Upper Conewago Creek TMDL

Adams County, Pennsylvania

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

A Total Maximum Daily Load (TMDL) for sediment was developed for the Upper Conewago Impaired Subwatershed (Figures 1 and 2) to address the siltation impairments noted in the 2016 Final Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated Report), including the Clean Water Act Section 303(d) List. Agriculture has been identified as the cause of these impairments. Because Pennsylvania does not have numeric water quality criteria for sediment, the loading rate from a similar unimpaired subwatershed was used to calculate the TMDL.

Existing sediment loading in the Upper Conewago Impaired Subwatershed is estimated to be 5,766,550 pounds per year or 15,799 pounds per day. To meet water quality objectives, sediment loading should be reduced by 32% to 3,904,307 pounds per year or 10,697 pounds per day. Allocation of sediment loading among the TMDL variables is summarized in Table 1. To achieve this reduction, while maintaining a 10% margin of safety and minor allowance for point sources, loading from croplands should be reduced by 42%, while loading from hay/pasture lands and streambanks should each be reduced by 36%.

Table 1. Summary of TMDL for the Upper Conewago Impaired Subwatershed

lbs/yr:						
Pollutant	TMDL	MOS	WLA	LA	LNR	ALA
Sediment	3,904,307	390,431	72,623	3,441,253	28,676	3,412,577
lbs/d:						
Pollutant	TMDL	MOS	WLA	LA	LNR	ALA
Sediment	10,697	1,070	199	9,428	79	9,350

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.

Introduction

Conewago Creek originates within South Mountain near the western border of Adams County and then flows northeast through the Gettysburg Newark Section of the Piedmont Province. It ultimately discharges to the Susquehanna River at the Borough of York Haven in York County. This TMDL addresses a small portion of the Upper Conewago watershed in Adams County; the area just east of South Mountain, between Arendtsville and the confluence of Opossum Creek (Figures 1 and 2). This area, henceforth referred to as the "Upper Conewago Impaired Subwatershed" is approximately 15 square miles and includes a cluster of small tributary systems that are impaired for siltation per the 2016 Final Integrated Report. This area contains approximately 43 stream miles, with the mainstem designated for Cold Water Fishes (CWF) and the tributaries designated for Warm Water Fishes (WWF) per PA Code 25 § 93.9n (Table 2). All of these stream segments have been designated for Migratory Fishes (MF) as well. Given that the overall Conewago watershed exceeds 500 square miles, truncating the study watershed in this way allows for the selection of a nearby reference watershed that is of similar size. It also allows for better consideration of local land use practices that may be contributing to the impairments noted in this specific region. Since the mainstem is not impaired, upstream inputs to the impaired subwatershed were irrelevant, and the TMDL calculations are only applicable to loading within the study area.

Agriculture was identified as the source of the siltation 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. While Pennsylvania does not have numeric water quality criteria for sediment, 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 is cited as the source of these impairments, this TMDL document is applicable to all significant sources of solids that may settle to form deposits.

According to the "Model My Watershed" application, land use in the Upper Conewago Impaired Subwatershed is estimated to be 21% forest/naturally vegetated lands, 66% agriculture, and 12% mixed development. The agricultural lands were classified as approximately 37% croplands and 29% hay/pasture (Appendix B, Table B1). The areas north and west of Biglerville are within the "Adams County Fruitbelt". Pennsylvania is the fourth largest apple producer in the nation (TCG 2018), and its greatest concentration of orchards occurs within a four to six-mile-wide, approximately 25 miles long swath within Adams County (PHMC 2015). This area, running along the eastern border of South Mountain and the Triassic foothills of the Gettysburg Newark Section of the Piedmont Province, has a microclimate, topography and soils that are particularly suited to apple production (Growing Magazine 2010). Based on a visual inspection of the satellite imagery provided in the Model My Watershed Application, the National Land Cover Database tended to classify the orchard land as hay/pasture lands. This may be appropriate for modelling sediment loading, as orchard tree rows were separated by mowed strips, and weed control beneath the trees was accomplished using herbicides rather than tilling (Figure 3). The permit for Biglersville's wastewater treatment plant was the only NPDES permitted point source discharge in the study subwatershed with limits relevant to sedimentation (total suspended solids) (Table 3, Figure 4).

Stream segments within the study area have also been identified as recreationally impaired for pathogens from unknown sources (Table 2), however this document only addresses sedimentation.

