Pleasant Valley Run Sediment and Phosphorus TMDLs

Bedford County, Pennsylvania

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

"Total Maximum Daily Loads" (TMDLs) for sediment and phosphorus were developed for the Pleasant Valley Run Watershed (Figure 1) to address the siltation and nutrient impairments noted in the 2018 Final Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated Report), including the Clean Water Act Section 303(d) List. Agriculture and crop related agriculture were identified as the cause of these impairments. Because Pennsylvania does not have numeric water quality criteria for sediment or phosphorus, the loading rates from a similar unimpaired watershed were used to calculate the TMDLs.

"TMDLs" were calculated using both a long-term annual average value ($TMDL_{Avg}$) which would be protective under most conditions, as well as a 99th percentile daily value ($TMDL_{Max}$) which would be relevant to extreme flow events. Existing annual average sediment loading in the Pleasant Valley Run Watershed was estimated to be 912,269 pounds per year. Phosphorus loading was estimated to be 2,401 pounds per year. To meet water quality objectives, annual average sediment loading should be reduced by 34% to 604,266 pounds per year, and phosphorus loading should be reduced by 21% to 1,895 pounds per year. Allocation among the annual average TMDL variables is summarized in Table 1. To achieve these reductions while maintaining 10% margins of safety and minor allowances for point sources, annual average sediment loading from croplands, hay/pasture lands, and streambanks should be reduced by 42% each. Annual average phosphorus loadings from croplands, hay/pasture lands, streambanks, and farm animals should be reduced by 36% each.

Table 1. Summary of Annual Average $TMDL_{Avg}$ Variables for the Pleasant Valley Run Watershed

lbs/yr:						
Pollutant	$TMDL_{Avg}$	MOS_{Avg}	WLA_{Avg}	LA_{Avg}	LNR_{Avg}	ALA_{Avg}
Sediment	604,266	60,427	6,043	537,797	16,426	521,370
Phosphorus	1,895	189	19	1,686	414	1,272

TMDL=Total Maximum Daily Load; MOS = Margin of Safety; WLA=Wasteload Allocation (point sources); LA = Load Allocation (nonpoint sources). The LA is further divided into LNR = Loads Not Reduced and ALA=Adjusted Load Allocation.
Subscript "Avg" indicates that these values are expressed as annual averages.

Current 99thpercentile daily loading in the Pleasant Valley Run Watershed was estimated to be 27,969 pounds per day of sediment and 93 pounds per day of phosphorus. To meet water quality objectives, 99th percentile daily sediment loading should be reduced by 49% to 14,245 pounds per day. 99th percentile daily phosphorus loading should be reduced by 6% to 87 pounds per day. Allocation of 99th percentile daily sediment and phosphorus loading among the TMDL variables is summarized in Table 2.

Table 2. Summary of 99th Percentile Daily Loading $TMDL_{Max}$ Variables for the Pleasant Valley Run Watershed						
lbs/d:						
Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}	LNR_{Max}	ALA_{Max}
Sediment	14,245	1,425	142	12,678	387	12,291
Phosphorus	87	9	1	78	19	59

TMDL=Total Maximum Daily Load; MOS = Margin of Safety; WLA=Wasteload Allocation (point sources); LA = Load Allocation (nonpoint sources). The LA is further divided into LNR = Loads Not Reduced and ALA=Adjusted Load Allocation.
Subscript "Max" indicates that these values are expressed as 99^{th} percentile for daily loading.

Introduction

Pleasant Valley Run is a tributary of Dunning Creek, with the confluence approximately 3 miles northeast of Bedford Borough. This Total Maximum Daily Load (TMDL) document has been prepared to address the siltation and nutrient impairments noted in the Pleasant Valley Run Watershed per the 2018 Final Integrated Report (see Appendix A for a description of assessment methodology). The study watershed (Figure 1) contains approximately 24 stream miles, all of which were designated for cold water fishes (Table 3).

Agriculture and crop related agriculture were identified as the source of the impairments. The removal of natural vegetation and disturbance of soils associated with agriculture increases soil erosion leading to sediment deposition in streams. Excessive fine sediment deposition may destroy the coarse-substrate habitats required by many stream organisms. Soil erosion, along with animal waste and fertilizer use, may lead to excessive phosphorus loading in streams and in turn eutrophication, which may lower dissolved oxygen concentrations, increase pH, change community composition, and degrade aesthetic value.

While Pennsylvania does not have numeric water quality criteria for sediment or phosphorus, it does have applicable narrative criteria:

> *Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. (25 PA Code Chapter 93.6 (a));*
>
> *and,*
>
> *In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, odors, turbidity or settle to form deposits. (25 PA Code, Chapter 93.6 (b))*.

While agriculture has been identified as the source of the impairments, this TMDL document is applicable to all significant sources of phosphorus that may contribute to eutrophication, as well as all significant sources of sediment and solids that may settle to form deposits.

According to the “Model My Watershed” application, land use in this watershed is estimated to be 70% forest/naturally vegetated lands, 27% agriculture, and 3% mixed development (including developed open space). The agricultural lands were dominated by pasture/hay lands (20% or total land cover, see Appendix B, Table B1). There were no NPDES permitted point source discharges in the watershed with numeric limits relevant to sedimentation or phosphorus (Table 4).

Table 3. Aquatic-Life Impaired Stream Segments in the Pleasant Valley Run Watershed per the 2018 Final Pennsylvania Integrated Report

HUC: 2050303 – Raystown			
Source	EPA 305(b) Cause Code	Miles	Designated Use
Agriculture	Nutrients	4.8	CWF, MF
Ag. or Crop Related Ag.	Siltation	12.5	CWF, MF

HUC= Hydrologic Unit Code; CWF=Cold Water Fish; MF= Migratory Fishes
The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.
See Appendix C for a listing of each stream segment and Appendix A for more information on the listings and listing process

Pleasant Valley Run Watershed

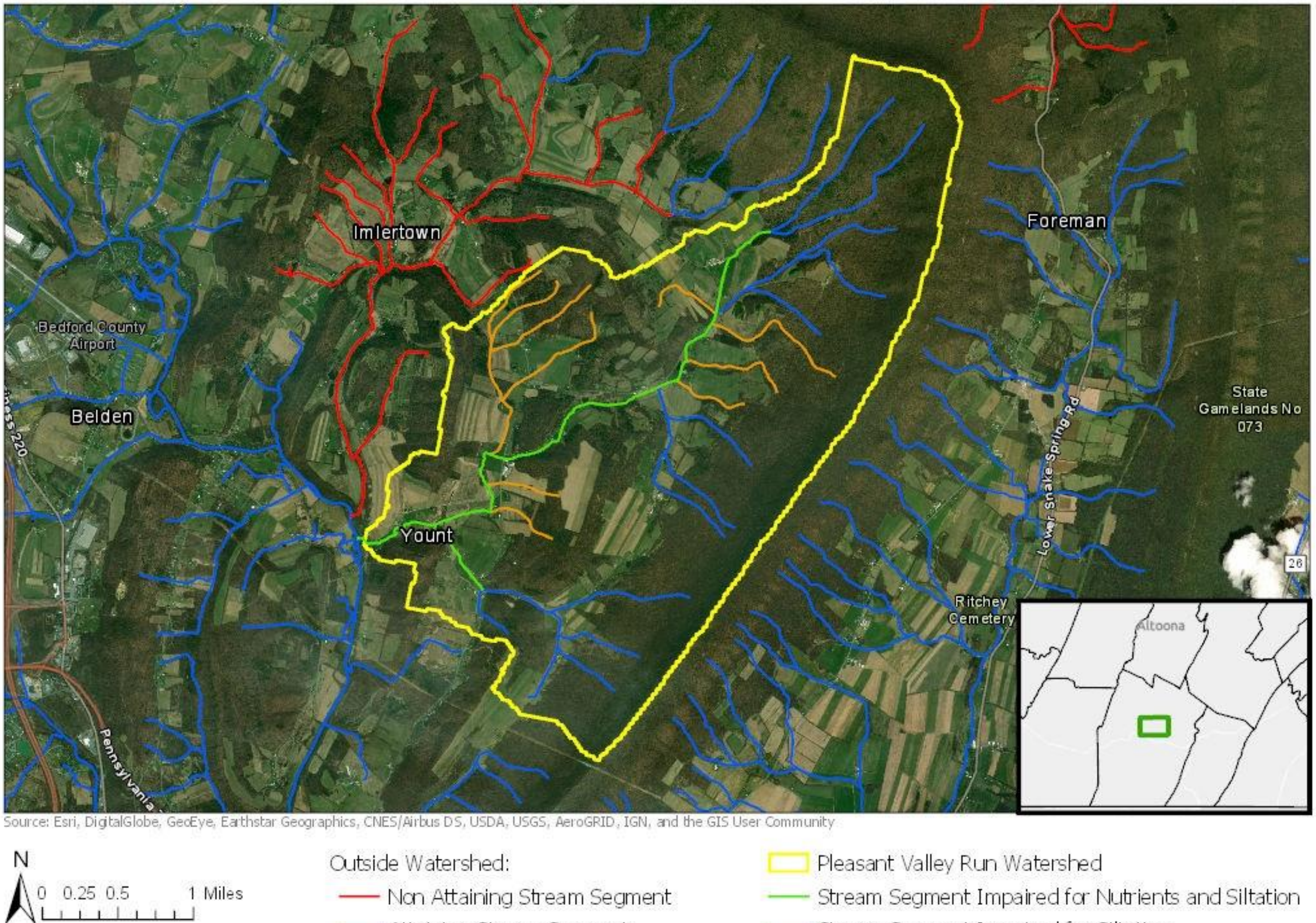

Figure 1. Pleasant Valley Run Watershed. Stream segments within the watershed were either listed as attaining for aquatic life use, impaired for siltation, or impaired for siltation and nutrients per the 2018 final Integrated Report (see PA DEP's 2018 Integrated Report Viewer available at: https://www.depgis.state.pa.us/integrated_report_viewer/index.html)

Table 4. Existing NPDES Permitted Discharges in the Pleasant Valley Run Watershed and their Potential Contribution to Sediment and Phosphorus Loading.					
		Sediment Load		Phosphorus Load	
Permit No.	Facility Name	mean lb/yr	max lb/d	mean lb/yr	max lb/d
None	None	NA	NA	NA	NA

Permits within the watershed were based on DEP's eMapPA available at http://www.depgis.state.pa.us/emappa/ and EPA's Watershed Resources Registry available at https://watershedresourcesregistry.org/map/?config=stateConfigs/pennsylvania.json

NA – Not applicable.

Note that given their transient nature, any stormwater construction permits were not included above.

TMDL Approach

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

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculation of a TMDL that appropriately accounts for any critical conditions and seasonal variations;
3. Allocation of pollutant loads to various sources;
4. Submission of draft reports for public review and comments; and
5. EPA approval of the TMDL.

