302	Agriculture	Nutrients and Siltation	0.51
278	2002	Warriors Mark Run (Right Branch) (UNT 15707)	02050302	Agriculture	Nutrients and Siltation	0.93
278	2002	Warriors Mark Run (Right Branch) (UNT 15708)	02050302	Agriculture	Nutrients and Siltation	0.61
278	2002	Warriors Mark Run (Right Branch) (UNT 15709)	02050302	Agriculture	Nutrients and Siltation	1.29

# **Attachment I**

## **Comment & Response Document for the Warriors Mark Run Subwatershed TMDL**

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