

OCTORARO CREEK WATERSHED TMDL

Chester and Lancaster Counties

Prepared for:

Pennsylvania Department of Environmental Protection



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**Octoraro Creek Watershed
Chester and Lancaster Counties, Pennsylvania**

INTRODUCTION

This report presents the Total Maximum Daily Loads (TMDLs) developed for impaired segments in the Octoraro Creek Watershed (Attachment A). These are done to address the impairments noted on the 2002 Pennsylvania Section 303(d) list of impaired waters and subsequent Integrated Reports, required under the Clean Water Act. Octoraro Creek is listed as impaired for nutrients and siltation from agriculture. The mainstem West Branch and East Branch Octoraro Creeks are listed for potable water supply impairments (nutrients). Many of the contributing tributaries are listed for aquatic life impairments (nutrients and siltation). The TMDLs address nitrate (potable water supply), phosphorus (nutrients – aquatic life), and siltation (aquatic life). The potable water supply impairments were addressed using the Load Duration Curve Method. The aquatic life use impairments (siltation and nutrients) of the Octoraro Creek were addressed using ArcView Generalized Watershed Loading Function.

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

State Water Plan (SWP) Subbasin: 07K					
HUC: 02050306 Lower Susquehanna					
Watershed – Octoraro Creek					
Waterbody	Source*	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Bells Run	Agriculture	Nutrients, Siltation	7.54	TSF	Aquatic Life
Buck Run	Agriculture	Nutrients, Siltation	7.60	TSF	Aquatic Life
East Branch Octoraro Creek	Agriculture	Nutrients, Siltation	2.36	TSF	Aquatic Life
East Branch Octoraro Creek	Agriculture	Nutrients	15.65	TSF	Potable Water Supply
Knight Run	Agriculture	Siltation	11.91	TSF	Aquatic Life
Meetinghouse Creek	Agriculture	Nutrients, Siltation	6.63	HQ-CWF	Aquatic Life
Meetinghouse Creek	Agriculture	Nutrients	0.11	HQ-CWF	Potable Water Supply
Muddy Run	Agriculture	Siltation	25.66	TSF	Aquatic Life
Nickel Mines Run	Agriculture	Nutrients, Siltation	7.02	HQ-CWF	Aquatic Life
Octoraro Creek	Agriculture	Nutrients	8.10	HQ-CWF, TSF	Potable Water Supply
Pine Creek	Agriculture	Nutrients, Siltation	3.50	TSF	Aquatic Life
Valley Creek	Agriculture	Siltation	4.66	TSF	Aquatic Life
Valley Run	Agriculture	Nutrients, Siltation	6.62	TSF	Aquatic Life
West Branch Octoraro Creek	Agriculture	Nutrients, Siltation	1.79	HQ-CWF	Aquatic Life
West Branch Octoraro Creek	Agriculture	Nutrients	12.37	HQ-CWF	Potable Water Supply
Williams Run	Agriculture	Nutrients, Siltation	6.66	TSF	Aquatic Life

*See Attachment C for more details
 TSF = Trout Stocked Fisheries
 HQ-CWF = High Quality Cold Water Fisheries

Location

The Octoraro Creek Watershed is approximately 175.6 square miles in area (Pa. portion only) (Figure 1). There are two branches of the Octoraro Creek, the West Branch and the East Branch. The headwaters of East Branch Octoraro Creek are located along the eastern edge of Lancaster County, in Sadbury Township. The West Branch Octoraro Creek headwaters are located in the eastern portion of Lancaster County in Bart Township. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Parkesburg, Gap, Quarryville, Wakefield, Kirkwood, and Oxford, Pa., and Conowingo Dam and Rising Sun, Md. The two branches flow south until they meet forming the Octoraro Reservoir. Octoraro Creek is dammed at the confluence of the branches and Chester Water Authority operates a surface water intake from the reservoir. The major tributaries to East Branch Octoraro Creek include Leech, Muddy, Coopers, Bells, Knight, Valley, and Williams Runs and Valley and Pine Creeks. Tributaries to the West Branch Octoraro Creek include Meetinghouse Creek and Nickel Mines, Bowery, and Stewart Runs. Numerous state and township roads provide access to the Octoraro Creek Watershed.

Hydrology, Geology and Land Use

The headwaters of the East Branch Octoraro Creek begin near Christiana, Pa. The East Branch Octoraro Creek flows south on the Lancaster/Chester County border until it meets the West Branch Octoraro Creek to form the reservoir. The East Branch Octoraro Creek Watershed contains about 154.4 stream miles and flows through predominately agricultural land.

The West Branch Octoraro Creek begins in Bart Township, Lancaster County, Pa. The watershed contains approximately 76.1 stream miles and flows south until it meets the East Branch Octoraro Creek. Agricultural lands are the principal land use in the watershed.

The TMDL watershed is located within the Appalachian Highlands of the Piedmont Upland physiographic province. The majority of the watershed lies in the Piedmont Upland region of the Northern Piedmont ecoregion. There is a narrow band of Piedmont Limestone/Dolomite Lowlands region that bisects the northern portion of the watershed. The highest elevations are located in the northern portion of the watershed.

The majority of the rock type in the watershed is metamorphic/igneous (94 percent), predominantly associated with the Wissahickon Formation, Peters Creek Formation, Granitic Gneiss, and Serpentine (Attachment A). The remaining rock types found in the watershed are carbonate, associated with the Conestoga Formation (4 percent) and conglomerate associated with the Chickies Formation (2 percent).

Chester-Glenelg-Manor soil is the predominant soil type in the TMDL watershed (93 percent). This soil is listed as a well-drained, silt-loam soil with medium runoff potential. The Chester soil series covers the entire watershed with the exception of a portion of the northeastern edge of the watershed and the southern portion of the watershed along the Maryland border (Attachment A).

Based on GIS datasets created in 2006, land use values were calculated for the TMDL watershed. Agriculture was the dominant land use at approximately 70 percent (Attachment A).

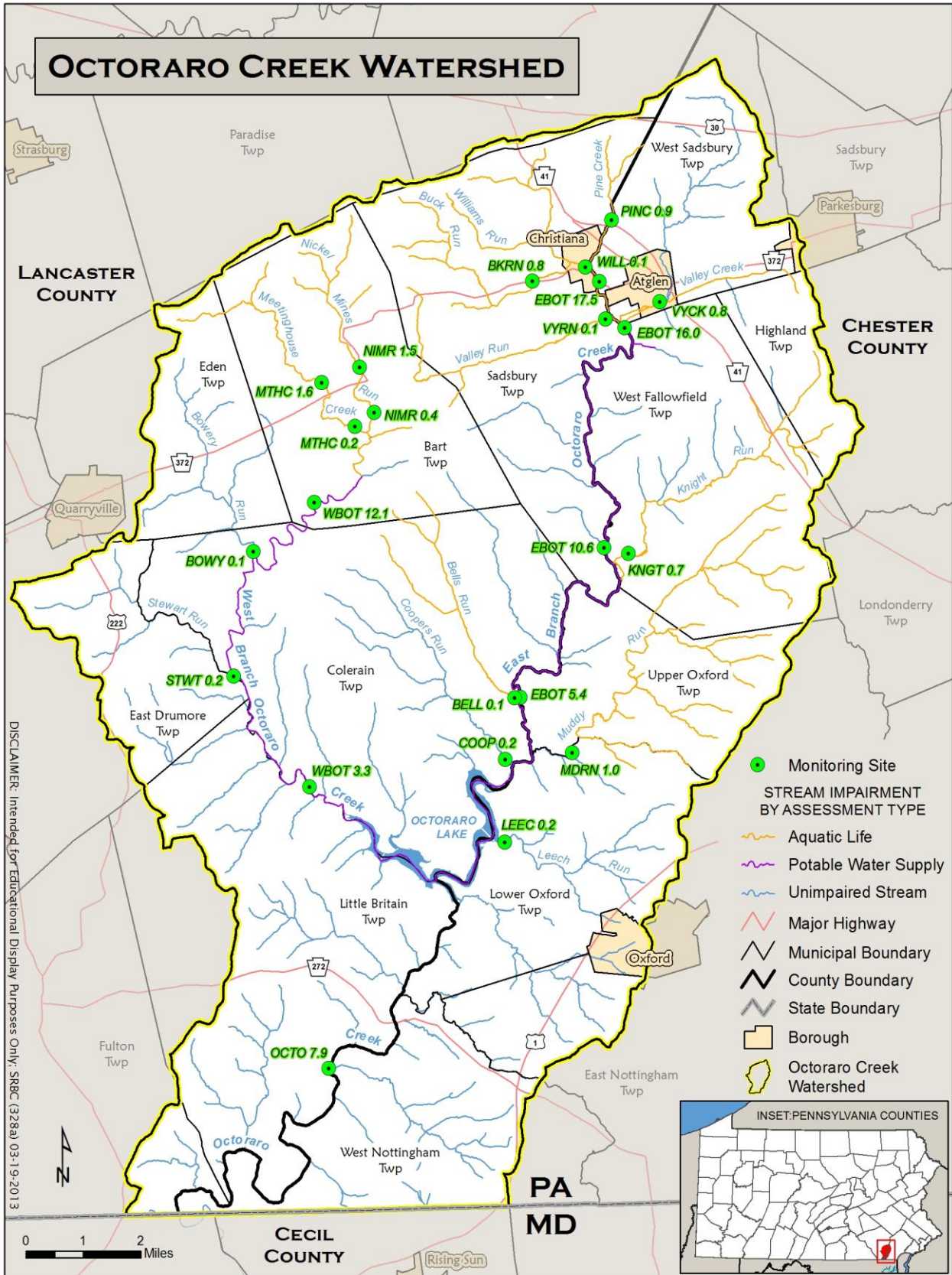


Figure 1. Location Map for the Octoraro Creek Watershed

Forested land uses account for approximately 26 percent of the watershed. Developed areas are 3 percent of the watershed, covering low-intensity residential and transitional. Riparian buffer zones are nearly nonexistent in most of the agricultural lands (Figure 2). Livestock also have unlimited access to streambanks in certain parts of the watershed, resulting in streambank trampling and severe erosion (Figure 3). Some contiguous forested tracts remain in the watershed.



Figure 2. No Riparian Buffer on Bells Run



Figure 3. Streambank Erosion

Segments Addressed in this TMDL

Octoraro Creek is affected by pollution from agriculture. This pollution has caused high concentrations of nitrate, phosphorus, and siltation. Two methods are used in this report to establish TMDLs for nitrate, phosphorus, and sediment. The Load Duration method is used to establish a nitrate TMDL for the potable water use listings (nitrate) and the reference watershed approach is used to establish TMDLs for aquatic life use listings (phosphorus and sediment).

The Load Duration method requires numeric water quality in order to determine the allowable load of the parameter. Pennsylvania has a drinking water standard for nitrate of 10 mg/l allowing the Load Duration method to be used for the potable water supply use listings in the Octoraro Creek Watershed. Aquatic life nutrient and sediment water quality standards are not available in Pennsylvania. Because of this, the reference watershed method is used to compare the impaired watershed to a non-impaired watershed with similar characteristics. More information on these methods is contained in sections “Nitrate TMDL Determination” and Sediment and Phosphorus TMDL Determination” of this document.

Waste Load Allocations (WLA) are assigned to all dischargers in the watershed. There are five permitted nutrient and sediment dischargers in Octoraro Creek Watershed – two in the West Branch Octoraro Creek drainage area and three in the East Branch Octoraro Creek drainage area. Table 2 indicates which dischargers receive WLAs for nitrate, phosphorus, and sediment.

Table 2. Permitted Dischargers in the Octoraro Creek Watershed

Permit Number	Permit Name	Nitrate WLA	Phosphorus WLA	Sediment WLA
PA0083933	Georgetown Area Sewer Authority	X	X	X
PA0081116	Solanco School District	X		
PA0024651	Atglen Borough Sewer Authority	X		X
PA0025399	Christiana Borough Sewer Authority	X		
PA0024889	Octoraro Area School District	X		X

Clean Water Act Requirements

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

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

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

- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;
- States to submit the list of waters to USEPA every two years (April 1 of the even numbered years);
- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- USEPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

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

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

Section 303(d) Listing Process

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

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

The assessment method requires selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. A biologist selects as many sites as necessary to establish an accurate assessment for a

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

stream segment; the length of the stream segment can vary between sites. All the biological surveys include kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates are identified to the family level in the field.

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

Basic Steps for Determining a TMDL

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

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

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

Watershed History

The Octoraro Creek Watershed historically was and currently is dominated by agriculture land uses. Over 70 percent of the landscape is row crops and grazing lands with Old Order Amish farming the majority of it with traditional practices. Grazing cattle have unlimited access to streambanks in many parts of the watershed leading to erosion. Conventional tillage is used in the bulk of the agricultural areas, including fall plowing, which can lead to increased soil erosion.

Since the 1990s, the Octoraro Creek Watershed Association, county conservation districts, and other conservation groups have actively been pursuing funding for educational and on-the-ground BMPs in the watershed. Several streambank fencing and restorations efforts have been funded on both the East and West Branches of Octoraro Creek. Educational grants have been used for demonstration sites and educational aids (i.e., calendars). The watershed continues to

need BMPs located in agricultural areas to reduce the amount of sediment and nutrients that enter the streams.

There are several population centers in the watershed (3 percent of the area) with small municipal discharges: Christiana Borough (PA0025399), Atglen Borough (PA0024651), and Georgetown Area (PA0083933) and two school districts: Solanco School District (PA0081116) and Octoraro Area School District (PA0042889). Stormwater runoff discharges are permitted in the watershed. While only a small portion of the watershed is developed currently, it is projected that the population will increase (Octoraro Creek, 2002).

In the 1940s, Chester Water Authority (Authority) purchased 2500 acres of the Octoraro Creek Watershed near the confluence of the East and West Branch Octoraro Creek. A concrete dam was built in 1947 and 670 acres of land were flooded to form the Octoraro Lake. The lake is used as a public water supply by the Authority and provides water for communities and industry in southwestern Delaware County and southern Chester County. Water is sold in bulk to other water companies in Pennsylvania and Delaware. In total, over 200,000 people are serviced water from the Chester Water Authority.

Shortly after the Authority constructed the lake, they restored the adjacent land and began to allow recreation on parts of the lake. Fishing and birding are popular activities on the lake. Mud flats are typically exposed during summer months around the lake, providing excellent birding conditions. Octoraro Creek was designated as the first Pennsylvania Scenic River by Legislative Act 1883-43.

NITRATE TMDL DETERMINATION

A two-step approach was used for the TMDL analysis of agricultural impaired stream segments. The first step uses a statistical method for determining the allowable instream concentration at the point of interest necessary to meet water quality standards. This is done at each point of interest (sample point) in the watershed. The second step is a mass balance of the loads as they pass through the watershed. Loads at these points are computed based on 50th percentile flow.

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

Allowable loads are determined for each point of interest using the Load Duration Curve method. The load duration curve characterizes water quality concentrations at different flow regimes. The method shows the frequency and magnitude of water quality standard

exceedances, current loadings, allowable loadings, and load reductions needed. Flow duration curves, wasteload allocations, margins of safety and seasonal variations are critical components of the load duration curve.

A flow duration curve looks at the cumulative frequency of historic flow data over a period of time and is generated for each point of interest. The percent of time a specified flow value meets or exceeds that value is represented in a flow duration curve. A flow duration curve runs from high to low (Figure 4) and the full range of streams flows is accounted for. The flow duration curve below shows that a flow of 5.3 cfs is exceeded 50 percent of the time.

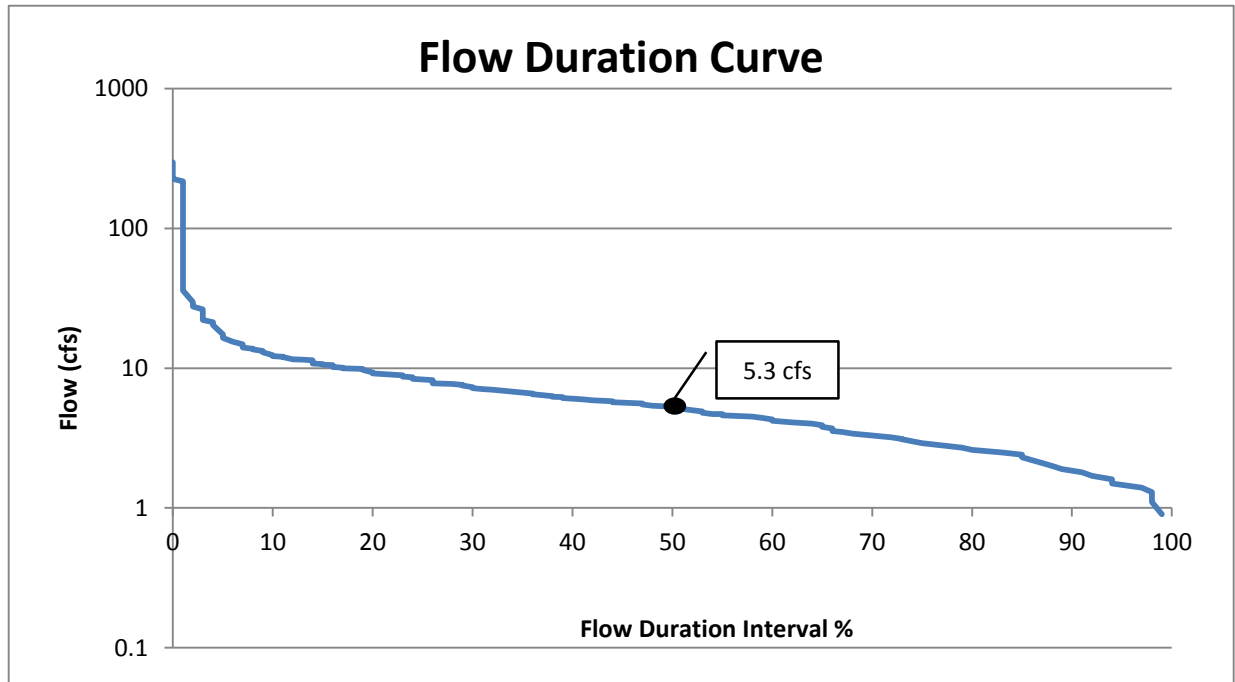


Figure 4. Flow Duration Curve

The load duration curve uses the flow duration curve to help develop a TMDL. A load duration curve is established by multiplying flow, a numeric water quality standard, and conversion factors for each pollutant (Figure 5). The TMDL dataset in Figure 5 represents the maximum loading capacity of nitrate a stream can assimilate at each flow measurement. The pollutant source was evaluated using the Load Duration Curve method to determine the required percent reduction so the water quality criteria, as defined in the *Pennsylvania Code, Title 25 Environmental Protection, Department of Environmental Protection, Chapter 93, Water Quality Standards*, will be met instream at least 99 percent of the time (Figure 6).

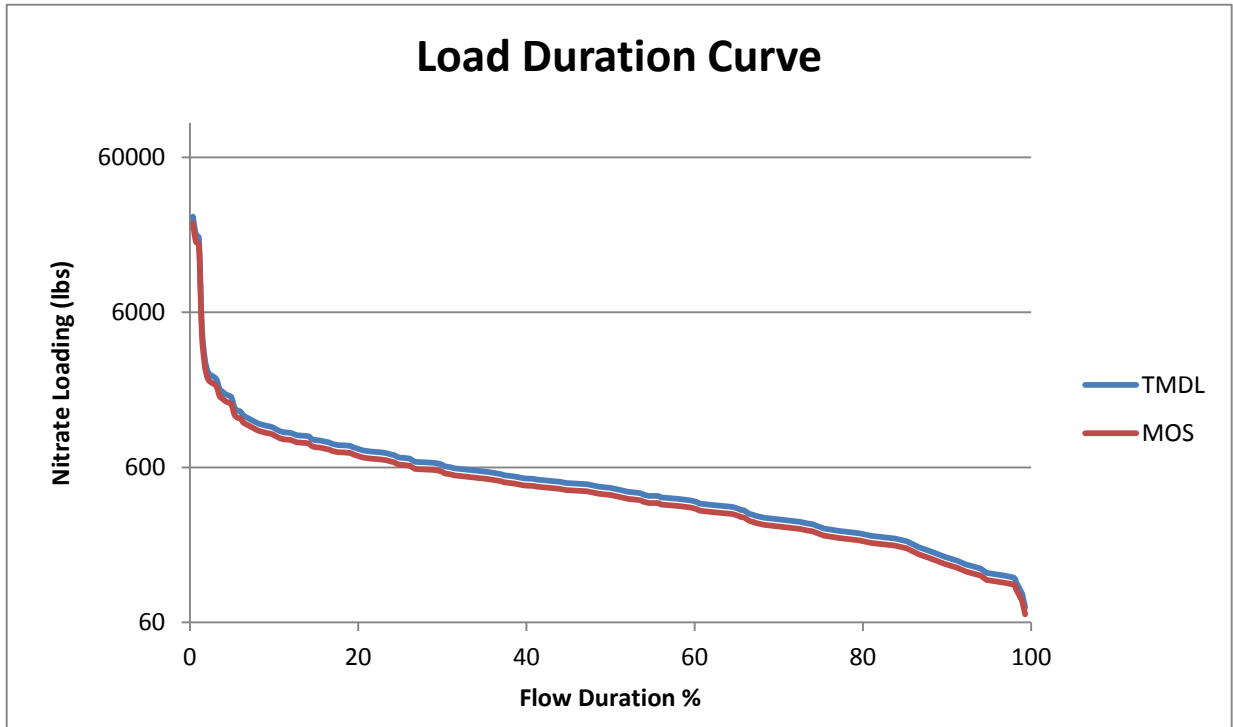


Figure 5. Load Duration Curve

In order to be protective of the water quality standard for nitrate (10 mg/l), a TMDL needs to be established. The existing nitrate loading at each sampling site is determined by multiplying the 50th percentile value of flow, the 99th percentile concentration of nitrate, and a conversion factor. The load allocation for each sampling site is established by multiplying the 50th percentile flow, the water quality standard minus the MOS, and a conversion factor. The percent reduction needed at each sampling site is established by subtracting the load allocation for nitrate from the existing nitrate load.

$$PR = (E99N * 50F * 8.345) - (50F * (WQS - MOS) * 8.345) \text{ where}$$

PR = percent reduction

E99N = 99th percentile of existing nitrate concentration

50F = 50th percentile of flow

WQS = water quality standard (10 mg/l)

MOS = margin of safety (1.0 mg/l)

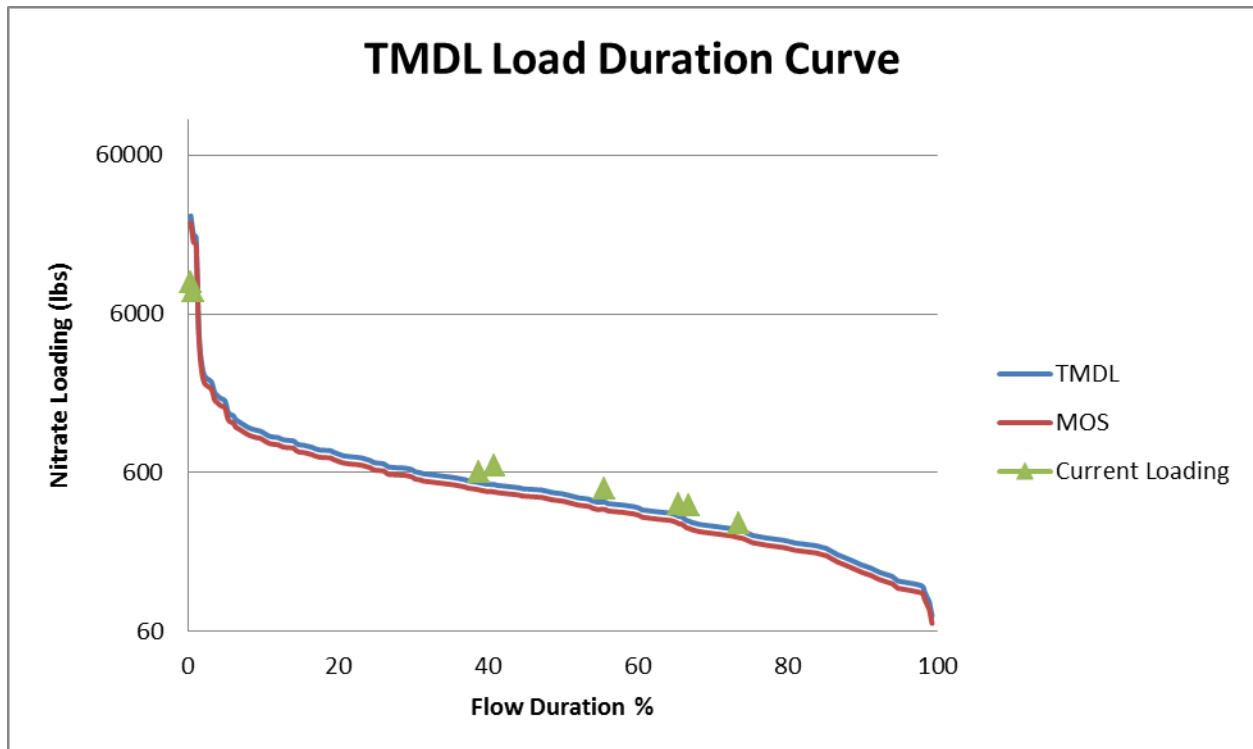


Figure 6. TMDL Load Duration Curve

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

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

TMDL Endpoints

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

Because of the nature of the pollution sources in the watershed, the TMDL's components makeup will be load allocations (LAs) that are specified above a point in the stream segment. All allocations will be specified as long-term average daily concentrations. These long-term average daily concentrations are expected to meet water quality criteria 99 percent of the time. Pa. Title 25 Chapter 96.3(c) specifies that the water quality standards must be met 99 percent of the time. Table 3 shows the water quality criteria for the selected parameters.

Table 3. Applicable Water Quality Criteria

<i>Parameter</i>	<i>Criterion Value (mg/l)</i>	<i>Total Recoverable/Dissolved</i>
Nitrate	10.0	Total Recoverable

TMDL Elements (WLA, LA, MOS)

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

Allocations Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each watershed. The reduction schemes in Table 4 for each segment are based on the assumption that all upstream allocations are implemented and take into account all upstream reductions. Attachment D contains the TMDLs by Segment analysis for each allocation point in a detailed discussion. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. An explicit MOS based on setting the numeric target at a more conservative level is included in the TMDL calculations. Ten percent of the numeric water quality standard is set aside for the MOS (Figure 2).

$$\text{MOS(nitrate)} = 10.0 \text{ mg/l (WQS)} \times 0.1 = 1.0 \text{ mg/l}$$

The allowable long-term average (LTA) concentration in each segment is calculated by subtracting the MOS from the water quality standard. The allowable load is then determined by multiplying the allowable concentration by the 50th percentile flow and a conversion factor at each sample point. The allowable load is the TMDL at that point.

Each permitted discharge in a segment is assigned a WLA and is included in this table. The difference between the TMDL and the WLA at each point is the LA at the point. The LA at each point includes all loads entering the segment including those from upstream allocation points. The percent reduction is calculated to show the amount of load that needs to be reduced from nonpoint sources within a segment in order for water quality standards to be met at the point.

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

Table 4. Octoraro Creek Watershed Summary Table

Sample Site	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	NPS Load Reduction (lbs/day)	NPS % Reduction
NIMR 1.5	239.90	172.86	5.74	167.12	72.78	30
NIMR 0.4	260.10	196.06	1.96	194.10	-1.04	0
MTHC 1.6	185.86	139.16	1.39	137.77	48.09	26
MTHC 0.2	262.94	212.04	2.12	209.92	6.22	2
WBOT 12.1	687.95	560.32	5.50	554.72	18.29	3
BOWY 0.1	300.64	319.83	3.20	316.63	-15.99	0
STWT 0.2	437.20	287.63	5.75	281.88	155.32	36
WBOT 3.3	1,620.08	1,261.31	12.61	1,248.70	113.37	7
PINC 0.9	75.59	75.59	0.76	74.83	0.76	1
BKRN 0.8	181.08	143.59	1.44	142.15	38.93	21
WILL 0.1	388.87	338.15	3.38	334.77	16.51	4
EBOT 17.5	476.01	450.96	4.51	446.45	-44.20	0
VYRN 0.1	157.14	173.31	1.73	171.58	-14.44	0
VYCK 0.8	361.79	391.36	24.18	367.18	-5.39	0
EBOT 16.0	1,101.31	1,198.53	43.50	1,155.03	-33.03	0
EBOT 10.6	1,494.76	1,681.60	16.82	1,664.78	-72.80	0
KNGT 0.7	401.28	309.73	13.11	296.62	104.66	26
EBOT 5.4	3,791.80	2,524.13	25.24	2,498.89	1,388.20	37
BELL 0.1	256.53	178.15	1.78	176.37	80.16	31
MDRN 1.0	695.08	598.06	5.98	592.08	103.00	15
COOP 0.2	381.44	261.06	2.61	258.45	122.99	35
LEEC 0.2	228.90	228.39	2.28	226.11	2.79	1

The following is an example of how the allocations in Table 3, for a stream segment are calculated. For this example, nitrate allocations for WILL 0.1 of Williams Run are shown. As demonstrated in the example, all upstream contributing loads are accounted for at each point. Attachment D contains the TMDLs by Segment analysis for each allocation point in a detailed discussion. These analyses follow the example below. Figure 1 shows a map of the sampling point locations for reference.

<i>Allocations for BKRN 0.8</i>	
	<i>Nitrate (lbs/day)</i>
Existing load at BKRN 0.8	181.08
Allowable load at BKRN 0.8	143.59

Allowable Load = 143.59

Load input = 207.79
(Difference between existing loads At BKRN 0.8 and WILL 0.1)



<i>Allocations at WILL 0.1</i>	
	<i>Nitrate (lbs/day)</i>
Existing load at WILL 0.1	388.87
Difference of measured loads between loads that enter and existing WILL 0.1	207.79
Percent loss due calculated at WILL 0.1	0
Additional loads tracked from above samples	143.59
Percentage of upstream loads that reach WILL 0.1	100
Total load tacked between BKRN 0.8 and WILL 0.1	351.28
Allowable load at WILL 0.1	338.15
WLA	3.38
LA	334.77
Load Reduction at WILL 0.1	16.51
Percent reduction required at WILL 0.1	4

→

Allowable load= 338.15

The allowable nitrate load tracked from BKRN 0.8 is 143.59 lbs/day. The existing load at BKRN 0.8 was subtracted from the existing load at WILL 0.1 to show the actual measured increase of nitrate load that has entered the stream between these upstream sites and WILL 0.1 (207.79 lbs/day). This increased value was then added to the calculated allowable load from BKRN 0.8 to calculate the total load that was tracked between BKRN 0.8 and WILL 0.1 (allowable loads @ BKRN 0.8 + the difference in existing load between BKRN 0.8 and WILL 0.1). The WLA at WILL 0.1 was then subtracted from the allowable load at WILL 0.1 to calculate the LA (334.77). This total load tracked was then subtracted from the calculated LA at WILL 0.1 to determine the amount of load to be reduced at BKRN 0.8. This total load was found to be 351.28 lbs/day; it was 16.51 lbs/day greater than the LA at WILL 0.1 of 334.77 lbs/day. Therefore, a 4 percent nitrate reduction at WILL 0.1 is necessary.

Groundwater Summary

During base flow conditions, groundwater impacts have a greater influence on surface water. Groundwater is a significant contributor of nitrogen to the Chesapeake Bay – 48 percent (Phillips et al., 1999). Several studies have looked at groundwater and nitrates in the Octoraro Creek Watershed. Recently, the SSM Group, Inc. (SSM) modeled the groundwater contributions in the

subwatersheds in the Octoraro Creek Watershed for source water protection. Even though Chester Water Authority operates a surface water intake in the watershed, it has been well documented that groundwater influences the surface water in this watershed. Numerous water chemistry samples taken from wells in both Lancaster and Chester Counties shows nitrate concentrations significantly over the 10 mg/l drinking water standard.