Because Pennsylvania does not have numeric water quality criteria for sediment or phosphorus, the “Reference Watershed Approach” was used. This method estimates loading rates in both the impaired watershed as well as a similar watershed that is not listed as impaired. Then, the loading rates in the unimpaired watersheds are scaled to the area of the impaired watershed so that necessary load reductions may be calculated. It is assumed that reducing loading rates in the impaired watershed to the levels found in the unimpaired watershed will result in the impaired stream segments attaining their designated uses.

Selection of the Reference Watershed

In addition to anthropogenic influences, there are many other natural factors affecting sediment and nutrient loading rates. Thus, selection of a reference watershed with similar natural characteristics as the impaired watershed is crucial. Failure to use an appropriate reference watershed could result in problems such as the setting of reduction goals that are unattainable, or nonsensical TMDL calculations that suggest that loadings in the impaired watershed should be increased.

Shortly before working on Pleasant Valley Run a draft TMDL document was prepared for a neighboring watershed, Imlertown Run. Because the two watersheds were so similar, the same reference watershed, Tonoloway Creek, was explored for use in the present study. The following two paragraphs describe how the Tonoloway Creek Subwatershed was chosen as a potential reference for the prior study.

To find a reference site, the Department’s Integrated Report GIS-based website (available at https://www.depgis.state.pa.us/integrated_report_viewer/index.html) was used to search for nearby watersheds that were of similar size as the Imlertown Run Watershed but lacked stream segments listed as impaired for sediment or nutrients. Once potential references were identified, they were screened to determine which ones were most like the impaired watershed with regard to factors such as landscape position, topography, bedrock geology, hydrology, soil drainage types, land use etc. Furthermore, benthic macroinvertebrate and physical habitat assessment scores were reviewed to confirm that a reference was attaining its aquatic life use and not impaired for sediment. Preliminary modelling was conducted to make sure that use of a particular reference would result in reasonable pollution reductions.

Considering that it was nearby (only about 16 miles away), occupied a similar landscape position within the Appalachian Mountain Section of the Ridge and Valley Physiographic Province (Figure 2), and not listed as impaired for sediment or nutrients, the Tonoloway Creek Watershed in Fulton County was explored for use as a reference. Since it is required that the reference watershed be +/-30% of the impaired watershed's area, a delineation point was chosen upstream of the mouth of Tonoloway Creek to create a subwatershed that was approximately the same size as the impaired watershed (Figure 3).

It was ultimately concluded that the Tonoloway Creek Subwatershed was a suitable reference for both the Imlertown Run and Pleasant Valley Run Watersheds (Table 5).

Table 5. Comparison of the Impaired (Pleasant Valley Run) and Reference (Tonoloway Creek) Watersheds.

	Pleasant Valley Run Watershed	Tonoloway Creek Subwatershed
Phys. Province[1]	Appalachian Mountain Section of the Ridge and Valley Province	Appalachian Mountain Section of the Ridge and Valley Province
Area[2], ac	5,363	5,119
Land Use[2]	27% Agriculture 70% Forest/Natural Vegetation 3% Developed Areas	19% Agriculture 76% Forest/Natural Vegetation 5% Developed Areas
Soil Infiltration[3]	32% Group A 21% Group B 3% Group B/D 26% Group C 3% Group C/D 17% Group D	26% Group A 27% Group B 4% Group B/D 11% Group C 0% Group C/D 32% Group D
Dominant Bedrock[4]	38% Shale 36% Calcareous Shale 16% Quartzite 10% Limestone 1% Sandstone	87% Sandstone 12% Argillaceous Sandstone 0.3% Siltstone
Average Precipitation[5], in/yr	40.4	40.4

Average Surface Runoff[5], in/yr	1.4	1.5
Average Elevation[5] (ft)	1,417	1,242
Average Slope[5]	18%	18%
Stream Channel Slope[5]	1st Order: 7.8% 2nd Order: 0.8%	1st Order: 5.6% 2nd Order: 1.4%

[1]Per PA_Physio_Sections GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources
[2]MMW output based on NLCD 2011
[3]As reported by Model My Watershed's analysis of USDA gSSURGO 2016
[4]Per Bedrock Geology GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources
[5]As reported by Model My Watershed

Based on the summaries of landcover reported by the "Model My Watershed" application, both watersheds were dominated by naturally vegetated lands (Table 5). The percentage of agricultural landcover was similar but higher in the Pleasant Valley Run Watershed versus the Tonoloway Creek Subwatershed (27% versus 19%). Both watersheds had very little developed lands and had substantial amounts of both high (Class A) and slow (Class D) infiltration soils. The calculated surface runoff rates and average topographic slopes were very similar in the two watersheds. With regard to bedrock, both watersheds were dominated by non-karst sedimentary formations, though the Pleasant Valley Run Watershed was dominated by shale whereas the Tonoloway Creek Subwatershed was nearly entirely comprised of sandstone.

While Pleasant Valley Run was designated for cold water fishes, the Tonoloway Creek was designated for warm water fishes. Most importantly however, neither watershed contained stream segments designated for special protection (high quality or exceptional value). Also, as was the case for the Pleasant Valley Run Watershed, there were no NPDES permitted point source discharges in the Tonoloway Creek Subwatershed (Table 6).

Table 6. Existing NPDES Permitted Discharges in the Tonoloway Creek Subwatershed and their Potential Contribution to Sediment and Phosphorus Loading.

		Sediment Load		Phosphorus Load	
Permit No.	Facility Name	mean lb/yr	max lb/d	mean lb/yr	max lb/d
None	None	NA	NA	NA	NA

Permits within the watershed were based on DEP's eMapPA available at http://www.depgis.state.pa.us/emappa/ and EPA's Watershed Resources Registry available at https://watershedresourcesregistry.org/map/?config=stateConfigs/pennsylvania.json.

Note that given their transient nature, any stormwater construction permits were not included above.

After selecting the potential reference, the two watersheds were visited during February 2020 to determine the severity of pollution, confirm the suitability of the reference, as well as to explore whether there were any obvious land use differences that may help to explain why one watershed was impaired for sediment and nutrients while the other was attaining. A substantial fine sediment deposition problem was obvious in many stream segments of the Pleasant Valley Run Watershed (Figure 4). However, streambed conditions were very heterogenous, and some reaches, including a mainstem reach of the lower watershed, did not have obvious problems. This was likely because it was a high-gradient constrained reach that exported sediments downstream.

Considering that overall agricultural landcover was moderate (27%) and dominated by hay/pasture lands rather than croplands (20% vs 8%, see Appendix Table B1, Figure 5), it is hypothesized that the Pleasant Valley Run Watershed's impairments had more to do with degrading agricultural practices/lack of appropriate best management practices (BMPs) (Figures 6, 7 and 8) rather than intensive agricultural use. For instance, some agricultural fields were observed with little or no riparian buffers (Figure 6), and sites were observed where livestock had direct access to streams. Some barnyard areas were bare and drained to streams (Figure 7) and pasture sites were observed with badly eroding streambanks (Figures 7 and 8). It should also be noted that there were many agricultural sites within the watershed that appeared to be managed appropriately. Many agricultural fields had high winter vegetative cover and BMPs such as forested riparian buffers, new riparian buffer plantings, and cattle exclusion stream fencing (Figure 9).

Like the Pleasant Valley Run Watershed, the Tonoloway creek Subwatershed also had substantial agricultural land area dominated by hay/pasture lands (Figures 3 and 10, see also Appendix Table B2). However, stream substrate conditions were typically rockier and had less fine sediment deposition in the Tonoloway Creek Subwatershed versus the Pleasant Valley Run Watershed (compare Figures 4 and 11). In addition to having less agricultural land, the agricultural practices appeared to be substantially better in the Tonoloway Creek Subwatershed, especially with regard to the allowance for expansive forested riparian buffers that occurred along most (Figure 12), but not all (Figure 13), stream segments. Likewise, areas with livestock access to the stream or degraded barnyard areas/pasture lands were rare or absent at the time of the winter visit. It should also be noted that better streambed conditions within the Tonoloway Creek Subwatershed may also be in part due to it having somewhat steeper stream channel slopes in its downstream reaches versus the Pleasant Valley Watershed (Table 5).

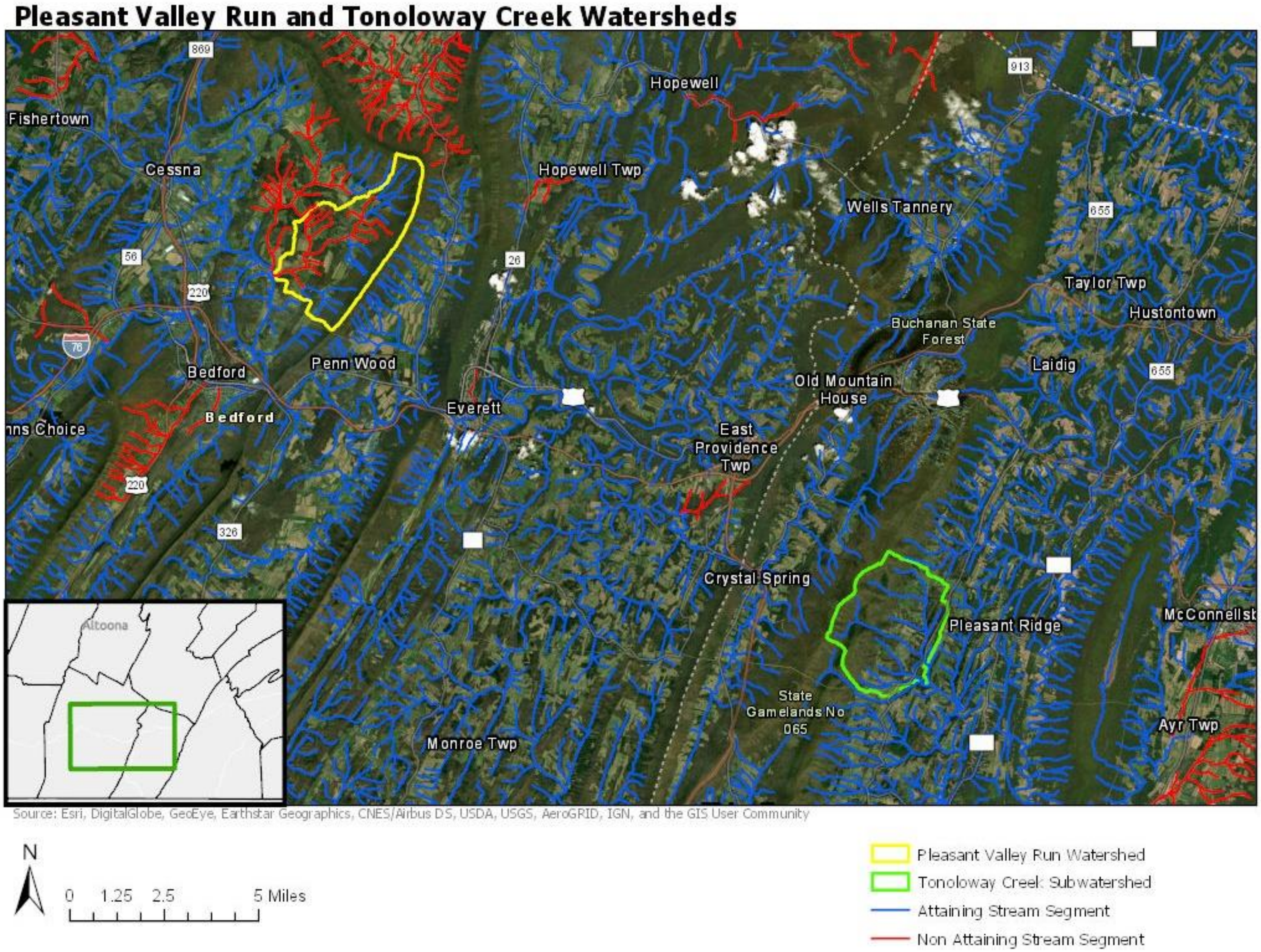

Figure 2. Pleasant Valley Run and Tonoloway Creek Watersheds.