Table 2. Impaired stream segments in the Upper Conewago Impaired Subwatershed per the 2016 Final Pennsylvania Integrated Report

HUC: 02050306 – Conewago Creek				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Agriculture	Siltation	35	WWF, MF	Aquatic Life
Unknown	Pathogens	42	CWF, WWF, MF	Recreational

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

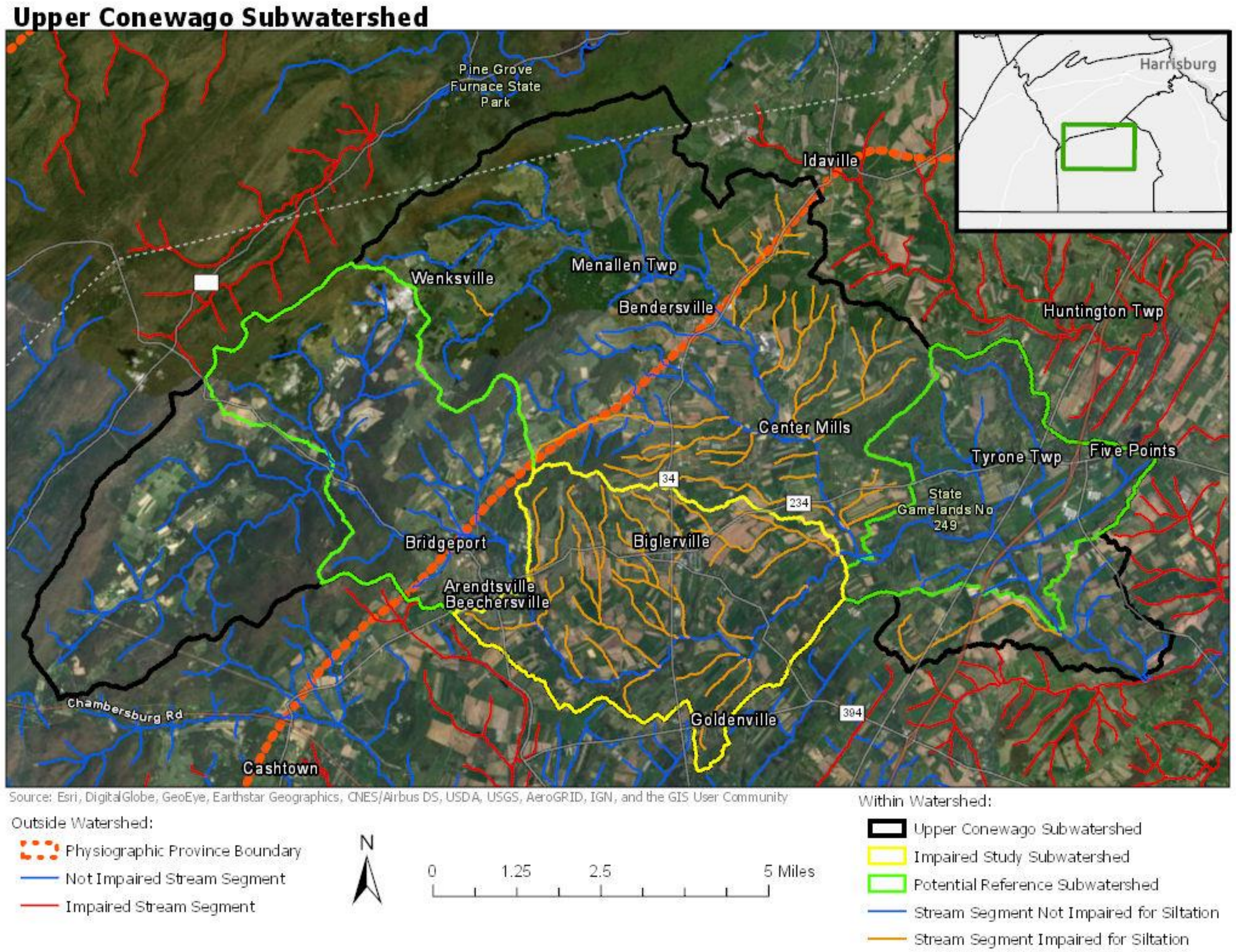

Figure 1. Upper Conewago Watershed delineated upstream of Beaverdam Creek. The watershed is further divided into the impaired subwatershed, outlined in yellow, and the two potential reference watersheds, outlined in green. The Upper Conewago Watershed originates in the South Mountain Section of the Blue Ridge Province and then flows into the Gettysburg-Newark Lowland Section of the Piedmont Province. Within the watersheds, stream segments are either shown as impaired for siltation or not impaired for siltation. Outside the watershed, streams are shown as impaired for any reason or not impaired. Stream assessments correspond to the approved 2016 Integrated Report.