SSM used well observation data, stream discharge values, groundwater recharge data, soil and geology types, and slope, among other things, to determine groundwater contributions to surface water in the Octoraro Creek Watershed through modeling. SSM calculated that almost 70 percent of the surface water flow during base flow conditions is from groundwater (Guissepe, 2012).

Time-of-travel was also modeled in the Octoraro Creek Watershed. It was found that the majority of groundwater in the watershed has a short time-of-travel (less than 35 years). Generally speaking, all groundwater in the watershed reaches the surface water in a short time period (Guissepe, 2012). This information indicates the high nitrate concentrations in the groundwater are adversely impacting the surface water in the Octoraro Creek Watershed.

SEDIMENT AND PHOSPHORUS TMDL DETERMINATION

Each pollutant on the 303(d) for the Octoraro Creek list will be addressed as a separate TMDL. These TMDLs are expressed as long-term average loadings. Due to the nature and complexity of agricultural effects on the watershed, expressing the TMDL as a long-term average gives better representation of the data used for calculations. Based on the number of impaired stream miles and watershed size, the Octoraro Creek Watershed was divided into seven subwatersheds to determine the sediment and phosphorus TMDLs. Maps showing location, land use, geology, and soils of Octoraro Creek subwatersheds are located in Attachment A.

East Branch Octoraro Creek Headwaters

1. The impaired stream segments addressed by this TMDL are mainly in Sadsbury Township and Christiana Borough, Lancaster County, Pa., and West Sadsbury Township, Chester County, Pa. The stream segments drain approximately 11.7 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2002 303(d) List and 2008 Integrated List identified 18.5 stream miles within the East Branch Octoraro Creek Headwaters Watershed as impaired by sediment and nutrients for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the East Branch Octoraro Creek Headwaters Watershed, mean annual loading will need to be limited to 10,147.4148 lbs/day for sediment and 4.6707 lbs/day for phosphorus.

The major components of the East Branch Octoraro Creek Headwaters Watershed TMDL are summarized below.

East Branch Octoraro Creek Headwaters Components	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	11,401.5897	5.2480
WLA (Waste load Allocation)	114.0159	0.0525
MOS (Margin of Safety)	1,140.1590	0.5248
LA (Load Allocation)	10,147.4148	4.6707

3. Mean annual sediment and phosphorus loadings are estimated to be 13,122.0184 lbs/day and 18.5225 lbs/day, respectively. To meet the TMDL, the sediment loadings will require reductions of 23 percent and phosphorus loadings require a reduction of 75 percent.
4. There are no point sources addressed in these TMDL segments; a bulk reserve WLA is assigned to the watershed.
5. The adjusted load allocation (ALA) is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 10,119.0312 lbs/day and a phosphorus nonpoint source ALA of 4.5585 lbs/day. Sediment and phosphorus loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the East Branch Octoraro Creek Headwaters Watershed TMDL are summarized below.

East Branch Octoraro Creek Headwaters: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	11,401.5897	10,119.0312	11
Phosphorus	5.2480	4.5585	13

6. Ten percent of the East Branch Octoraro Creek Headwaters Watershed sediment and phosphorus TMDLs were set-aside as a 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 TMDLs are 1,140.1590 lbs/day and 0.5248 lbs/day, respectively.
7. The continuous simulation model used for developing the East Branch Octoraro Creek Headwaters 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.

Valley Run

1. The impaired stream segments addressed by this TMDL are mainly in Sadsbury Township and Bart Township, Lancaster County, Pa. The stream segments drain approximately 5.5 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2002 303(d) List and 2008 Integrated List identified 6.6 stream miles within the Valley Run Watershed as impaired by sediment and nutrients for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Valley Run Watershed, mean annual loading will need to be limited to 5,052.1427 lbs/day for sediment and 6.2857 lbs/day for phosphorus.

The major components of the Valley Run Watershed TMDL are summarized below.

Valley Run Components	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	5,676.5648	7.0626
WLA	56.7656	0.0706
MOS	567.6565	0.7063
LA	5,052.1427	6.2857

3. Mean annual sediment and phosphorus loadings are estimated to be 6,630.5990 lbs/day and 11.1687 lbs/day, respectively. To meet the TMDL, the sediment loadings will require reductions of 24 percent and phosphorus loadings require a reduction of 44 percent.
4. There are no point sources addressed in these TMDL segments; a bulk reserve WLA is assigned to the watershed.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 5,018.6085 lbs/day and a phosphorus nonpoint source ALA of 6.2032 lbs/day. Sediment and phosphorus loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Valley Run Watershed TMDL are summarized below.

Valley Run: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	5,676.5648	5,018.6085	12
Phosphorus	7.0626	6.2032	12

6. Ten percent of the Valley Run Watershed sediment and phosphorus TMDLs were set-aside as a 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 TMDLs are 567.6565 lbs/day and 0.7063 lbs/day, respectively.

7. The continuous simulation model used for developing the Valley Run 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.

Valley Creek

1. The impaired stream segments addressed by this TMDL are mainly in Sadsbury, West Fallowfield, and Highland Townships and Atglen Borough, Chester County, Pa. The stream segments drain approximately 10.6 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2006 Integrated List identified 4.6 stream miles within the Valley Creek Watershed as impaired by sediment for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Valley Creek Watershed, mean annual sediment loadings will need to be limited to 10,981.0337 lbs/day.

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

Valley Creek Components	Sediment (lbs/day)
TMDL	12,363.5564
WLA	146.1671
MOS	1,236.3556
LA	10,981.0337

3. Mean annual sediment loadings are estimated to be 14,726.6524 lbs/day. To meet the TMDL, the sediment loadings will require reductions of 25 percent.
4. There is one point source addressed in these TMDL segments and a bulk reserve WLA is assigned to the watershed. Atglen Borough Sewer Authority discharges suspended solids and is included in the WLA.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 10,898.3487 lbs/day. Sediment loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment to controllable nonpoint sources, or the ALA, for the Valley Creek Watershed TMDL are summarized below.

Valley Creek: Adjusted Load Allocations for Sources of Sediment			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	12,363.5564	10,898.3487	12

6. Ten percent of the Valley Creek Watershed sediment TMDL was set-aside as a 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 TMDL is 1,236.3556 lbs/day.
7. The continuous simulation model used for developing the Valley 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.

Knight Run

1. The impaired stream segments addressed by this TMDL are mainly in West Fallowfield and Highland Townships, Chester County, Pa. The stream segments drain approximately 9.0 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2006 Integrated List identified 10.95 stream miles within the Knight Run Watershed as impaired by sediment for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Knight Run Watershed, mean annual sediment loadings will need to be limited to 5,597.7818 lbs/day.

The major components of the Knight Run Watershed TMDL are summarized below.

Knight Run Components	Sediment (lbs/day)
TMDL (Total Maximum Daily Load)	6,298.0812
WLA (Waste load Allocation)	70.4913
MOS (Margin of Safety)	629.8081
LA (Load Allocation)	5,597.7818

3. Mean annual sediment loadings are estimated to be 14,090.8296 lbs/day. To meet the TMDL, the sediment loadings will require reductions of 60 percent.
4. There is one point source addressed in these TMDL segments and a bulk reserve WLA is assigned to the watershed. Octoraro Area School District discharges suspended solids and is included in the WLA.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 5,578.8229 lbs/day. Sediment loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment to controllable nonpoint sources, or the ALA, for the Knight Run Watershed TMDL are summarized below.

Knight Run: Adjusted Load Allocations for Sources of Sediment			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	6,298.0812	5,578.8229	11

6. Ten percent of the Knight Run Watershed sediment TMDL was set-aside as a 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 TMDL is 629.8081 lbs/day.
7. The continuous simulation model used for developing the Knight Run 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.

Bells Run

1. The impaired stream segments addressed by this TMDL are located in Colerain Township, Lancaster County, Pa. The stream segments drain approximately 4.2 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2002 303(d) List identified 7.5 stream miles within the Bells Run Watershed as impaired by sediment and nutrients for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Bells Run Watershed, mean annual loading will need to be limited to 3,832.2061 lbs/day for sediment and 4.7679 lbs/day for phosphorus.

The major components of the Bells Run Watershed TMDL are summarized below.

Bells Run Components	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	4,305.8495	5.3572
WLA	43.0585	0.0536
MOS	430.5849	0.5357
LA	3,832.2061	4.7679

3. Mean annual sediment and phosphorus loadings are estimated to be 5,515.3789 lbs/day and 8.6603 lbs/day, respectively. To meet the TMDL, the sediment loadings will require reductions of 31 percent and phosphorus loadings require a reduction of 45 percent.
4. There are no point sources addressed in these TMDL segments; a bulk reserve WLA is assigned to the watershed.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 3,819.4937 lbs/day and a phosphorus nonpoint source ALA of 4.7282 lbs/day. Sediment and phosphorus loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Bells Run Watershed TMDL are summarized below.

Bells Run: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	4,305.8495	3,819.4937	11
Phosphorus	5.3572	4.7282	12

6. Ten percent of the Bells Run Watershed sediment and phosphorus TMDLs were set-aside as a 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 TMDLs are 430.5849 lbs/day and 0.5357 lbs/day, respectively.
7. The continuous simulation model used for developing the Bells Run 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.

Muddy Run

1. The impaired stream segments addressed by this TMDL are located in Upper Oxford and West Fallowfield Townships, Chester County, Pa. The stream segments drain approximately 14.7 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is trout-stocked fisheries (25 Pa. Code Chapter 93).
2. Pennsylvania's 2006 Integrated List identified 25.7 stream miles within the Muddy Run Watershed as impaired by sediment for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Muddy Run Watershed, mean annual sediment loadings will need to be limited to 9,085.6859 lbs/day.

The major components of the Muddy Run Watershed TMDL are summarized below.

Muddy Run Components	Sediment (lbs/day)
TMDL	10,208.6359
WLA	102.0864
MOS	1,020.8636
LA	9,085.6859

3. Mean annual sediment loadings are estimated to be 33,045.2996 lbs/day. To meet the TMDL, the sediment loadings will require reductions of 73 percent.
4. There are no point sources addressed in these TMDL segments; a bulk reserve WLA is assigned to the watershed.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 9,052.4256 lbs/day. Sediment loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment to controllable nonpoint sources, or the ALA, for the Muddy Run Watershed TMDL are summarized below.

Muddy Run: Adjusted Load Allocations for Sources of Sediment			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	10,208.6359	9,052.4256	11

6. Ten percent of the Muddy Run Watershed sediment TMDL was set-aside as a 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 TMDL is 1,020.8636 lbs/day.
7. The continuous simulation model used for developing the Muddy Run 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.

Nickel Mines Run/Meetinghouse Creek

1. The impaired stream segments addressed by this TMDL are located in Bart Township, Lancaster County, Pa. The stream segments drain approximately 17.4 square miles, as part of State Water Plan subbasin 07K. The aquatic life existing use for the impaired segments is high quality cold water fisheries (25 Pa. Code Chapter 93).

2. Pennsylvania's 2002 303(d) List identified 14.5 stream miles within the Nickel Mines Run/Meetinghouse Creek Watershed as impaired by sediment and nutrients for aquatic life from agriculture. In order to ensure attainment and maintenance of water quality standards in the Nickel Mines Run/Meetinghouse Creek Watershed, mean annual loading will need to be limited to 6,318.6356 lbs/day for sediment and 5.6843 lbs/day for phosphorus.

The major components of the Nickel Mines Run/Meetinghouse Creek Watershed TMDL are summarized below.

Nickel Mines Run/Meetinghouse Creek Components	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	7,110.8422	6.5285
WLA	81.1224	0.1913
MOS	711.0842	0.6529
LA	6,318.6356	5.6843

3. Mean annual sediment and phosphorus loadings are estimated to be 12,600.1750 lbs/day and 21.3805 lbs/day, respectively. To meet the TMDL, the sediment loadings will require reductions of 50 percent and phosphorus loadings require a reduction of 73 percent.
4. There is one point source addressed in these TMDL segments and a bulk reserve WLA is assigned to the watershed. Georgetown Area Sewer Authority discharges suspended solids and phosphorus and is included in the WLA.
5. The ALA is the actual portion of the 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 TMDL includes a sediment nonpoint source ALA of 6,307.7315 lbs/day and a phosphorus nonpoint source ALA of 5.6086 lbs/day. Sediment and phosphorus loadings from all other sources, such as forested areas, were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Nickel Mines Run/Meetinghouse Creek Watershed TMDL are summarized below.

Nickel Mines Run/Meetinghouse Creek: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	Current Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	7,110.8422	6,307.7315	11
Phosphorus	6.5285	5.6086	14

6. Ten percent of the Nickel Mines Run/Meetinghouse Creek Watershed sediment and phosphorus TMDLs were set-aside as a 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 TMDLs are 711.0842 lbs/day and 0.6529 lbs/day, respectively.
7. The continuous simulation model used for developing the Nickel Mines Run/Meetinghouse 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.

Pollutants & Sources

Sediment and nutrients have been identified as the pollutants causing designated aquatic use impairments in the Octoraro Creek Watershed TMDL, with the sources listed as agriculture. At present, there are three point source contributions within the segments addressed in these TMDLs.

As stated in previous sections, the land use is dominantly agriculture. Row crops and pasture land uses extend to the streambanks with little to no riparian buffer zones present. Based on visual observations, streambank erosion is severe in most reaches of the streams.

TMDL Endpoints

In an effort to address the sediment and nutrient problems found in the Octoraro Creek Watershed, a TMDL was developed to establish loading limits for sediment and phosphorus. The TMDL is intended to address sediment and nutrient impairments from agriculture that were first identified in Pennsylvania's 2002 303(d) list.

Reference Watershed Approach

The TMDL developed for the Octoraro Creek Watershed addresses sediment and phosphorus. Because neither Pennsylvania nor the USEPA has instream numerical water quality criteria for sediment or 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 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 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 20-30 percent of the impaired watershed area. The search for reference watersheds for the Octoraro Creek Watershed that would satisfy the above characteristics was created with several GIS coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land cover/use grid, Pennsylvania's streams database, and geologic rock types.

In order to meet the requirements for selecting a reference watershed, the aquatic use impaired segments of the Octoraro Creek Watershed were divided into seven subwatersheds. Four reference watersheds were selected to develop the seven aquatic life TMDLs in the Octoraro Creek Watershed (Table 5).

Table 5. Reference Watersheds

Octoraro Creek Subwatershed	Reference Watershed
East Branch Octoraro Creek Headwaters	Licking Creek
Valley Run	Goods Run
Valley Creek	Marsh Creek
Knight Run	West Branch Big Elk Creek
Bells Run	Goods Run
Muddy Run	West Branch Big Elk Creek
Nickel Mines Run/Meetinghouse Creek	West Branch Big Elk Creek

The Licking Creek Watershed was selected as the reference watershed for developing the East Branch Octoraro Creek Headwaters TMDL. Licking Creek is located near the Quakertown Airport in Bucks County; the headwaters are located in Lehigh County (Figure 7). The watershed is located in State Water Plan subbasin 03E, and the protected use is aquatic life. Licking Creek is designated as a high-quality trout stocked fisheries under §93.9z in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001). Based on PADEP assessments, Licking Creek is currently attaining its designated uses. The attainment of designated uses is based on sampling done by PADEP in 2002 as part of its State Surface Water Assessment Program. Drainage area, location, and other physical characteristics of the impaired segments of the East Branch Octoraro Creek Watershed were compared to the Licking Creek Watershed (Table 6).

The Goods Run Watershed was selected as the reference watershed for developing the Valley Run and Bells Run TMDLs. Goods Run is located in Pequea Township, Lancaster County, Pa. (Figure 8). The watershed is located in State Water Plan subbasin 07K, and the protected use is aquatic life. Goods Run is designated under the §93.9z in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001) as trout stocked fisheries. The attainment of designated uses is based on sampling done by PADEP in 1999 as part of its State Surface Water Assessment Program. Drainage area, location, and other physical characteristics of the impaired segments of the Valley Run and Bells Run Watersheds were compared to the Goods Run Watershed in Tables 7 and 8, respectively.

The Marsh Creek Watershed was selected as the reference watershed for developing the Valley Creek TMDL. Marsh Creek is located in East Nantmeal Township, Chester County, near Glenmoore, Pa. (Figure 9). The watershed is located in State Water Plan subbasin 03H, and its protected use is aquatic life. Marsh Creek is designated as a high-quality trout stocked fisheries

under §93.9z in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001). Based on PADEP assessments, Marsh Creek is currently attaining its designated uses. The attainment of designated uses is based on sampling done by PADEP in 2002 as part of its State Surface Water Assessment Program. Drainage area, location, and other physical characteristics of the impaired segments of the Valley Creek Watershed were compared to the Marsh Creek Watershed (Table 9).

The West Branch Big Elk Creek Watershed was selected as the reference watershed for developing the Knight Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek TMDLs.

Table 6. Comparison between Impaired Segments of the East Branch Octoraro Creek Headwaters and Licking Creek Watersheds

Attribute	Watershed	
	East Branch Octoraro Creek Headwaters	Licking Creek
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Gettysburg-Newark Lowland Section – 100%
Area (mi²)	11.7	9.7
Land Use	Agriculture – 75% Forested– 16% Developed – 9%	Agriculture – 68% Forested– 27% Developed – 5%
Geology	Granitic Gneiss – 89% Chickies Formation – 7% Antietam Fm & Harpers Fm Undiv– 2% Serpentine – 2%	Brunswick Formation – 69% Quartz Fanoglomerate – 24% Diabase– 7%
Soils	Chester-Glenelg-Manor – 97% Neshaminy-Lehigh-Glenelg – 2% Hagerstown-Duffield-Clarksburg – 1%	Highfield-Arendtsville-Catoctin – 53% Ungers-Penn-Klinesville – 25% Neshaminy-Lehigh-Glenelg – 22%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7% Neshaminy-Lehigh-Glenelg A – 0% B – 55% C – 27% D – 18% Hagerstown-Duffield-Clarksburg A – 0% B – 36% C – 60% D – 2%	Highfield-Arendtsville-Catoctin A – 0% B – 71% C – 21% D – 8% Ungers-Penn-Klinesville A – 0% B – 41% C – 40% D – 19% Neshaminy-Lehigh-Glenelg A – 0% B – 55% C – 27% D – 18%
K Factor	Chester-Glenelg-Manor – 0.32 Neshaminy-Lehigh-Glenelg – 0.32 Hagerstown-Duffield-Clarksburg – 0.32	Highfield-Arendtsville-Catoctin – 0.27 Ungers-Penn-Klinesville – 0.30 Neshaminy-Lehigh-Glenelg – 0.32
20-Yr. Ave. Rainfall (in)	39.5	43.2
20-Yr. Ave. Runoff (in)	1.68	2.04

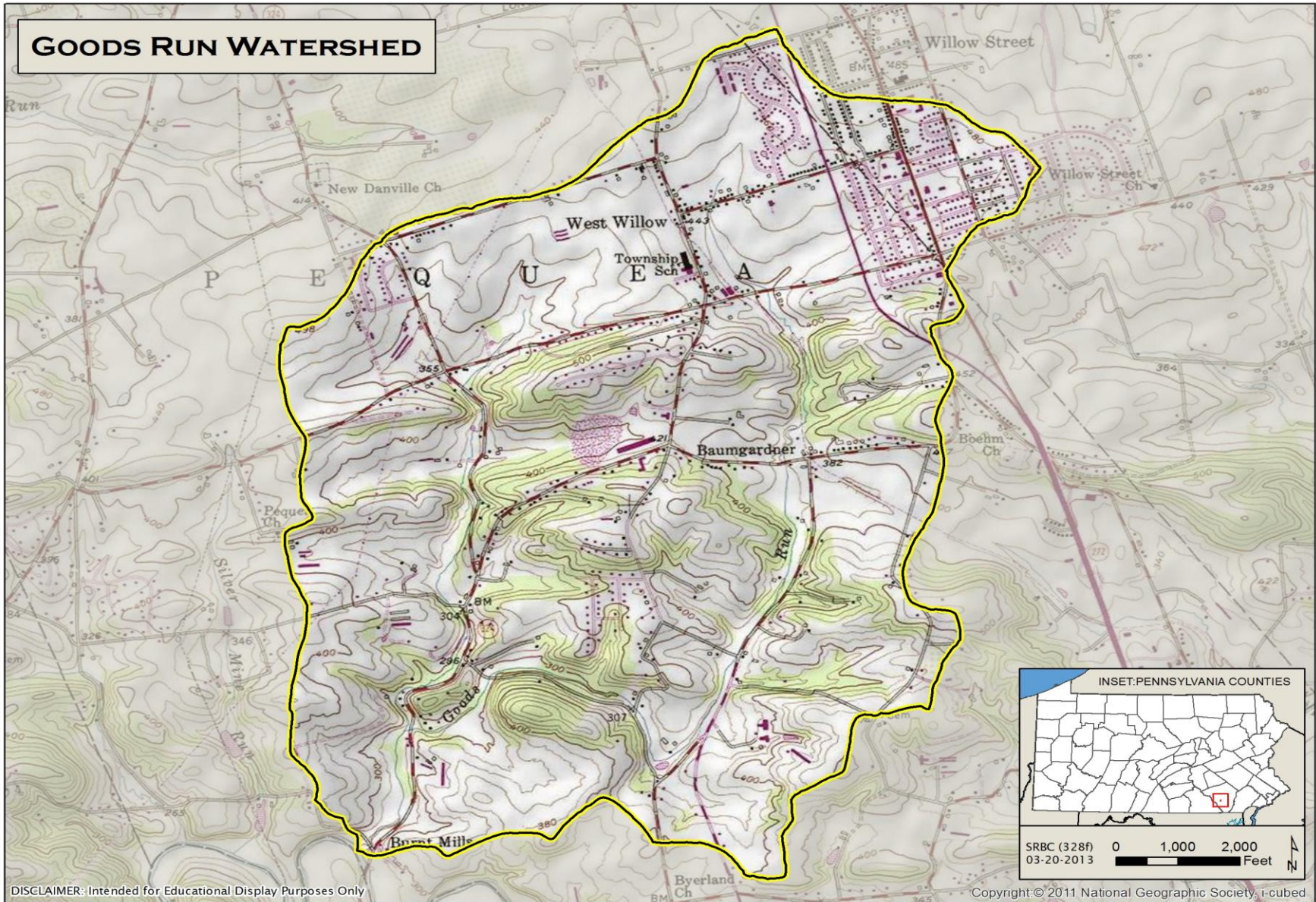


Figure 8. Location of the Goods Run Reference Watershed

Table 7. Comparison between Impaired Segments of the Valley Run and Goods Run Watersheds

Attribute	Watershed	
	Valley Run	Goods Run
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 75% Piedmont Province Piedmont Lowland Section – 25%
Area (mi ²)	5.5	4.5
Land Use	Agriculture – 77% Forested – 18% Developed – 5%	Agriculture – 67% Forested – 20% Developed – 13%
Geology	Wissahickon Fm (Albite-Chlorite Schist) – 44% Conestoga Formation – 35% Granitic Gneiss – 14% Antietam Fm & Harpers Fm Undivided – 4% Chickies Formation – 3%	Conestoga Formation – 49% Antietam Fm & Harpers Fm Undivided – 42% Vintage Formation – 9%
Soils	Chester-Glenelg-Manor – 100%	Letort-Pequea-Conestoga – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%	Letort-Pequea-Conestoga A – 0% B – 87% C – 13% D – 0%
K Factor	Chester-Glenelg-Manor – 0.32	Letort-Pequea-Conestoga – 0.35
20-Yr. Ave. Rainfall (in)	39.5	39.5
20-Yr. Ave. Runoff (in)	1.44	1.68

Table 8. Comparison between Impaired Segments of the Bells Run and Goods Run Watersheds

Attribute	Watershed	
	Bells Run	Goods Run
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 75% Piedmont Province Piedmont Lowland Section – 25%
Area (mi ²)	4.2	4.5
Land Use	Agriculture – 82% Forested – 13% Developed – 5%	Agriculture – 67% Forested – 20% Developed – 13%
Geology	Peters Creek Schist – 55% Wissahickon Fm (Albite-Chlorite Schist) – 45%	Conestoga Formation – 49% Antietam Fm & Harpers Fm Undivided – 42% Vintage Formation – 9%
Soils	Chester-Glenelg-Manor – 100%	Letort-Pequea-Conestoga – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%	Letort-Pequea-Conestoga A – 0% B – 87% C – 13% D – 0%
K Factor	Chester-Glenelg-Manor – 0.32	Letort-Pequea-Conestoga – 0.35
20-Yr. Ave. Rainfall (in)	39.5	39.5
20-Yr. Ave. Runoff (in)	1.32	1.68

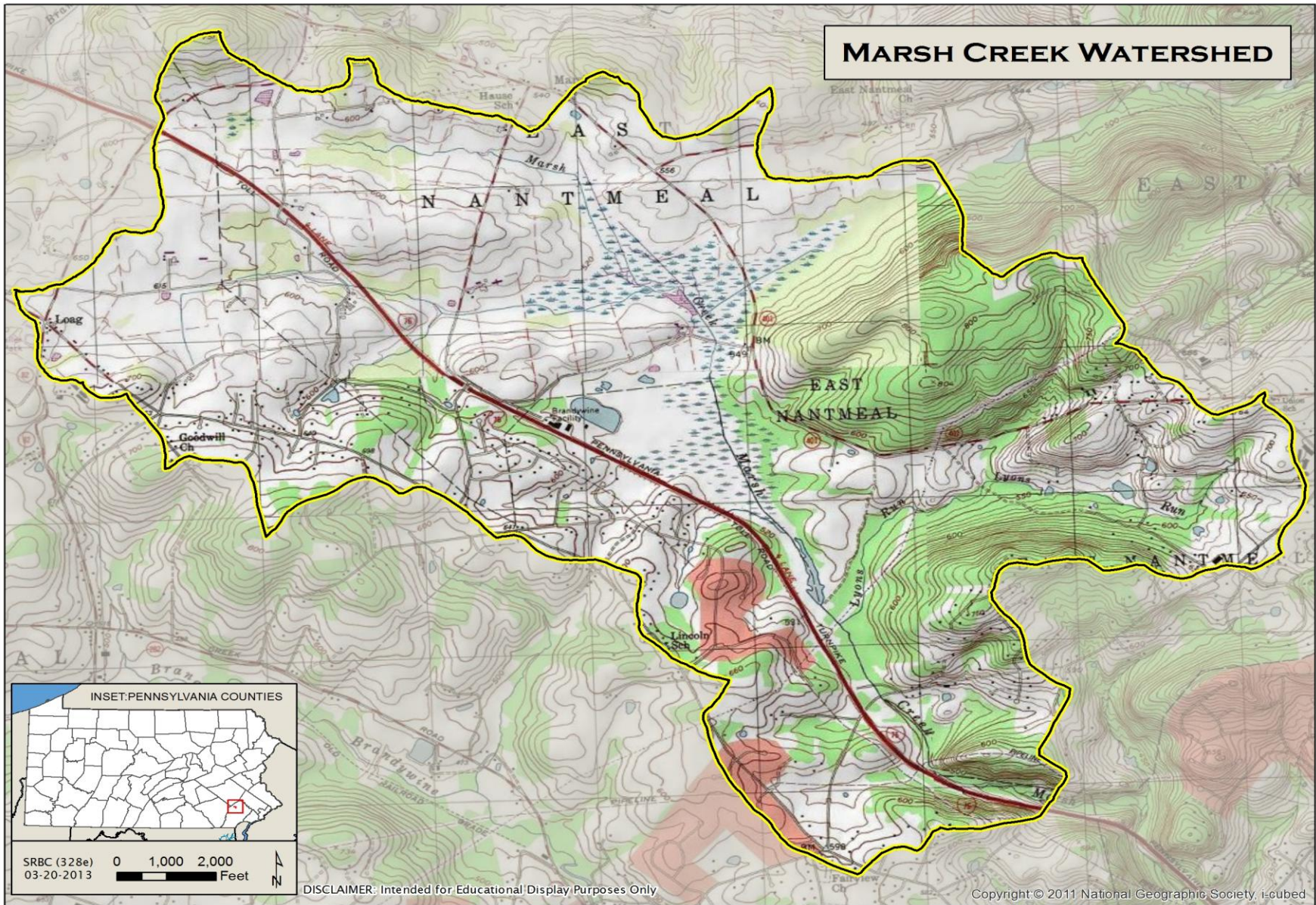


Figure 9. Location of the Marsh Creek Reference Watershed

Table 9. Comparison between Impaired Segments of the Valley Creek and Marsh Creek Watersheds

Attribute	Watershed	
	Valley Creek	Marsh Creek
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 100%
Area (mi²)	10.6	8.5
Land Use	Agriculture – 66% Forested– 23% Developed – 11%	Agriculture – 46% Forested– 51% Developed – 3%
Geology	Granitic Gneiss – 34% Wissahickon Fm (Albite-Cholrite Schist) – 28% Conestoga Formation – 22% Chickies Formation – 10% Antietam Fm & Harpers Fm Undivided – 4% Gabbroic Gneiss and Gabbro – 2%	Quartz Monzonite & Quartz Monzonite Gneiss – 65% Granitic Gneiss – 35%
Soils	Chester-Glenelg-Manor – 58% Neshaminy-Lehigh-Glenelg – 24% Hagerstown-Duffield-Clarksburg – 18%	Chester-Glenelg-Manor – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7% Neshaminy-Lehigh-Glenelg A – 0% B – 55% C – 27% D – 18% Hagerstown-Duffield-Clarksburg A – 0% B – 36% C – 60% D – 2%	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%
K Factor	Chester-Glenelg-Manor – 0.32 Neshaminy-Lehigh-Glenelg – 0.32 Hagerstown-Duffield-Clarksburg – 0.32	Chester-Glenelg-Manor – 0.32
20-Yr. Ave. Rainfall (in)	43.2	44.4
20-Yr. Ave. Runoff (in)	2.28	2.4

West Branch Big Elk Creek borders the eastern side of the Muddy Run Watershed in Chester County, Pa. (Figure 10). The watershed is located in State Water Plan subbasin 07K; however, it flows directly into the Chesapeake Bay. The protected use is aquatic life. West Branch Big Elk Creek is designated as high quality trout stocked fisheries under the §93.9z in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001). Based on PADEP assessments, West Branch Big Elk Creek is currently attaining its designated uses. The attainment of designated uses is based on sampling done by PADEP in 2002 as part of its State Surface Water Assessment Program. Drainage area, location, and other physical characteristics of the impaired segments of the Knight Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek Watersheds were compared to the West Branch Big Elk Creek Watershed in Tables 10-12, respectively.