Tonoloway Creek Watershed

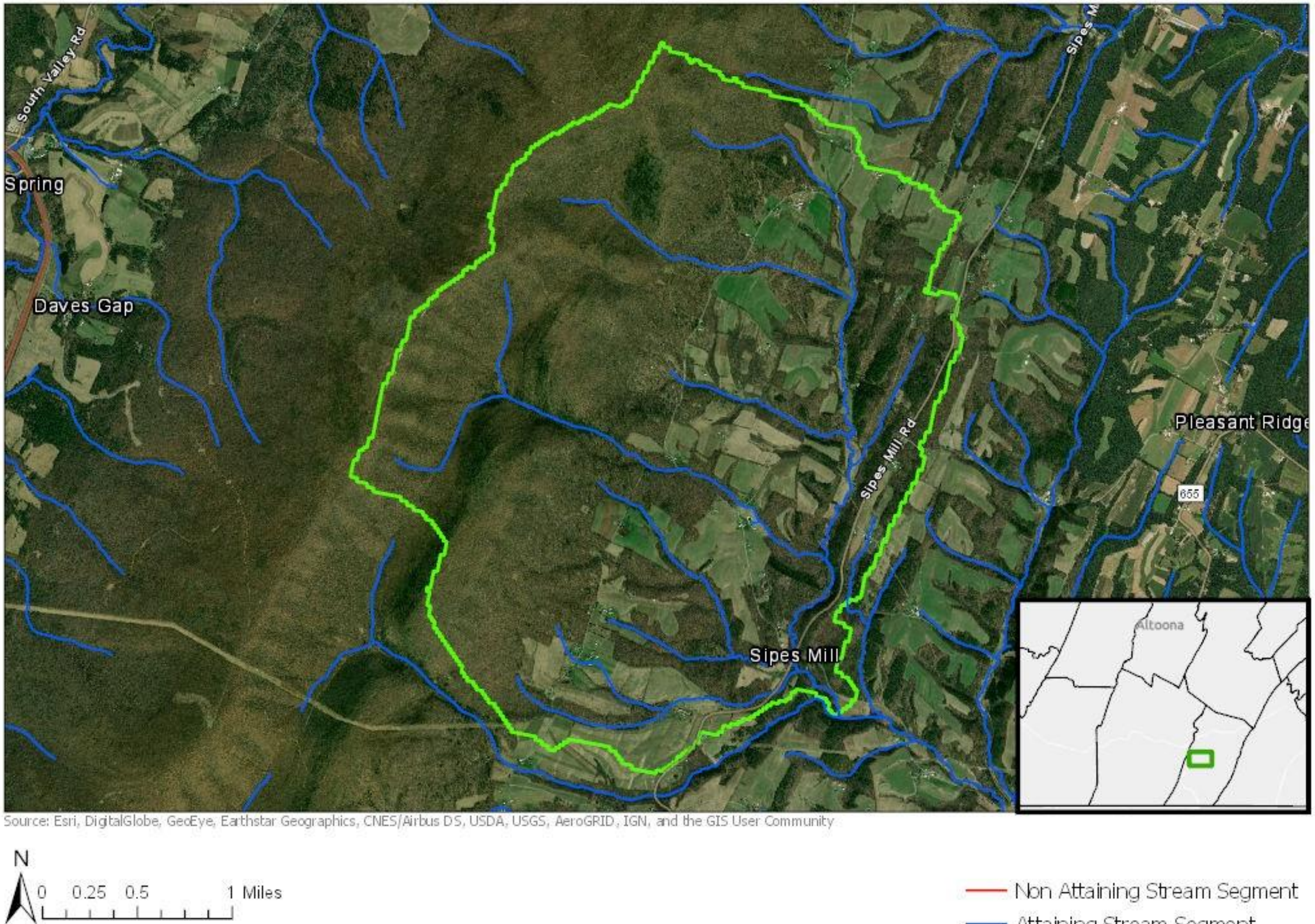

Figure 3. Tonoloway Creek Subwatershed. All stream segments were listed as attaining for aquatic life per the 2018 Final Pennsylvania Integrated Report.

Figure 4. Example stream substrate conditions in the Pleasant Valley Run Watershed. Channel substrates ranged from rocky (photographs A and B), rocky but with fine sediment deposition in pools/backwaters (photographs C and D), and dominated by fines (photographs E and F). There was much spatial variability within the watershed, probably having to do with landscape position/gradient. For instance, photograph E was taken only about a mile upstream of photograph A, and no major tributaries occurred between these two points. The drastic difference in conditions was most likely due to photograph A being taken in a constrained high-gradient reach whereas photograph E was taken in a low gradient floodplain environment.

Figure 5. Agricultural landscapes within the Pleasant Valley Run Watershed. Note the mixture of agricultural, forested and wetland areas and the abundance of hay/pastureland rather than croplands.

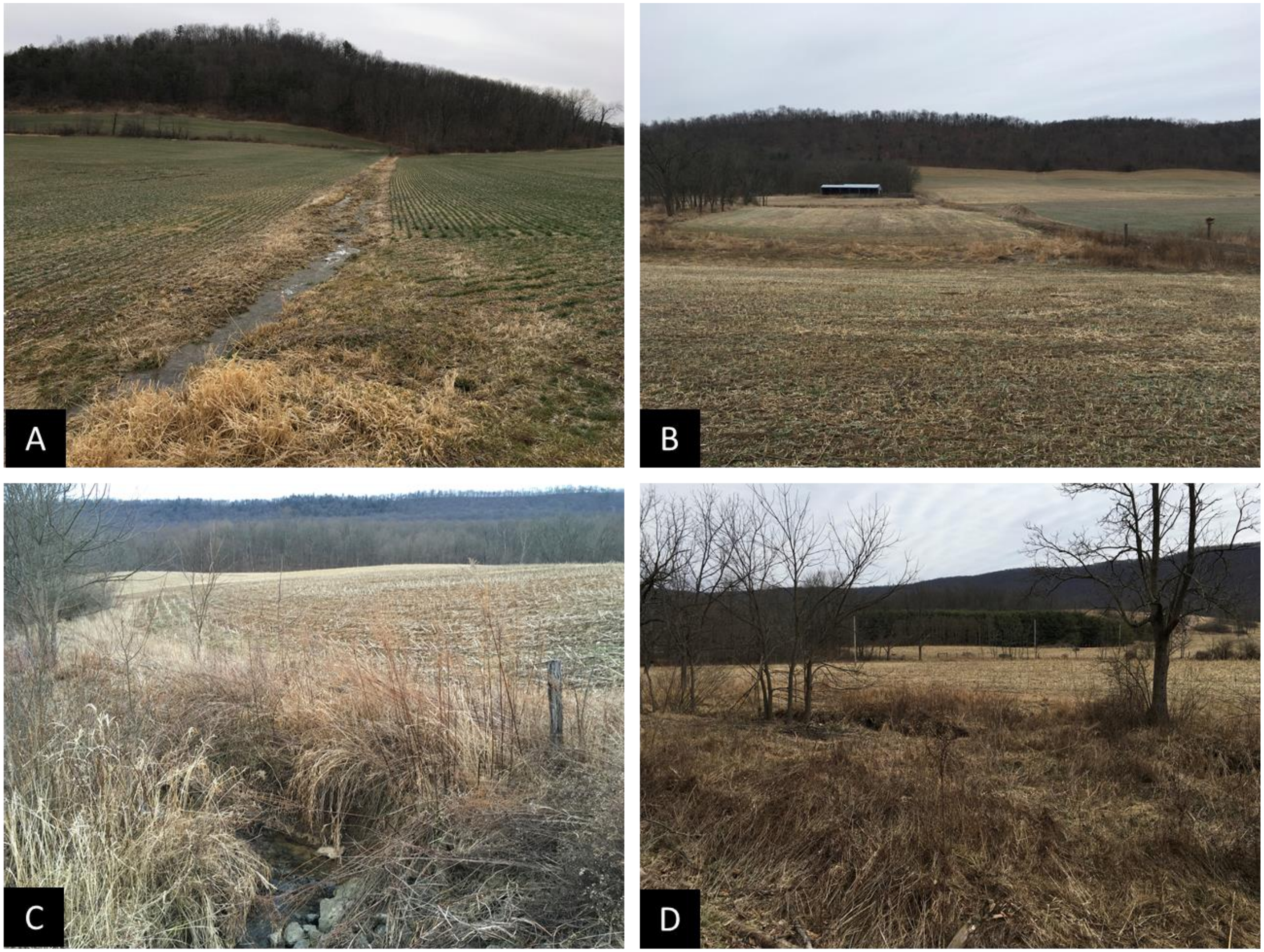

Figure 6. Cropland and hay field conditions in the Pleasant Valley Run Watershed that may exacerbate sediment loading. While all of these sites had substantial winter vegetative/crop residue cover, riparian buffers were absent (Photograph A) or likely too narrow to adequately protect the stream segment/drainageway (Photographs B-D).

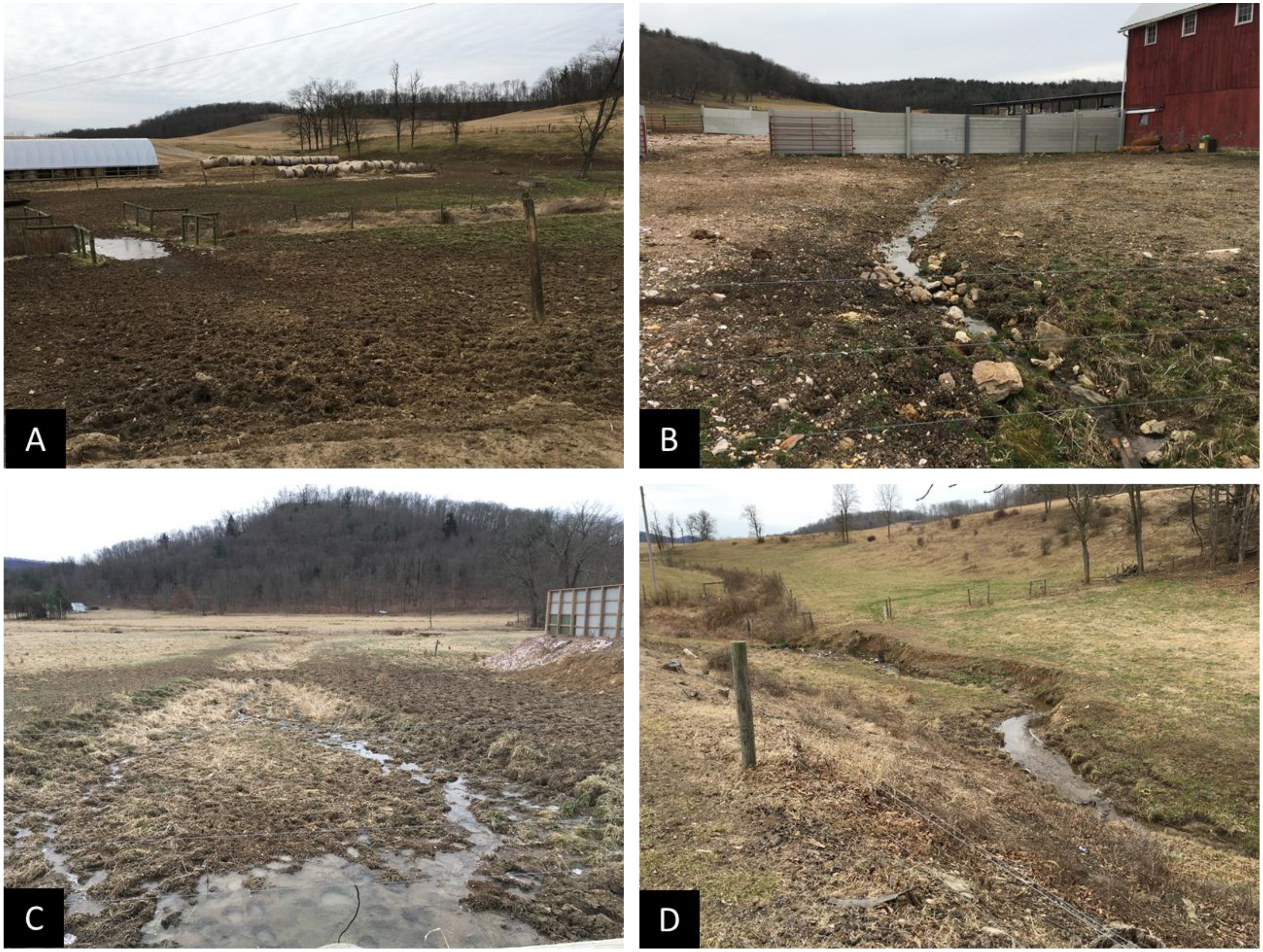

Figure 7. Degraded pasturelands within the Pleasant Valley Run Watershed. Some pasturelands/barnyard areas were degraded to the point of leaving erosive bare soils that drained directly to streams/drainageways (Photographs A through C). While vegetative coverage was better in photograph D, cattle access to the stream appeared to be contributing to excessive bank erosion.

Figure 8. Example stream segments in the Pleasant Valley Run Watershed with excessive bank erosion. Note both sites were in pasture lands.

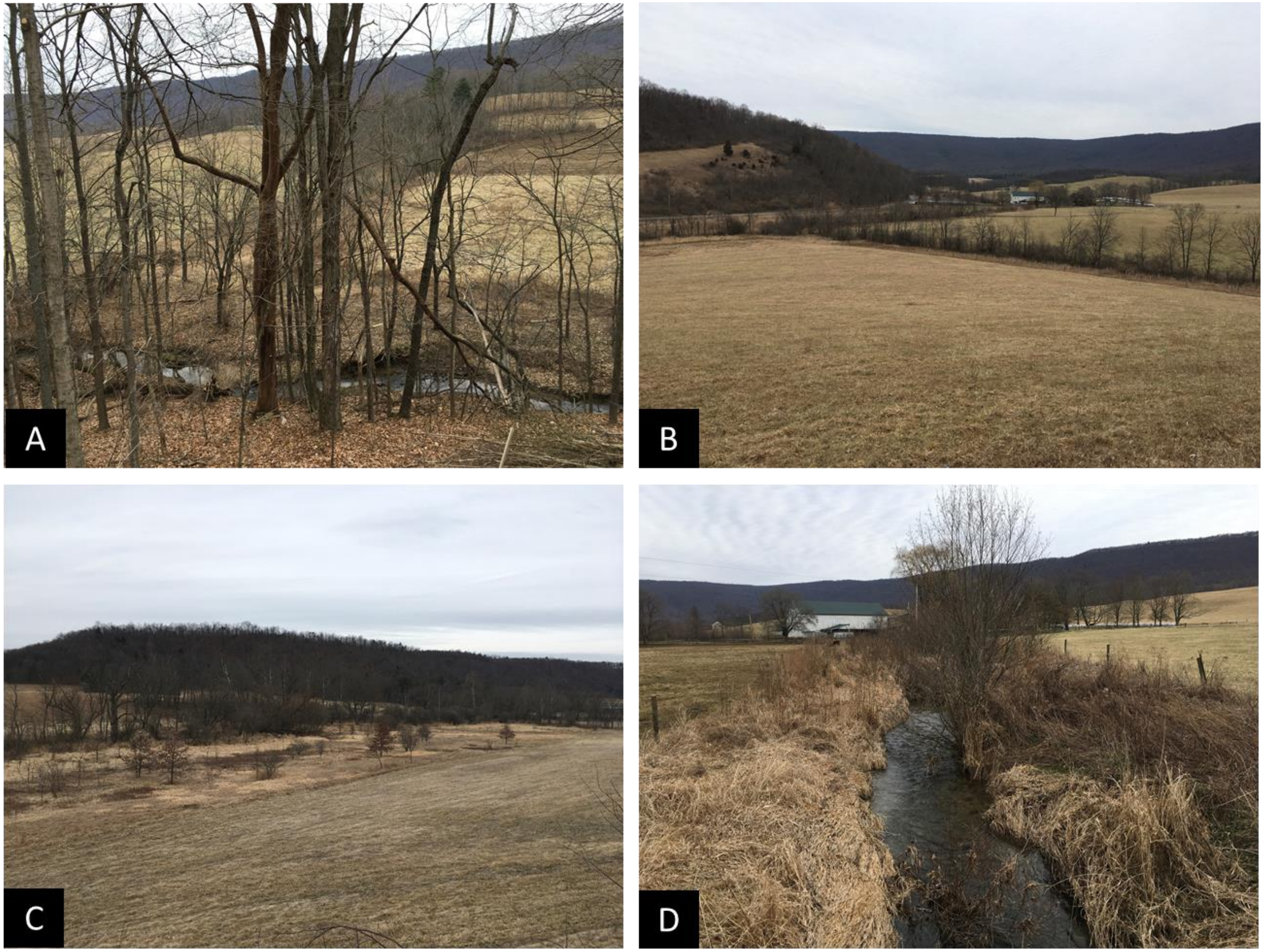

Figure 9. Landscapes and practices within the Pleasant Valley Run Watershed that may be protective of streams. All of these photographs show stream reaches with substantial riparian buffers among agricultural fields with high amounts of winter cover. Buffer width appears to have been recently expanded in photographs B and C. In photograph D cattle have been fenced out of the stream.

Figure 10. Agricultural landscape within the Tonoloway Creek Subwatershed. Note that most agricultural lands were hay/pasture lands rather than croplands. Also note the forested drainageway.

Figure 11. Stream substrate conditions within the Tonoloway Creek Subwatershed. Most riffle and run areas had rocky-dominated substrates as in photographs A, B, and C. While there was some fine sediment deposition in the pool depicted in photograph D, the underlying cobble substrate was evident.

Figure 12. Forested buffers within the Tonoloway Creek Subwatershed. Stream segments commonly flowed through expansive forested patches as in Photograph A. Photographs B and C show wide forested buffers that protect the stream from upslope agricultural lands. Photograph D shows a drainageway through a hay field without a buffer, but a wide forested buffer occurred downstream as the drainageway grew towards becoming a stream.

Figure 13. Examples of unbuffered stream segments in the Tonoloway Creek Subwatershed. While most stream segments had forested buffers, there were some exceptions, as was the case for the stream flowing through hay and lawn lands in the upper photo and the small headwater stream flowing through lawn and pasturelands in the lower photo.

Hydrologic / Water Quality Modeling

This section deals primarily with the $TMDL_{Avg}$ calculations, as use of annual average values were determined to be the most relevant way to express the “TMDL” variables. For information about modifications that were made to allow for calculation of $TMDL_{Max}$, see the later “Calculation of a Daily Maximum ‘$TMDL_{Max}$’” section.

Estimates of sediment loading for the impaired and reference watersheds were calculated using the “Model My Watershed” application (MMW), which is part of the WikiWatershed web toolkit developed through an initiative of the Stroud Water Research Center. MMW is a replacement for the MapShed desktop modelling application. Both programs calculate sediment and nutrient fluxes using the “Generalized Watershed Loading Function Enhanced” (GWLF-E) model. However, MapShed was built using a MapWindow GIS package that is no longer supported, whereas MMW operates with GeoTrellis, an open-source geographic data processing engine and framework. The MMW application is freely available for use at https://wikiwatershed.org/model/. In addition to the changes to the GIS framework, the MMW application continues to be updated and improved relative to its predecessor.

In the present study, watershed areas were defined using MMW’s Watershed Delineation tool (see https://wikiwatershed.org/documentation/mmw-tech/#delineate-watershed). Then, the mathematical model used in MMW, GWLF-E, was used to simulate 30-years of daily water, nitrogen, phosphorus and sediment fluxes. To provide a general understanding of how the model functions, the following excerpts are quoted from Model My Watershed’s technical documentation.

> The GWLF model provides the ability to simulate runoff, sediment, and nutrient (nitrogen and phosphorus) loads from a 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 that 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 considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various “landscape” attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each source area into a watershed total; in other words there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated subsurface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.
>
> With respect to major processes, GWLF simulates surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs from the EPA Center for Exposure Assessment Modeling (CEAM) meteorological data distribution. Erosion and sediment yield are

estimated using monthly erosion calculations based on the USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly KLSCP values for each source area (i.e., land cover/soil type combination). A sediment delivery ratio based on watershed size and transport capacity, which is based on average daily runoff, is then applied to the calculated erosion to determine sediment yield for each source sector. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area.

Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values.

Streambank erosion was calculated as a function of factors such as the length of streams, the monthly stream flow, the percent developed land in the watershed, animal density in the watershed, the watersheds curve number and soil k factor, and mean topographic slope

For a detailed discussion of this modelling program, including a description of the data input sources, see Evans and Corradini (2016) and Stroud Research Center (2020).