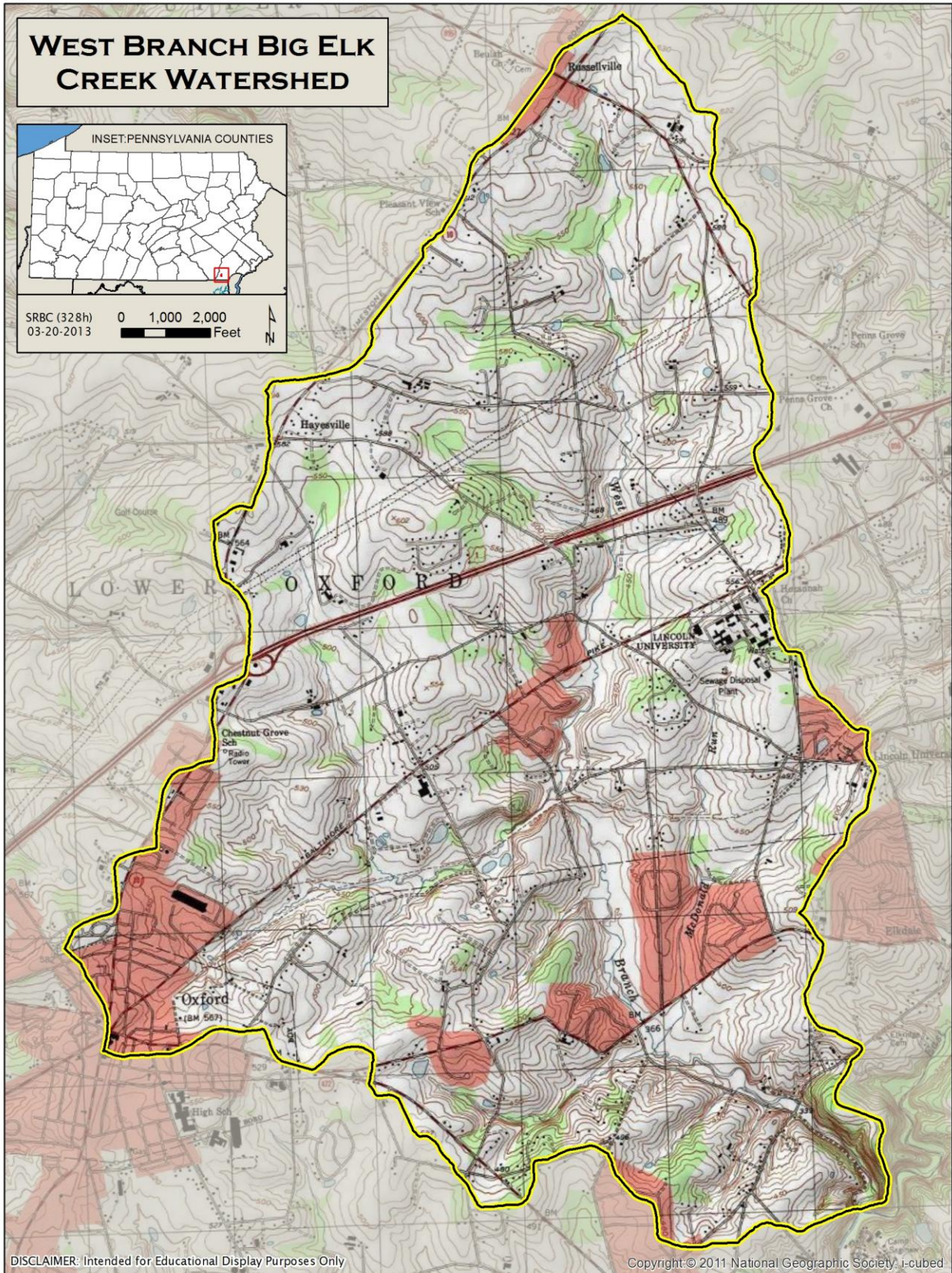


Figure 10. Location of the West Branch Big Elk Creek Reference Watershed

Table 10. Comparison between Impaired Segments of the Knight Run and West Branch Big Elk Creek Watersheds

Attribute	Watershed	
	Knight Run	West Branch Big Elk Creek
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 100%
Area (mi ²)	9.0	10.3
Land Use	Agriculture – 79% Forested – 17% Developed – 4%	Agriculture – 76% Forested – 15% Developed – 9%
Geology	Peters Creek Schist – 99% Wissahickon Fm (Oligoclase Mica Schist) – 1%	Wissahickon Fm (Oligoclase Mica Schist) – 95% Peters Creek Schist – 5%
Soils	Chester-Glenelg-Manor – 100%	Chester-Glenelg-Manor – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%
K Factor	Chester-Glenelg-Manor – 0.32	Chester-Glenelg-Manor – 0.32
20-Yr. Ave. Rainfall (in)	41.6	41.6
20-Yr. Ave. Runoff (in)	1.68	2.28

Table 11. Comparison between Impaired Segments of the Muddy Run and West Branch Big Elk Creek Watersheds

Attribute	Watershed	
	Muddy Run	West Branch Big Elk Creek
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 100%
Area (mi ²)	14.7	10.3
Land Use	Agriculture – 74% Forested – 20% Developed – 6%	Agriculture – 76% Forested – 15% Developed – 9%
Geology	Peters Creek Schist – 99% Wissahickon Fm (Oligoclase Mica Schist) – 1%	Wissahickon Fm (Oligoclase Mica Schist) – 95% Peters Creek Schist – 5%
Soils	Chester-Glenelg-Manor – 100%	Chester-Glenelg-Manor – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%
K Factor	Chester-Glenelg-Manor – 0.32	Chester-Glenelg-Manor – 0.32
20-Yr. Ave. Rainfall (in)	41.6	41.6
20-Yr. Ave. Runoff (in)	1.56	2.28

Table 12. Comparison between Impaired Segments of the Nickel Mines Run/Meetinghouse Creek and West Branch Big Elk Creek Watersheds

Attribute	Watershed	
	Nickel Mines Run/Meetinghouse Creek	West Branch Big Elk Creek
Physiographic Province	Piedmont Province Piedmont Upland Section – 100%	Piedmont Province Piedmont Upland Section – 100%
Area (mi²)	10.2	10.3
Land Use	Agriculture – 86% Forested – 8% Developed – 6%	Agriculture – 76% Forested – 15% Developed – 9%
Geology	Granitic Gneiss – 62% Wissahickon Fm (Albite-Chlorite Schist) – 10% Chickies Formation – 10% Conestoga Formation – 9% Antietam Fm & Harpers Fm Undivided – 4% Quartz Monzonite & Quartz Monzonite Gneiss – 3% Metagabbro – 2%	Wissahickon Fm (Oligoclase Mica Schist) – 95% Peters Creek Schist – 5%
Soils	Chester-Glenelg-Manor – 100%	Chester-Glenelg-Manor – 100%
Dominant HSG	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%	Chester-Glenelg-Manor A – 6% B – 74% C – 9% D – 7%
K Factor	Chester-Glenelg-Manor – 0.32	Chester-Glenelg-Manor – 0.32
20-Yr. Ave. Rainfall (in)	39.5	41.6
20-Yr. Ave. Runoff (in)	1.56	2.28

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Octoraro Creek subwatersheds were developed using the ArcView Generalized Watershed Loading Function model (AVGWLF) as described in Attachment G. The AVGWLF model was used to establish existing loading conditions for the impaired segments of the Octoraro Creek subwatersheds and the reference watersheds. All modeling inputs have been attached to this TMDL as Attachments H and I.

The AVGWLF model produced information on watershed size, land use, nutrients, and sediment loading. The sediment and nutrient loads represent an annual average over a 17-year period, from 1975 to 1991, for Muddy Run, Knight Run, West Branch Big Elk Creek, and Marsh Creek Watersheds. Valley Run, Bells Run, Goods Run, Nickel Mines Run and Meetinghouse Creek, Buck Run, Licking Creek, and Valley Creek sediment and nutrient loads represent an annual average over a 21-year period, from 1978 to 1998. This information was then used to calculate existing unit area loading rates for the 11 watersheds. Acreage for both the impaired watersheds and the reference watersheds is shown in Table 13. Sediment and phosphorus loading information for the impaired watersheds and the reference watersheds is shown in Tables 14 and 15, respectively.

Table 13. Land Use Comparisons in Acres

Land Use	Impaired Watersheds							Reference Watersheds			
	EB Octoraro Creek Headwaters	Valley Run	Valley Creek	Knight Run	Bells Run	Muddy Run	Nickel Mines Run/Meetinghouse Creek	Licking Creek	Goods Run	Marsh Creek	WB Big Elk Creek
HAY/PAST	3,106.1	1,672.9	1,999.1	2,485.9	1,502.4	4,124.2	3,207.4	1,534.5	795.7	652.4	2,226.4
CROPLAND	1,601.2	719.1	1,569.1	1,784.1	640.0	2,117.7	1,880.5	1,131.7	353.4	1,074.9	1,151.5
FOREST	1,420.9	719.1	1,808.8	1,129.3	427.5	2,310.4	672.1	2,122.6	951.4	2,483.4	1,213.3
WETLAND	128.5	71.7	113.7	14.8	22.2	42.0	79.1	168.0		375.6	17.3
TURF_GRASS				2.5							
UNPAVED_Rd	17.3		2.5	4.9		9.9	2.5				
TRANSITION	143.3	54.4	135.9	27.2	14.8	66.7	56.8	224.9	29.7	84.0	66.7
LO_INT_DEV	1,037.8	294.1	1,119.4	321.2	71.7	679.5	630.1	1,037.8	736.4	773.4	1,833.5
HI_INT_DEV	42.0		34.6	12.4		22.2		4.9	32.1	2.5	81.5
TOTAL	7,497.1	3,531.3	6,783.1	5,782.3	2,678.6	9,372.6	6,528.5	6,224.4	2,898.7	5,446.2	6,590.2

Table 14. Existing Sediment Loads and Yields

Land Use	Impaired Watersheds							Reference Watersheds			
	EB Octoraro Creek Headwaters (lbs/day) (lbs/ac/day)	Valley Run (lbs/day) (lbs/ac/day)	Valley Creek (lbs/day) (lbs/ac/day)	Knight Run (lbs/day) (lbs/ac/day)	Bells Run (lbs/day) (lbs/ac/day)	Muddy Run (lbs/day) (lbs/ac/day)	Nickel Mines Run/Meetinghouse Creek (lbs/day) (lbs/ac/day)	Licking Creek (lbs/day) (lbs/ac/day)	Goods Run (lbs/day) (lbs/ac/day)	Marsh Creek (lbs/day) (lbs/ac/day)	WB Big Elk Creek (lbs/day) (lbs/ac/day)
HAY/PAST	864.2740 0.2783	611.4521 0.3655	575.0685 0.2877	762.2466 0.3066	581.9178 0.3873	2,680.6027 0.6450	773.3699 0.2411	372.2740 0.2426	438.4658 0.5510	228.3836 0.3501	491.6712 0.2208
CROPLAND	8,999.0685 5.6202	5,057.3151 7.0328	10,617.0411 6.7663	12,097.2603 6.7806	4,625.5342 7.2274	27,402.5206 12.9398	9,991.9452 5.3135	5,050.2466 4.4625	3,161.5342 8.9461	7,360.2192 6.8474	2,881.9178 2.5028
FOREST	27.3425 0.0192	32.8767 0.0457	82.1918 0.0454	18.8493 0.0167	12.4932 0.0292	32.8767 0.0142	10.2466 0.0152	24.8767 0.0117	47.2329 0.0496	71.8904 0.0289	13.4795 0.0111
WETLAND	1.0411 0.0081	0.6575 0.0092	0.4932 0.0043	0.1096 0.0074	0.2192 0.0099	0.3836 0.0091	0.6575 0.0083	1.1507 0.0068		2.3014 0.0061	0.1096 0.0063
TURF_GRASS				0.1096 0.0438							
UNPAVED_Rd	24.2192 1.4000		2.4110 0.9644	4.9315 1.0064		9.9726 1.0073	1.5890 0.6356				
TRANSITION	222.7397 1.5544	123.3425 2.2673	378.9589 2.7885	26.4658 0.9730	22.5205 1.5217	71.5068 1.0721	62.1918 1.0949	1,154.8493 5.1349	93.4795 3.1475	562.1370 6.6921	335.4521 5.0293
LO_INT_DEV	559.7260 0.5393	395.8904 1.3461	734.4658 0.6561	113.4247 0.3531	24.8767 0.3470	180.7123 0.2659	188.2192 0.2987	373.0959 0.3595	305.0411 0.4142	456.6027 0.5904	395.1781 0.2155
HI_INT_DEV	4.3836 0.1044		10.8493 0.3136	0.8219 0.0663		2.2466 0.1012		0.2192 0.0447	5.5342 0.1724	0.4932 0.1973	8.1096 0.0995
Streambank	2,419.2239 --	409.0648 --	2,325.1730 --	1,066.6104 --	247.8173 --	2,664.4777 --	1571.9558 --	2,489.1831 --	608.3779 --	1,244.5376 --	3,052.0568 --
TOTAL	13,122.0184 1.7503	6,630.5990 1.8777	14,726.6524 2.1711	14,090.8296 2.4369	5,515.3789 2.0591	33,045.2996 3.5257	12,600.1750 1.9300	9,465.8955 1.5208	4,659.6656 1.6075	9,926.5650 1.8227	7,177.9746 1.0892

Table 15. Existing Phosphorus Loads and Yields

Land Use	Impaired Watersheds				Reference Watersheds		
	EB Octoraro Creek Headwaters (lbs/day) (lbs/ac/day)	Valley Run (lbs/day) (lbs/ac/day)	Bells Run (lbs/day) (lbs/ac/day)	Nickel Mines Run/Meetingho use Creek (lbs/day) (lbs/ac/day)	Licking Creek (lbs/day) (lbs/ac/day)	Goods Run (lbs/day) (lbs/ac/day)	WB Big Elk Creek (lbs/day) (lbs/ac/day)
HAY/PAST	2.0661 0.0007	1.4385 0.0009	1.1364 0.0008	2.1170 0.0007	0.3022 0.0002	0.7426 0.0009	0.8758 0.0004
CROPLAND	14.3380 0.0090	8.7582 0.0122	6.9894 0.0109	17.7398 0.0094	1.6327 0.0014	4.1803 0.0118	3.6659 0.0032
FOREST	0.0440 0.0000	0.0555 0.0001	0.0191 0.0000	0.0186 0.0000	0.0124 0.0000	0.0615 0.0001	0.0187 0.0000
WETLAND	0.0032 0.0000	0.0020 0.0000	0.0006 0.0000	0.0021 0.0000	0.0028 0.0000		0.0004 0.0000
UNPAVED_Rd	0.0443 0.0026			0.0039 0.0015			
TRANSITION	0.3995 0.0028	0.2285 0.0042	0.0397 0.0027	0.1305 0.0023	0.4067 0.0018	0.1317 0.0044	0.4133 0.0062
LO_INT_DEV	0.1357 0.0001	0.0384 0.0001	0.0094 0.0001	0.0824 0.0001	0.1518 0.0001	0.0963 0.0001	0.2655 0.0001
HI_INT_DEV	0.0638 0.0015				0.0083 0.0017	0.0488 0.0015	0.1311 0.0016
Streambank	0.0532 --	0.0090 --	0.0054 --	0.0346 --	0.0548 --	0.0134 --	0.0672 --
Groundwater	1.3098 --	0.6136 --	0.4404 --	1.1967 --	1.5938 --	0.5699 --	1.3564 --
Septic Systems	0.0650 --	0.0250 --	0.0200 --	0.0550 --	0.0150 --	0.0050 --	0.0400 --
TOTAL	18.5225 0.0025	11.1687 0.0032	8.6603 0.0032	21.3805 0.0033	4.1805 0.0007	5.8494 0.0020	6.8342 0.0010

TMDLS

The targeted TMDL value for the East Branch Octoraro Creek Headwaters Watershed was established based on current loading rates for sediment and phosphorus in the Licking Creek Reference Watershed. The target TMDL values for Valley Run and Bells Run were established based on the current loading rates for sediment and phosphorus in the Goods Run Reference Watershed. Current sediment loading rates in the Marsh Creek Reference Watershed were used to find the target TMDL value for the Valley Creek Watershed. Sediment and phosphorus loading rates in West Branch Big Elk Creek Reference Watershed were used to determine target TMDLs in Knight Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek Watersheds.

Biological assessments have determined the four reference watersheds are currently attaining their designated uses. Reducing the loading rate of sediment and phosphorus in the impaired watersheds to levels equivalent to those in the reference watersheds 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 values for sediment and phosphorus were determined by multiplying the total area of the East Branch Octoraro Creek Headwaters Watershed (7,497.1 acres) by the appropriate unit-area loading rate for the Licking Creek reference watershed (Table 16). The existing mean annual loading of sediment (13,122.0184 lbs/day) to the East Branch Octoraro Creek Headwaters will need to be reduced by 13 percent to meet the targeted TMDL of 11,401.5897 lbs/day. The existing mean annual loading of phosphorus (18.5225 lbs/day) will need to be reduced by 72 percent to meet the targeted TMDL of 5.2480 lbs/day.

Table 16. Targeted TMDL for the East Branch Octoraro Creek Headwaters Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Licking Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for East Branch Octoraro Creek Headwaters (lbs/day)
Sediment	7,497.1	1.5208	11,401.5897
Phosphorus	7,497.1	0.0007	5.2480

The targeted TMDL values for sediment and phosphorus were determined by multiplying the total area of the Valley Run Watershed (3,531.3 acres) by the appropriate unit-area loading rate

for the Goods Run reference watershed (Table 17). The existing mean annual loading of sediment (6,630.5990 lbs/day) to Valley Run will need to be reduced by 14 percent to meet the targeted TMDL of 5,676.5648 lbs/day. The existing mean annual loading of phosphorus (11.1687 lbs/day) will need to be reduced by 37 percent to meet the targeted TMDL of 7.0626 lbs/day.

Table 17. Targeted TMDL for the Valley Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Goods Run Reference Watershed (lbs/ac/day)	Targeted TMDL for Valley Run Watershed (lbs/day)
Sediment	3,531.3	1.6075	5,676.5648
Phosphorus	3,531.3	0.0020	7.0626

The targeted TMDL value for sediment was determined by multiplying the total area of the Valley Creek Watershed (6,783.1 acres) by the appropriate unit-area loading rate for the Marsh Creek reference watershed (Table 18). The existing mean annual loading of sediment (14,726.6524 lbs/day) to Valley Creek will need to be reduced by 16 percent to meet the targeted TMDL of 12,363.5564 lbs/day.

Table 18. Targeted TMDL for the Valley Creek Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Marsh Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Valley Creek Watershed (lbs/day)
Sediment	6,783.1	1.8227	12,363.5564

The targeted TMDL value for sediment was determined by multiplying the total area of the Knight Run Watershed (5,782.3 acres) by the appropriate unit-area loading rate for the West Branch Big Elk Creek reference watershed (Table 19). The existing mean annual loading of sediment (14,090.8296 lbs/day) to Knight Run will need to be reduced by 55 percent to meet the targeted TMDL of 6,298.0812 lbs/day.

Table 19. Targeted TMDL for the Knight Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate West Branch Big Elk Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Knight Run Watershed (lbs/day)
Sediment	5,782.3	1.0892	6,298.0812

The targeted TMDL values for sediment and phosphorus were determined by multiplying the total area of the Bells Run Watershed (2,678.6 acres) by the appropriate unit-area loading rate for the Goods Run reference watershed (Table 20). The existing mean annual loading of sediment (5,515.3789 lbs/day) to Bells will need to be reduced by 22 percent to meet the targeted TMDL of 4,305.8495 lbs/day. The existing mean annual loading of phosphorus (8.6603 lbs/day) will need to be reduced by 38 percent to meet the targeted TMDL of 5.3572 lbs/day.

Table 20. Targeted TMDL for the Bells Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Goods Run Reference Watershed (lbs/ac/day)	Targeted TMDL for Bells Run Watershed (lbs/day)
Sediment	2,678.6	1.6075	4,305.8495
Phosphorus	2,678.6	0.0020	5.3572

The targeted TMDL value for sediment was determined by multiplying the total area of the Muddy Run Watershed (9,372.6 acres) by the appropriate unit-area loading rate for the West Branch Big Elk Creek reference watershed (Table 21). The existing mean annual loading of sediment (33,045.2996 lbs/day) to Muddy Run will need to be reduced by 69 percent to meet the targeted TMDL of 10,208.6359 lbs/day.

Table 21. Targeted TMDL for the Muddy Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate West Branch Big Elk Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Muddy Run Watershed (lbs/day)
Sediment	9,372.6	1.0892	10,208.6359

The targeted TMDL values for sediment and phosphorus were determined by multiplying the total area of the Nickel Mines Run/Meetinghouse Creek Watershed (6,528.5 acres) by the appropriate unit-area loading rate for the West Branch Big Elk Creek reference watershed (Table 22). The existing mean annual loading of sediment (12,600.1750 lbs/day) to Nickel Mines Run/Meetinghouse Creek will need to be reduced by 44 percent to meet the targeted TMDL of 7,110.8422 lbs/day. The existing mean annual loading of phosphorus (21.3805 lbs/day) will need to be reduced by 69 percent to meet the targeted TMDL of 6.5285 lbs/day.

Table 22. Targeted TMDL for the Nickel Mines Run/Meetinghouse Creek Watershed

Pollutant	Area (ac)	Unit Area Loading Rate West Branch Big Elk Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Nickel Mines Run/Meetinghouse Creek Watershed (lbs/day)
Sediment	6,528.5	1.0892	7,110.8422
Phosphorus	6,528.5	0.0010	6.5285

Targeted TMDL values were used as the basis for LAs and reductions in the Octoraro 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 Allocations

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 three point source discharges for sediment and phosphorus in the watershed (Table 22).

The Atglen Borough Sewer Authority discharges treated sewage effluent into the Valley Creek Watershed covered by this TMDL, permit number PA0024651. The instantaneous maximum is 30.0 mg/l for suspended solids, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Atglen Borough Sewer Authority is 0.09 mgd (million gallons per day). Based on the instantaneous maximums for this facility, the potential for sediment loads if the Atglen Borough Sewer Authority capacities were fully utilized is 22.5313 lbs/day. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The Octoraro Area School District discharges treated sewage effluent into the Knight Run Watershed covered by this TMDL, permit number PA0042889. The instantaneous maximum is 30.0 mg/l for suspended solids, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Octoraro Area School District is 0.03 mgd. Based on the instantaneous maximums for this facility, the potential for sediment loads if the Octoraro Area School District capacities were fully utilized is 7.5105 lbs/day. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The Georgetown Area Sewer Authority discharges treated sewage effluent into the Nickel Mines Run/Meetinghouse Creek Watershed covered by this TMDL, permit number PA0083933. The instantaneous maximums for suspended solids is 30.0 mg/l and 0.3775 mg/l for phosphorus, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Georgetown Area Sewer Authority is 0.04 mgd. Based on the instantaneous maximums for this facility, the potential for sediment and phosphorus loads if the Georgetown Area Sewer Authority capacities were fully utilized is 10.0140 lbs/day and 0.1260 lbs/day, respectively. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The bulk reserve is explicit and is calculated as 1 percent of the targeted TMDL. This bulk reserve enables the TMDL to account for the dynamic nature of permit activity (Table 23).

Table 23. Waste Load Allocations

Subwatershed	Permit Number	Facility Name	Total Phosphorus (lbs/day)	Total Suspended Solids (lbs/day)
East Branch Octoraro Creek Headwaters		Bulk Reserve	0.0525	114.0159
Valley Run		Bulk Reserve	0.0706	56.7656
Valley Creek	PA0024651	Atglen Borough Sewer Authority		22.5315
		Bulk Reserve		123.6356
		Total		146.1671
Knight Run	PA0042889	Octoraro Area School District		7.5105
		Bulk Reserve		62.9808
		Total		70.4913
Bells Run		Bulk Reserve	0.0536	43.0585
Muddy Run		Bulk Reserve		102.0864
Nickel Mines Run/Meetinghouse Creek	PA0083933	Georgetown Area Sewer Authority	0.1260	10.0140
		Bulk Reserve	0.0653	71.1084
		Total	0.1913	81.1224

Margin of Safety

The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDLs for sediment and phosphorus were reserved as the MOS. Using 10 percent of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of the Octoraro Creek Watershed. The MOS used for the sediment and phosphorus TMDLs are shown below.

East Branch Octoraro Creek Headwaters:

MOS (sediment) = 11,401.5897 lbs/day (TMDL) x 0.1 = 1,140.1590 lbs/day

MOS (phosphorus) = 5.2480 lbs/day (TMDL) x 0.1 = 0.5248 lbs/day

Valley Run

MOS (sediment) = 5,676.5648 lbs/day (TMDL) x 0.1 = 567.6565 lbs/day

MOS (phosphorus) = 7.0626 lbs/day (TMDL) x 0.1 = 0.7063 lbs/day

Valley Creek

MOS (sediment) = 12,363.5564 lbs/day (TMDL) x 0.1 = 1,236.3556 lbs/day

Knight Run

MOS (sediment) = 6,298.0812 lbs/day (TMDL) x 0.1 = 629.8081 lbs/day

Bells Run

MOS (sediment) = 4,305.8492 lbs/day (TMDL) x 0.1 = 430.5849 lbs/day

MOS (phosphorus) = 5.3572 lbs/day (TMDL) x 0.1 = 0.5357 lbs/day

Muddy Run

$$\text{MOS (sediment)} = 10,208.6359 \text{ lbs/day (TMDL)} \times 0.1 = 1,020.8636 \text{ lbs/day}$$

Nickel Mines Run/Meetinghouse Creek

$$\text{MOS (sediment)} = 7,110.8422 \text{ lbs/day (TMDL)} \times 0.1 = 711.0842 \text{ lbs/day}$$

$$\text{MOS (sediment)} = 6.5285 \text{ lbs/day (TMDL)} \times 0.1 = 0.6529 \text{ lbs/day}$$

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, HI_INT_DEV, UNPAVED_Rd, TRANSITION, and Turf_Grass), streambanks, and groundwater. Those land uses/sources for which existing loads were not reduced (FOREST, WETLANDS, and Septic Systems) were carried through at their existing loading values (Tables 24-30).

Table 24. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the East Branch Octoraro Creek Headwaters Watershed

	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	10,147.4148	4.6707
Loads not Reduced	28.3836	0.1122
FOREST	27.3425	0.0440
WETLANDS	1.0411	0.0032
SEPTIC SYSTEMS		0.0650
Adjusted Load Allocation	10,119.0312	4.5585

Table 25. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Valley Run Watershed

	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	5,052.1427	6.2857
Loads not Reduced	33.5342	0.0825
FOREST	32.8767	0.0555
WETLANDS	0.6575	0.0020
SEPTIC SYSTEMS		0.0250
Adjusted Load Allocation	5,018.6085	6.2032

Table 26. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Valley Creek Watershed

	Sediment (lbs/day)
Load Allocation	10,981.0337
Loads not Reduced	82.6850
FOREST	82.1918
WETLANDS	0.4932
Adjusted Load Allocation	10,898.3487

Table 27. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Knight Run Watershed

	Sediment (lbs/day)
Load Allocation	5,597.7818
Loads not Reduced	18.9589
FOREST	18.8493
WETLANDS	0.1096
Adjusted Load Allocation	5,578.8229

Table 28. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Bells Run Watershed

	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	3,832.2061	4.7679
Loads not Reduced	12.7124	0.0397
FOREST	12.4932	0.0191
WETLANDS	0.2192	0.0006
SEPTIC SYSTEMS		0.0200
Adjusted Load Allocation	3,819.4937	4.7282

Table 29. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Muddy Run Watershed

	Sediment (lbs/day)
Load Allocation	9,085.6859
Loads not Reduced	33.2603
FOREST	32.8767
WETLANDS	0.3836
Adjusted Load Allocation	9,052.4256

Table 30. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Nickel Mines Run/Meetinghouse Creek Watershed

	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	6,318.6356	5.6843
Loads not Reduced	10.9041	0.0757
FOREST	10.2466	0.0186
WETLANDS	0.6575	0.0021
SEPTIC SYSTEMS		0.0550
Adjusted Load Allocation	6,307.7315	5.6086

TMDLs

The sediment and phosphorus TMDLs established for the East Branch Octoraro Creek Headwaters, Valley Run, Valley Creek, Knight Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek Watersheds consists of a LA, WLA, and MOS. The individual components of the TMDLs are summarized in Tables 31-37.

Table 31. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the East Branch Octoraro Creek Headwaters Watershed

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	11,401.5897	5.2480
WLA (Waste Load Allocation)	114.0159	0.0525
MOS (Margin of Safety)	1,140.1590	0.5248
LA (Load Allocation)	10,147.4148	4.6707
LNR (Loads not Reduced)	28.3836	0.1122
ALA (Adjusted Load Allocation)	10,119.0312	4.5585

Table 32. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Valley Run Watershed

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	5,676.5648	7.0626
WLA	56.7656	0.0706
MOS	567.6565	0.7063
LA	5,052.1427	6.2857
LNR	33.5342	0.0825
ALA	5,018.6085	6.2032

Table 33. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Valley Creek Watershed

Component	Sediment (lbs/day)
TMDL	12,363.5564
WLA	146.1671
MOS	1,236.3556
LA	10,981.0337
LNR	82.6850
ALA	10,898.3487

Table 34. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Knight Run Watershed

Component	Sediment (lbs/day)
TMDL	6,298.0812
WLA	70.4913
MOS	629.8081
LA	5,597.7818
LNR	18.9589
ALA	5,578.8229

Table 35. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Bells Run Watershed

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	4,305.8495	5.3572
WLA	43.0585	0.0536
MOS	430.5849	0.5357
LA	3,832.2061	4.7679
LNR	12.7124	0.0397
ALA	3,819.4937	4.7282

Table 36. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Muddy Run Watershed

Component	Sediment (lbs/day)
TMDL	10,208.6359
WLA	102.0864
MOS	1,020.8636
LA	9,085.6859
LNR	33.2603
ALA	9,052.4256

Table 37. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for the Nickel Mines Run/Meetinghouse Creek Watershed

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL	7,110.8422	6.5285
WLA	81.1224	0.1913
MOS	711.0842	0.6529
LA	6,318.6356	5.6843
LNR	10.9041	0.0757
ALA	6,307.7315	5.6086

Calculation of Sediment and Phosphorus 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 East Branch Octoraro Creek Headwaters, Valley Run, Valley Creek, Knight Run, Bells Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek Watersheds. The ALA for sediment and phosphorus were allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire East Branch Octoraro Creek Headwaters, Valley Run, Valley Creek, Knight Run, Bells Run, Muddy Run, and Nickel Mines Run/Meetinghouse Creek Watersheds using the Equal Marginal Percent Reduction (EMPR) allocation method (Attachment J). The LA and EMPR procedures were performed using MS Excel, and results are presented in Attachment K.

In order to meet the sediment and phosphorus TMDLs, the loads currently emanating from controllable sources must be reduced (Tables 24-30). This can be achieved through reductions in current sediment and phosphorus loadings from cropland, hay/pasture, developed areas, groundwater, and streambanks (Tables 38-44).

Groundwater and surface water are closely tied together in the Octoraro Creek Watershed because of the geology and the groundwater time-of-travel to surface water. The geology in the watershed allows activities on the surface to impact the groundwater. High concentrations of nitrate have been found in wells in both the East and West Branches of the Octoraro Creek Watershed. Based on modeling conducted by The SSM Group, Inc., the majority of groundwater in this watershed impacts the surface water within 35 years (Guiseppe, 2012). Reductions to phosphorus loadings from groundwater are necessary to reach allowable loadings.