Model My Watershed allows the user to adjust model parameters, such as the area of land coverage types, the use of and efficiency of conservation practices, the watershed's sediment delivery ratio, etc. Default values were used for the modelling runs. However, after the modelling run, corrections were made for the presence of existing riparian buffers. These corrections were made using the BMP Spreadsheet Tool provided by Model My Watershed. The following paragraphs describe this methodology.

Riparian buffer coverage was estimated via a GIS analysis. Briefly, landcover per a high resolution landcover dataset (University of Vermont Spatial Analysis Laboratory 2016) was examined within 100 feet of NHD flowlines. To determine riparian buffering within the "agricultural area," a polygon tool was used to clip riparian areas that, based on cursory visible inspection, appeared to be in an agricultural-dominated valley or have significant, obvious agricultural land on at least one side. The selection polygons are shown in Figures 14 and 15. Then the sum of raster pixels that were classified as either "Emergent Wetlands", "Tree Canopy" or "Shrub/Scrub" was divided by the total number of non-water pixels to determine percent riparian buffer. Using this methodology, percent riparian buffer was determined to be 38% in the agricultural area of the impaired watershed versus 77% in the reference watershed.

An additional reduction credit was given to the reference watershed to account for the fact it had more riparian buffers than the impaired watershed. Applying a reduction credit solely to the reference watershed to account for its extra buffering was chosen as more appropriate than taking a reduction from both watersheds because the model has been calibrated at a number of actual sites (see https://wikiwatershed.org/help/model-help/mmw-tech/) with varying amounts of existing riparian buffers. If a reduction were taken from all sites to account for existing buffers, the datapoints would likely have a poorer fit to the calibration curve versus simply providing an additional credit to a reference site.

When accounting for the buffering of croplands using the BMP Spreadsheet Tool, the user enters the length of buffer on both sides of the stream. To estimate the extra length of buffers in the agricultural area of the reference watershed over the amount found in the impaired watershed, the approximate length of NHD flowlines within the reference watershed was multiplied by the proportion of riparian pixels that were within the agricultural area selection polygons (see Figures 14 and 15) and then by the difference in the proportion of buffering between the agricultural area of the reference watershed versus that of the impaired watershed, and then by two since both sides of the stream are considered. The BMP spreadsheet tool then calculates sediment reduction using a similar methodology as the Chesapeake Assessment Scenario Tool (CAST). The length of riparian buffers is converted to acres, assuming that the buffers are 100 feet wide. For sediment and phosphorus loading the spreadsheet tool assumes that 2 acres of croplands are treated per acre of buffer. Thus, twice the acreage of buffer was multiplied by the sediment or phosphorus loading rate calculated for croplands and then by a reduction coefficient of 0.54 for sediment and 0.40 for phosphorus. The BMP spreadsheet tool is designed to account for the area of lost cropland and gained forest when riparian buffers are created. However, this part of the reduction equation was deleted for the present study since historic rather than proposed buffers were being accounted for.

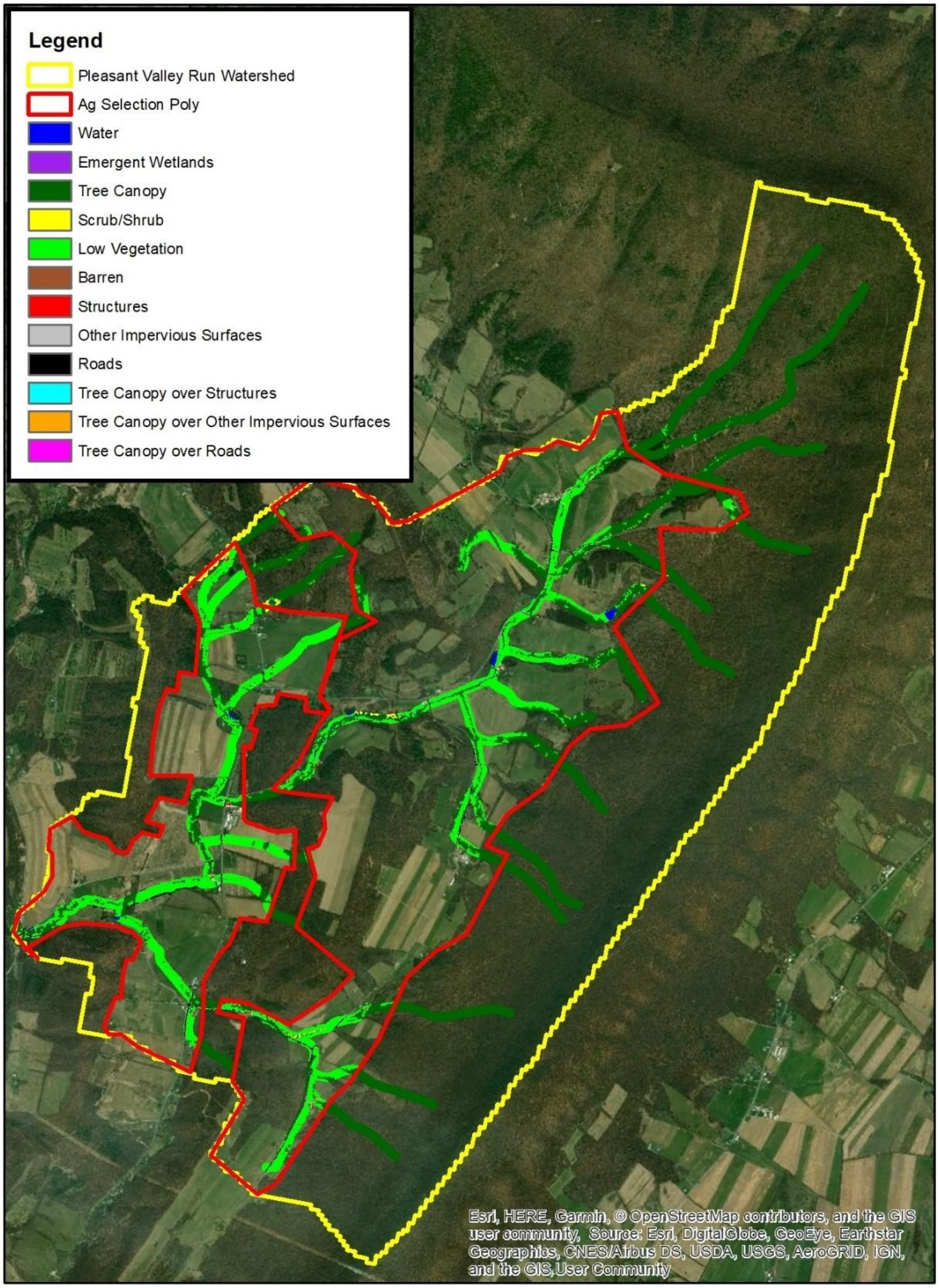

Figure 14. Riparian buffer analysis in the Pleasant Valley Run Watershed. A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Lab 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering within the agricultural area selection polygons was estimated to be about 38%.

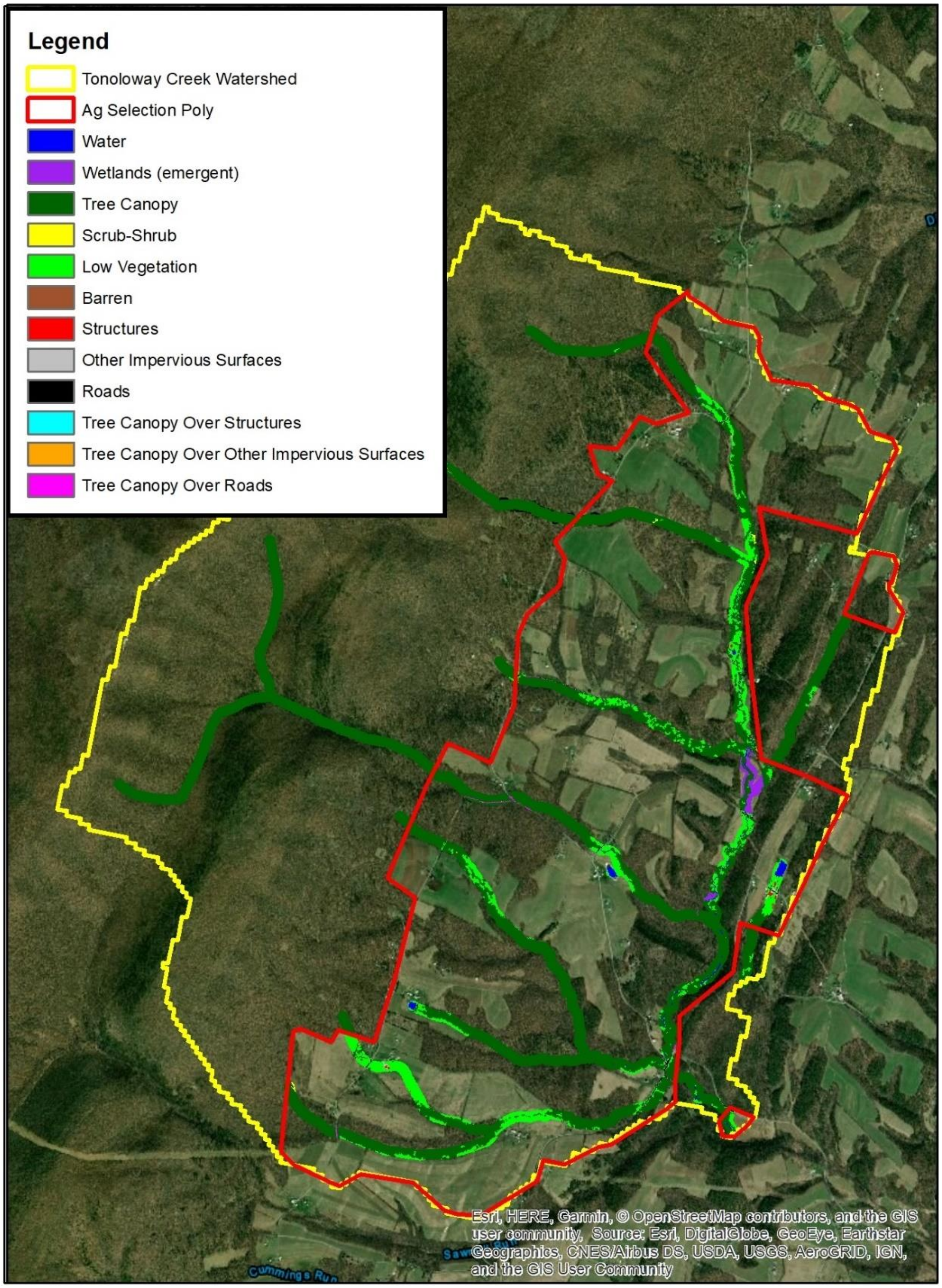

Figure 15. Riparian buffer analysis in the Tonoloway Creek Subwatershed. A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Lab 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering within the agricultural area selection polygons was estimated to be about 77%.

Calculation of the TMDL

The mean annual loading rates for the unimpaired reference subwatershed (Tonoloway Creek) were estimated to be 113 pounds per acre per year of sediment and 0.35 pounds per acre per year of phosphorus (Table 7). These were substantially lower than the estimated mean annual loading rates in the impaired Pleasant Valley Run Watershed (170 pounds per acre per year of sediment and 0.45 pounds per acre per year of phosphorus, Table 8). To achieve the loading rates of the unimpaired watershed, loadings in the Pleasant Valley Run Watershed should be reduced to 604,266 pounds per year of sediment and 1,895 pounds per year of phosphorus, or less (Table 9).

Table 7. Existing Annual Average Loading Values for the Tonoloway Creek Subwatershed, Reference

Source	Area, ac	Sediment, lbs/yr	Sediment, lb/ac/yr	P lbs/yr	P lbs/ac/yr
Hay/Pasture	931	407,787	438	558	0.60
Cropland	62	72,532	1,175	86	1.39
Forest and Shrub/Scrub	3,877	12,417	3	20	0.005
Low Intensity Mixed Development	249	2,571	10	6	0.024
Medium Density Mixed Development		17			
Streambank[1]		217,241		49	
Farm Animals				876	
Groundwater				333	
Extra Buffer Discount[2]		-135,842		-119	
total	5,119	576,723	113	1,808	0.35

[1]"Streambank" sediment loads were calculated using Model My Watershed's streambank routine which uses length rather than area.

[2]Accounts for the amount of extra riparian buffering in the agricultural area of reference watershed versus the impaired watershed. For details on this calculation, see the "Hydrologic / Water Quality Modelling" section.

Table 8. Existing Annual Average Loading Values for the Pleasant Valley Run Watershed, impaired

Source	Area, ac	Sediment, lbs/yr	Sediment, lb/ac/yr	P lbs/yr	P lbs/ac/yr
Hay/Pasture	1,047	213,249	204	479	0.46
Cropland	420	521,816	1,243	721	1.72
Forest and Shrub/Scrub	3,746	14,554	4	21	0.005

Open Land	5	228	46	0.22	0.045
Low Intensity Mixed Development	143	1,503	10	4	0.025
Medium Intensity Mixed Development	2	142	57	0.22	0.089
Streambank		160,778		42	
Farm Animals				744	
Groundwater				390	
total	5,363	912,269	170	2,401	0.45

"Streambank" loads were calculated using Model My Watershed's streambank routine which uses length rather than area.

Table 9. Calculation of Annual Average TMDL Values for the Pleasant Valley Run Watershed

Pollutant	Mean Loading Rate in Reference, lbs/ac/yr	Total Area in Impaired Watershed, ac	Target $TMDL_{Avg}$ Value, lbs/yr
Sediment	113	5,363	604,266
Phosphorus	0.35	5,363	1,895

Calculation of Load Allocations

In the TMDL equation, the load allocation (LA) is the load derived from nonpoint sources. The LA is further divided into the adjusted loads allocation (ALA), which is comprised of the nonpoint sources causing the impairment and targeted for reduction, as well as the loads not reduced (LNR), which is comprised of the natural and anthropogenic sources that are not considered responsible for the impairment nor targeted for reduction. Thus:

LA =ALA + LNR

Considering that the total maximum daily load (TMDL) is the sum of the margin of safety (MOS), the wasteload allocation (WLA), and the load allocation (LA):

TMDL = MOS + WLA + LA,

then the load allocation is calculated as follows:

LA = TMDL - MOS - WLA

Thus, before calculating the load allocations, the margins of safety and wasteload allocations must be defined.

Margin of Safety

The margin of safety (MOS) is a portion of pollutant loading that is reserved to account for uncertainties. Reserving a portion of the load as a safety factor requires further load reductions from the ALA to achieve the TMDL. For this analysis, the MOS_{Avg} for each TMDL was explicitly designated as ten-percent of the $TMDL_{Avg}$ based on professional judgment. Thus:

Sediment: 604,266 lbs/yr $TMDL_{Avg}$ * 0.1 = 60,427 lbs/yr MOS_{Avg}

Phosphorus: 1,895 lbs/yr $TMDL_{Avg}$ * 0.1= 189 lbs/yr MOS_{Avg}

Wasteload Allocation

The wasteload allocation (WLA) is the pollutant loading assigned to existing permitted point sources as well as future point sources. There were no National Pollutant Discharge Elimination System (NPDES) point source discharges in the impaired subwatershed (Table 4). Bulk reserves were included as part of the wasteload allocations to allow for insignificant dischargers and minor increases from point sources as a result of future growth of existing or new sources.

Since there were no permits with numeric effluent limits for sediment or phosphorus, the WLAs were simply comprised of the bulk reserves, which we defined as one percent of the targeted TMDLs. Therefore:

Sediment: 604,266 lbs/yr $TMDL_{Avg}$ * 0.01 = 6,043 lbs/yr bulk $reserve_{Avg}$ + 0 lb/yr permitted loads = 6,043 lbs/yr WLA_{Avg}

Phosphorus: 1,895 lbs/yr $TMDL_{Avg}$*0.01 = 19 lbs/yr bulk $reserve_{Avg}$ + 0 lbs/yr permitted loads = 19 lbs/yr WLA_{Avg}

Load Allocation

Now that the margins of safety and wasteload allocations have been defined, the load allocations (LA) are calculated as:

Sediment: 604,266 lbs/yr $TMDL_{Avg}$ – (60,427 lbs/yr MOS_{Avg} + 6,043 lbs/yr WLA_{Avg}) = 537,797 lbs/yr LA_{Avg}

Phosphorus: 1,895 lbs/yr $TMDL_{Avg}$ – (189 lbs/yr MOS_{Avg} + 19 lbs/yr WLA_{Avg}) = 1,686 lbs/yr LA_{Avg}

Loads Not Reduced and Adjusted Load Allocation

Since the impairments addressed by this TMDL are due to agriculture, sediment and phosphorus contributions from forests, open lands (non-agricultural herbaceous/grassland), developed lands, and groundwater (for phosphorus) within the Pleasant Valley Run Watershed were considered loads not reduced (LNR). LNR_{Avg} were calculated to be 16,426 lbs/yr for sediment and 414 lbs/yr for phosphorus (Table 10).

The LNRs were subtracted from the LAs to determine the ALAs:

Sediment: 537,797 lbs/yr LA_{Avg} – 16,426 lbs/yr LNR_{Avg} = 521,370 lbs/yr ALA_{Avg}

Phosphorus: 1,686 lbs/yr LA_{Avg} – 414 lbs/yr LNR_{Avg} = 1,272 lbs/yr ALA_{Avg}

Table 10. Average Annual Load Allocation, Loads Not Reduced and Adjusted Load Allocation

	Sediment lbs/yr	Phosphorus lbs/yr
Load Allocation (LA_{Avg})	**537,797**	**1,686**
Loads Not Reduced (LNR_{Avg}):	**16,426**	**414**
Forest	14,554	21
Open Land	228	0.2
Low Intensity Mixed Development	1,503	4
Med. Intensity Mixed Development	142	0.2
Groundwater		390
Adjusted Load Allocation (ALA_{Avg})	**521,370**	**1,272**

Note, the ALA is comprised of the anthropogenic sources targeted for reduction: croplands, hay/pasturelands, streambanks (assuming an elevated erosion rate) and farm animals. The LNR is comprised of both natural and anthropogenic sediment and phosphorus sources. While anthropogenic, developed lands were considered a negligible sediment and phosphorus source in this watershed and thus not targeted for reduction. Forests, open land (non-agricultural herbaceous/grassland) and groundwater were considered natural sediment or phosphorus sources.

Calculation of Load Reductions

To calculate load reductions by source, the ALAs were further analyzed using the Equal Marginal Percent Reduction (EMPR) allocation method described in Appendix D. Although the Pleasant Valley Run TMDLs were developed to address impairments caused by agricultural activities, streambanks were also significant contributors to the sediment and phosphorus loadings in the watershed, and streambank erosion rates are influenced by agricultural activities. Thus, streambanks were included in the ALA and targeted for reduction.

In this analysis, croplands, hay/pasture lands and streambanks all received sediment reduction goals of 42% (Table 11). Similarly, croplands, hay/pasture lands, streambanks and farm animals received the same prescribed annual average phosphorus reduction of 36% (Table 12).

Table 11. Annual Average Sediment Load Allocations for Source Sectors in the Pleasant Valley Run Watershed

		Load Allocation	Current Load	Reduction Goal
Land Use	Acres	lbs/yr	lbs/yr	
CROPLAND	420	303,583	521,816	42%
HAY/PASTURE	1,047	124,170	213,249	42%
STREAMBANK		93,617	160,778	42%
AGGREGATE		521,370	895,843	42%

Table 12. Annual Average Phosphorus Load Allocations for Source Sectors in the Pleasant Valley Run Watershed

		Load Allocation	Current Load	Reduction Goal
Land Use	Acres	lbs/yr	lbs/yr	
CROPLAND	420	462	721	36%
HAY/PASTURE	1,047	307	479	36%
STREAMBANK		27	42	36%
FARM ANIMALS		477	744	36%
AGGREGATE		1,272	1,987	36%

Calculation of Daily Maximum “$TMDL_{Max}$” Values

When choosing the best timescale for expressing pollutant loading limits for siltation and phosphorus, several factors must be considered:

1) Sediment and nonpoint-source phosphorus loading is driven by storm events, and loads vary greatly even under natural conditions.
2) Siltation pollution typically harms aquatic communities through habitat degradation as a result of chronically excessive loading.

3) Nonpoint-source phosphorus pollution typically harms aquatic communities through eutrophication degradation as a result of chronically excessive loading.

Considering then that siltation and nonpoint-source phosphorus pollution has more to do with chronic degradation rather than acutely toxic loads/concentrations, pollution reduction goals based on average annual conditions are much more relevant than daily maximum values. Nevertheless, true "Total Maximum Daily Loads" ($TMDL_{Max}$) are also calculated in the following.

Model My Watershed currently does not report daily loading rates, but its predecessor program, "MapShed" does. Thus, for the calculation of $TMDL_{Max}$ values, modelling was initially conducted in Model My Watershed, and the "Export GMS" feature was used to provide input data files that were run in MapShed. The daily output was opened in Microsoft Excel (Version 1902), and current maximum daily loads were calculated as the 99^{th} percentiles (using the percentile.exc function) of estimated daily sediment and phosphorus loads in both the Pleasant Valley Run (impaired) and Tonoloway Creek (reference) watersheds. The first years of data were excluded to account for the time it takes for the model calculations to become reliable. 99^{th} percentiles were chosen because 1) sediment and phosphorus loading increases with the size of storm events, so, as long as there could be an even larger flood, true upper limits to loading cannot be defined and 2) 99% of the time attainment of water quality criteria is prescribed for other types of pollutants per PA regulations (see PA Code Title 25, Chapter 96, Section 96.3(e)).