Table 38. Sediment and Phosphorus Load Allocations & Reductions for the East Branch Octoraro Headwaters Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	3,106.10	0.2783	0.2150	864.2740	667.9288	23
Cropland	1,601.20	5.6202	4.3434	8,999.0685	6,954.6658	23
Developed	1,240.40	0.6539	0.5053	811.0685	626.8105	23
Streambanks	-	-	-	2,419.2239	1,869.6261	23
Total	-	-	-	13,093.6349	10,119.0312	23
Phosphorus						
Hay/Pasture	3,106.10	0.0007	0.0004	2.0661	1.0912	47
Cropland	1,601.20	0.0090	0.0015	14.3380	2.4076	83
Developed	1,240.40	0.0005	0.0003	0.6433	0.3398	47
Groundwater	-	-	-	1.3098	0.6918	47
Streambanks	-	-	-	0.0532	0.0281	47
Total	-	-	-	18.4104	4.5585	75

Table 39. Sediment and Phosphorus Load Allocations & Reductions for the Valley Run Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	1672.90	0.3655	0.2797	611.4521	467.8974	23
Cropland	719.10	7.0328	5.3405	5,057.3151	3,840.3561	24
Developed	348.50	1.4899	1.1401	519.2329	397.3291	23
Streambanks	-	-	-	409.0648	313.0259	23
Total	-	-	-	6,597.0649	5,018.6085	24
Phosphorus						
Hay/Pasture	1672.90	0.0006	0.0005	1.0515	0.7941	24
Cropland	719.10	0.0138	0.0065	9.9273	4.6845	53
Developed	348.50	0.0007	0.0005	0.2357	0.1780	24
Groundwater	-	-	-	0.6136	0.4634	24
Streambanks	-	-	-	0.1104	0.0834	24
Total	-	-	-	11.9385	6.2032	48

Table 40. Sediment Load Allocations & Reductions for the Valley 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	1,999.10	0.2877	0.2141	575.0685	427.9781	26
Cropland	1,569.10	6.7663	5.0356	10,617.0411	7,901.4253	26
Developed	1,371.50	0.8215	0.6114	1,126.6850	838.5027	26
Streambanks	-	-	-	2,325.1730	1,730.4426	26
Total	-	-	-	14,643.9676	10,898.3487	26

Table 41. Sediment Load Allocations & Reductions for the Knight Run Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	2,485.90	0.3066	0.2265	762.2466	562.9809	26
Cropland	1,784.10	6.7806	2.3095	12,097.2603	4,120.4129	66
Developed	368.20	0.3959	0.2924	145.7535	107.6508	26
Streambanks	-	-	-	1,066.6104	787.7782	26
Total	-	-	-	14,071.8708	5,578.8229	60

Table 42. Sediment and Phosphorus Load Allocations & Reductions for the Bells Run Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	1,502.40	0.3873	0.3150	581.9178	473.2400	19
Cropland	640.00	7.2274	4.8534	4,625.5342	3,106.1728	33
Developed	86.50	0.5479	0.4456	47.3972	38.5454	19
Streambanks	-	-	-	247.8173	201.5354	19
Total	-	-	-	5,502.6665	3,819.4937	31
Phosphorus						
Hay/Pasture	1,502.40	0.0008	0.0006	1.1364	0.8449	26
Cropland	640.00	0.0109	0.0055	6.9894	3.5153	50
Developed	86.50	0.0006	0.0004	0.0491	0.0365	26
Groundwater	-	-	-	0.4404	0.3274	26
Streambanks	-	-	-	0.0054	0.0040	26
Total	-	-	-	8.6207	4.7282	45

Table 43. Sediment Load Allocations & Reductions for the Muddy Run Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	4,124.20	0.2278	0.1916	1,145.7534	790.2150	31
Cropland	2,117.70	5.7787	2.9482	12,237.5342	6,243.3698	49
Developed	820.30	0.3222	0.2222	264.3200	182.2989	31
Streambanks	-	-	-	2,662.8504	1,836.5420	31
Total	-	-	-	16,310.4580	9,052.4256	44

Table 44. Sediment and Phosphorus Load Allocations & Reductions for the Nickel Mines Run/Meetinghouse 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	3,207.40	0.2411	0.1708	773.3699	547.8022	29
Cropland	1,880.50	5.3135	2.3759	9,991.9452	4,467.9642	55
Developed	689.40	0.3655	0.2589	252.0000	178.4995	29
Streambanks	-	-	-	1,571.9558	1,113.4656	29
Total	-	-	-	12,589.2709	6,307.7315	50
Phosphorus						
Hay/Pasture	3,207.40	0.0007	0.0004	2.1170	1.2943	39
Cropland	1,880.50	0.0094	0.0018	17.7398	3.4290	81
Developed	689.40	0.0003	0.0002	0.2168	0.1325	39
				1.1967	0.7316	39
Streambanks	-	-	-	0.0346	0.0212	39
Total	-	-	-	21.3049	5.6086	74

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

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 Octoraro Creek Watershed TMDLs identify the necessary overall load reductions for sediment, phosphorus, and nitrate 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 nutrients reaching Octoraro 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.nrcg.nrcs.usda.gov/nhcp_2.html.

Numerous groups and agencies are active in the Octoraro Creek Watershed. The Octoraro Creek Watershed Association (Association) was formed in 1967 by individuals in Lancaster and Chester Counties. This group is dedicated to protecting the Octoraro Creek Watershed and has been instrumental educating the public on watershed protection and implementing BMPs. The Association has partnered with the county conservation districts, NRCS, the Chesapeake Bay Foundation among other groups and agencies to begin to install BMPs in the watershed. The watershed continues to need BMPs installed in agricultural areas to prevent sediment and nutrients from entering the streams.

In 2002, the Octoraro Creek Watershed Action Plan (Plan) was developed by several stakeholders. This plan outlines impairments and concerns in the watershed and proposes priority management options. These management options have identified the action and description, lead group, and potential cost of each priority action. The Plan looks at both surface and groundwater, which is critical, since both have been identified as contributing to the high concentrations of nutrients in the watershed. This plan provides a guide when pursuing grant opportunities for BMP installation within the Octoraro Creek Watershed.

It is recommended to use both the Octoraro Creek Watershed Action Plan and the work done by The SSM Group, Inc. to find the best locations in the watershed for BMPs. Together these sources will show the optimal locations for BMPs to be installed to have the greatest impact on surface- and groundwater. The Chester Water Authority has two long-term monitoring sites in the watershed (one on each main branch) that will assist with indicating if water quality is improving in the watershed as BMPs are installed.

The Chesapeake Bay TMDL, established by EPA in 2010, requires reductions of nitrogen, phosphorus, and sediment loads throughout the Bay watershed to meet water quality standards that protect the designated uses in the Bay and its tidal tributaries. Pennsylvania's Phase I and Phase II WIPs together with the State's schedule of two-year milestones provide implementation strategies and a time line for achieving sediment reductions across Pennsylvania's Chesapeake Bay watershed to meet Chesapeake Bay interim target loads by 2017, equivalent to 60% of the final target goals set for 2025 to fully implement the Chesapeake Bay TMDL in Pennsylvania. A Phase III Plan will be developed in 2018 to address the additional reductions needed from 2018 through 2025 to meet the final targets.

The sediment reductions for the Bay TMDL are independent of those needed to implement any TMDLs developed to address sediment-related impairments in Pennsylvania's non-tidal waterbodies, although their reduction goals and strategies do overlap. For example, the implementation planning framework, developed by the Bay watershed jurisdictions in partnership with EPA, provides a staged approach to achieving Bay TMDL sediment reduction goals that is also applicable to implementation of sediment TMDLs in local non-tidal watersheds. In short, sediment reductions required to meet the Chesapeake Bay TMDL will also support the

restoration and protection of local water quality and vice versa. Links to Chesapeake Bay TMDL related documents are provided below.

PADEP Chesapeake Bay Program website:

http://www.portal.state.pa.us/portal/server.pt/community/chesapeake_bay_program/10513

Pennsylvania's Phase I WIP:

<http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/WIPs/REVISED%20FINAL%20Chesapeake%20Bay%20WIP%20-%20sent%20to%20EPA%2012-23-10.pdf>

Pennsylvania's Phase II WIP:

[http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/4-2-2012/Clean%20FINAL%20Phase%202%20WIP%203-30-2012%20\(2\).pdf](http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/4-2-2012/Clean%20FINAL%20Phase%202%20WIP%203-30-2012%20(2).pdf)

Pennsylvania's Phase II WIP Wastewater Supplement:

http://files.dep.state.pa.us/Water/Wastewater%20Management/EDMRPortalFiles/Phase_2_WIP_Supplement.pdf

Pennsylvania's Milestones for 2012-2013:

<http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/7-9-2012/PA%20FINAL%202012-2013%20Milestones.pdf>

By developing sediment and nutrient TMDLs for the Octoraro 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 Southcentral Regional Office (717-705-4700).

Public Participation

In the beginning stages of the Octoraro Creek Watershed TMDL, a meeting with all stakeholders and interested parties was held on March 14, 2008, at the Colerain Township Building. Stakeholders were encouraged to submit any information on the watershed for TMDL development. During TMDL development, several emails were sent to the stakeholders to keep them up-to-date with the progress of the TMDL. The status of the TMDL was discussed during several meetings throughout the development time period. PADEP considered all the information submitted and all pertinent information was included in the report.

Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* on September 20, 2008, and ---- newspaper on October 4, 2008 to foster public comment on the allowable loads calculated. A public meeting was held on October 7, 2008, at the --- to discuss the proposed TMDL.

Future TMDL Modifications

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

Changes in TMDLs That May Require USEPA Approval

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

Changes in TMDLs That May Not Require USEPA Approval

- Total loading shift less than or equal to 1% of the total load.
- Increase of WLA results in greater LA reductions provided reasonable assurance of implementation is demonstrated (a compliance/implementation plan and schedule).
- Changes among WLAs with no other changes; TMDL public notice concurrent with permit public notice.
- Removal of a pollutant source that will not be reallocated.
- Reallocation between LAs.
- Changes in land use.

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

Octoraro Creek Watershed Maps

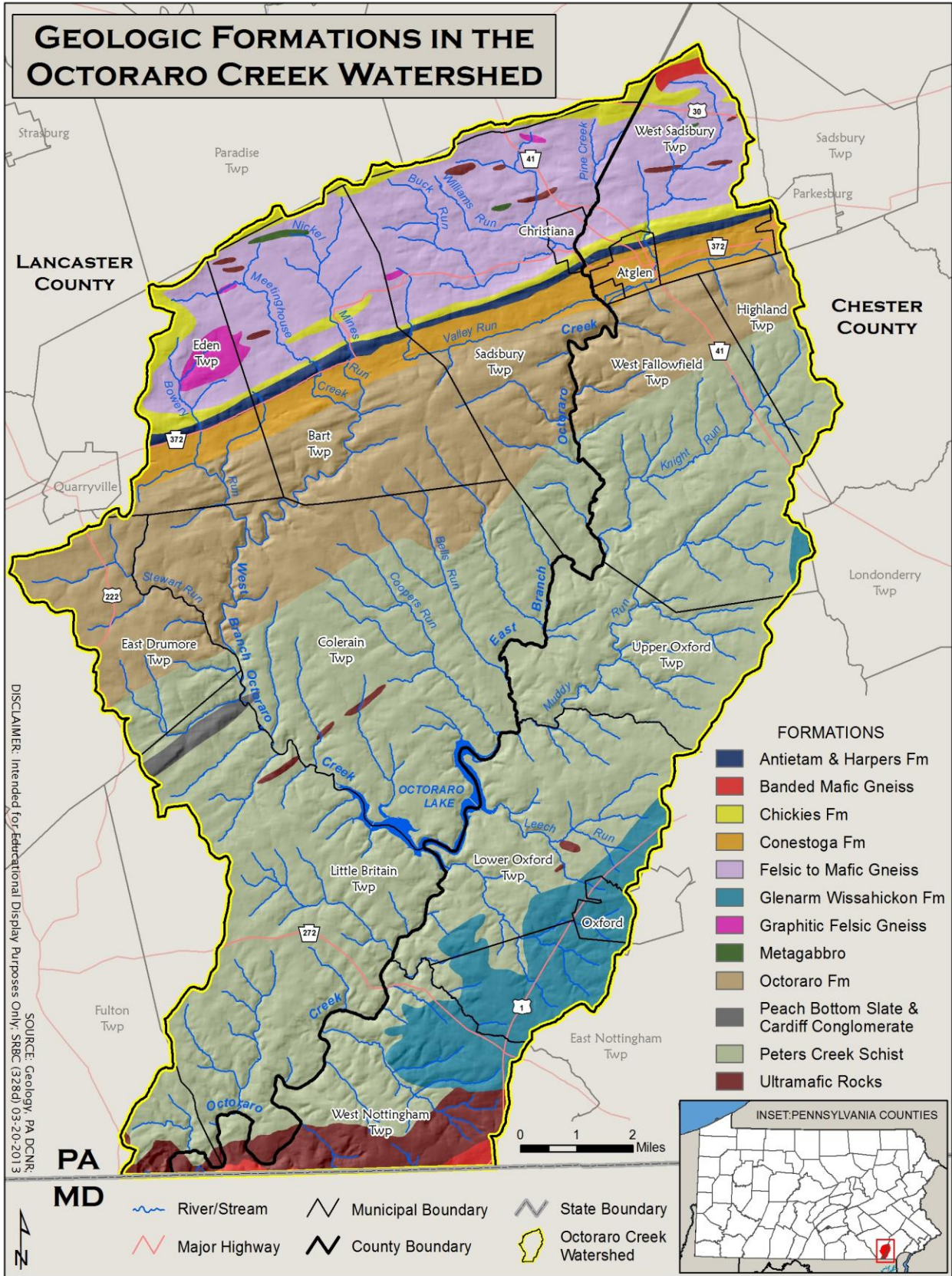


Figure A1. Geology Map of the Octoraro Creek Watershed

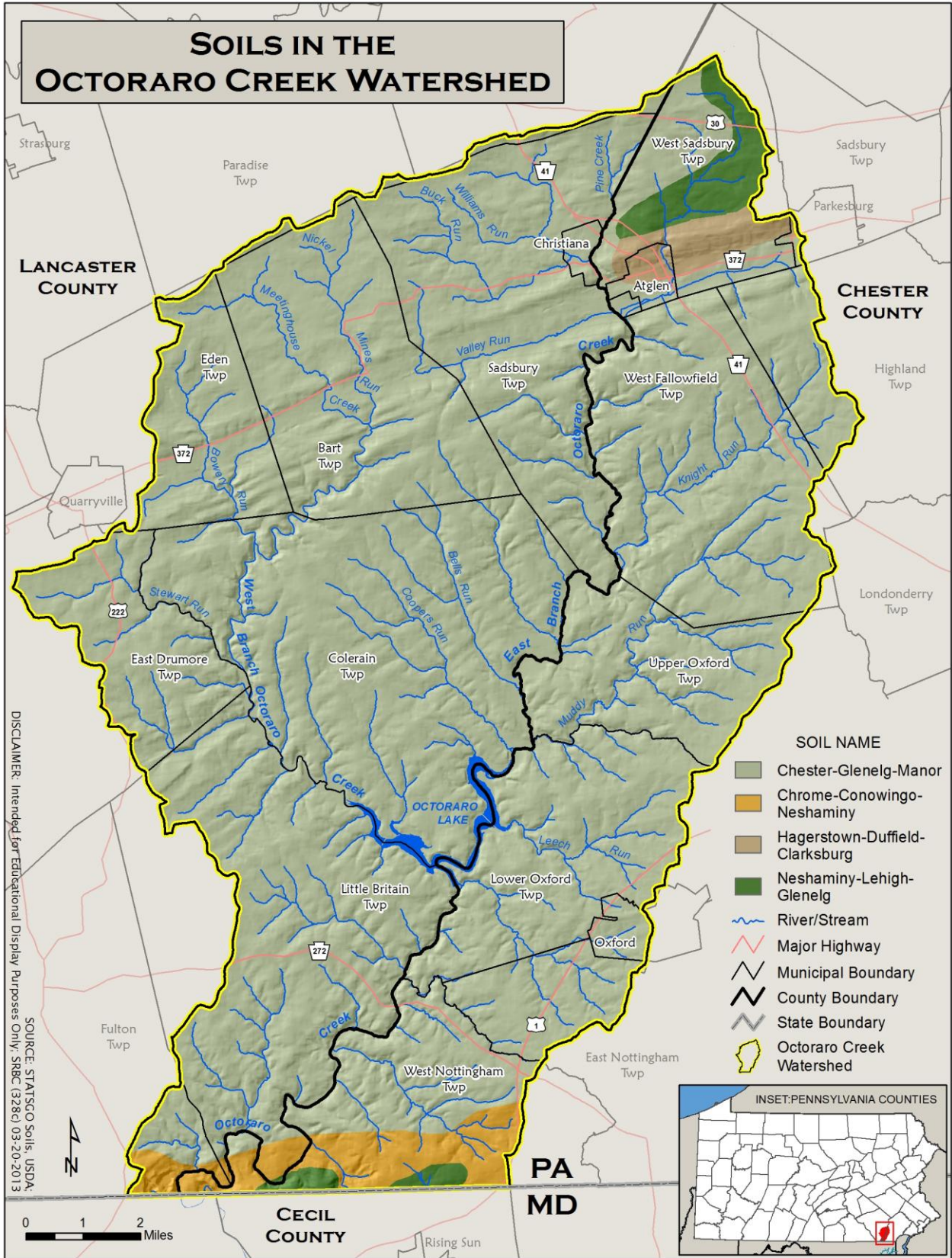


Figure A2. Soils Map for the Octoraro Creek Watershed

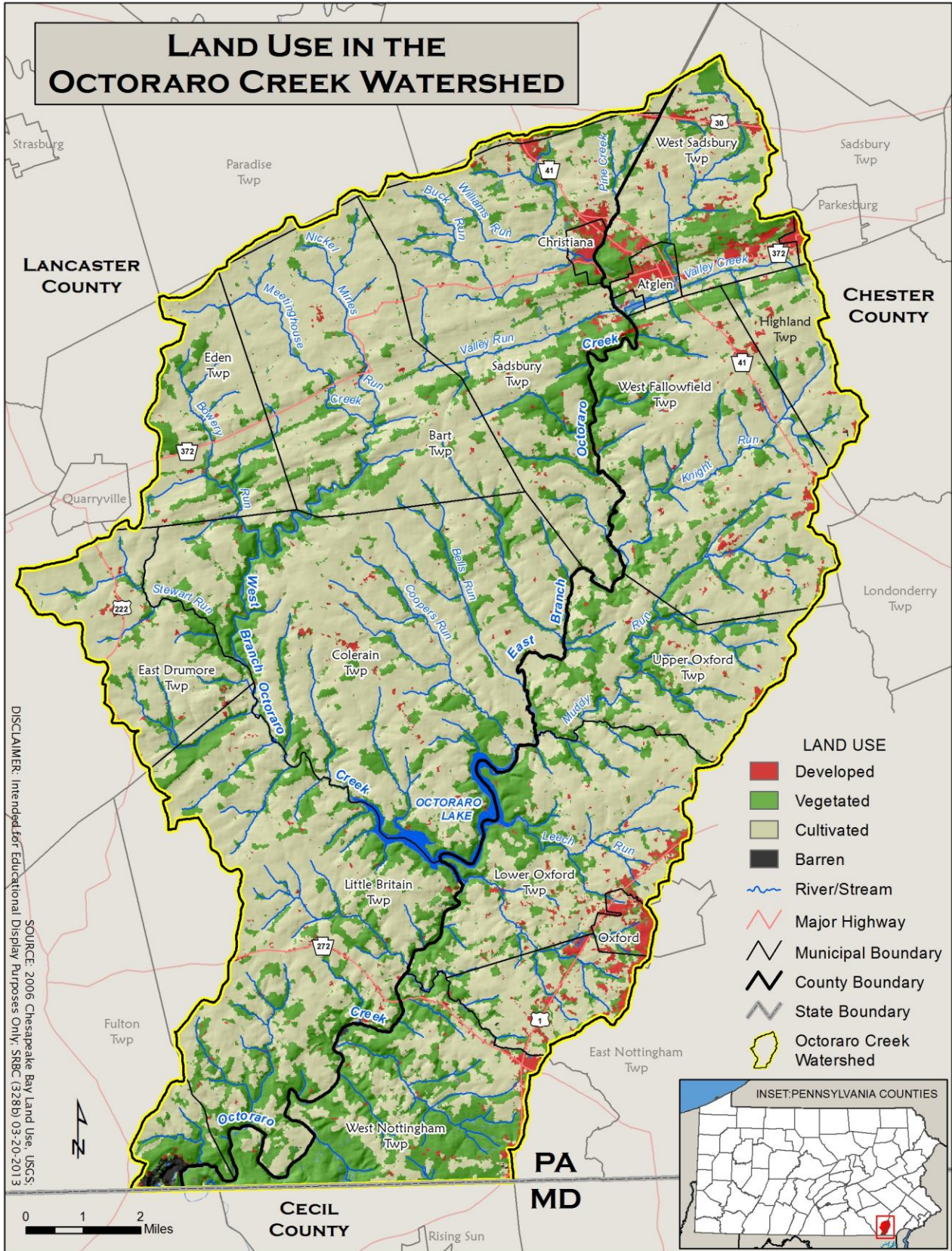


Figure A3. Land Use Map for the Octoraro Creek Watershed

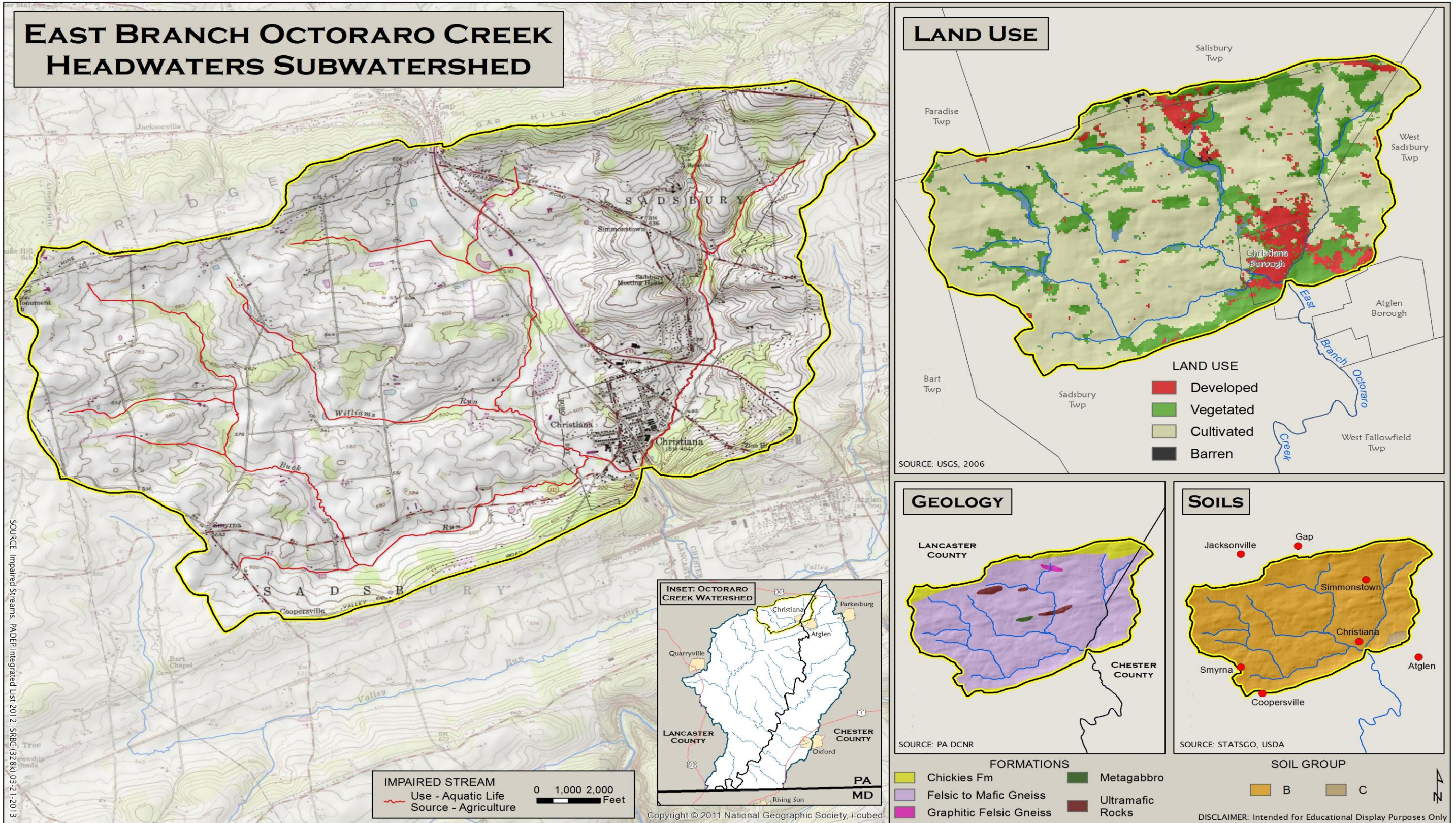


Figure A4. East Branch Octoraro Creek Headwaters Subwatershed

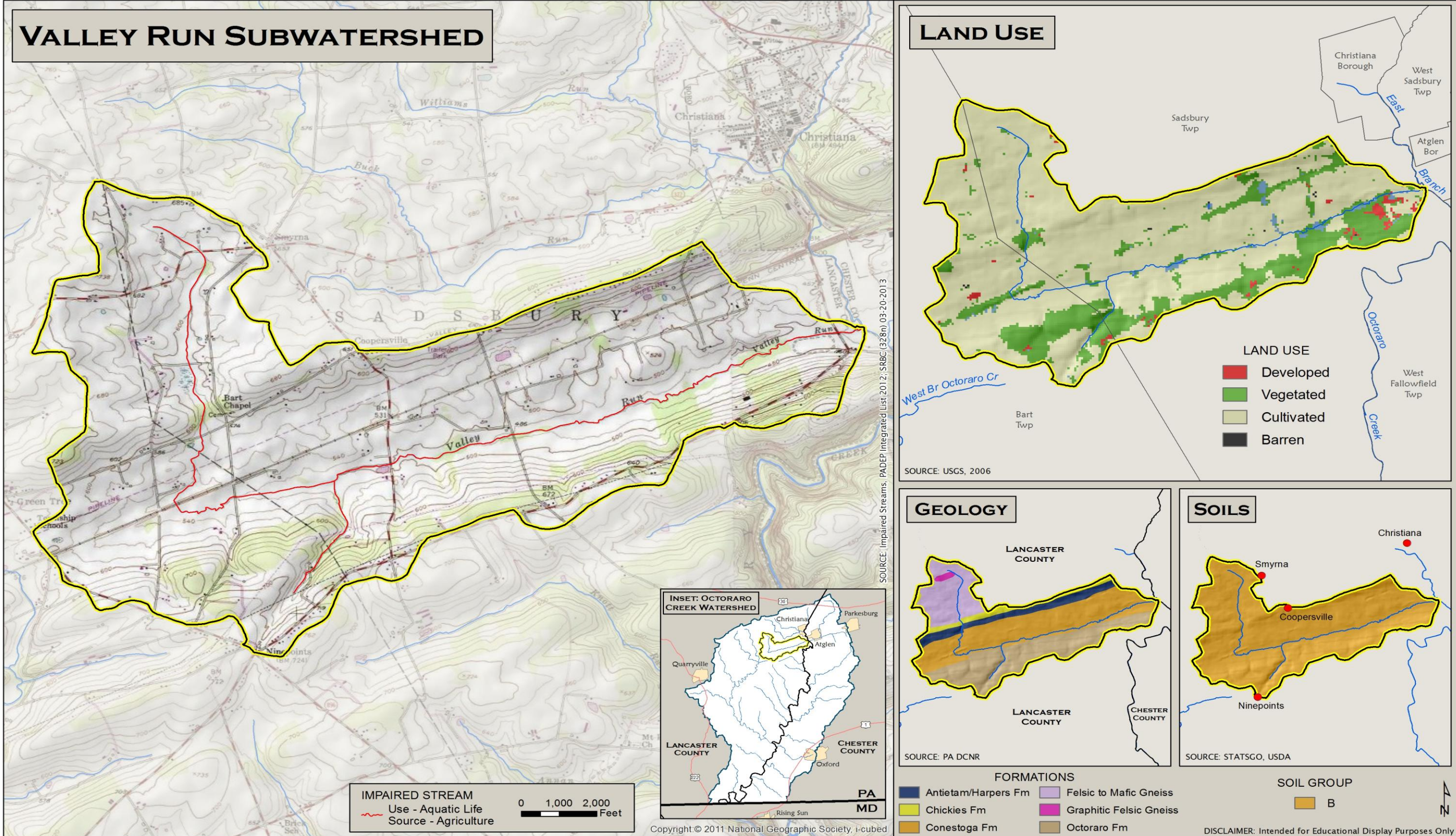


Figure A5. Valley Run Subwatershed

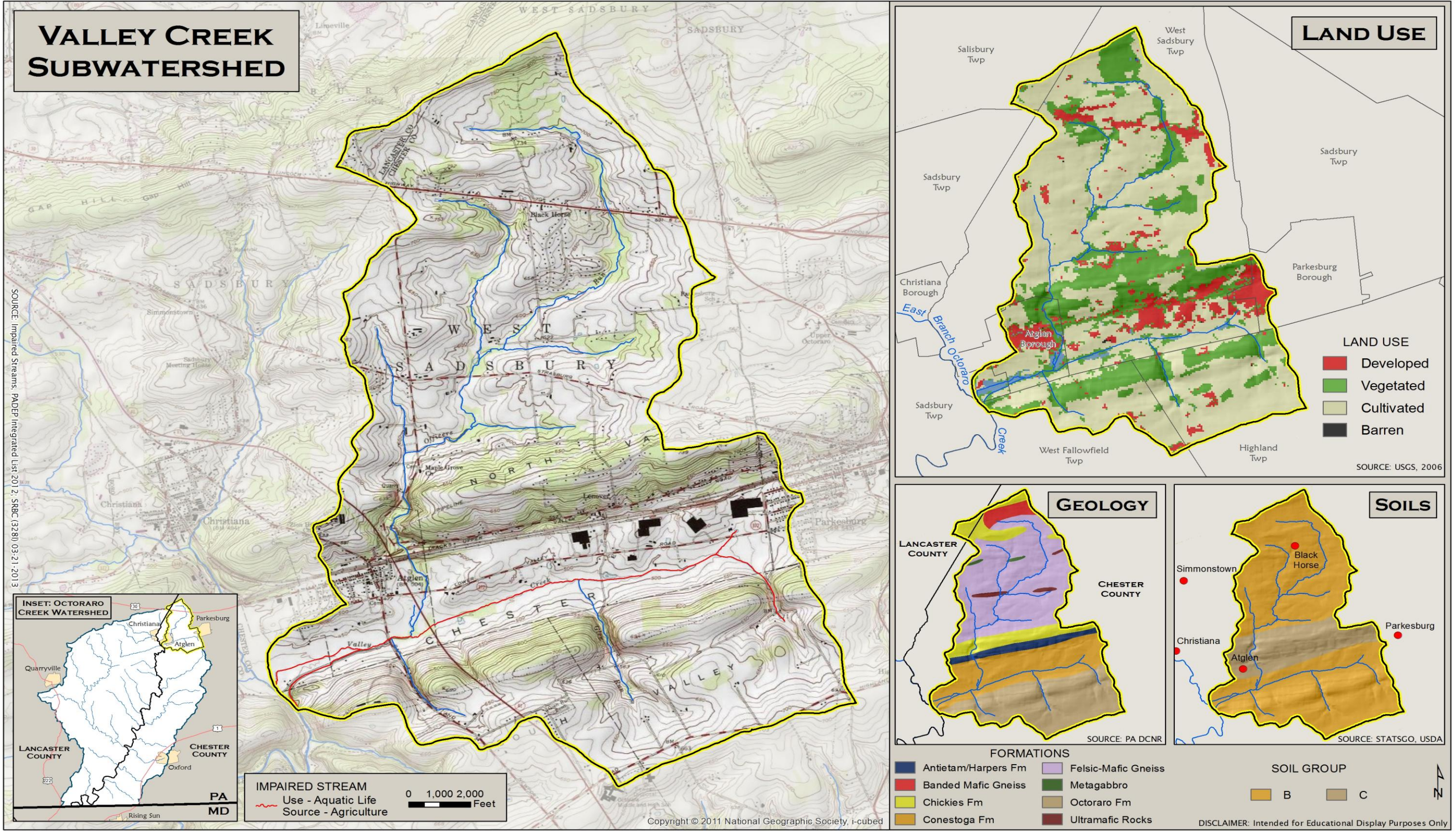


Figure A6. Valley Creek Subwatershed

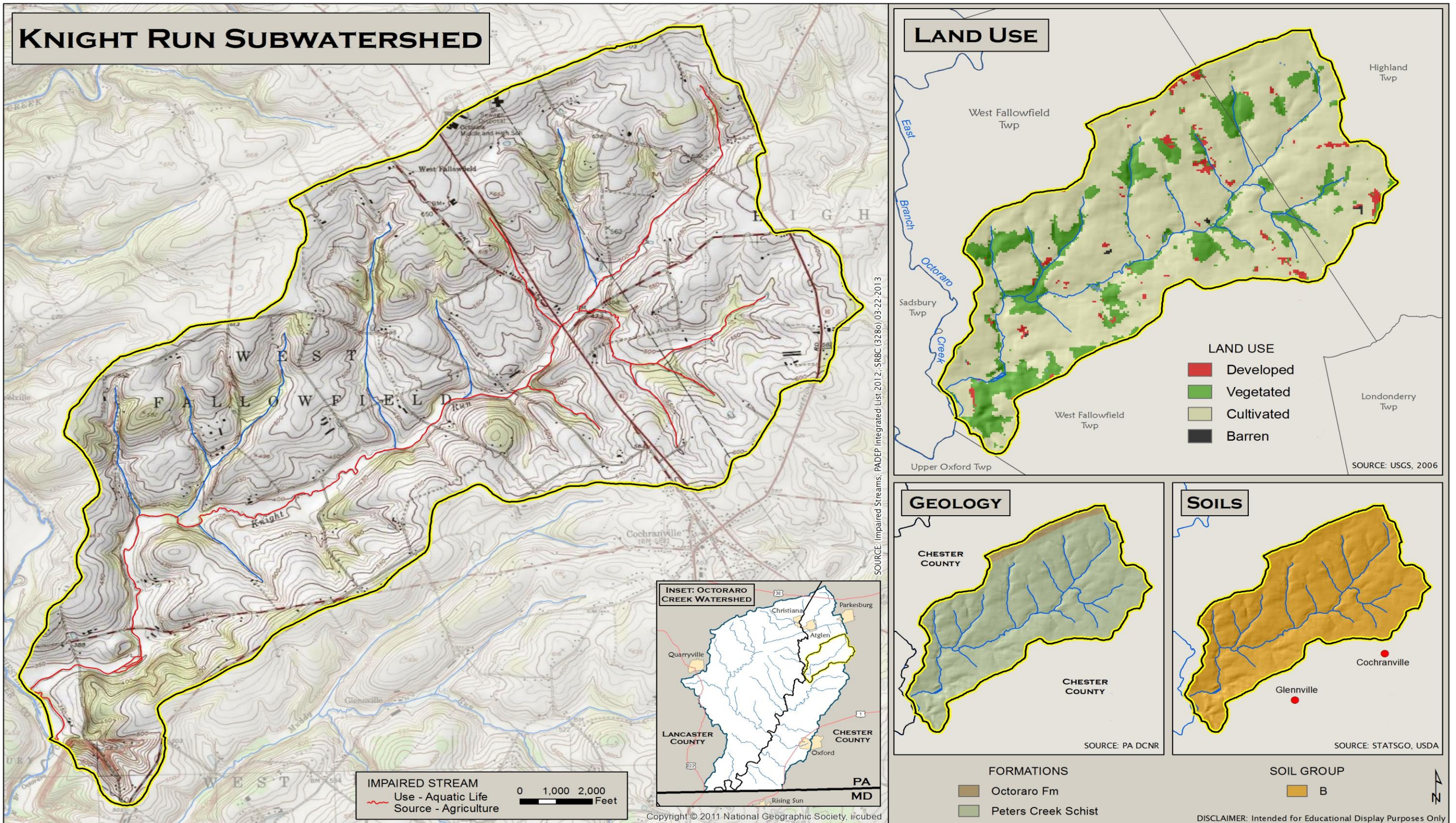


Figure A7. Knight Run Subwatershed

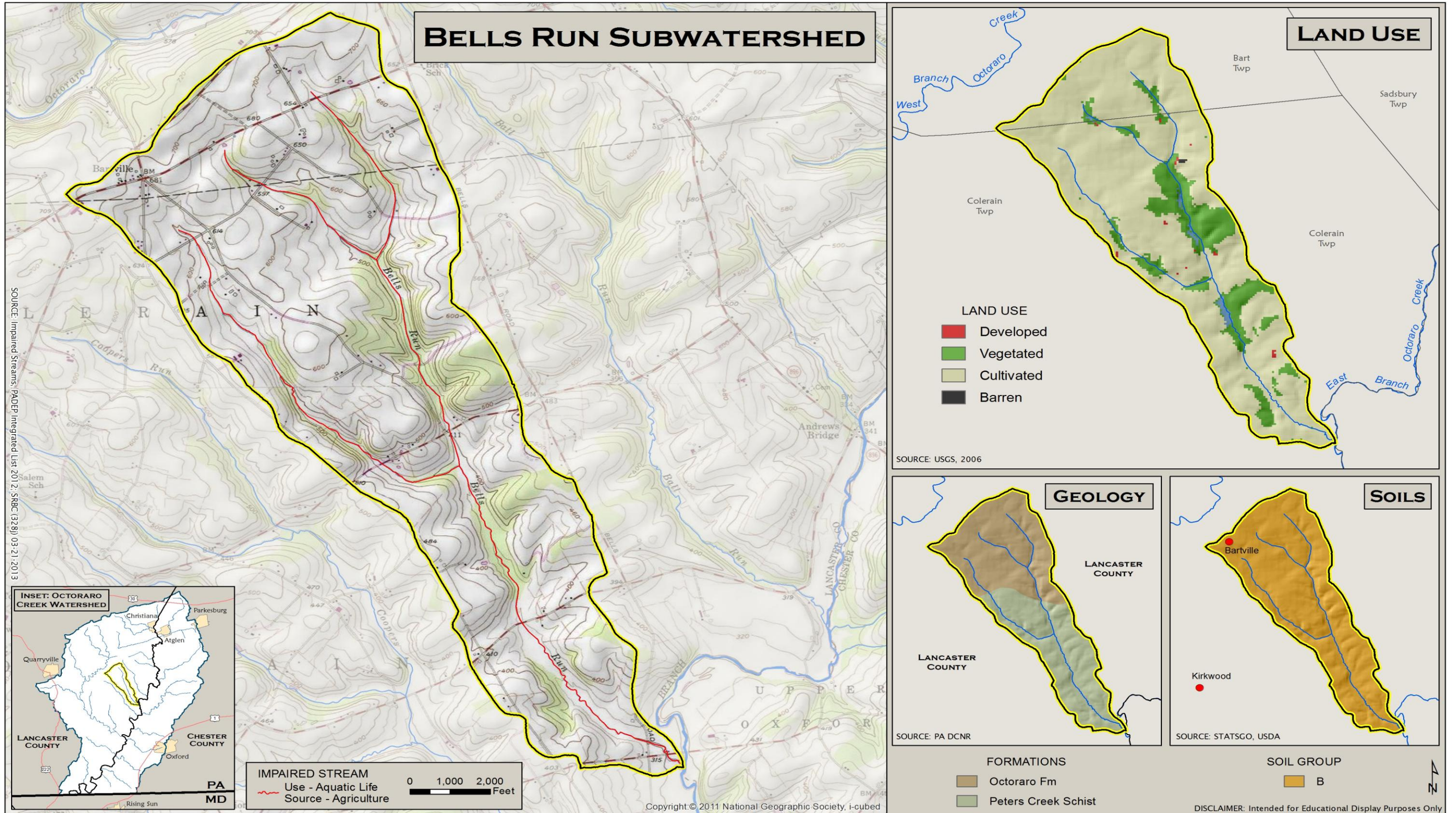


Figure A8. Bells Run Subwatershed

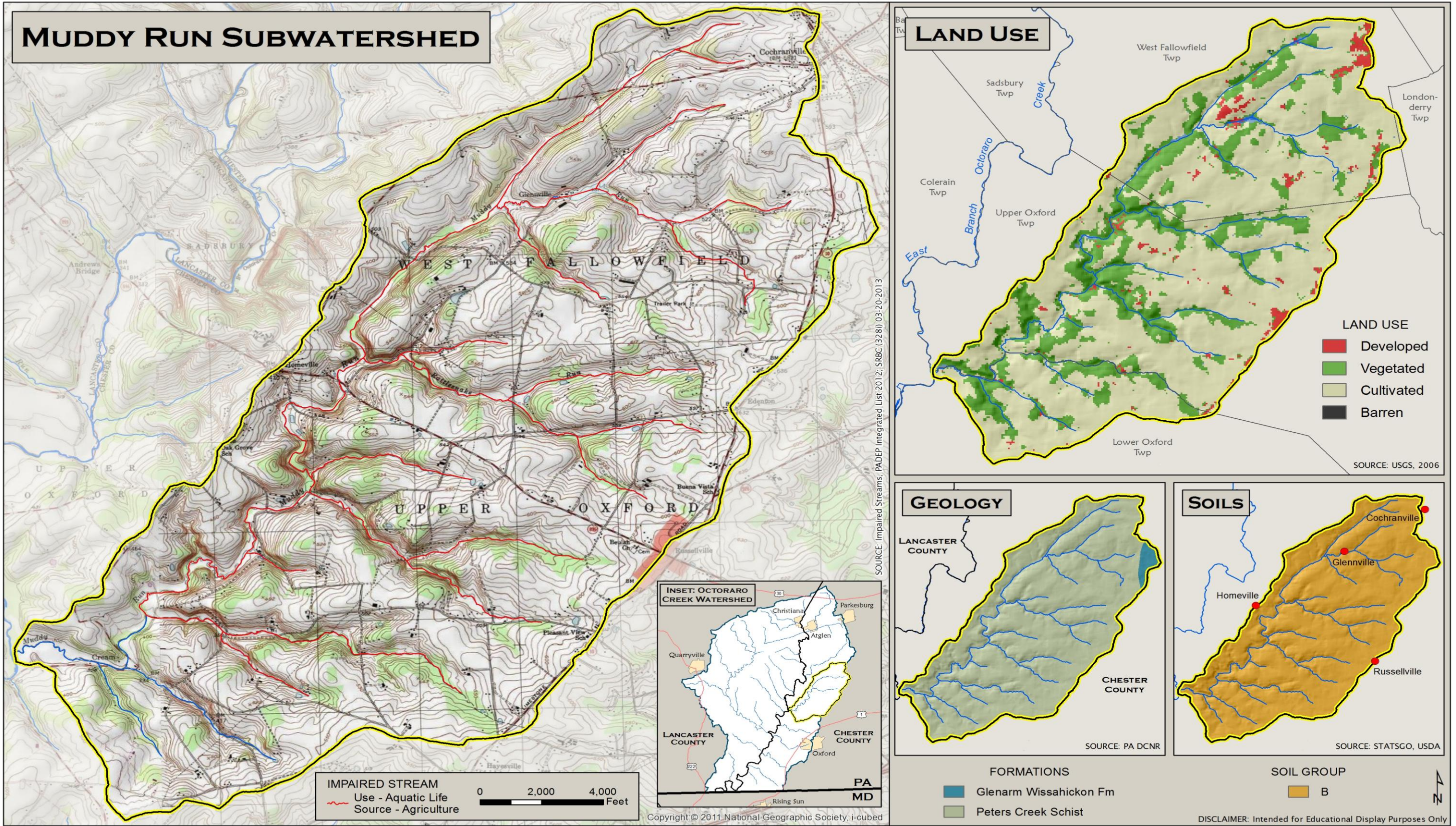


Figure A9. Muddy Run Subwatershed

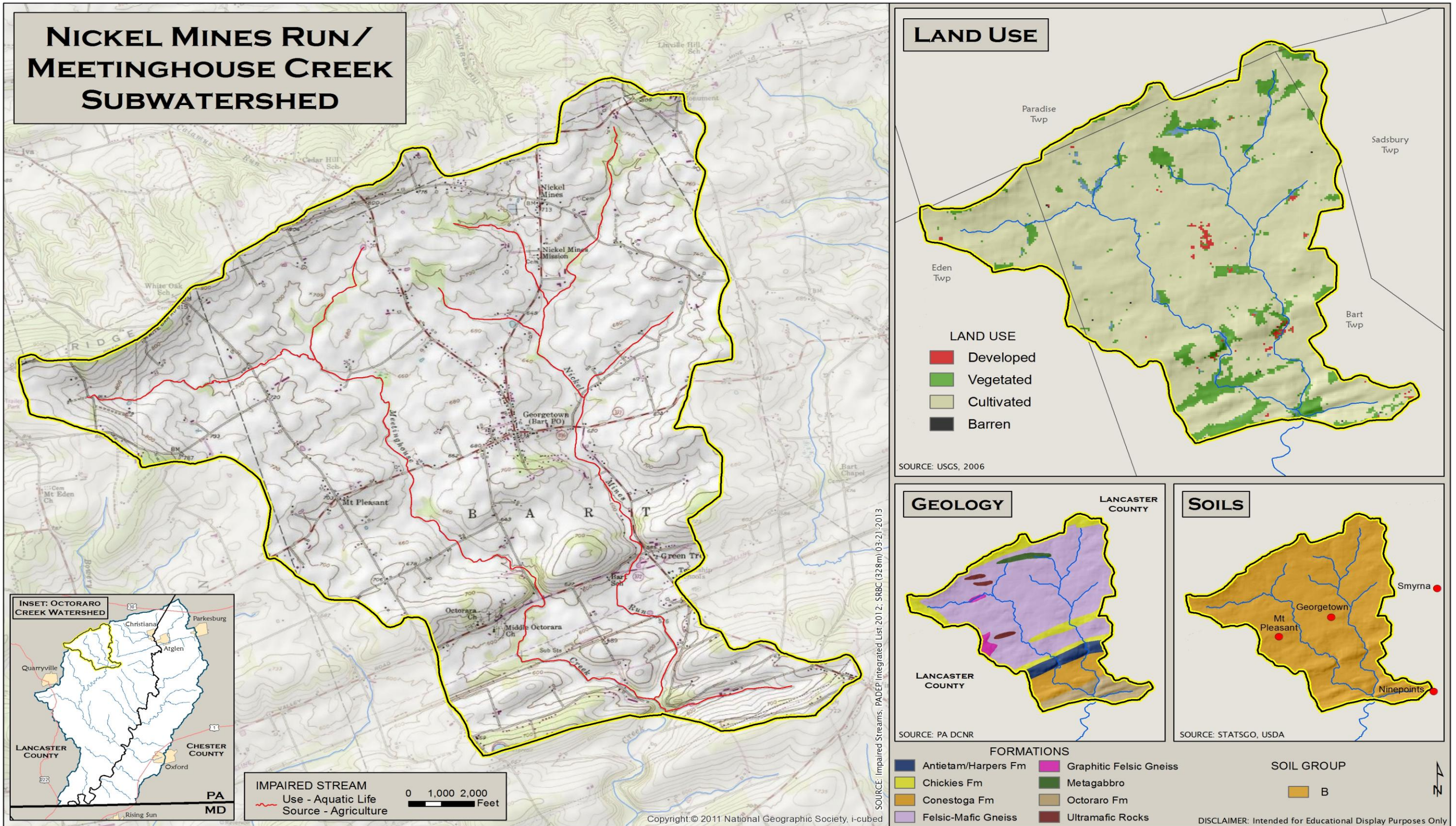


Figure A10. Nickel Mines Run/Meetinghouse Creek Subwatershed

Attachment B

**Excerpts Justifying Changes Between the 1996,
1998, and 2002 Section 303(d) Lists and
Integrated Report/List (2004, 2006, 2008)**

The following are excerpts from the PADEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, and 2002 303(d) Lists and Integrated Report/List (2004, 2006, and 2008). The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

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

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

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

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

Migration to National Hydrography Data (NHD)

New to the 2006 report is use of the 1/24,000 National Hydrography Data (NHD) streams GIS layer. Up until 2006, PADEP relied upon its own internally developed stream layer. Subsequently, the United States Geologic Survey (USGS) developed 1/24,000 NHD streams layer for the Commonwealth based upon national geodatabase standards. In 2005, PADEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old PADEP stream assessment information to the improved NHD and the old PADEP streams layer was archived. Overall, this marked an improvement in the quality of the streams layer and made the stream assessment data compatible with national standards but it necessitated a change in the Integrated Listing format. The NHD is not attributed with the old PADEP five digit stream codes so segments can no longer be listed by stream code but rather only by stream name or a fixed combination of NHD fields known as reachcode and ComID. The NHD is aggregated by Hydrologic Unit Code (HUC) watersheds so HUCs rather than the old State Water Plan (SWP) watersheds are now used to group streams together. A more basic

change was the shift in data management philosophy from one of “dynamic segmentation” to “fixed segments.” The dynamic segmentation records were proving too difficult to manage from a historical tracking perspective. The fixed segment methods will remedy that problem. The stream assessment data management has gone through many changes over the years as system requirements and software changed. It is hoped that with the shift to the NHD and OIT’s (Office of Information Technology) fulltime staff to manage and maintain SLIMS the systems and formats will now remain stable over many Integrated Listing cycles.

Attachment C

Octoraro Creek Watershed Impaired Segment Listings

State Master Plan (SWP) Subbasin: 07K

HUC: 02050306 Lower Susquehanna

Year	Miles	Use Designation	Assessment ID	Segment ID	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
2002	2.25	Aquatic Life	2522	20010724-1115-JCO	Bells Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	2.21	Aquatic Life	10989	990722-1415-BPG	Bells Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	0.98	Aquatic Life	2522	20010724-1115-JCO	UNT Bells Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	2.1	Aquatic Life	2522	20010724-1115-JCO	UNT Bells Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	5.05	Aquatic Life	11018	990729-1135-BPG	Buck Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	1.06	Aquatic Life	11018	990729-1135-BPG	UNT Buck Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	0.68	Aquatic Life	11018	990729-1135-BPG	UNT Buck Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	0.81	Aquatic Life	11018	990729-1135-BPG	UNT Buck Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	1.67	Aquatic Life	11004	990727-1325-BPG	East Branch Octoraro Creek	TSF	305(b)	Agriculture	Nutrients Siltation
2002	0.69	Aquatic Life	12314	20040625-1431-ACE	East Branch Octoraro Creek	TSF	305(b)	Agriculture	Siltation
2006	15.23	Potable Water Supply	12747	20041220-0006-PWS	East Branch Octoraro Creek	TSF	305(b)	Agriculture	Nutrients
2006	0.42	Potable Water Supply	12747	20041220-0006-PWS	UNT East Branch Octoraro Creek	TSF	305(b)	Agriculture	Nutrients
2006	1.67	Aquatic Life	7407	20040927-1830-ACE	Knight Run	TSF	305(b)	Agriculture	Siltation
2006	6.58	Aquatic Life	12298	20040630-1401-ACE	Knight Run	TSF	305(b)	Agriculture	Siltation
2006	0.36	Aquatic Life	12298	20040630-1401-ACE	UNT Knight Run	TSF	305(b)	Agriculture	Siltation
2006	0.57	Aquatic Life	12298	20040630-1401-ACE	UNT Knight Run	TSF	305(b)	Agriculture	Siltation

2006	0.76	Aquatic Life	12298	20040630-1401-ACE	UNT Knight Run	TSF	305(b)	Agriculture	Siltation
2006	1.47	Aquatic Life	12298	20040630-1401-ACE	UNT Knight Run	TSF	305(b)	Agriculture	Siltation
2006	0.5	Aquatic Life	12298	20040630-1401-ACE	UNT Knight Run	TSF	305(b)	Agriculture	Siltation
2002	5.02	Aquatic Life	10950	990719-1125-BPG	Meetinghouse Creek	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2006	0.11	Potable Water Supply	12747	20041220-0006-PWS	Meetinghouse Creek	HQ-CWF	305(b)	Agriculture	Nutrients
2002	1.61	Aquatic Life	10950	990719-1125-BPG	UNT Meetinghouse Creek	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2006	2.13	Aquatic Life	7405	20040927-1805-ACE	Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	3.65	Aquatic Life	12322	20040927-1805-ACE	Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	1.67	Aquatic Life	12325	20040803-1102-ACE	Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	0.44	Aquatic Life	7405	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	1.04	Aquatic Life	12326	20040722-1131-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	0.75	Aquatic Life	12322	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	1.04	Aquatic Life	7405	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	0.97	Aquatic Life	7405	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	2.03	Aquatic Life	7405	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	0.98	Aquatic Life	7405	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	1.12	Aquatic Life	12322	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	2.03	Aquatic Life	12326	20040722-1131-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation

2006	0.41	Aquatic Life	12329	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2006	2.31	Aquatic Life	12322	20040927-1805-ACE	UNT Muddy Run	TSF	305(b)	Agriculture	Siltation
2002	4.13	Aquatic Life	10953	990719-1335-BPG	Nickel Mines Run	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2002	1.36	Aquatic Life	10953	990719-1335-BPG	UNT Nickel Mines Run	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2002	0.75	Aquatic Life	10953	990719-1335-BPG	UNT Nickel Mines Run	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2002	0.78	Aquatic Life	10953	990719-1335-BPG	UNT Nickel Mines Run	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2006	8.1	Potable Water Supply	12747	20041220-0006-PWS	Octoraro Creek	HQ-CWF/TSF	305(b)	Agriculture	Nutrients
2002	2.56	Aquatic Life	11004	990727-1325-BPG	Pine Creek	TSF	305(b)	Agriculture	Nutrients Siltation
2002	0.94	Aquatic Life	11004	990727-1325-BPG	UNT Pine Creek	TSF	305(b)	Agriculture	Nutrients Siltation
2006	2.37	Aquatic Life	12323	20040720-1131-ACE	Rattlesnake Run	TSF	305(b)	Agriculture	Siltation
2006	0.67	Aquatic Life	12323	20040720-1131-ACE	UNT Rattlesnake Run	TSF	305(b)	Agriculture	Siltation
2006	0.7	Aquatic Life	12323	20040720-1131-ACE	UNT Rattlesnake Run	TSF	305(b)	Agriculture	Siltation
2006	1.35	Aquatic Life	12323	20040720-1131-ACE	UNT Rattlesnake Run	TSF	305(b)	Agriculture	Siltation
2006	2.89	Aquatic Life	12314	20040625-1431-ACE	Valley Creek	TSF	305(b)	Agriculture	Siltation
2006	1.56	Aquatic Life	12316	20040630-1231-ACE	Valley Creek	TSF	305(b)	Agriculture	Siltation
2006	0.21	Aquatic Life	7410	20040927-1850-ACE	UNT Valley Creek	TSF	305(b)	Agriculture	Siltation
2002	3.1	Aquatic Life	11004	990727-1325-BPG	Valley Run	TSF	305(b)	Agriculture	Nutrients Siltation
2008	2.78	Aquatic Life	13403	20061005-0911-C-jehoffma	Valley Run	TSF	305(b)	Agriculture	Nutrients Siltation

2008	0.74	Aquatic Life	13403	20061005-0911-C-jehoffma	UNT Valley Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	1.79	Aquatic Life	10950	990719-1125-BPG	West Branch Octoraro Creek	HQ-CWF	305(b)	Agriculture	Nutrients Siltation
2006	12.37	Potable Water Supply	12747	20041220-0006-PWS	West Branch Octoraro Creek	HQ-CWF	305(b)	Agriculture	Nutrients
2002	3.13	Aquatic Life	11018	990729-1135-BPG	Williams Run	TSF	305(b)	Agriculture	Nutrients Siltation
2008	0.87	Aquatic Life	13404	20061005-0912-C-jehoffma	UNT Williams Run	TSF	305(b)	Agriculture	Nutrients Siltation
2002	1.45	Aquatic Life	11018	990729-1135-BPG	UNT Williams Run	TSF	305(b)	Agriculture	Nutrients Siltation
2008	1.21	Aquatic Life	13404	20061005-0912-C-jehoffma	UNT Williams Run	TSF	305(b)	Agriculture	Nutrients Siltation

TSF = Trout Stocked Fisheries

HQ-CWF = High Quality Cold Water Fisheries

See Attachment B, *Excerpts Justifying Changes 2002 Section 303(d) List and Integrated Report/List (2004, 2006, 2008, 2010)*. The use designations for the stream segments in this TMDL can found in PA Title 25 Chapter 93.

Attachment D

TMDLs By Segment

Octoraro Creek

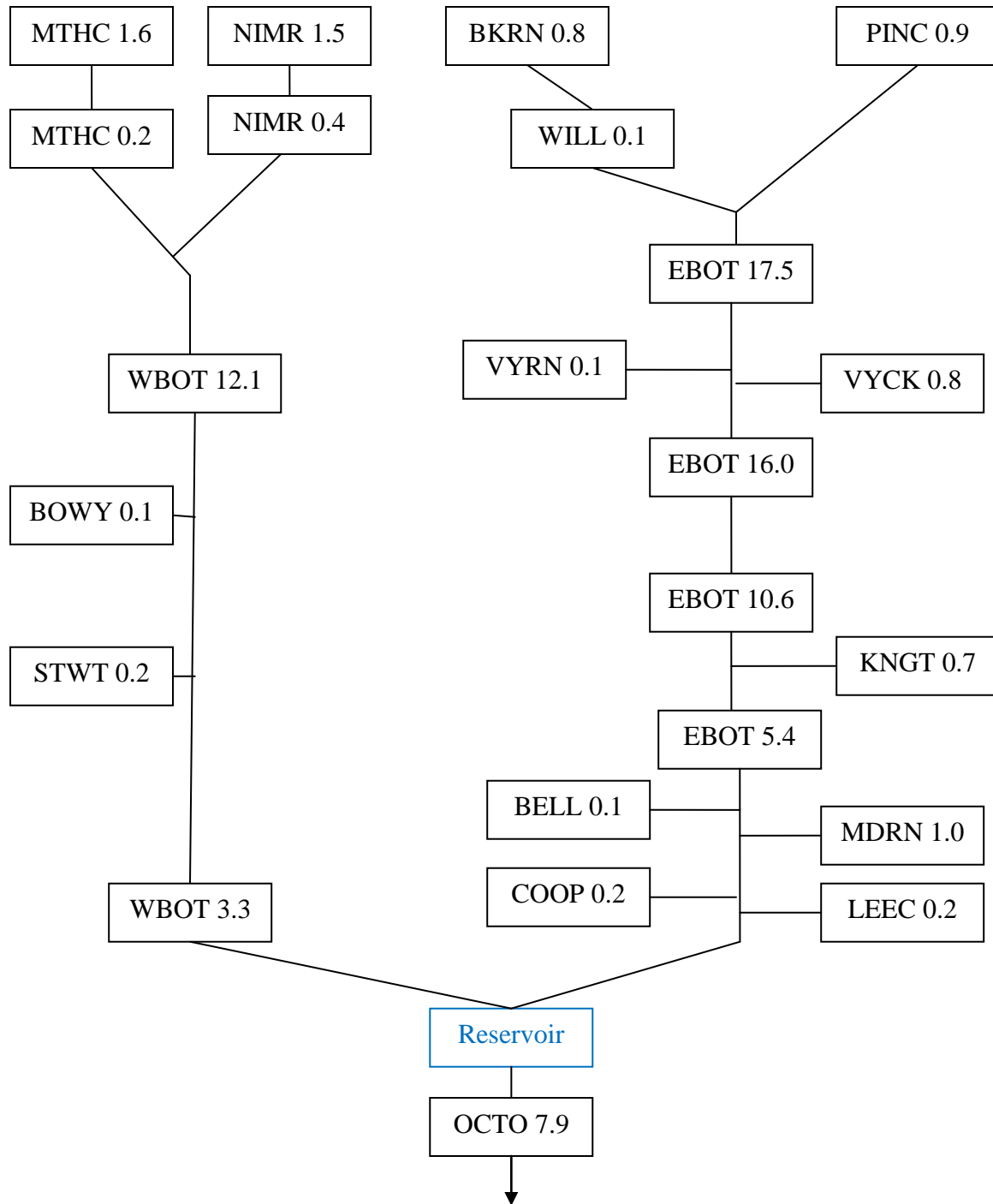
The TMDL for Octoraro Creek consists of LAs to 23 sampling sites on the East Branch Octoraro Creek, West Branch Octoraro Creek, and mainstem Octoraro Creek. Eight sampling sites are located on the West Branch Octoraro Creek and its tributaries (NIMR 1.5, NIMR 0.4, MTHC 1.6, MTHC 0.2, WBOT 12.1, BOWY 0.1, STWT 0.2, and WBOT 3.3). Samples were collected at 14 sites on the East Branch Octoraro Creek and its tributaries (PINC 0.9, BKRN 0.8, WILL 0.1, EBOT 17.5, VYRN 0.1, VYCK 0.8, EBOT 16.0, EBOT 10.6, KNGT 0.7, EBOT 5.4, BELL 0.1, MDRN 1.0, COOP 0.2, and LEEC 0.2). The remaining site is located on the mainstem Octoraro Creek below the reservoir. Eight sample datasets were collected between 2008 and 2012. All sample points are shown on the maps in Attachment A as well as on the loading schematic presented on the following page.

Octoraro Creek is listed on the 2002 303(d) and subsequent Integrated Lists for nutrients and siltation from agriculture as the cause of the stream degradation for aquatic life use. Potable water supply use impairments were added to the list of impairments on the 2006 Integrated List. Nutrients from agriculture are the source of impairment. The TMDL will focus on nitrate loadings for the potable water use impairment.

An allowable long-term average instream concentration for nitrate is determined at each sample point. These analyses are designed to produce a long-term average value that, when met, will be protective of the water quality criterion for that parameter 99 percent of the time. An analysis was performed using load duration curve method to determine the necessary long-term average concentration needed to attain water quality criteria 99 percent of the time. The bulk reserve is explicit and is calculated as one percent of the targeted TMDL. This bulk reserve enables the TMDL to account for the dynamic nature of permit activity. For each sampling site, a percent reduction was calculated, if necessary, to meet water quality criteria.

Octoraro Creek Sampling Diagram

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



NIMR 1.5: Nickel Mines Run upstream of carbonate geology

Nickel Mines Run begins near Nickel Mines, Lancaster County, Pa. Traditional farming practices have led to eroding streambanks and increased nutrient and sediment loads. Sampling point NIMR 1.5 is located along State Route 896 north of the intersection of SR 372. This portion of the stream is mowed to the stream edge and runs parallel with the road.

The TMDL for this section of Nickel Mines Run consists of a load allocation to the watershed area above NIMR 1.5. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point NIMR 1.5 (2.303 MGD). The LA at point NIMR 1.5 for this stream segment is presented in Table D1.

Table D1. TMDL Calculations at Point NIMR 1.5				
Flow = 2.303 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	12.49	239.90	9.00	172.86

A WLA is assigned to Georgetown Area Sewer Authority (PA0083933) for nitrate (Table D2). A bulk reserve WLA is assigned to point NIMR 1.5.

Table D2. Nitrate Waste Load Allocations for NIMR 1.5			
<i>Facility Name</i>	<i>Monthly Avg. Allowable Conc. (mg/L)</i>	<i>Average Flow (MGD)</i>	<i>Allowable Load (lbs/day)</i>
Georgetown Area Sewer Authority	12.01	0.04	4.01
Bulk Reserve			1.73
Total			5.74

Necessary reductions at point NIMR 1.5 are shown in Table D3.

Table D3. Calculation of Load Reduction Necessary at Point NIMR 1.5	
	<i>Nitrate (lbs/day)</i>
Existing load at NIMR 1.5	239.90
Difference of measured loads between loads that enter and existing NIMR 1.5	239.90
Percent loss due calculated at NIMR 1.5	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach NIMR 1.5	100
Total load at NIMR 1.5	239.90
Allowable load at NIMR 1.5	172.86
WLA	5.74
LA	167.12
Load Reduction at NIMR 1.5	72.78
Percent reduction required at NIMR 1.5	30

The TMDL for point NIMR 1.5 requires a load allocation for nitrate.

NIMR 0.4: Mouth of Nickel Mines Run downstream of carbonate geology

NIMR 0.4 is located along Heyberger Road in Lancaster County, Pa., near the mouth of Nickel Mines Run. Traditional farming practices have led to eroding streambanks and increased nutrient and sediment loads. The right bank is bordered by pasture and the left bank is a mixture of old fields and forest.