As with the average loading values reported previously (see the Hydrologic / Water Quality Modelling section), a correction was made for the additional amount of existing riparian buffers in the reference watershed versus the impaired watershed. This was calculated simply by reducing the 99^{th} percentile loading rates for the reference watershed by the same reduction percentages that were calculated previously for the average loading rates.

Then, similarly to the $TMDL_{Avg}$ values reported in Table 9, $TMDL_{Max}$ values were calculated as the 99^{th} percentile daily loads of the reference watershed, divided by the acres of the reference watershed, and then multiplied by the acres of the impaired watershed. The $TMDL_{Max}$ loading rate for sediment was calculated as 14,245 pounds per day (Table 13), which would be a 49% reduction from the Pleasant Valley Run Watershed's current 99^{th} percentile daily loading rate of 27,969 pounds per day. For phosphorus, the $TMDL_{Max}$ loading rate was calculated as 87 pounds per day (Table 13), which would be a 6% reduction from the Pleasant Valley Run Watershed's current 99^{th} percentile daily loading rate of 93 pounds per day.

Table 13. Calculation of $TMDL_{Max}$ Values for the Pleasant Valley Run Watershed

Pollutant	99^{th} Percentile Loading Rate in Reference, lbs/ac/d	Total Land Area in Impaired Watershed, ac	Target $TMDL_{Max}$ Value, lbs/d
Sediment	2.7	5,363	14,245
Phosphorus	0.016	5,363	87

Also, in accordance with the previous "Calculation of Load Allocations" section, the WLA_{Max} would consist solely of a bulk reserve defined as 1% of the $TMDL_{Max}$ and the MOS_{Max} would be 10% of the $TMDL_{Max}$. The LA_{Max} would then be calculated as the amount remaining after subtracting the WLA_{Max} and the MOS_{Max} from the $TMDL_{Max}$. See Table 14 for a summary of these $TMDL_{Max}$ variables.

Table 14. 99th Percentile of Daily Loading TMDL ($TMDL_{Max}$) Variables for the Pleasant Valley Run Watershed

lbs/d:				
Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}
Sediment	14,245	1,425	142	12,678
Phosphorus	87	9	1	78

The modelling program however did not break down daily loads by land use type. Thus, the daily maximum load allocation variables were calculated assuming the same distribution as occurred for the annual average load allocation variables. For instance, if the streambanks allocation was 17% of LA_{Avg} it was assumed that it was also 17% of LA_{Max}. While the distribution of sources likely changes with varying flow levels, this might be an acceptable assumption considering that the largest flow events may control the bulk of annual sediment loading (see Sloto et al. 2012). See Tables 15 and 16 for a summary of these LA_{Max} variables.

Table 15. Allocation of the 99th Percentile Daily Sediment Load Allocation (LA_{Max}) for the Pleasant Valley Run Watershed

	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	537,797		12,678
Loads Not Reduced	16,426	0.03	387
Adjusted Loads Allocation	521,370	0.97	12,291
Croplands	303,583	0.56	7,157
Hay/Pasturelands	124,170	0.23	2,927
Streambanks	93,617	0.17	2,207

Because the modelling program did not break down daily loadings by land use types, the load allocations for $TMDL_{Max}$ were calculated by assuming the same distribution as occurred for the LA_{Avg} variables. For instance, if the streambanks allocation was 17% of LA_{Avg} it was assumed that it was also 17% of LA_{Max}.

Table 16. Allocation of the 99th Percentile Daily Phosphorus Load Allocation (LA_{Max}) for the Pleasant Valley Run Watershed			
	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	1,686		78
Loads Not Reduced	414	0.25	19
Adjusted Loads Allocation	1,272	0.75	59
Croplands	721	0.27	21
Hay/Pasturelands	479	0.18	14
Streambanks	42	0.02	1
Farm Animals	744	0.28	22

Because the modelling program did not break down daily loadings by land use types, the load allocations for $TMDL_{Max}$ were calculated by assuming the same distribution as occurred for the LA_{Avg} variables. For instance, if the streambanks allocation was 2% of LA_{Avg} it was assumed that it was also 2% of LA_{Max}.

Because both sediment and phosphorus loading vary so greatly with discharge, the $TMDL_{Max}$ values would probably only be relevant on a handful of days each year with the highest flow conditions. And, while these times are especially important to overall annual sediment and nutrient loading (see-Sloto and Olson 2011, Sloto et al. 2012), it is cautioned that reliance solely on a $TMDL_{Max}$ values may not be protective because chronic excessive inputs occurring at lower discharge levels may be ignored. Take for instance an extreme scenario where the $TMDL_{Max}$ value for sediment was met every day but never exceeded. In this case, annual sediment loading in the Pleasant Valley Run Watershed would skyrocket to 5,199,491 lbs/yr, which is more than five-times the current annual average. The $TMDL_{Avg}$ value on the other hand is sensitive to typical conditions, extreme events, and long-term effects, and thus is the most relevant of the two TMDL targets for achieving restoration in the Pleasant Valley Run Watershed. Therefore, while adherence with the loading requirements of this TMDL include meeting both the $TMDL_{Avg}$ and the $TMDL_{Max}$, BMP implementation would ultimately be deemed adequate if the prescribed annual average reductions were satisfied.

Consideration of Critical Conditions and Seasonal Variations

Model My Watershed" uses a continuous simulation model with daily time steps for weather data and water balance (precipitation, stream flow, surface runoff, subsurface flow, and evapotranspiration) calculations. The source of the weather data (precipitation and temperature) was a dataset compiled by USEPA ranging from 1963-1990. The evapotranspiration calculations also take into account the length of the growing season and changing day length. Monthly calculations are made for loads, based on daily water balance accumulated in monthly values. Therefore, variable flow conditions and seasonal changes are inherently accounted for in the loading calculations. Furthermore, this document calculates both annual average and 99th percentile daily "TMDL" values. See the discussion on the relevance of these values in the previous section. Seeking to attain both values will be protective under both long-term average and extreme flow event conditions.

Summary and Recommendations

This document proposes a 34% reduction in annual average sediment loading and 21% reduction in annual average phosphorus loading for the Pleasant Valley Run Watershed. To achieve these goals while maintaining margins of safety and minor allowances for point sources, it is proposed to reduce sediment loading from croplands, hay/pasture lands and streambanks by 42%. Annual average Phosphorus loading from croplands, hay/pasture lands, farm animals and streambanks should be reduced by 36% each. In addition, 99^{th} percentile daily sediment and phosphorus loading should be reduced by 49% and 6%, respectively.

Reductions in stream sediment and nutrient loading due to agricultural activities can be made through the implementation of required Erosion and Sediment Control and Nutrient Management Plans (Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Chapter 102.4) and through the use of BMPs such as conservation tillage, cover crops, vegetated filter strips, rotational grazing, livestock exclusion fencing, riparian buffers, legacy sediment removal etc.

Use of forested riparian buffers is widely recognized as one of the best ways to promote stream health. Riparian buffers protect streams from sedimentation and nutrient impairments by filtering these pollutants from runoff and floodwaters and by protecting streambanks from erosion. However, riparian buffers are also beneficial for many other reasons beyond just protecting from sedimentation and nutrients. For instance, riparian buffers may: filter out other pollutants such as pesticides; provide habitat and nutrition for aquatic, semi-aquatic and terrestrial organisms; and moderate stream temperature. Thus, use of forested riparian buffers should be encouraged wherever possible.

Development of a more detailed watershed implementation plan is recommended. Further ground truthing should be performed to assess both the extent of existing BMPs and to determine the most cost effective and environmentally protective combination of new BMPs needed to achieve the prescribed sediment and phosphorus reductions. Key personnel from the regional DEP office, the County Conservation District, and other state and local agencies and/or watershed groups should be involved in developing a restoration strategy. There are a number of possible funding sources for agricultural BMPs and stream restoration projects, including: The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act), PA DEP's Growing Greener Grant Program, United States Department of Agriculture's Natural Resource Conservation Service funding, and National Fish and Wildlife Foundation Grants.

Public Participation

Public notice of a draft of this TMDL was published in the Pennsylvania Bulletin on April 25th to foster public comment. A 30-day period was provided for the submittal of comments. No public comments were received.

Citations

Note: maps for this document were originally made with either:
ArcMap version 10.4.1 by Esri.
ArcGIS Pro 2.2.0 by Esri.

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Appendix A: Background on Stream Assessment Methodology

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

Assessment Methods:

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be listed in the Integrated Water Quality Monitoring and Assessment Report. Prior to 2004 the impaired waters were found on the 303(d) List; from 2004 to present, the 303(d) List was incorporated into the Integrated Water Quality Monitoring and Assessment Report and found on List 5. Table A1. summarizes the changes to listing documents and assessment methods over time.

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

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

The listings found in the Integrated Water Quality Monitoring and Assessment Reports from 2008 to present were derived based on the Instream Comprehensive Evaluation protocol (ICE). Like the superseded SSWAP protocol, the ICE protocol called for selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist was to select as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. The biological surveys were to include D-frame kicknet sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples were returned to the laboratory where the samples were subsampled for a target benthic macroinvertebrate sample of 200 ± 20% (N = 160-240). The benthic macroinvertebrates in this subsample were then typically identified to the generic level. The ICE protocol is a modification of the

EPA Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP.

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

Once a stream segment is listed as impaired, a TMDL typically must be developed for it. A TMDL addresses only one pollutant. If a stream segment is impaired by multiple pollutants, each pollutant receives a separate and specific TMDL within that stream segment. Adjoining stream segments with the same source and cause listings are addressed collectively on a watershed basis.

Table A1. Impairment Documentation and Assessment Chronology

Listing Date:	Listing Document:	Assessment Method:
1998	303(d) List	SSWAP
2002	303(d) List	SSWAP
2004	Integrated List	SSWAP
2006	Integrated List	SSWAP
2008-Present	Integrated List	ICE

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

Justification of Mapping Changes to 303(d) Lists 1998 to Present

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996-2002 303(d) Lists and the 2004 to present Integrated Water Quality Monitoring and Assessment Reports. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

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

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

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

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

Migration to National Hydrography Data (NHD)

New to the 2006 report is use of the 1/24,000 National Hydrography Data (NHD) streams GIS layer. Up until 2006 the Department relied upon its own internally developed stream layer. Subsequently, the United States Geologic Survey (USGS) developed 1/24,000 NHD streams layer for the Commonwealth based upon national geodatabase standards. In 2005, DEP contracted with USGS to add missing streams and correct errors in the NHD. A GIS contractor transferred the old DEP stream assessment information to the improved NHD and the old DEP streams layer was archived. Overall, this marked an improvement in the quality of the streams layer and made the stream assessment data compatible with national standards but it necessitated a change in the Integrated Listing format. The NHD is not attributed with the old DEP five-digit stream codes so segments can no longer be listed by stream code but rather only by stream name or a fixed combination of NHD fields known as reachcode and ComID. The NHD is aggregated by Hydrologic Unit Code (HUC) watersheds so HUCs rather than the old State Water Plan (SWP) watersheds are now used to group streams together. A more basic change was the shift in data management philosophy from one of “dynamic segmentation” to “fixed segments”. The dynamic segmentation records were proving too difficult to manage from an historical tracking perspective. The fixed segment methods will remedy that problem. The stream assessment data management has gone through many changes over the years as system requirements and software changed. It is hoped that with the shift to the NHD and OIT's (Office of Information Technology) fulltime staff to manage and maintain SLIMS the systems and formats will now remain stable over many Integrated Listing cycles.