The TMDL for this section of Nickel Mines Run consists of a load allocation to the watershed area between NIMR 1.5 and NIMR 0.4. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point NIMR 0.4 (2.612 MGD). The LA at point NIMR 0.4 for this stream segment is presented in Table D4.

Table D4. TMDL Calculations at Point NIMR 0.4				
Flow = 2.612 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.94	260.10	9.00	196.06

The loading reduction for point NIMR 1.5 was used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point NIMR 0.4. This value was compared to the allowable load at point NIMR 1.5. A bulk reserve WLA (1 percent of the allowable load) is assigned to point NIMR 0.4 (1.96 lbs/day). Necessary reductions at point NIMR 0.4 are shown in Table D5.

Table D5. Calculation of Load Reduction Necessary at Point NIMR 0.4	
	<i>Nitrate (lbs/day)</i>
Existing load at NIMR 0.4	260.10
Difference of measured loads between loads that enter and existing NIMR 0.4	20.2
Percent loss due calculated at NIMR 0.4	0
Additional loads tracked from above samples	172.86
Percentage of upstream loads that reach NIMR 0.4	100
Total load at NIMR 0.4	193.06
Allowable load at NIMR 0.4	196.06
WLA	1.96
LA	194.10
Load Reduction at NIMR 0.4	-1.04
Percent reduction required at NIMR 0.4	0

The TMDL for point NIMR 0.4 requires no load reductions for nitrate.

MTHC 1.6: Meetinghouse Creek upstream of carbonate geology

MTHC 1.6 is located near the Bart Township Building in Lancaster County, Pa. This section of the stream is surrounded by a small forested buffer, but agriculture dominates the drainage area. The TMDL for this section of Meetinghouse Creek consists of a load allocation to the watershed

area above MTHC 1.6. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point MTHC 1.6 (1.854 MGD). The LA at point MTHC 1.6 for this stream segment is presented in Table D6.

Table D6. TMDL Calculations at Point MTHC 1.6				
Flow = 1.854 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	12.02	185.86	9.00	139.16

A bulk reserve WLA was assigned to point MTHC 1.6 (1.39 lbs/day). The load reduction necessary for this stream segment is presented in Table D7.

Table D7. Calculation of Load Reduction Necessary at Point MTHC 1.6	
	<i>Nitrate (lbs/day)</i>
Existing load at MTHC 1.6	185.86
Difference of measured loads between loads that enter and existing MTHC 1.6	185.86
Percent loss due calculated at MTHC 1.6	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach MTHC 1.6	100
Total load at MTHC 1.6	185.86
Allowable load at MTHC 1.6	139.16
WLA	1.39
LA	137.77
Load Reduction at MTHC 1.6	48.09
Percent reduction required at MTHC 1.6	26

The TMDL for point MTHC 1.6 requires a load allocation for nitrate.

MTHC 0.2: Mouth of Meetinghouse Creek downstream of carbonate geology

MTHC 0.2 is located along Lamparter Road near Gibble Hill Rd in Bart Township, Lancaster County, Pa. Traditional farming practices have led to eroding streambanks and increased nutrient and sediment loads. The sampling location is surrounded by pasture land.

The TMDL for this section of Meetinghouse Creek consists of a load allocation to the watershed area between MTHC 1.6 and MTHC 0.2. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point MTHC 0.2 (2.825 MGD). The LA at point MTHC 0.2 for this stream segment is presented in Table D8.

Table D8. TMDL Calculations at Point MTHC 0.2				
Flow = 2.825 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.16	262.94	9.00	212.04

The loading reduction for point MTHC 1.6 was used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point MTHC 0.2. This value was compared to the allowable load at point MTHC 1.6. A bulk reserve WLA was assigned to point MTHC 0.2 (2.12 lbs/day). Necessary reductions at point MTHC 0.2 are shown in Table D9.

Table D9. Calculation of Load Reduction Necessary at Point MTHC 0.2	
	<i>Nitrate (lbs/day)</i>
Existing load at MTHC 0.2	262.94
Difference of measured loads between loads that enter and existing MTHC 0.2	77.08
Percent loss due calculated at MTHC 0.2	0
Additional loads tracked from above samples	139.16
Percentage of upstream loads that reach MTHC 0.2	100
Total load at MTHC 0.2	216.14
Allowable load at MTHC 0.2	212.04
WLA	2.12
LA	209.92
Load Reduction at MTHC 0.2	6.22
Percent reduction required at MTHC 0.2	2

The TMDL for point MTHC 0.2 requires a load allocation for nitrate.

WBOT 12.1: West Branch Octoraro Creek at Hollow Road

WBOT 12.1 is located downstream of the Jackson Mills covered bridge on Hollow Road in Bart Township, Lancaster County, Pa. Traditional farming practices have led to eroding stream banks and increased nutrient and sediment loads.

The TMDL for this section of the West Branch Octoraro Creek consists of a load allocation to the watershed area upstream of WBOT 12.1. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point WBOT 12.1 (7.465 MGD). The LA at point WBOT 12.1 for this stream segment is presented in Table D10.

Table D10. TMDL Calculations at Point WBOT 12.1				
Flow = 7.465 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.05	687.95	9.00	560.32

The loading reduction for points NIMR 0.4 and MTHC 0.2 were used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point WBOT 12.1. This value was compared to the allowable loads at points NIMR 0.4 and MTHC 0.2. A bulk reserve WLA was assigned to point WBOT 12.1 (5.60 lbs/day). Necessary reductions at point WBOT 12.1 are shown in Table D11.

Table D11. Calculation of Load Reduction Necessary at Point WBOT 12.1	
	<i>Nitrate (lbs/day)</i>
Existing load at WBOT 12.1	687.95
Difference of measured loads between loads that enter and existing WBOT 12.1	164.91
Percent loss due calculated at WBOT 12.1	0
Additional loads tracked from above samples	408.10
Percentage of upstream loads that reach WBOT 12.1	100
Total load at WBOT 12.1	573.01
Allowable load at WBOT 12.1	560.32
WLA	5.60
LA	554.72
Load Reduction at WBOT 12.1	18.29
Percent reduction required at WBOT 12.1	3

The TMDL for point WBOT 12.1 requires a load allocation for nitrate.

BOWY 0.1: Mouth of Bowery Run

BOWY 0.1 is located near the intersection of Pumping Station Road and Fairview Road in Colerain Township, Lancaster County, Pa. This section of Bowery Run has a forested buffer on both streambanks, but agriculture dominates the watershed.

The TMDL for this section of Bowery Run consists of a load allocation to the watershed area above BOWY 0.1. A 50th percentile instream flow measurement was available for point BOWY 0.1 (4.261 MGD). The LA at point BOWY 0.1 for this stream segment is presented in Table D12.

Table D12. TMDL Calculations at Point BOWY 0.1				
Flow = 4.261 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	8.46	300.64	9.00	319.83

A bulk reserve WLA was assigned to point BOWY 0.1 (3.20 lbs/day). The load reduction necessary for this stream segment is presented in Table D13.

Table D13. Calculation of Load Reduction Necessary at Point BOWY 0.1	
	<i>Nitrate (lbs/day)</i>
Existing load at BOWY 0.1	300.64
Difference of measured loads between loads that enter and existing BOWY 0.1	300.64
Percent loss due calculated at BOWY 0.1	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach BOWY 0.1	100
Total load at BOWY 0.1	300.64
Allowable load at BOWY 0.1	319.83
WLA	3.20
LA	316.63
Load Reduction at BOWY 0.1	-15.99
Percent reduction required at BOWY 0.1	0

The TMDL for point BOWY 0.1 requires no load reductions for nitrate.

STWT 0.2: Mouth of Stewart Run

STWT 0.2 is located in the Theodore A. Parker III Natural Area near Puseyville, Lancaster County, Pa. The section of the stream is surrounded by a large forested buffer on streambanks. However, traditional farming practices upstream have led to eroding streambanks and increased nutrient and sediment loads.

The TMDL for this section of South Branch consists of a load allocation to the watershed area above STWT 0.2. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point STWT 0.2 (3.832 MGD). The LA at point STWT 0.2 for this stream segment is presented in Table D14.

Table D14. TMDL Calculations at Point STWT 0.2				
Flow = 3.832 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	13.68	437.20	9.00	287.63

A WLA is assigned to Solanco School District (PA0081116) for nitrate (Table D15). A bulk reserve WLA is assigned to point NIMR 1.5.

Table D15. Nitrate Waste Load Allocations for STWT 0.2			
<i>Facility Name</i>	<i>Monthly Avg. Allowable Conc. (mg/L)</i>	<i>Average Flow (MGD)</i>	<i>Allowable Load (lbs/day)</i>
Solanco School District	17.20	0.02	2.87
Bulk Reserve			2.88
Total			5.75

Necessary reductions at point STWT 0.2 are shown in Table D16.

Table D16. Calculation of Load Reduction Necessary at Point STWT 0.2	
	<i>Nitrate (lbs/day)</i>
Existing load at STWT 0.2	437.20
Difference of measured loads between loads that enter and existing STWT 0.2	437.20
Percent loss due calculated at STWT 0.2	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach STWT 0.2	100
Total load at STWT 0.2	437.20
Allowable load at STWT 0.2	287.63
WLA	5.75
LA	281.88
Load Reduction at STWT 0.2	155.32
Percent reduction required at STWT 0.2	36

The TMDL for point STWT 0.2 requires a load allocation for nitrate.

WBOT 3.3: West Branch Octoraro Creek at the White Rock covered bridge

WBOT 3.3 is located near White Rock, Pa., at the intersection of King Pen Road and White Rock Road. Traditional farming practices in the watershed have led to eroding streambanks and increased nutrient and sediment loads.

The TMDL for this section of the West Branch Octoraro Creek consists of a load allocation to the watershed area between WBOT 12.1 and WBOT 3.3. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point WBOT 3.3 (16.804 MGD). The LA at point WBOT 3.3 for this stream segment is presented in Table D17.

Table D17. TMDL Calculations at Point WBOT 3.3				
Flow = 16.804 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.56	1,620.08	9.00	1,261.31

The loading reduction for points WBOT 12.1, BOWY 0.1, and STWT 0.2 were used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point WBOT 3.3. This value was compared to the allowable load at point WBOT 3.3. A bulk reserve WLA was assigned to point WBOT 3.3 (12.61 lbs/day). Necessary reductions at point WBOT 3.3 are shown in Table D18.

Table D18. Calculation of Load Reduction Necessary at Point WBOT 3.3	
	<i>Nitrate (lbs/day)</i>
Existing load at WBOT 3.3	1,620.08
Difference of measured loads between loads that enter and existing WBOT 3.3	194.29
Percent loss due calculated at WBOT 3.3	0
Additional loads tracked from above samples	1,267.78
Percentage of upstream loads that reach WBOT 3.3	100
Total load at WBOT 3.3	1,362.07
Allowable load at WBOT 3.3	1,261.31
WLA	12.61
LA	1,248.70
Load Reduction at WBOT 3.3	113.37
Percent reduction required at WBOT 3.3	7

The TMDL for point WBOT 3.3 requires a load allocation for nitrate.

PINC 0.9: Pine Creek upstream of Christiana Borough

PINC 0.9 is located north of Christiana, Lancaster County, Pa. The sampling site is located on Sadsbury Lane. The stream is bordered by pastures on both banks with no streambank fencing.

The TMDL for this section of Pine Creek consists of a load allocation to the watershed area above PINC 0.9. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point PINC 0.9 (1.047 MGD). The LA at point PINC 0.9 for this stream segment is presented in Table D19.

Table D19. TMDL Calculations at Point PINC 0.9				
Flow = 1.047 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	9.00	75.59	9.00	75.59

A bulk reserve WLA was assigned to point PINC 0.9 (0.76 lbs/day). The load reduction necessary for this stream segment is presented in Table D20.

Table D20. Calculation of Load Reduction Necessary at Point PINC 0.9	
	<i>Nitrate (lbs/day)</i>
Existing load at PINC 0.9	75.59
Difference of measured loads between loads that enter and existing PINC 0.9	75.59
Percent loss due calculated at PINC 0.9	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach PINC 0.9	100
Total load at PINC 0.9	75.59
Allowable load at PINC 0.9	75.59
WLA	0.76
LA	74.83
Load Reduction at PINC 0.9	0.76
Percent reduction required at PINC 0.9	1

The TMDL for point PINC 0.9 requires a load allocation for nitrate.

BKRN 0.8: Buck Run west of Christiana Borough

BKRN 0.8 is located along SR 372 in Sadsbury Township, Lancaster County, Pa. BKRN 0.8 is surrounded by pasture land with no streambank fencing. Traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads.

The TMDL for this section of Buck Run consists of a load allocation to the watershed area above BKRN 0.8. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point BKRN 0.8 (1.913 MGD). The LA at point BKRN 0.8 for this stream segment is presented in Table D21.

Table D21. TMDL Calculations at Point BKRN 0.8				
Flow = 1.913 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.35	181.08	9.00	143.59

A bulk reserve WLA was assigned to point BKRN 0.8 (1.44 lbs/day). The load reduction necessary for this stream segment is presented in Table D22.

Table D22. Calculation of Load Reduction Necessary at Point BKRN 0.8	
	<i>Nitrate (lbs/day)</i>
Existing load at BKRN 0.8	181.08
Difference of measured loads between loads that enter and existing BKRN 0.8	181.08
Percent loss due calculated at BKRN 0.8	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach BKRN 0.8	100
Total load at BKRN 0.8	181.08
Allowable load at BRKN 0.8	143.59
WLA	1.44
LA	142.15
Load Reduction at BKRN 0.8	38.93
Percent reduction required at BKRN 0.8	21

The TMDL for point BKRN 0.8 requires a load allocation for nitrate.

WILL 0.1: Mouth of Williams Run

WILL 0.1 is located at the mouth of Williams Run in Christiana, Lancaster County, Pa. This section of stream is bordered by mowed grass on both banks. The contributing watershed is dominated by agriculture.

The TMDL for this section of Williams Run consists of a load allocation to the watershed area between BKRN 0.8 and WILL 0.1 and Williams Run above the confluence of Buck Run. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point WILL 0.1 (4.505 MGD). The LA at point WILL 0.1 for this stream segment is presented in Table D23.

Table D23. TMDL Calculations at Point WILL 0.1				
Flow = 4.505 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	10.35	388.87	9.00	338.15

The loading reduction for point BKRN 0.8 was used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point WILL 0.1. This value was compared to the allowable load at point WILL 0.1. A bulk reserve WLA was assigned to point WILL 0.1 (3.38 lbs/day). Necessary reductions at point WILL 0.1 are shown in Table D24.

Table D24. Calculation of Load Reduction Necessary at Point WILL 0.1	
	<i>Nitrate (lbs/day)</i>
Existing load at WILL 0.1	388.87
Difference of measured loads between loads that enter and existing WILL 0.1	207.79
Percent loss due calculated at WILL 0.1	0
Additional loads tracked from above samples	143.59
Percentage of upstream loads that reach WILL 0.1	100
Total load tracked between BKRN 0.8 and WILL 0.1	351.28
Allowable load at WILL 0.1	338.15
WLA	3.38
LA	334.77
Load Reduction at WILL 0.1	16.51
Percent reduction required at WILL 0.1	4

The TMDL for point WILL 0.1 requires a load allocation for nitrate.

EBOT 17.5: East Branch Octoraro Creek near Christiana Borough

EBOT 17.5 is located on SR 372 in Christiana, Lancaster County, Pa. The sampling site is upstream of the bridge and is bordered by a small forested riparian buffer. The contributing watershed is dominated by agriculture.

The TMDL for this section of East Branch Octoraro Creek consists of a load allocation to the watershed area between PINC 0.9 and EBOT 17.5. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point EBOT 17.5 (6.008 MGD). The LA at point EBOT 17.5 for this stream segment is presented in Table D25.

Table D25. TMDL Calculations at Point EBOT 17.5				
Flow = 6.008 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	9.50	476.01	9.00	450.96

The loading reduction for points PINC 0.9 and WILL 0.1 were used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point EBOT 17.5. This value was compared to the allowable load at point EBOT 17.5. A bulk reserve WLA was assigned to point EBOT 17.5 (4.51 lbs/day). Necessary reductions at point EBOT 17.5 are shown in Table D26.

Table D26. Calculation of Load Reduction Necessary at Point EBOT 17.5	
	<i>Nitrate (lbs/day)</i>
Existing load at EBOT 17.5	476.01
Difference of measured loads between loads that enter and existing EBOT 17.5	-93.94
Percent loss due calculated at EBOT 17.5	16.5
Additional loads tracked from above samples	481.74
Percentage of upstream loads that reach EBOT 17.5	83.5
Total load tracked between upstream points and EBOT 17.5	402.25
Allowable load at EBOT 17.5	450.96
WLA	4.51
LA	446.45
Load Reduction at EBOT 17.5	-44.20
Percent reduction required at EBOT 17.5	0

The TMDL for point EBOT 17.5 requires no load reductions for nitrate.

VYRN 0.1: Valley Run downstream of Christiana Borough

VYRN 0.1 is located along Noble Road in Sadsbury Township, Lancaster County, Pa. VYRN 0.1 is surrounded by pasture land; traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads.

The TMDL for this section of Valley Run consists of a load allocation to the watershed area above VYRN 0.1. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point VYRN 0.1 (2.309 MGD). The LA at point VYRN 0.1 for this stream segment is presented in Table D27.

Table D27. TMDL Calculations at Point VYRN 0.1				
Flow = 2.309 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	8.16	157.14	9.00	173.31

A bulk reserve WLA was assigned to point VYRN 0.1 (1.73 lbs/day). The load reduction necessary for this stream segment is presented in Table D28.

Table D28. Calculation of Load Reduction Necessary at Point VYRN 0.1	
	<i>Nitrate (lbs/day)</i>
Existing load at VYRN 0.1	157.14
Difference of measured loads between loads that enter and existing VYRN 0.1	157.14
Percent loss due calculated at VYRN 0.1	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach VYRN 0.1	100
Total load at VYRN 0.1	157.14
Allowable load at VYRN 0.1	173.31
WLA	1.73
LA	171.58
Load Reduction at VYRN 0.1	-14.44
Percent reduction required at VYRN 0.1	0

The TMDL for point VYRN 0.1 requires no load reductions for nitrate.

VYCK 0.8: Valley Creek downstream in Atglen Borough

VYCK 0.8 is located along Main Street in Atglen Borough in Chester County, Pa. The sampling site is downstream of the bridge making it downstream of the Atglen Borough Sewer Authority discharge. VYCK 0.8 is bordered by a small forested buffer in this area of the stream.

The TMDL for this section of Valley Creek consists of a load allocation to the watershed area above VYCK 0.8. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point VYCK 0.8 (5.214 MGD). The LA at point VYCK 0.8 for this stream segment is presented in Table D29.

Table D29. TMDL Calculations at Point VYCK 0.8				
Flow = 5.214 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	8.32	361.79	9.00	391.36

A WLA is assigned to Atglen Borough Sewer Authority (PA0024651) for nitrate (Table D30). A bulk reserve WLA is assigned to point VYCK 0.8.

Table D30. Nitrate Waste Load Allocations for VYCK 0.8			
<i>Facility Name</i>	<i>Monthly Avg. Allowable Conc. (mg/L)</i>	<i>Average Flow (MGD)</i>	<i>Allowable Load (lbs/day)</i>
Atglen Borough Sewer Authority	26.99	0.09	20.27
Bulk Reserve			3.91
Total			24.18

A load allocation was included in this segment of Valley Creek for the municipal discharge from Atglen Borough Sewer Authority. Necessary reductions at point VYCK 0.8 are shown in Table D31.

Table D31. Calculation of Load Reduction Necessary at Point VYCK 0.8	
	<i>Nitrate (lbs/day)</i>
Existing load at VYCK 0.8	361.79
Difference of measured loads between loads that enter and existing VYCK 0.8	361.79
Percent loss due calculated at VYCK 0.8	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach VYCK 0.8	100
Total load at VYCK 0.8	361.79
Allowable load at VYCK 0.8	391.36
WLA (Atglen Borough Sewer Authority)	24.18
LA	367.18
Load Reduction at VYCK 0.8	-5.39
Percent reduction required at VYCK 0.8	0

The TMDL for point VYCK 0.8 requires no load reductions for nitrate.

EBOT 16.0: East Branch Octoraro Creek downstream of Valley Run

EBOT 16.0 is located along Creek Road in West Fallowfield Township, Chester County, Pa. EBOT 16.0 is bordered by a road on the right bank and grazing land on the left bank. Sediment deposition is evident in this section of the stream.

The TMDL for this section of Valley Run consists of a load allocation to the watershed area between EBOT 17.5 and EBOT 16.0. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point EBOT 16.0 (15.958 MGD). The LA at point EBOT 16.0 for this stream segment is presented in Table D32.

Table D32. TMDL Calculations at Point EBOT 16.0				
Flow = 15.958 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	8.27	1,101.31	9.00	1,198.53

A WLA is assigned to Christiana Borough Sewer Authority (PA0025399) for nitrate (Table D33). A bulk reserve WLA is assigned to point EBOT 16.0.

Table D33. Nitrate Waste Load Allocations for EBOT 16.0			
<i>Facility Name</i>	<i>Monthly Avg. Allowable Conc. (mg/L)</i>	<i>Average Flow (MGD)</i>	<i>Allowable Load (lbs/day)</i>
Christiana Borough Sewer Authority	15.10	0.25	31.51
Bulk Reserve			11.99
Total			43.50

The loading reduction for points EBOT 17.5, VYRN 0.1, and VYCK 0.8 were used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point EBOT 16.0. This value was compared to the

allowable load at point EBOT 16.0. Necessary reductions at point EBOT 16.0 are shown in Table D34.

Table D34. Calculation of Load Reduction Necessary at Point EBOT 16.0	
	<i>Nitrate (lbs/day)</i>
Existing load at EBOT 16.0	1,101.31
Difference of measured loads between loads that enter and existing EBOT 16.0	106.37
Percent loss due calculated at EBOT 16.0	0
Additional loads tracked from above samples	1,015.63
Percentage of upstream loads that reach EBOT 16.0	100
Total load tracked between upstream points and EBOT 16.0	1,122.00
Allowable load at EBOT 16.0	1,198.53
WLA	43.50
LA	1,155.03
Load Reduction at EBOT 16.0	-33.03
Percent reduction required at EBOT 16.0	0

The TMDL for point EBOT 16.0 requires no load reductions for nitrate.

EBOT 10.6: East Branch Octoraro Creek upstream of Knight Run

EBOT 10.6 is located on Ross Fording Road in West Fallowfield Township, Chester County, Pa. The sampling site is downstream of the bridge and is bordered by a small forested riparian buffer. The contributing watershed is dominated by agriculture.

The TMDL for this section of East Branch Octoraro Creek consists of a load allocation to the watershed area between EBOT 16.0 and EBOT 10.6. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point EBOT 10.6 (22.390 MGD). The LA at point EBOT 10.6 for this stream segment is presented in Table D35.

Table D35. TMDL Calculations at Point EBOT 10.6				
Flow = 22.390 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	8.00	1,494.76	9.00	1,681.60

The loading reduction for point EBOT 16.0 was used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point EBOT 10.6. This value was compared to the allowable load at point EBOT 10.6. A bulk reserve WLA was assigned to point EBOT 10.6 (16.82 lbs/days). Necessary reductions at point EBOT 10.6 are shown in Table D36.

Table D36. Calculation of Load Reduction Necessary at Point EBOT 10.6	
	<i>Nitrate (lbs/day)</i>
Existing load at EBOT 10.6	1,494.76
Difference of measured loads between loads that enter and existing EBOT 10.6	393.45
Percent loss due calculated at EBOT 10.6	0
Additional loads tracked from above samples	1,198.53
Percentage of upstream loads that reach EBOT 10.6	100
Total load tracked between EBOT 16.0 and EBOT 10.6	1,591.98
Allowable load at EBOT 10.6	1,681.60
WLA	16.82
LA	1,664.78
Load Reduction at EBOT 10.6	-72.80
Percent reduction required at EBOT 10.6	0

The TMDL for point EBOT 10.6 requires no load reductions for nitrate.

KNGT 0.7: Knight Run at Bryson Road

KNGT 0.7 is located on Bryson Road in West Fallowfield Township, Chester County, Pa. KNGT 0.7 is surrounded by pasture land; traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads. Sediment deposition is very prevalent in this section of Knight Run.

The TMDL for this section of Knight Run consists of a load allocation to the watershed area above KNGT 0.7. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point KNGT 0.7 (4.124 MGD). The LA at point KNGT 0.7 for this stream segment is presented in Table D37.

Table D37. TMDL Calculations at Point KNGT 0.7				
Flow = 4.124 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	11.66	401.28	9.00	309.73

A WLA is assigned to the Octoraro Area School District (PA0042889) for nitrate (Table D38). A bulk reserve WLA is assigned to point KNGT 0.7.

Table D38. Nitrate Waste Load Allocations for KNGT 0.7			
<i>Facility Name</i>	<i>Monthly Avg. Allowable Conc. (mg/L)</i>	<i>Average Flow (MGD)</i>	<i>Allowable Load (lbs/day)</i>
Octoraro Area School District	39.98	0.03	10.01
Bulk Reserve			3.10
Total			13.11

The load reduction necessary for this stream segment is presented in Table D39.

Table D39. Calculation of Load Reduction Necessary at Point KNGT 0.7	
	<i>Nitrate (lbs/day)</i>
Existing load at KNGT 0.7	401.28
Difference of measured loads between loads that enter and existing KNGT 0.7	401.28
Percent loss due calculated at KNGT 0.7	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach KNGT 0.7	100
Total load tracked to point KNGT 0.7	401.28
Allowable load at KNGT 0.7	309.73
WLA	13.11
LA	296.62
Load Reduction at KNGT 0.7	104.66
Percent reduction required at KNGT 0.7	26

The TMDL for point KNGT 0.7 requires a load allocation for nitrate.

EBOT 5.4: East Branch Octoraro Creek upstream of Bells Run

EBOT 5.4 is located just upstream of Bells Run on Street Road in Upper Oxford Township, Chester County, Pa. The sampling site is downstream of the bridge and is bordered by pastures on both banks. The contributing watershed is dominated by agriculture.

The TMDL for this section of East Branch Octoraro Creek consists of a load allocation to the watershed area between EBOT 10.6 and EBOT 5.4. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point EBOT 5.4 (33.608 MGD). The LA at point EBOT 5.4 for this stream segment is presented in Table D40.

Table D40. TMDL Calculations at Point EBOT 5.4				
Flow = 33.608 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	13.52	3,791.80	9.00	2,524.13

The loading reduction for points EBOT 10.6 and KNGT 0.7 were used to show the total load that was removed from upstream sources. The total load that was removed upstream was subtracted from the existing load at point EBOT 5.4. This value was compared to the allowable load at point EBOT 5.4. A bulk reserve WLA was assigned to point EBOT 5.4 (25.24 lbs/day). Necessary reductions at point EBOT 5.4 are shown in Table D41.

Table D41. Calculation of Load Reduction Necessary at Point EBOT 5.4	
	<i>Nitrate (lbs/day)</i>
Existing load at EBOT 5.4	3,791.80
Difference of measured loads between loads that enter and existing EBOT 5.4	1,895.76
Percent loss due calculated at EBOT 5.4	0
Additional loads tracked from above samples	1,991.33
Percentage of upstream loads that reach EBOT 5.4	100
Total load tracked between upstream points and EBOT 5.4	3,887.09
Allowable load at EBOT 5.4	2,524.13
WLA	25.24
LA	2,498.89
Load Reduction at EBOT 5.4	1,388.20
Percent reduction required at EBOT 5.4	37

The TMDL for point EBOT 5.4 requires a load allocation for nitrate.

BELL 0.1: Mouth of Bells Run

BELL 0.1 is located on Street Road in Upper Oxford Township, Chester County, Pa. BELL 0.1 is an incised channel surrounded by pasture land; traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads.

The TMDL for this section of Bells Run consists of a load allocation to the watershed area above BELL 0.1. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point BELL 0.1 (2.372 MGD). The LA at point BELL 0.1 for this stream segment is presented in Table D42.

Table D42. TMDL Calculations at Point BELL 0.1				
Flow = 2.372 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	12.96	256.53	9.00	178.15

A bulk reserve WLA was assigned to point BELL 0.1 (1.78 lbs/day). The load reduction necessary for this stream segment is presented in Table D43.

Table D43. Calculation of Load Reduction Necessary at Point BELL 0.1	
	<i>Nitrate (lbs/day)</i>
Existing load at BELL 0.1	256.53
Difference of measured loads between loads that enter and existing BELL 0.1	256.53
Percent loss due calculated at BELL 0.1	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach BELL 0.1	100
Total load at BELL 0.1	256.53
Allowable load at BELL 0.1	178.25
WLA	1.78
LA	176.37
Load Reduction at BELL 0.1	80.16
Percent reduction required at BELL 0.1	31

The TMDL for point BELL 0.1 requires a load allocation for nitrate.

MDRN 1.0: Muddy Run on Homeville Road

MDRN 1.0 is located on Homeville Road on the border of Upper and Lower Oxford Townships, Chester County, Pa. MDRN 1.0 is surrounded by pasture land and mowed lawns; traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads.

The TMDL for this section of Muddy Run consists of a load allocation to the watershed area above MDRN 1.0. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point MDRN 1.0 (7.963 MGD). The LA at point MDRN 1.0 for this stream segment is presented in Table D44.

Table D44. TMDL Calculations at Point MDRN 1.0				
Flow = 7.963 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	10.46	695.08	9.00	598.06

A bulk reserve WLA was assigned to point MDRN 1.0 (5.98 lbs/day). The load reduction necessary for this stream segment is presented in Table D45.

Table D45. Calculation of Load Reduction Necessary at Point MDRN 1.0	
	<i>Nitrate (lbs/day)</i>
Existing load at MDRN 1.0	695.08
Difference of measured loads between loads that enter and existing MDRN 1.0	695.08
Percent loss due calculated at MDRN 1.0	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach MDRN 1.0	100
Total load at MDRN 1.0	695.08
Allowable load at MDRN 1.0	598.06
WLA	5.98
LA	592.08
Load Reduction at MDRN 1.0	103.00
Percent reduction required at MDRN 1.0	15

The TMDL for point MDRN 1.0 requires a load allocation for nitrate.

COOP 0.2: Mouth of Coopers Run

COOP 0.2 is located near the mouth of Coopers Run on Mouth Eden Road in Colerain Township, Lancaster County, Pa. COOP 0.2 is surrounded by pasture land with some small forested buffers. Traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads.

The TMDL for this section of Coopers Run consists of a load allocation to the watershed area above COOP 0.2. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point COOP 0.2 (3.476 MGD). The LA at point COOP 0.2 for this stream segment is presented in Table D46.

Table D46. TMDL Calculations at Point COOP 0.2				
Flow = 3.476 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>	
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>
Nitrate	13.15	381.44	9.00	261.06

A bulk reserve WLA was assigned to point COOP 0.2 (2.61 lbs/day). The load reduction necessary for this stream segment is presented in Table D47.

Table D47. Calculation of Load Reduction Necessary at Point COOP 0.2	
	<i>Nitrate (lbs/day)</i>
Existing load at COOP 0.2	381.44
Difference of measured loads between loads that enter and existing COOP 0.2	381.44
Percent loss due calculated at COOP 0.2	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach COOP 0.2	100
Total load at COOP 0.2	381.44
Allowable load at COOP 0.2	261.06
WLA	2.61
LA	258.45
Load Reduction at COOP 0.2	122.99
Percent reduction required at COOP 0.2	35

The TMDL for point COOP 0.2 requires a load allocation for nitrate.

LEEC 0.2: Mouth of Leech Run

LEEC 0.2 is located on Jackson School Road in West Lower Oxford, Chester County, Pa. It enters directly into the Octoraro Reservoir. LEEC 0.2 is surrounded by grass land; traditional farming practices in the drainage area have led to increased bank erosion and nutrient loads. This portion of Leech Run is slow moving with sediment deposition prevalent.

The TMDL for this section of Leech Run consists of a load allocation to the watershed area above LEEC 0.2. Addressing the agricultural impacts above this point addresses the impairment for the stream segment. A 50th percentile instream flow measurement was available for point LEEC 0.2 (3.041 MGD). The LA at point LEEC 0.2 for this stream segment is presented in Table D48.

Table D48. TMDL Calculations at Point LEEC 0.2					
Flow = 3.041 MGD	<i>Measured Sample Data</i>		<i>Allowable</i>		<i>Load Reduction</i>
<i>Parameter</i>	<i>Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lbs/day)</i>	<i>Percent</i>
Nitrate	9.02	228.90	9.00	228.39	0

A bulk reserve WLA was assigned to point LEEC 0.2 (2.28 lbs/day). The load reduction necessary for this stream segment is presented in Table D49.

Table D49. Calculation of Load Reduction Necessary at Point LEEC 0.2	
	<i>Nitrate (lbs/day)</i>
Existing load at LEEC 0.2	228.90
Difference of measured loads between loads that enter and existing LEEC 0.2	228.90
Percent loss due calculated at LEEC 0.2	0
Additional loads tracked from above samples	0
Percentage of upstream loads that reach LEEC 0.2	100
Total load at LEEC 0.2	228.90
Allowable load at LEEC 0.2	228.39
WLA	2.28
LA	226.11
Load Reduction at LEEC 0.2	2.79
Percent reduction required at LEEC 0.2	1

The TMDL for point LEEC 0.2 requires a load allocation for nitrate.

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. For this analysis, the MOS is explicit. Ten percent of the allowable long-term average concentration for nitrate was reserved as the MOS. Using ten percent of the allowable long-term average concentration is based on professional judgment and will provide an additional level of protection to the designated uses of the Octoraro Creek Watershed. The MOS used for the nitrate TMDLs is shown below.

$$\text{MOS (nitrate)} = 10 \text{ mg/l (WQS)} \times 0.10 = 9.0 \text{ mg/l}$$

Seasonal Variation

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

Critical Conditions

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

Attachment E

Water Quality Data Used in TMDL Calculations

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
NIMR 1.5	9/30/2010	101.8	2	1.73
	3/13/2010	60.8	3	2.61
	5/18/2009	4.04	85	10.70
	2/4/2009	3.563	102	8.77
	1/25/2011	3.346	114	10.50
	11/15/2010	2.149	161	12.60
	10/14/2009	1.68	197	9.99
99th Percentile				12.486
50th Percentile		3.563		
NIMR 0.4	3/13/2010	128.8	2	1.68
	9/30/2010	77.0	3	2.12
	5/18/2009	5.358	81	10.10
	2/3/2009	4.53	102	7.06
	11/18/2010	3.553	132	9.19
	1/25/2011	3.088	147	11.96
	10/14/2009	2.878	154	11.70
	8/18/2008	2.334	181	8.77
99th Percentile				11.942
50th Percentile		4.042		
MTHC 1.6	9/30/2010	99.3	2	1.39
	3/13/2010	55.7	3	1.88
	5/18/2009	3.748	85	10.50
	2/4/2009	3.135	113	9.20
	1/25/2011	2.601	132	11.20
	11/15/2010	2.426	139	6.62
	10/14/2009	2.324	144	12.08
	8/20/2008	1.415	207	9.12
99th Percentile				12.018
50th Percentile		2.868		
MTHC 0.2	3/13/2010	126.1	2	1.35
	9/30/2010	75.3	3	1.52
	2/3/2009	4.874	88	4.48
	5/18/2009	4.813	89	9.10
	11/18/2010	3.93	120	7.04
	1/25/2011	3.254	139	11.23
	10/14/2009	3.066	148	10.20
	8/18/2008	1.797	211	7.43
99th Percentile				11.158
50th Percentile		4.372		
WBOT 12.1	3/13/2010	346.8	2	1.56
	9/30/2010	207.1	3	1.61
	5/18/2009	13.488	85	8.83
	2/3/2009	13.167	88	5.07
	11/18/2010	9.933	123	6.98
	10/15/2009	8.29	147	10.40
	1/25/2011	6.63	170	11.10
	8/18/2008	5.37	202	7.98

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
99th Percentile				11.051
50th Percentile		11.550		
BOWY 0.1	3/13/2010	215.0	2	2.15
	9/30/2010	128.4	3	3.23
	5/18/2009	7.43	101	7.28
	2/3/2009	6.965	114	6.76
	11/18/2010	6.22	123	6.98
	10/15/2009	5.329	143	8.03
	1/25/2011	4.812	150	8.49
	8/18/2008	4.175	171	6.80
99th Percentile				8.458
50th Percentile		6.593		
STWT 0.2	3/13/2010	181.9	2	6.04
	9/30/2010	108.7	3	3.49
	5/19/2009	6.78	92	9.74
	2/3/2009	5.954	113	9.778
	10/15/2009	5.903	115	12.10
	11/18/2010	4.481	143	10.30
	8/18/2008	2.673	206	11.20
	1/24/2011	2.176	225	13.80
99th Percentile				13.681
50th Percentile		5.923		
WBOT 3.3	1/19/1996	1326	1	1.11
	3/13/2010	1092.5	2	2.80
	9/30/2010	652.5	3	2.18
	11/15/1995	344	4	3.60
	9/17/1999	251	5	5.00
	1/15/1999	211	6	2.64
	12/18/1996	192	7	8.3
	3/23/2000	152	8	7.2
	1/25/1996	149	9	4.9
	4/2/1998	127	10	4.6
	12/12/1996	124	11	6.1
	12/26/1996	120	12	9
	3/7/1996	118	13	8.6
	11/27/1996	116	14	6.6
	1/16/1997	101	15	7.9
	12/5/1996	100	16	8.5
	4/18/1996	99	17	12
	3/9/1995	99	17	5.18
	3/20/1997	91	19	8.2
	9/30/1999	90	20	4.5
	2/22/1996	88	21	6
	4/3/1997	86	22	5.6
	3/30/2000	83	23	8.19
	6/20/1996	83	23	5.9
	5/9/1996	83	23	5.1
	2/6/1997	82	26	5.7
	11/2/1995	80	27	7.9

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	1/2/1997	79	28	9.6
	3/19/1998	77	29	3.5
	3/21/1996	76	30	8
	8/15/1996	76	30	6.7
	5/16/1996	73	32	7.6
	1/30/1997	71	33	8.8
	4/11/1996	70	34	11
	11/22/1995	70	34	9.7
	4/4/1996	70	34	8.4
	8/1/1996	70	34	6.4
	1/9/1997	69	38	9.9
	12/15/1999	66	39	6.3
	4/25/1996	65	40	9.8
	11/14/1996	64	41	8.9
	1/23/1997	64	41	8.5
	3/6/1997	64	41	6.5
	5/2/1996	62	44	9
	10/24/1996	62	44	8.4
	5/11/2000	62	44	7.86
	8/20/1998	62	44	7.8
	5/8/1998	60	48	5.9
	5/23/1996	59	49	11
	2/1/1996	58	50	11
	5/30/1996	58	50	8.1
	10/10/1996	58	50	6.6
	4/27/2000	57	53	8.94
	4/13/2000	56	54	8.83
	11/9/1995	56	54	7.8
	1/29/1998	56	54	6.2
	2/20/1997	54	57	8.6
	5/25/2000	54	57	7.32
	3/22/2001	54	57	6.63
	3/28/1996	53	60	9.1
	2/18/1999	53	60	7.81
	1/4/1996	52	62	6.3
	11/21/1996	50	63	9.3
	2/16/2000	49	64	7.34
	2/13/1997	48	65	9.1
	2/8/1996	48	65	8.9
	3/14/1996	48	65	8.5
	2/27/1997	48	65	8.5
	4/10/1997	47	69	8.8
	5/21/1998	47	69	8.3
	3/27/1997	47	69	8
	2/24/2000	47	69	7.64
	4/17/1997	46	73	8.4
	2/29/1996	45	74	8.6
	10/31/1996	44	75	9.2
	6/6/1996	44	75	8.4
	2/1/2001	44	75	4.85
	10/26/1995	43	78	8.4
	3/13/1997	42	79	8.8

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	2/26/1998	42	79	7.6
	2/3/2009	41.65	81	5.78
	8/22/1996	41	82	7.5
	7/18/1996	40	83	8.5
	9/19/1996	40	83	7.2
	9/23/1999	40	83	6.9
	7/9/1998	40	83	6.7
	5/1/1997	39	87	11
	5/28/1998	39	87	9.3
	3/12/1998	39	87	8.7
	6/13/1996	39	87	7.2
	3/4/1999	39	87	6.51
	5/19/2009	38.855	92	8.58
	2/15/1996	38	93	8.2
	6/8/2000	38	93	7.92
	6/22/2000	38	93	7.22
	11/7/1996	37	96	10.2
	3/16/1995	37	96	9.39
	4/16/1998	37	96	9.3
	7/10/1997	37	96	6.5
	10/19/1995	36	100	13
	5/8/1997	36	100	9.4
	9/25/1996	36	100	8.4
	2/24/1995	36	100	8.29
	7/3/1996	36	100	7.3
	2/19/1998	36	100	7.2
	10/3/1996	35	106	8.2
	6/11/1998	34	107	8.5
	3/2/1995	34	107	8.39
	8/29/1996	34	107	7.9
	3/17/1999	34	107	7.9
	7/20/1995	33	111	6.12
	5/15/1997	32	112	9.6
	3/25/1999	32	112	7.4
	3/23/1995	32	112	4.61
	4/30/1998	31	115	9.1
	3/2/2000	31	115	8.98
	4/13/1995	31	115	8.66
	1/22/1999	31	115	8.37
	6/27/1996	31	115	7.7
	2/13/1998	31	115	7.1
	2/5/1998	30	121	9.3
	7/25/1996	30	121	8.9
	6/25/1998	30	121	8.6
	11/29/1995	29	124	8.9
	12/26/1997	29	124	8.2
	8/8/1996	29	124	7.3
	11/18/2010	28.883	127	8.38
	10/17/1996	28	128	9
	10/14/1999	28	128	8.6
	1/8/1998	28	128	8
	6/5/1997	27	131	10

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	7/24/1997	27	131	5.2
	3/30/1995	27	131	3.96
	10/12/1995	26	134	11
	5/29/1997	26	134	11
	9/5/1996	26	134	8.4
	7/23/1998	26	134	8.3
	10/15/2009	25.476	138	10.1
	5/22/1997	25	139	10
	5/13/1999	25	139	6.7
	12/6/1995	24	141	10.4
	1/28/1999	24	141	9.01
	1/6/2000	24	141	8.98
	4/14/1999	24	141	8.1
	6/19/1997	23	145	11
	10/25/1999	23	145	9.4
	4/5/1995	23	145	9.18
	9/12/1996	23	145	8.9
	7/11/1996	23	145	8.8
	2/4/1999	23	145	8.3
	2/8/2001	23	145	7.82
	4/19/2001	23	145	7.22
	6/12/1997	22	153	11
	11/26/1997	22	153	9.7
	5/11/1995	22	153	8.92
	5/4/1995	22	153	8.02
	3/8/2001	22	153	7.19
	8/18/2008	21.357	158	8.42
	1/22/1998	21	159	9.3
	8/6/1998	21	159	7.6
	12/13/1995	20	161	11.7
	12/11/1997	20	161	9.6
	12/1/1999	20	161	9.5
	11/13/1997	20	161	8.8
	4/7/1999	20	161	8.7
	3/10/1999	20	161	8.59
	7/3/1997	20	161	8.5
	9/3/1998	20	161	8.1
	4/20/1995	20	161	7.48
	9/9/1999	20	161	5.1
	2/10/2000	19	171	10.4
	11/20/1997	19	171	9.7
	4/21/1999	19	171	9.6
	6/26/1997	19	171	9.4
	2/10/1999	19	171	9.07
	3/16/2000	19	171	9.05
	7/20/2000	19	171	8.5
	4/5/2001	19	171	8.14
	7/6/2000	19	171	7.25
	5/18/1995	19	171	6.97
	1/27/2000	18	181	10.2
	11/10/1999	18	181	9.5
	12/4/1997	18	181	9.4

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	10/8/1998	18	181	8.9
	4/27/1995	18	181	8.61
	11/6/1997	18	181	8.2
	7/6/1995	18	181	7.13
	1/19/2000	17	188	11.3
	5/6/1999	17	188	7.8
	9/28/2000	17	188	7.49
	9/11/1997	17	188	5.9
	2/3/2000	16	192	10.4
	2/25/1999	16	192	9.92
	10/30/1997	16	192	8.3
	8/3/2000	16	192	7.59
	7/31/1997	16	192	7
	1/25/2001	15	197	11.5
	8/10/1995	15	197	10.1
	5/31/2001	15	197	8.73
	8/17/2000	15	197	7.02
	2/8/2000	14	201	10.1
	2/22/2001	14	201	9.49
	5/3/2001	14	201	8.59
	6/16/1995	14	201	8.4
	8/21/1997	14	201	6.5
	7/13/1995	14	201	5.77
	10/22/1998	13	207	9.6
	5/25/1995	13	207	9.31
	5/27/1999	13	207	8.2
	6/1/1995	13	207	7.7
	6/24/1999	13	207	7.6
	7/17/1997	13	207	6.9
	6/17/1999	13	207	6.9
	9/17/1998	13	207	5.7
	8/31/2000	12	215	10.3
	11/5/1998	12	215	10.2
	12/2/1998	12	215	9.4
	11/19/1998	12	215	8.9
	6/3/1999	12	215	8
	8/3/1995	12	215	5.12
	12/31/1998	11	221	9.9
	5/17/2001	11	221	9.83
	8/7/1997	11	221	8.6
	6/9/1995	11	221	8
	7/5/2001	11	221	7.73
	7/8/1999	11	221	6.5
	12/27/2000	10	227	10.09
	10/23/1997	10	227	8.3
	8/14/1997	10	227	7.8
	6/22/1995	10	227	3.82
	8/17/1995	9	231	10.9
	12/13/2000	9	231	9.58
	1/18/2001	9	231	9.23
	6/14/2001	9	231	7.88
	8/28/1997	9	231	7.5

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	6/29/1995	9	231	7.16
	7/27/1995	8	237	9.83
	10/12/2000	8	237	9.68
	10/26/2000	8	237	8.93
	11/29/2000	8	237	8.9
	10/9/1997	8	237	8.7
	9/25/1997	8	237	8.6
	10/2/1997	8	237	8.5
	10/16/1997	8	237	8.1
	9/18/1997	8	237	8
	9/4/1997	8	237	7.8
	11/9/2000	8	237	7.65
	7/15/1999	8	237	7.6
	9/12/1995	8	237	7.52
	7/22/1999	8	237	6.7
	9/14/2000	8	237	6.02
	8/26/1999	8	237	5.9
	11/16/2000	7	253	8.78
	11/28/2001	7	253	8.05
	7/20/2001	7	253	7.46
	8/20/2001	7	253	7.3
	9/7/1995	7	253	7.15
	8/24/1995	7	253	6.93
	8/12/1999	7	253	6.4
	8/5/1999	7	253	6.2
	12/26/2001	6	261	10
	11/14/2001	6	261	8.49
	10/31/2001	6	261	8.23
	10/3/2001	6	261	7.97
	9/4/2001	6	261	7.51
	8/1/2001	6	261	7.34
	10/17/2001	6	261	6.96
	12/12/2001	5	268	9.3
	9/18/2001	4	269	9.24
99th Percentile				11.564
50th Percentile		26		
PINC 0.9	9/30/2010	89.376	1	3.74
	3/13/2010	67.994	2	1.90
	5/18/2009	2.688	66	7.94
	2/4/2009	1.828	116	8.95
	11/15/2010	1.411	155	8.17
	1/25/2011	1.387	159	8.96
	10/14/2009	1.291	172	9.00
	8/18/2008	1.0	200	8.66
99th Percentile				9.00
50th Percentile		1.620		
BKRN 0.8	9/30/2010	173.048	1	2.51
	3/13/2010	131.552	2	1.80
	5/18/2009	4.537	82	9.14
	2/4/2009	3.163	137	10.70

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	1/25/2011	2.758	155	11.37
	11/15/2010	2.595	169	10.57
	10/14/2009	2.494	173	11.10
	8/20/2008	1.745	211	8.84
99th Percentile				11.351
50th Percentile		2.971		
WILL 0.1	9/30/2010	387.296	1	1.8
	3/13/2010	294.424	2	1.5
	5/18/2009	9.327	89	8.52
	2/4/2009	7.768	120	9.78
	1/25/2011	6.173	155	10.37
	11/15/2010	5.808	169	9.66
	10/14/2009	5.582	173	10.1
	8/20/2008	3.905	211	7.98
99th Percentile				10.351
50th Percentile		6.971		
EBOT 17.5	9/30/2010	446.88	1	1.92
	3/13/2010	339.72	2	1.54
	5/18/2009	13.465	66	7.94
	2/4/2009	9.342	111	9.24
	1/25/2011	9.249	114	9.51
	11/15/2010	9.063	118	9.00
	10/14/2009	6.454	172	9.36
	8/20/2008	4.628	211	6.92
99th Percentile				9.500
50th Percentile		9.296		
VYRN 0.1	9/30/2010	178.752	1	1.97
	3/13/2010	135.888	2	1.32
	5/18/2009	4.287	89	5.94
	2/4/2009	3.849	107	7.18
	1/25/2011	3.297	138	8.19
	11/15/2010	2.982	153	7.25
	10/14/2009	2.526	173	7.73
	8/20/2008	1.788	213	6.59
99th Percentile				8.158
50th Percentile		3.573		
VYCK 0.8	9/30/2010	446.88	1	2.28
	3/13/2010	339.72	2	1.24
	5/18/2009	10.984	86	7.18
	2/4/2009	8.227	137	8.09
	1/25/2011	7.909	144	7.84
	11/15/2010	6.538	171	7.35
	10/14/2009	6.309	173	8.34
	8/20/2008	4.65	209	7.26
99th Percentile				8.323
50th Percentile		8.068		
EBOT 16.0	9/30/2010	1,221.472	1	1.98

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	3/13/2010	928.568	2	1.32
	5/18/2009	30.781	85	6.88
	2/4/2009	24.69	116	7.97
	11/15/2010	20.889	148	8.10
	10/14/2009	16.992	177	8.28
	8/20/2008	13.216	205	7.86
99th Percentile				8.269
50th Percentile		24.690		
EBOT 10.6	9/30/2010	1519.392	1	1.76
	3/13/2010	1155.048	2	1.52
	5/19/2009	37.027	88	7.08
	2/4/2009	34.643	102	7.28
	11/15/2010	27.007	144	7.74
	10/14/2009	22.488	169	8.02
	8/20/2008	15.8111	208	6.91
99th Percentile				8.003
50th Percentile		34.643		
KNGT 0.7	9/30/2010	417.88	1	3.34
	3/13/2010	317.072	2	2.62
	5/19/2009	10.097	88	9.92
	2/5/2009	6.38	163	11.70
	10/14/2009	5.652	182	11.00
	8/19/2008	4.965	189	9.71
	11/15/2010	4.911	190	10.40
99th Percentile				11.658
50th Percentile		6.380		
EBOT 5.4	9/30/2010	2979.2	1	1.85
	3/13/2010	2264.8	2	1.9
	1/19/1996	2169	3	0.81
	9/17/1999	582	4	5.02
	3/9/1995	360	5	4.27
	1/15/1999	298	6	2.27
	4/2/1998	283	7	4
	3/23/2000	276	8	6.28
	11/15/1995	264	9	3.6
	12/18/1996	230	10	7.8
	3/7/1996	221	11	7.4
	1/25/1996	213	12	5.3
	1/16/1997	209	13	7.6
	9/30/1999	203	14	5.81
	12/12/1996	175	15	4.7
	3/19/1998	167	16	1
	5/9/1996	165	17	5.8
	4/3/1997	155	18	4.7
	4/18/1996	155	18	12
	12/5/1996	148	20	7.7
12/26/1996	148	20	8	
12/15/1999	136	22	5.54	
11/27/1996	136	22	5.8	

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	3/30/2000	133	24	6.83
	2/24/2000	132	25	6.61
	2/22/1996	130	26	5.7
	10/5/1995	130	26	26.6
	2/1/1996	124	28	10
	1/2/1997	122	29	9.4
	3/22/2001	121	30	5.52
	2/16/2000	121	30	7.1
	5/16/1996	120	32	5.4
	3/21/1996	120	32	7.2
	2/6/1997	116	34	5.9
	4/4/1996	116	34	7.3
	1/18/2001	115	36	7.87
	11/21/1996	115	36	8.3
	1/23/1997	114	38	7
	3/6/1997	110	39	5.6
	10/24/1996	108	40	7.8
	2/18/1999	108	40	8.15
	9/23/1999	107	42	6.24
	5/11/2000	106	43	6.15
	4/25/1996	105	44	9.5
	1/30/1997	104	45	7.7
	11/14/1996	102	46	8.1
	6/22/2000	101	47	6.36
	10/10/1996	100	48	6.4
	5/8/1998	100	48	7.2
	1/9/1997	100	48	9
	4/12/1996	100	48	12
	6/20/1996	99	52	4.5
	7/9/1998	97	53	5.32
	7/3/1996	97	53	6.8
	4/27/2000	97	53	8
	4/10/1997	93	56	7.6
	4/13/2000	92	57	8.14
	5/2/1996	92	57	9.8
	3/20/1997	91	59	7
	3/2/2000	91	59	8.18
	2/1/2001	90	61	3.92
	2/20/1997	90	61	7.6
	1/27/2000	89	63	8.85
	10/31/1996	88	64	8.5
	7/24/1997	87	65	5
	2/27/1997	86	66	7.1
	4/17/1997	84	67	7.4
	3/27/1997	83	68	6.7
	2/13/1997	83	68	7.8
	3/16/1995	83	68	8.92
	5/23/1996	82	71	9.4
	5/30/1996	80	72	7.7
	8/26/1999	78	73	3.92
	5/25/2000	78	73	6.89
	10/14/1999	78	73	7.95

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	3/28/1996	78	73	8.3
	4/13/1995	78	73	9.12
	11/7/1996	78	73	9.3
	2/3/2000	77	79	9.5
	3/13/1997	75	80	7.5
	11/2/1995	73	81	6.7
	2/15/1996	73	81	7.3
	4/16/1998	72	83	8.5
	8/15/1996	71	84	6.2
	2/29/1996	71	84	7.6
	5/1/1997	71	84	10
	3/23/1995	70	87	4.61
	3/14/1996	70	87	7.9
	10/25/1999	70	87	8.59
	5/21/1998	69	90	7.6
	1/19/2000	69	90	10.4
	3/2/1995	69	90	11.7
	8/1/1996	68	93	5.7
	3/12/1998	68	93	8.4
	2/8/2001	67	95	5.58
	6/25/1998	67	95	7.7
	3/25/1999	66	97	6.9
	3/4/1999	66	97	6.98
	10/8/1998	65	99	7.6
	2/26/1998	64	100	6.7
	1/6/2000	64	100	7.78
	5/8/1997	64	100	8.1
	10/3/1996	63	103	7.1
	7/10/1997	62	104	6.7
	3/16/2000	62	104	8.25
	6/13/1996	61	106	7.2
	6/6/1996	61	106	7.8
	3/30/1995	60	108	3.96
	3/17/1999	60	108	6.59
	6/26/1997	60	108	7.9
	5/15/1997	60	108	8.4
	5/13/1999	59	112	6.35
	12/1/1999	59	112	8.73
	6/5/1997	59	112	9.6
	6/12/1997	59	112	9.7
	1/29/1998	58	116	5.2
	11/10/1999	58	116	8.45
	8/22/1996	57	118	6.8
	10/17/1996	57	118	7.8
	4/30/1998	57	118	8.1
	5/28/1998	57	118	8.2
	11/22/1995	57	118	8.6
	5/29/1997	57	118	9.2
	2/10/2000	57	118	9.71
	5/11/1995	56	125	7.49
	2/8/2000	56	125	9.55
	9/25/1996	55	127	7.5

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	6/11/1998	55	127	7.7
	9/19/1996	54	129	6.3
	7/3/1997	54	129	6.6
	1/8/1998	54	129	7
	5/22/1997	54	129	9.5
	6/8/2000	53	133	6.76
	8/21/1997	52	134	5.7
	7/23/1998	52	134	8.4
	9/3/1998	51	136	7.3
	1/22/1999	51	136	7.8
	9/11/1997	50	138	5.9
	2/19/1998	50	138	6.2
	4/19/2001	50	138	6.9
	4/5/1995	50	138	8.14
	7/18/1996	49	142	7.4
	6/27/1996	48	143	7.1
	2/24/1995	48	143	7.85
	8/29/1996	47	145	7.1
	4/14/1999	47	145	7.28
	4/5/2001	47	145	7.69
	8/20/1998	46	148	6
	4/20/1995	46	148	6.72
	9/5/1996	46	148	7.4
	2/5/1998	46	148	8.2
	11/29/1995	46	148	8.3
	5/4/1995	45	153	6.7
	9/12/1996	45	153	7.6
	7/25/1996	45	153	7.7
	7/6/2000	45	153	8.46
	9/17/1998	44	157	4.3
	7/11/1996	44	157	7.5
	1/28/1999	43	159	8.21
	2/13/1998	42	160	5.7
	12/26/1997	42	160	6.4
	4/7/1999	42	160	7.43
	10/22/1998	42	160	7.7
	4/21/1999	42	160	8.52
	10/14/2009	42	160	8.54
	11/9/1995	41	166	6.3
	2/4/1999	41	166	7.18
	4/27/1995	41	166	7.79
	3/8/2001	41	166	8.61
	12/6/1995	41	166	9.1
	3/10/1999	40	171	7.86
	5/18/1995	40	171	8.25
	8/8/1996	39	173	6.4
	11/5/1998	38	174	8.6
	12/13/1995	37	175	10.7
	6/1/1995	36	176	6.3
	8/6/1998	35	177	6.4
	5/25/1995	35	177	8.46
	6/19/1997	35	177	9.4

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	2/5/2009	34.075	180	8.99
	6/9/1995	34	181	6.1
	7/17/1997	34	181	6.6
	5/6/1999	34	181	6.88
	2/22/2001	34	181	8.29
	12/31/1998	34	181	8.5
	2/25/1999	34	181	8.87
	10/12/2000	33	187	5.9
	8/14/1997	33	187	6.2
	11/19/1998	33	187	7.7
	7/20/2000	33	187	7.99
	8/3/2000	33	187	7.99
	2/10/1999	33	187	8.12
	8/19/2008	32.5	193	6.8
	6/29/1995	32	194	4.35
	6/16/1995	32	194	6.7
	7/31/1997	32	194	6.8
	6/22/1995	31	197	3.33
	10/26/1995	31	197	6.3
	7/6/1995	30	199	5.33
	12/11/1997	30	199	8.4
	8/28/1997	29	201	5.9
	8/7/1997	29	201	6.9
	6/3/1999	29	201	7.19
	5/31/2001	29	201	7.73
	1/25/2001	29	201	9.96
	9/18/1997	28	206	5.8
	10/16/1997	28	206	6.1
	7/5/2001	28	206	6.7
	5/3/2001	28	206	7.84
	12/27/2000	28	206	8.27
	11/26/1997	28	206	8.3
	11/20/1997	28	206	8.6
	9/4/1997	27	213	6
	5/27/1999	27	213	7.17
	11/13/1997	27	213	7.3
	12/4/1997	27	213	7.9
	9/9/1999	26	217	4.36
	7/20/1995	26	217	5.26
	10/30/1997	26	217	6.5
	11/6/1997	26	217	6.6
	6/14/2001	26	217	6.7
	10/23/1997	26	217	6.8
	9/25/1997	26	217	6.9
	1/22/1998	26	217	8
	6/17/1999	25	225	5.71
	10/2/1997	25	225	6.4
	8/17/2000	25	225	6.6
	12/2/1998	25	225	8
	5/17/2001	24	229	9.04
	10/9/1997	23	230	6.1
	8/31/2000	23	230	6.24

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	6/24/1999	22	232	6.5
	10/19/1995	22	232	6.7
	9/14/2000	22	232	8.98
	9/28/2000	21	235	5.82
	7/20/2001	21	235	6.26
	10/26/2000	21	235	8.24
	7/13/1995	20	238	3.82
	10/17/2001	20	238	5.66
	7/27/1995	20	238	7.67
	8/20/2001	19	241	6.68
	10/3/2001	19	241	7.08
	11/9/2000	19	241	7.72
	8/10/1995	19	241	8.81
	8/1/2001	18	245	5.95
	11/29/2000	18	245	7.17
	11/16/2000	18	245	8.97
	10/31/2001	17	248	7
	8/17/1995	17	248	7.6
	9/18/2001	17	248	7.61
	10/12/1995	17	248	9
	9/21/1995	17	248	30.7
	9/4/2001	16	253	6.09
	9/28/1995	16	253	16.6
	8/12/1999	15	255	3.64
	8/5/1999	15	255	3.71
	8/3/1995	15	255	3.74
	7/22/1999	15	255	4.88
	7/8/1999	15	255	4.89
	7/15/1999	15	255	5.93
	11/28/2001	15	255	6.02
	12/13/2000	15	255	7.41
	11/14/2001	15	255	7.88
	8/24/1995	14	264	4.37
	12/12/2001	13	265	8.06
	12/26/2001	13	265	8.2
	9/7/1995	11	267	4.12
	9/12/1995	11	267	4.26
99th Percentile				13.518
50th Percentile		52.0		
BELL 0.1	9/30/2010	178.752	1	5.23
	3/13/2010	135.888	2	7.33
	2/5/2009	4.15	95	13.00
	5/19/2009	3.67	113	11.10
	10/14/2009	2.32	185	12.40
	11/15/2010	2.08	192	12.14
	8/19/2008	2.02	199	12.00
99th Percentile				12.964
50th Percentile		3.67		
MDRN 1.0	9/30/2010	685.216	1	3.38
	3/13/2010	520.904	2	2.86

Station	Date	Flow (cfs)	Flow Exceedance Rank	Nitrate (mg/l)
	2/5/2009	14.388	110	9.58
	5/19/2009	14.217	113	8.18
	10/14/2009	10.421	164	9.86
	1/31/2011	9.448	177	10.50
	11/15/2010	9.059	186	9.49
	8/19/2008	6.96	211	7.72
99th Percentile				10.455
50th Percentile		12.319		
COOP 0.2	9/30/2010	297.92	1	3.84
	3/13/2010	226.48	2	4.36
	5/19/2009	6.255	110	11.6
	2/5/2009	6.058	116	13.2
	10/14/2009	4.698	158	12.2
	11/15/2010	3.821	186	11.9
	1/31/2011	3.561	190	12.53
	8/19/2008	3.113	209	11
99th Percentile				13.153
50th Percentile		5.378		
LEEC 0.2	9/30/2010	268.128	1	2.5
	3/13/2010	203.832	2	2.49
	5/19/2009	6.115	101	7.58
	11/15/2010	4.705	143	8.47
	2/5/2009	4.637	146	9.06
	10/14/2009	4.338	154	8.34
	8/19/2008	2.474	224	8.06
99th Percentile				9.025
50th Percentile		4.705		

Attachment F

Information Sheet for the Octoraro Creek TMDL

What is being proposed?

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Octoraro 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 WLAs for point sources, LAs 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 Octoraro Creek Watershed is impaired due to sediment and nutrients emanating from agriculture. The plans include a calculation of the loading for sediment and nutrients that will correct the problem and meet water quality objectives.

Why was the Octoraro Creek Watershed selected for TMDL development?