Appendix B: Model My Watershed Generated Data Tables

Type	NLCD Code	Area (km^2)	Coverage (%)
Open Water	11	0	0
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	0.51	2.3
Developed, Low Intensity	22	0.07	0.3
Developed, Medium Intensity	23	0.01	0
Developed, High Intensity	24	0	0
Barren Land (Rock/Sand/Clay)	31	0	0
Deciduous Forest	41	14.1	65
Evergreen Forest	42	0.42	1.9
Mixed Forest	43	0.65	3
Shrub/Scrub	52	0	0
Grassland/Herbaceous	71	0.02	0.1
Pasture/Hay	81	4.24	19.5
Cultivated Crops	82	1.7	7.8
Woody Wetlands	90	0	0
Emergent Herbaceous Wetlands	95	0	0

Table B1. "Model My Watershed" Land Cover Outputs for the Pleasant Valley Run Watershed.

Type	NLCD Code	Area (km^2)	Coverage (%)
Open Water	11	0	0
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	0.93	4.5
Developed, Low Intensity	22	0.08	0.4
Developed, Medium Intensity	23	0	0
Developed, High Intensity	24	0	0
Barren Land (Rock/Sand/Clay)	31	0	0
Deciduous Forest	41	14.51	69.9
Evergreen Forest	42	0.99	4.8
Mixed Forest	43	0.2	1
Shrub/Scrub	52	0	0
Grassland/Herbaceous	71	0	0
Pasture/Hay	81	3.77	18.2
Cultivated Crops	82	0.25	1.2
Woody Wetlands	90	0	0
Emergent Herbaceous Wetlands	95	0	0

Table B2. "Model My Watershed" Land Cover Outputs for the Tonoloway Creek Subwatershed.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	5.48	0.44	5.03	0	0.5	6.99
Feb	6.18	0.44	5.74	0	0.76	7.05
Mar	6.52	0.19	6.33	0	2.33	8.11
Apr	5.35	0.03	5.32	0	5.32	7.97
May	3.44	0.13	3.3	0	9.9	10.69
Jun	2.49	0.67	1.82	0	12.61	9.93
Jul	0.82	0.15	0.67	0	10.5	9
Aug	0.27	0.14	0.13	0	8.92	9.19
Sep	0.72	0.48	0.24	0	6.02	8.94
Oct	1.28	0.35	0.93	0	3.93	7.94
Nov	1.58	0.19	1.39	0	2.1	8.57
Dec	4.36	0.34	4.02	0	0.99	8.2
Total	38.49	3.55	34.92	0	63.88	102.58

Table B3. "Model My Watershed" Hydrology Outputs for the Pleasant Valley Run Watershed

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	5.62	0.48	5.13	0	0.51	6.99
Feb	6.22	0.47	5.74	0	0.78	7.05
Mar	6.47	0.18	6.29	0	2.4	8.11
Apr	5.28	0.02	5.26	0	5.38	7.97
May	3.36	0.13	3.24	0	9.93	10.69
Jun	2.49	0.74	1.75	0	12.24	9.93
Jul	0.76	0.15	0.61	0	10.09	9
Aug	0.28	0.15	0.12	0	8.85	9.19
Sep	0.8	0.52	0.29	0	6	8.94
Oct	1.37	0.37	1	0	3.95	7.94
Nov	1.76	0.19	1.57	0	2.13	8.57
Dec	4.69	0.37	4.32	0	1.01	8.2
Total	39.1	3.77	35.32	0	63.27	102.58

Table B4. "Model My Watershed" Hydrology Outputs for the Tonoloway Creek Subwatershed

Sources	Sediment (kg)	Total P (kg)
Hay/Pasture	96,711.40	217.3
Cropland	236,651.40	327.2
Wooded Areas	6,600.50	9.3
Wetlands	0	0
Open Land	103.3	0.1
Barren Areas	0	0
Low-Density Mixed	82.7	0.2
Medium-Density Mixed	64.2	0.1
High-Density Mixed	0	0
Low-Density Open Space	598.9	1.4
Farm Animals	0	337.6
Stream Bank Erosion	72,915.00	19
Subsurface Flow	0	176.7
Point Sources	0	0
Septic Systems	0	0

Table B5. Model My Watershed outputs for sediment and phosphorus in the Pleasant Valley Run Watershed.

Sources	Sediment (kg)	Total P (kg)
Hay/Pasture	184,937.30	252.9
Cropland	32,894.20	38.9
Wooded Areas	5,631.50	9
Wetlands	0	0
Open Land	0	0
Barren Areas	0	0
Low-Density Mixed	87.4	0.2
Medium-Density Mixed	7.6	0
High-Density Mixed	0	0
Low-Density Open Space	1,078.80	2.5
Farm Animals	0	397.4
Stream Bank Erosion	98,522.00	22
Subsurface Flow	0	151.1
Point Sources	0	0
Septic Systems	0	0

Table B6. Model My Watershed outputs for sediment and phosphorus in the Tonoloway Creek Subwatershed.

Appendix C: Stream Segments in the Pleasant Valley Run Watershed with Aquatic Life Impairments

Stream Name:	Impairment Source:	Impairment Cause:	Date Listed:	COMID:	Miles:
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65846287	0.49
Pleasant Valley Run	Agriculture	Siltation	1998	65846317	0.39
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845943	0.35
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845941	0.93
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845797	0.62
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845795	0.64
Pleasant Valley Run	Agriculture	Siltation	1998	65845615	0.02
Pleasant Valley Run	Agriculture	Nutrients	1998	65846095	1.32
Pleasant Valley Run	Agriculture	Nutrients	1998	65845813	0.14
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845787	0.75
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65846087	0.43
Pleasant Valley Run	Agriculture	Siltation	1998	65846095	1.32
Pleasant Valley Run	Agriculture	Siltation	1998	65845651	0.08
Pleasant Valley Run	Agriculture	Nutrients	1998	65846379	0.65
Unnamed Tributary to Pleasant Valley Run	Agriculture	Nutrients	1998	65846435	0.57
Pleasant Valley Run	Agriculture	Nutrients	1998	65845847	0.13
Pleasant Valley Run	Agriculture	Siltation	1998	65845813	0.14
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845865	0.51
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845731	1.06
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845625	0.53
Pleasant Valley Run	Agriculture	Siltation	1998	65846175	0.28
Pleasant Valley Run	Agriculture	Nutrients	1998	65846317	0.39
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65846173	0.48
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845839	0.07
Unnamed Tributary to Pleasant Valley Run	Crop Related Agric	Siltation	2004	65845837	0.81
Pleasant Valley Run	Agriculture	Siltation	1998	65845765	0.34
Pleasant Valley Run	Agriculture	Nutrients	1998	65845651	0.08
Pleasant Valley Run	Agriculture	Siltation	1998	65846379	0.65
Unnamed Tributary to Pleasant Valley Run	Agriculture	Siltation	1998	65846435	0.57
Pleasant Valley Run	Agriculture	Siltation	1998	65845847	0.13
Pleasant Valley Run	Agriculture	Nutrients	1998	65845615	0.02
Pleasant Valley Run	Agriculture	Nutrients	1998	65846175	0.28
Pleasant Valley Run	Agriculture	Siltation	1998	65846241	0.18
Pleasant Valley Run	Agriculture	Nutrients	1998	65846241	0.18
Pleasant Valley Run	Agriculture	Nutrients	1998	65845765	0.34
Pleasant Valley Run	Agriculture	Siltation	1998	65845607	0.70
Pleasant Valley Run	Agriculture	Nutrients	1998	65845607	0.70

Table C1. Stream segments with aquatic life impairments in the Pleasant Valley Run Watershed.

Appendix D: Equal Marginal Percent Reduction Method

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

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

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

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

Step 3: Actual EMPR Process:

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

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

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

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

	Non-MS4 Sewershed Current Load, lbs/yr	Any > ALA?	If > ALA, reduce to ALA	How much does sum exceed ALA?	Proportions of total after initial adjust	Assign reductions still needed per proportions after intial adjust	ALA: subtract reductions still needed from initial adjust	proportion Reduction
Cropland	521,816	yes	521,370		0.58	217,787	303,583	0.42
Hay/Pasture	213,249	no	213,249	374,026	0.24	89,079	124,170	0.42
Streambank	160,778	no	160,778		0.18	67,160	93,617	0.42
sum	**895,843**		**895,396**		**1.00**	**374,026**	**521,370**	**0.42**

Table D1. Sediment Equal Marginal Percent Reduction calculations for the Pleasant Valley Run Watershed.

	Non-MS4 Sewershed Current Load, lbs/yr	Any > ALA?	If > ALA, reduce to ALA	How much does sum exceed ALA?	Proportions of total after initial adjust	Assign reductions still needed per proportions after intial adjust	ALA: subtract reductions still needed from initial adjust	proportion Reduction
Cropland	721	no	721		0.36	260	462	0.36
Hay/Pasture	479	no	479	715	0.24	172	307	0.36
Streambank	42	no	42		0.02	15	27	0.36
Farm Animal	744	no	744		0.37	268	477	0.36
sum	**1,987**		**1,987**		**1.00**	**715**	**1,272**	**0.36**

Table D2. Phosphorus Equal Marginal Percent Reduction calculations for the Pleasant Valley Run Watershed.

Appendix E: Legal Basis for the TMDL and Water Quality Regulations for Agricultural Operations

Clean Water Act Requirements

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

Additionally, the federal Clean Water Act and the United States Environmental Protection Agency’s (EPA) implementing regulations (40 CFR 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);
- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;
- States to submit the list of waters to EPA every two years (April 1 of the even numbered years);
- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- EPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Pennsylvania Clean Streams Law Requirements, Agricultural Operations

Pennsylvania farms are required by law to operate within regulatory compliance by implementing the applicable requirements outlined in the Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Part I Department of Environmental Protection, Subpart C Protection of Natural Resources, Article II Water Resources, Chapters: § 91.36 Pollution control and prevention at agricultural operations, § 92a.29 CAFO and § 102.4 Erosion and sediment control requirements. Water quality regulations can be found at following website: http://www.pacode.com/secure/data/025/025toc.html

Agricultural regulations are designed to reduce the amount of sediment and nutrients reaching the streams and ground water in a watershed.

Appendix F: Comment and Response

No public comments were received.