In 2002, 2006, and 2008, PADEP listed segments of the Octoraro Watershed under Section 303(d) of the federal Clean Water Act as impaired due to causes linked to sediment and nutrients.

What pollutants do these TMDLs address?

The proposed plans provide calculations of the stream's total capacity to accept sediment and nutrients.

Where do the pollutants come from?

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

The Load Duration Curve method was used to estimate the loading reduction of nitrate that would be necessary to meet the drinking water quality standard of 10 mg/l. Allowable loads are determined for each point of interest by multiplying the flow, water quality standard, and a conversion factor. The existing load is calculated for each sample point multiplying the flow, current nitrate concentration, and a conversion factor. The necessary reduction is calculated by subtracting the allowable load from the existing load.

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 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) 783-2951 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 **Date**, to the above address.

Attachment G

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Octoraro 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 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 datasets and provides an explanation of how they were used for development of the input files for the GWLF model.

<i>GIS Datasets</i>	
DATASET	DESCRIPTION
Censustr	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.
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 <i>rain_cool</i> and <i>rain_warm</i> 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 phosphorous 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 <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>muhs_g_dom</i> is used with land use cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in the 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 <i>aeu_acre</i> 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 H

AVGWLF Model Inputs for the Octoraro Creek Watershed

East Branch Octoraro Creek Headwaters Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems								
Rural Runoff	Dis N mg/L	Dis P mg/L	Month	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	4.35	0.357		Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems	
Cropland	4.35	0.357		Jan	0.0	0.0	0.0	528	0	13	0
Forest	0.19	0.006		Feb	0.0	0.0	0.0	528	0	13	0
Wetland	0.19	0.006		Mar	0.0	0.0	0.0	528	0	13	0
Unpaved_Rd	2.9	0.2		Apr	0.0	0.0	0.0	528	0	13	0
Transition	2.9	0.2		May	0.0	0.0	0.0	528	0	13	0
	0	0		Jun	0.0	0.0	0.0	528	0	13	0
	0	0		Jul	0.0	0.0	0.0	528	0	13	0
	0	0		Aug	0.0	0.0	0.0	528	0	13	0
Manure	3.66	0.57	Sep	0.0	0.0	0.0	528	0	13	0	
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Oct	0.0	0.0	0.0	528	0	13	0	
Lo_Int_Dev	0.012	0.002	Nov	0.0	0.0	0.0	528	0	13	0	
Hi_Int_Dev	0.101	0.011	Dec	0.0	0.0	0.0	528	0	13	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)	
2.602	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	1476.0	

East Branch Octoraro Creek Headwaters Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract							
Hay/Past	Area (ha)	CN	K	LS	C	P								Jan	0.72	9.4	0	0.12	0	0
Cropland	648	75	0.32	0.819	0.42	0.45								Feb	0.77	10.4	0	0.12	0	0
Forest	575	60	0.32	0.59	0.002	0.45								Mar	0.81	11.8	0	0.12	0	0
Wetland	52	80	0.32	0.218	0.01	0.1								Apr	0.96	13.2	1	0.3	0	0
	0	0	0	0	0	0								May	1.06	14.3	1	0.3	0	0
	0	0	0	0	0	0								Jun	1.11	14.8	1	0.3	0	0
	0	0	0	0	0	0								Jul	1.14	14.6	1	0.3	0	0
	0	0	0	0	0	0								Aug	1.16	13.6	1	0.3	0	0
	0	0	0	0	0	0								Sep	1.17	12.2	1	0.3	0	0
	0	0	0	0	0	0								Oct	1.17	10.8	1	0.12	0	0
	0	0	0	0	0	0								Nov	1.04	9.7	0	0.12	0	0
	0	0	0	0	0	0								Dec	0.96	9.2	0	0.12	0	0
Bare Land																				
Unpaved_Rd	Area (ha)	CN	K	LS	C	P														
Transition	58	82	0.32	0.535	0.1	0.8														
Urban LU																				
Lo_Int_Dev	Area (ha)	CN	K	LS	C	P														
Hi_Int_Dev	17	90	0.32	0.18	0.08	0.2														
Init Unsat Stor (cm)		10		Initial Snow (cm)		0		Recess Coefficient		0.1										
Init Sat Stor (cm)		0		Sed Delivery Ratio		0.16		Seepage Coefficient		0										
Unsat Avail Wat (cm)		20.6209		Tile Drain Ratio		0.5		Sediment A Factor		1.4671E-03										
				Tile Drain Density		0		Sed A Adjustment Factor		1										

Valley Run Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	4.35	0.387	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	4.35	0.387	Jan	0.0	0.0	0.0	234	0	5	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	234	0	5	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	234	0	5	0
Transition	2.9	0.2	Apr	0.0	0.0	0.0	234	0	5	0
	0	0	May	0.0	0.0	0.0	234	0	5	0
	0	0	Jun	0.0	0.0	0.0	234	0	5	0
	0	0	Jul	0.0	0.0	0.0	234	0	5	0
	0	0	Aug	0.0	0.0	0.0	234	0	5	0
	0	0	Sep	0.0	0.0	0.0	234	0	5	0
Manure	3.66	0.57	Oct	0.0	0.0	0.0	234	0	5	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	234	0	5	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	234	0	5	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)
2.647	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	1635.0

Valley Run Transport Input File

Rural LU							Month						
Hay/Past	Area (ha)	CN	K	LS	C	P	Month	Ket	Day	Season	Eros	Stream	Ground
Cropland	291	75	0.32	0.916	0.42	0.45	Jan	0.73	9.4	0	0.12	0	0
Forest	291	60	0.32	1.251	0.002	0.45	Feb	0.79	10.4	0	0.12	0	0
Wetland	29	80	0.32	0.226	0.01	0.1	Mar	0.82	11.8	0	0.12	0	0
	0	0	0	0	0	0	Apr	0.99	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.08	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.14	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.17	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.19	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.2	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.2	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.06	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.98	9.2	0	0.12	0	0
Bare Land													
Transition	Area (ha)	CN	K	LS	C	P							
	22	82	0.32	0.699	0.1	0.8							
Urban LU													
Lo_Int_Dev	Area (ha)	CN	K	LS	C	P							
	119	80	0.32	2.072	0.08	0.2							
	0	0	0	0	0	0							
Init Unsat Stor (cm)		Initial Snow (cm)		Recess Coefficient									
10		0		0.1									
Init Sat Stor (cm)		Sed Delivery Ratio		Seepage Coefficient									
0		0.179		0									
Unsat Avail Wat (cm)		Tile Drain Ratio		Sediment A Factor									
20.584		0.5		1.1078E-03									
		Tile Drain Density		Sed A Adjustment Factor									
		0		1									

Valley Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.261	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.261	Jan	0.0	0.0	0.0	563	0	17	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	563	0	17	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	563	0	17	0
Unpaved_Rd	2.9	0.2	Apr	0.0	0.0	0.0	563	0	17	0
Transition	2.9	0.2	May	0.0	0.0	0.0	563	0	17	0
	0	0	Jun	0.0	0.0	0.0	563	0	17	0
	0	0	Jul	0.0	0.0	0.0	563	0	17	0
	0	0	Aug	0.0	0.0	0.0	563	0	17	0
	0	0	Sep	0.0	0.0	0.0	563	0	17	0
Manure	2.44	0.38	Oct	0.0	0.0	0.0	563	0	17	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	563	0	17	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	563	0	17	0
Hi_Int_Dev	0.101	0.011								

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)
2.561	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	967.0

Valley Creek Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Area (ha)	CN	K	LS	C	P								
Hay/Past	809	63	0.32	0.464	0.03	0.45	Jan	0.68	9.4	0	0.12	0	0
Cropland	635	75	0.32	0.78	0.42	0.45	Feb	0.73	10.4	0	0.12	0	0
Forest	732	60	0.32	1.1	0.002	0.45	Mar	0.76	11.8	0	0.12	0	0
Wetland	46	80	0.32	0.092	0.01	0.1	Apr	0.92	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.01	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.07	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.1	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.11	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.13	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.13	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	0.99	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.91	9.2	0	0.12	0	0

Bare Land						
Area (ha)	CN	K	LS	C	P	
Unpaved_Rd	1	82	0.32	0.212	0.1	1
Transition	55	87	0.32	0.759	0.1	0.8

Urban LU						
Area (ha)	CN	K	LS	C	P	
Lo_Int_Dev	453	80	0.32	0.893	0.08	0.2
Hi_Int_Dev	14	90	0.32	0.428	0.08	0.2

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.163	Seepage Coefficient	0
Unsat Avail Wat (cm)	21.4097	Tile Drain Ratio	0.5	Sediment A Factor	1.4430E-03
		Tile Drain Density	0	Sed A Adjustment Factor	1

Knight Run Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.26	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.26	Jan	0.0	0.0	0.0	55	0	3	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	55	0	3	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	55	0	3	0
Turf_Grass	2.5	0.317	Apr	0.0	0.0	0.0	55	0	3	0
Unpaved_Rd	2.9	0.2	May	0.0	0.0	0.0	55	0	3	0
Transition	2.9	0.2	Jun	0.0	0.0	0.0	55	0	3	0
	0	0	Jul	0.0	0.0	0.0	55	0	3	0
	0	0	Aug	0.0	0.0	0.0	55	0	3	0
	0	0	Sep	0.0	0.0	0.0	55	0	3	0
Manure	2.44	0.38	Oct	0.0	0.0	0.0	55	0	3	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	55	0	3	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	55	0	3	0
Hi_Int_Dev	0.101	0.011								

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)
2.717	0.03	15	0.1	50	12	2.5	1.6	0.4	3000.0	960.0

Knight Run Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P	Month	Ket	Day Season Hours	Eros Coef	Stream Extract	Ground Extract	
Hay/Past	1006	63	0.32	0.419	0.03	0.45	Jan	0.67	9.4	0	0.12	0	0
Cropland	722	75	0.32	0.663	0.42	0.45	Feb	0.73	10.4	0	0.12	0	0
Forest	457	60	0.32	0.343	0.002	0.52	Mar	0.76	11.8	0	0.12	0	0
Wetland	6	80	0.32	0.205	0.01	0.1	Apr	0.95	13.2	1	0.3	0	0
Turf_Grass	1	58	0.32	0.067	0.08	0.2	May	1.05	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.12	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.15	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.17	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.19	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.19	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.03	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.93	9.2	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	0.168	Seepage Coefficient	0
Unsat Avail Wat (cm)	20.584	Tile Drain Ratio	0.5	Sediment A Factor	7.4983E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

Bells Run Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.35	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.35	Jan	0.0	0.0	0.0	133	0	4	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	133	0	4	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	133	0	4	0
Transition	2.9	0.2	Apr	0.0	0.0	0.0	133	0	4	0
	0	0	May	0.0	0.0	0.0	133	0	4	0
	0	0	Jun	0.0	0.0	0.0	133	0	4	0
	0	0	Jul	0.0	0.0	0.0	133	0	4	0
	0	0	Aug	0.0	0.0	0.0	133	0	4	0
Manure	2.44	0.38	Sep	0.0	0.0	0.0	133	0	4	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Oct	0.0	0.0	0.0	133	0	4	0
Lo_Int_Dev	0.012	0.002	Nov	0.0	0.0	0.0	133	0	4	0
	0	0	Dec	0.0	0.0	0.0	133	0	4	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)
2.502	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	1439.0

Bells Run Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Area (ha)	CN	K	LS	C	P								
Hay/Past	608	63	0.32	0.622	0.03	0.5	Jan	0.74	9.4	0	0.12	0	0
Cropland	259	75	0.32	0.757	0.46	0.5	Feb	0.79	10.4	0	0.12	0	0
Forest	173	60	0.32	0.783	0.002	0.45	Mar	0.83	11.8	0	0.12	0	0
Wetland	9	80	0.32	0.266	0.01	0.1	Apr	1.01	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.11	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.17	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.21	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.23	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.24	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.24	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.09	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	1.0	9.2	0	0.12	0	0

Bare Land						
Area (ha)	CN	K	LS	C	P	
0	0	0	0	0	0	
Transition	6	82	0.32	0.457	0.1	0.8

Urban LU						
Area (ha)	CN	K	LS	C	P	
Lo_Int_Dev	29	80	0.32	0.523	0.08	0.2
	0	0	0	0	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.183	Seepage Coefficient	0
Unsat Avail Wat (cm)	20.584	Tile Drain Ratio	0.5	Sediment A Factor	7.1522E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

Muddy Run Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.276	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.276	Jan	0.0	0.0	0.0	552	0	12	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	552	0	12	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	552	0	12	0
Unpaved_Rd	2.9	0.2	Apr	0.0	0.0	0.0	552	0	12	0
Transition	2.9	0.2	May	0.0	0.0	0.0	552	0	12	0
	0	0	Jun	0.0	0.0	0.0	552	0	12	0
	0	0	Jul	0.0	0.0	0.0	552	0	12	0
	0.0	0	Aug	0.0	0.0	0.0	552	0	12	0
	0.0	0	Sep	0.0	0.0	0.0	552	0	12	0
Manure	2.44	0.38	Oct	0.0	0.0	0.0	552	0	12	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	552	0	12	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	552	0	12	0
Hi_Int_Dev	0.101	0.011								

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)
2.572	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	1046.0

Muddy Run Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P	Month	Ket	Day Season Hours	Eros Coef	Stream Extract	Ground Extract	
Hay/Past	1669	63	0.32	0.42	0.03	0.52	Jan	0.7	9.4	0	0.12	0	0
Cropland	857	75	0.32	0.624	0.42	0.52	Feb	0.76	10.4	0	0.12	0	0
Forest	935	60	0.32	0.373	0.002	0.45	Mar	0.79	11.8	0	0.12	0	0
Wetland	17	80	0.32	0.195	0.01	0.1	Apr	0.96	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.06	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.12	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.16	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.17	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.19	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.19	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.04	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.96	9.2	0	0.12	0	0

Bare Land	Area (ha)	CN	K	LS	C	P						
Unpaved_Rd	4	82	0.32	0.238	0.1	1						
Transition	27	82	0.32	0.316	0.1	0.8						
Urban LU	Area (ha)	CN	K	LS	C	P						
Lo_Int_Dev	275	80	0.32	0.392	0.08	0.2						
Hi_Int_Dev	9	90	0.32	0.149	0.08	0.2						

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.152	Seepage Coefficient	0
Unsat Avail Wat (cm)	20.584	Tile Drain Ratio	0.5	Sediment A Factor	8.0422E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

Nickel Mines Run/Meetinghouse Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	4.35	0.389	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	4.35	0.389	Jan	0.0	0.0	0.0	434	0	11	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	434	0	11	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	434	0	11	0
Unpaved_Rd	2.9	0.2	Apr	0.0	0.0	0.0	434	0	11	0
Transition	2.9	0.2	May	0.0	0.0	0.0	434	0	11	0
	0	0	Jun	0.0	0.0	0.0	434	0	11	0
	0	0	Jul	0.0	0.0	0.0	434	0	11	0
	0	0	Aug	0.0	0.0	0.0	434	0	11	0
	0	0	Sep	0.0	0.0	0.0	434	0	11	0
Manure	3.66	0.57	Oct	0.0	0.0	0.0	434	0	11	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	434	0	11	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	434	0	11	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)				
2.974 0.031	15 0.1 50	12 2.5	1.6 0.4	3000.0 1647.0				

Nickel Mines Run/Meetinghouse Creek Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P	Month	Ket	Day Season Hours	Eros Coef	Stream Extract	Ground Extract	
Hay/Past	1298	63	0.32	0.415	0.03	0.52	Jan	0.71	9.4	0	0.12	0	0
Cropland	761	75	0.32	0.756	0.42	0.45	Feb	0.77	10.4	0	0.12	0	0
Forest	272	60	0.32	0.456	0.002	0.45	Mar	0.8	11.8	0	0.12	0	0
Wetland	32	80	0.32	0.217	0.01	0.1	Apr	0.98	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.08	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.14	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.17	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.19	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.21	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.21	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.06	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.97	9.2	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	0.164	Seepage Coefficient	0
Unsat Avail Wat (cm)	20.584	Tile Drain Ratio	0.5	Sediment A Factor	1.3288E-03
		Tile Drain Density	0	Sed A Adjustment Factor	1

Attachment I

AVGWLF Model Inputs for the Reference Watersheds

Licking Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems								
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations					
Hay/Past	2.9	0.089	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems	
Cropland	2.9	0.089	Jan	0.0	0.0	0.0	472	0	3	0	
Forest	0.19	0.006	Feb	0.0	0.0	0.0	472	0	3	0	
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	472	0	3	0	
Transition	2.9	0.2	Apr	0.0	0.0	0.0	472	0	3	0	
	0	0	May	0.0	0.0	0.0	472	0	3	0	
	0	0	Jun	0.0	0.0	0.0	472	0	3	0	
	0	0	Jul	0.0	0.0	0.0	472	0	3	0	
	0	0	Aug	0.0	0.0	0.0	472	0	3	0	
	0	0	Sep	0.0	0.0	0.0	472	0	3	0	
Manure	2.44	0.38	Oct	0.0	0.0	0.0	472	0	3	0	
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	472	0	3	0	
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	472	0	3	0	
Hi_Int_Dev	0.101	0.011									
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)
2.228	0.027		15	0.1	50	12	2.5	1.6	0.4	3000.0	238.0
<input type="button" value="Load File"/> <input type="button" value="Save File"/> <input type="button" value="Export to JPEG"/> <input type="button" value="Close"/>											

Licking Creek Transport Input File

Rural LU							Month						
Hay/Past	Area (ha)	CN	K	LS	C	P	Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Cropland	458	75	0.285	0.582	0.42	0.52	Jan	0.68	9.4	0	0.12	0	0
Forest	859	60	0.29	0.315	0.002	0.52	Feb	0.73	10.4	0	0.12	0	0
Wetland	68	80	0.293	0.184	0.01	0.1	Mar	0.76	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	1.0	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.05	14.9	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.08	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.1	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.11	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.11	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	0.98	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.91	9.1	0	0.12	0	0
Bare Land													
Transition	Area (ha)	CN	K	LS	C	P							
	0	0	0	0	0	0							
	91	82	0.292	0.223	0.8	0.8							
Urban LU													
Lo_Int_Dev	Area (ha)	CN	K	LS	C	P							
	420	80	0.293	0.623	0.08	0.2							
Hi_Int_Dev	Area (ha)	CN	K	LS	C	P							
	2	90	0.32	0.076	0.08	0.2							
Init Unsat Stor (cm)			Initial Snow (cm)			Recess Coefficient							
10			0			0.1							
Init Sat Stor (cm)			Sed Delivery Ratio			Seepage Coefficient							
0			0.166			0							
Unsat Avail Wat (cm)			Tile Drain Ratio			Sediment A Factor							
16.1956			0.5			1.1166E-03							
			Tile Drain Density			Sed A Adjustment Factor							
			0			1							
<input type="button" value="Load File"/> <input type="button" value="Save File"/> <input type="button" value="Export to JPEG"/> <input type="button" value="Close"/>													

Marsh Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems								
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations					
Hay/Past	2.9	0.101	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems	
Cropland	2.9	0.101	Jan	0.0	0.0	0.0	332	0	6	0	
Forest	0.19	0.006	Feb	0.0	0.0	0.0	332	0	6	0	
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	332	0	6	0	
Transition	2.9	0.2	Apr	0.0	0.0	0.0	332	0	6	0	
	0	0	May	0.0	0.0	0.0	332	0	6	0	
	0	0	Jun	0.0	0.0	0.0	332	0	6	0	
	0	0	Jul	0.0	0.0	0.0	332	0	6	0	
	0	0	Aug	0.0	0.0	0.0	332	0	6	0	
Manure	2.44	0.38	Sep	0.0	0.0	0.0	332	0	6	0	
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Oct	0.0	0.0	0.0	332	0	6	0	
Lo_Int_Dev	0.012	0.002	Nov	0.0	0.0	0.0	332	0	6	0	
Hi_Int_Dev	0.101	0.011	Dec	0.0	0.0	0.0	332	0	6	0	
Groundwater (mg/L)			Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N	P	Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)	
1.435	0.022	15	0.1	50	12	2.5	1.6	0.4	3000.0	520.0	

Marsh Creek Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Area (ha)	CN	K	LS	C	P								
Hay/Past	264	63	0.32	0.484	0.03	0.52	Jan	0.65	9.4	0	0.12	0	0
Cropland	435	75	0.32	0.676	0.42	0.52	Feb	0.71	10.4	0	0.12	0	0
Forest	1005	60	0.32	0.693	0.002	0.45	Mar	0.74	11.8	0	0.12	0	0
Wetland	152	80	0.32	0.131	0.01	0.1	Apr	0.89	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	0.98	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.04	14.9	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.07	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.09	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.1	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.1	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	0.97	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.89	9.1	0	0.12	0	0
Bare Land													
Area (ha)	CN	K	LS	C	P								
Transition	34	82	0.32	0.225	0.8	0.8							
Urban LU													
Area (ha)	CN	K	LS	C	P								
Lo_Int_Dev	313	80	0.32	0.795	0.08	0.2							
Hi_Int_Dev	1	90	0.32	0.268	0.08	0.2							
Init Unsat Stor (cm)		10	Initial Snow (cm)		0	Recess Coefficient		0.1					
Init Sat Stor (cm)		0	Sed Delivery Ratio		0.169	Seepage Coefficient		0					
Unsat Avail Wat (cm)		20.584	Tile Drain Ratio		0.5	Sediment A Factor		9.9420E-04					
			Tile Drain Density		0	Sed A Adjustment Factor		1					

West Branch Big Elk Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.127	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.127	Jan	0.0	0.0	0.0	445	0	8	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	445	0	8	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	445	0	8	0
Transition	2.9	0.2	Apr	0.0	0.0	0.0	445	0	8	0
	0	0	May	0.0	0.0	0.0	445	0	8	0
	0	0	Jun	0.0	0.0	0.0	445	0	8	0
	0	0	Jul	0.0	0.0	0.0	445	0	8	0
	0	0	Aug	0.0	0.0	0.0	445	0	8	0
Manure	2.44	0.38	Sep	0.0	0.0	0.0	445	0	8	0
			Oct	0.0	0.0	0.0	445	0	8	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	445	0	8	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	445	0	8	0
Hi_Int_Dev	0.101	0.011								

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)
2.549	0.029	15	0.1	50	12	2.5	1.6	0.4	3000.0	1117.0

West Branch Big Elk Creek Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Area (ha)	CN	K	LS	C	P								
Hay/Past	901	63	0.32	0.309	0.03	0.52	Jan	0.72	9.4	0	0.12	0	0
Cropland	466	75	0.32	0.251	0.42	0.52	Feb	0.78	10.4	0	0.12	0	0
Forest	491	60	0.32	0.233	0.002	0.52	Mar	0.81	11.8	0	0.12	0	0
Wetland	7	80	0.32	0.178	0.01	0.1	Apr	0.95	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	1.03	14.3	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.07	14.8	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.1	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.12	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.13	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.13	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	1.02	9.7	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.95	9.2	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	0.164	Seepage Coefficient	0
Unsat Avail Wat (cm)	20.584	Tile Drain Ratio	0.5	Sediment A Factor	1.7566E-03
		Tile Drain Density	0	Sed A Adjustment Factor	1

Attachment J

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 K. 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 LAs, and percent reduction for each pollutant source.

Attachment K

Equal Marginal Percent Reduction Calculations for the Octoraro Creek Watershed TMDL

East Branch Octoraro Creek Headwaters – Phosphorus

Step 1: TMDL Total Load				Step 2: Adjusted LA = (TMDL total load - MOS) - uncontrollable									
Load = loading rate in ref. * Acres in Impaired				4.5585		5							
5.2480													
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.	2.0661	18.4104	good	2	ADJUST	0.24	0.975	1.091	3106.10	0.000	47%		
Cropland	14.3380		bad	5		4	0.53	2.151	2.408	1601.20	0.002	83%	
Developed	0.6433		good	1			0.07	0.304	0.340	1240.40	0.000	47%	
Groundwater	1.3098		good	1			0.15	0.618	0.692			47%	
Streambank	0.0532		good	0			0.01	0.025	0.028			47%	
Total	18.4104			8.630873			1.00		4.558				
Step 4 All Ag. Loading Rat		0.00											
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
Final Hay/Past. LA	3106.10	0.0004	1.0912	0.0007	2.0661	47%							
Final Cropland LA	1601.20	0.0015	2.4076	0.0090	14.3380	83%							
Developed	1240.40	0.0003	0.3398	0.0005	0.6433	47%							
Groundwater			0.6918		1.3098	47%							
Streambank			0.0281		0.0532	47%							
Total			4.5585		18.4104	75%							
Phosphorus													
East Branch Octoraro Creek Headwaters													
Ref is Licking Creek													

Valley Run – Sediment

Step 1: TMDL Total Load				Step 2: Adjusted LA = (TMDL total load - MOS) - uncontrollable									
Load = loading rate in ref. * Acres in Impaired				5018.6085		5019							
5676.5648													
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.	611.4521	6597.0649	good	611	ADJUST	0.09	143.555	467.897	1672.90	0.280	23%		
Cropland	5057.3151		bad	5019	1540	0.77	1178.252	3840.356	719.10	5.341	24%		
Developed	519.2329		good	519		0.08	121.904	397.329	348.50	1.140	23%		
Streambank	409.0648		good	409		0.06	96.039	313.026			23%		
Total	6597.0649			6558.3583		1.00		5018.608					
Step 4 All Ag. Loading Rat		1.80											
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
Final Hay/Past. LA	1672.90	0.2797	467.8974	0.3655	611.4521	23%							
Final Cropland LA	719.10	5.3405	3840.3561	7.0328	5057.3151	24%							
Developed	348.50	1.1401	397.3291	1.4899	519.2329	23%							
Streambank			313.0259		409.0648	23%							
Total			5018.6085		6597.0649	24%							
Valley Run													
Reference is Goods Run													

Valley Run – Phosphorus

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
	Load = loading rate in ref. * Acres in Impaired					6.2032	6						
	7.0626												
	PHOSPHORUS LOADING												
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction	
	Hay/Past.	1.0515	11.9385	good	1	ADJUST	0.13	0.257	0.794	1672.90	0.000	24%	
	Cropland	9.9273		bad	6		2	0.76	1.519	4.684	719.10	0.007	53%
	Developed	0.2357		good	0			0.03	0.058	0.178	348.50	0.001	24%
	Groundwater	0.6136		good	1			0.07	0.150	0.463			24%
	Streambank	0.1104		good	0			0.01	0.027	0.083			24%
	Total	11.9385				8.21444		1.00		6.203			
Step 4:	All Ag. Loading Rat	0.00											
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
	Final Hay/Past. LA	1672.90	0.0005	0.7941	0.0006	1.0515	24%						
	Final Cropland LA	719.10	0.0065	4.6845	0.0138	9.9273	53%						
	Developed	348.50	0.0005	0.1780	0.0007	0.2357	24%						
	Groundwater			0.4634		0.6136	24%						
	Streambank			0.0834		0.1104	24%						
	Total			6.2032		11.9385	48%						
	Valley Run												
	Reference is Goods Run												

Valley Creek – Sediment

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					10898.3487	10898					
	12363.5564											
	SEDIMENT LOADING											
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reductor	Initial LA	Acres	Allowable Loading Rate	% Reduction
	Hay/Past.	575.0685	14643.968	good	575	ADJUST	0.04	147.090	427.978	1999.10	0.214	26%
	Cropland	10617.0411		good	10617	3746	0.73	2715.616	7901.425	1569.10	5.036	26%
	Developed	1126.6850		good	1127		0.08	288.182	838.503	1371.50	0.611	26%
	Streambank	2325.1730		good	2325		0.16	594.730	1730.443			26%
	Total	14643.9676			14643.968		1.00		10898.349			
Step 4:	All Ag. Loading Rat	2.33										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	1999.10	0.2141	427.9781	0.2877	575.0685	26%					
	Final Cropland LA	1569.10	5.0356	7901.4253	6.7663	10617.0411	26%					
	Developed	1371.50	0.6114	838.5027	0.8215	1126.6850	26%					
	Streambank			1730.4426		2325.1730	26%					
	Total			10898.3487		14643.9676	26%					
	Valley Creek											
	Ref is MarshCreek_2											

Bells Run – Sediment

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
	Load = loading rate in ref. * Acres in Impaired					3819.4937	3819						
	4305.8495												
	SEDIMENT LOADING												
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reductor	Initial LA	Acres	Allowable Loading Rate	% Reduction	
	Hay/Past.	581.9178	5502.6665	good	582	ADJUST	0.12	108.678	473.240	1502.40	0.315	19%	
	Cropland	4625.5342		bad	3819	877	0.81	713.321	3106.173	640.00	4.853	33%	
	Developed	47.3972		good	47		0.01	8.852	38.545	86.50	0.446	19%	
	Streambank	247.8173		good	248		0.05	46.282	201.535			19%	
	Total	5502.6665			4696.626		1.00		3819.494				
Step 4:	All Ag. Loading Rat	1.67											
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
	Final Hay/Past. LA	1502.40	0.3150	473.2400	0.3873	581.9178	19%						
	Final Cropland LA	640.00	4.8534	3106.1728	7.2274	4625.5342	33%						
	Developed	86.50	0.4456	38.5454	0.5479	47.3972	19%						
	Streambank			201.5354		247.8173	19%						
	Total			3819.4937		5502.6665	31%						
	Bells Run												
	Reference is Goods Run												

Bells Run - Phosphorus

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
	Load = loading rate in ref. * Acres in Impaired					4.7282	5						
	5.3572												
	PHOSPHORUS LOADING												
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reductor	Initial LA	Acres	Allowable Loading Rate	% Reduction	
	Hay/Past.	1.1364	8.6207247	good	1	ADJUST	0.18	0.292	0.845	1502.40	0.001	26%	
	Cropland	6.9894		bad	5		0.74	1.213	3.515	640.00	0.005	50%	
	Developed	0.0491		good	0		0.01	0.013	0.037	86.50	0.000	26%	
	Groundwater	0.4404		good	0		0.07	0.113	0.327			26%	
	Streambank	0.0054		good	0		0.00	0.001	0.004			26%	
	Total	8.6207			6.3595047		1.00		4.728				
Step 4:	All Ag. Loading Rat	0.00											
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
	Final Hay/Past. LA	1502.40	0.0006	0.8449	0.0008	1.1364	26%						
	Final Cropland LA	640.00	0.0055	3.5153	0.0109	6.9894	50%						
	Developed	86.50	0.0004	0.0365	0.0006	0.0491	26%						
	Groundwater			0.3274		0.4404	26%						
	Streambank			0.0040		0.0054	26%						
	Total			4.7282		8.6207	45%						
	Bells Run												
	Reference is Goods Run												

Nickel Mines Run/Meetinghouse Creek – Phosphorus

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
	Load = loading rate in ref. * Acres in Impaired					5.6086	6						
	6.5285												
	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.	2.1170	21.3049	good	2	ADJUST	0.23	0.823	1.294	3207.40	0.000	39%	
	Cropland	17.7398		bad	6		4	0.61	2.180	3.429	1880.50	0.002	81%
	Developed	0.2168		good	0			0.02	0.084	0.133	689.40	0.000	39%
	Groundwater	1.1967		good	1			0.13	0.465	0.732			39%
	Streambank	0.0346		good	0			0.00	0.013	0.021			39%
	Total	21.3049			9.1737			1.00		5.609			
Step 4:	All Ag. Loading Rat	0.00											
Step 5:	Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.							
	Final Hay/Past. LA	3207.40	0.0004	1.2943	0.0007	2.1170	39%						
	Final Cropland LA	1880.50	0.0018	3.4290	0.0094	17.7398	81%						
	Developed	689.40	0.0002	0.1325	0.0003	0.2168	39%						
	Groundwater			0.7316		1.1967	39%						
	Streambank			0.0212		0.0346	39%						
	Total			5.6086		21.3049	74%						
Nickel Mines Run/Meeting House Run													
Ref is WB Big Elk Creek													

Attachment L

Comment and Response