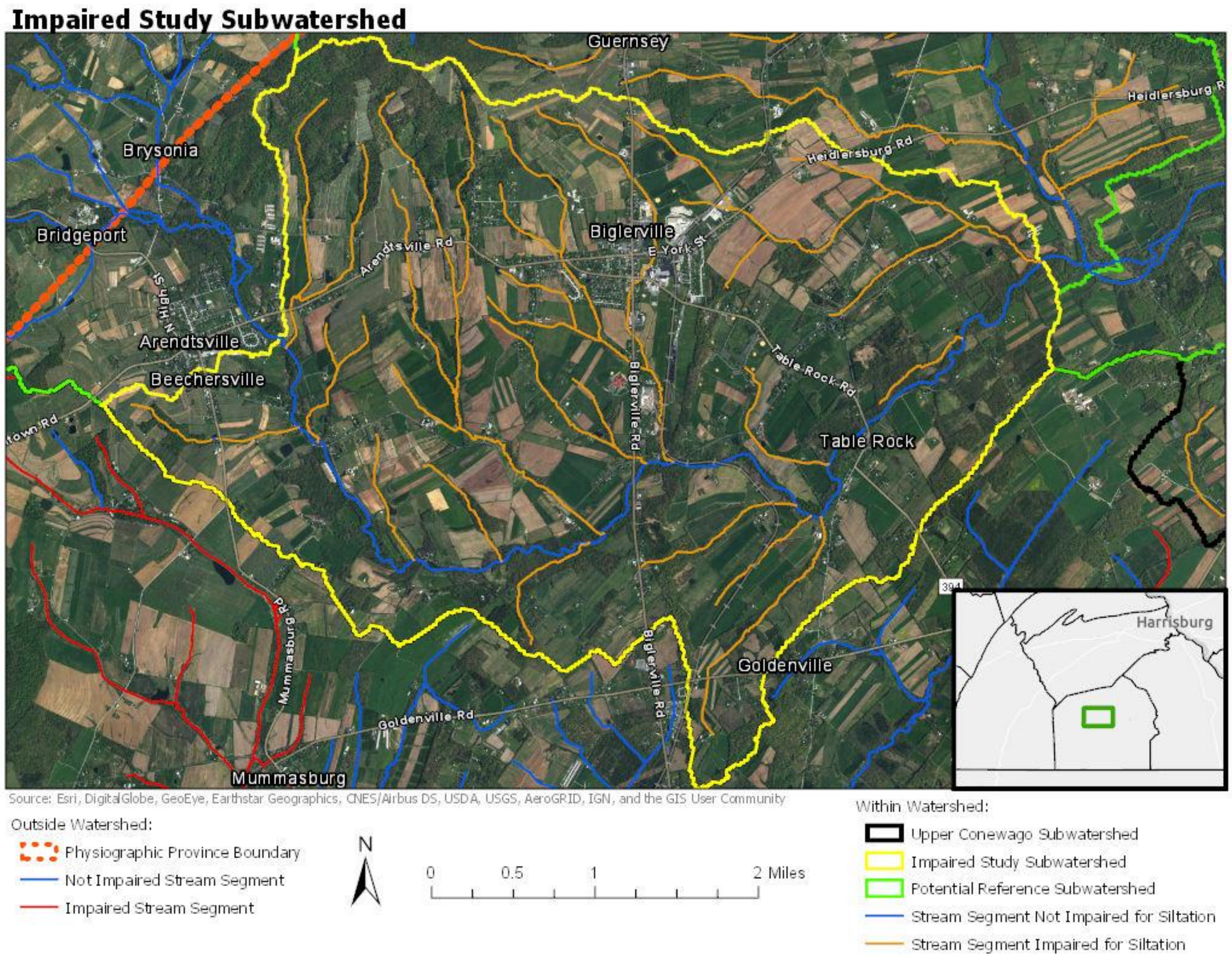

Figure 2. Closeup of the Upper Conewago Impaired Subwatershed. Within the watershed, stream segments are either shown as impaired for sediment or not impaired for sediment. Outside the watershed, streams are shown as impaired for any reason or not impaired. Stream assessments correspond to the approved 2016 Integrated Report.

Table 3. NPDES Permitted Discharges in the Upper Conewago Creek Impaired Subwatershed.

Permit No.	Facility Name	Load, lb/yr	Load, lb/day
PA0022250	Biglerville STP[1]	33,580	92
PAG123622	Heckenluber Poultry Farm[2]	NA	NA
PAG123847	Wetzel Poultry Farm[2]	NA	NA
PAG053555	PSU Fruit Research Farm Ext.	Terminated	Terminated
PAR143501	Temple Inland Biglerville MFG[3]	NA	NA
PAG033541	Knouse Foods Coop Inc/Biglerville[3]	NA	NA

-[1]Their permit issued April 18, 2014 includes a 92 lbs/d monthly average total suspended solids effluent limit.

NA – Not applicable. The NPDES permit did not include numerical effluent limitations relevant to sediment loading.

[2] In Pennsylvania, routine, dry-weather discharges from concentrated animal feeding operations (CAFOs) are not allowed. Wet weather discharges are controlled through best management practices, which result in infrequent discharges from production areas and reduced sediment loadings from lands under the control of CAFOs owner or operators, such as croplands where manure is applied. Although not quantified in this table, sediment loadings from CAFOs is accounted for in the modeling of land uses, with the assumption of no additional CAFO-related BMPs.

[3]Permits for industrial stormwater facilities. Note sediment loading associated with development is accounted for in Model My Watershed.

Figure 3. Orchard land in the Adams County Fruit Belt. The orchards typically occur on the rolling foothills at the base of South Mountain. Note the strips of mowed grass between tree rows. This photograph was taken outside of the study watershed.

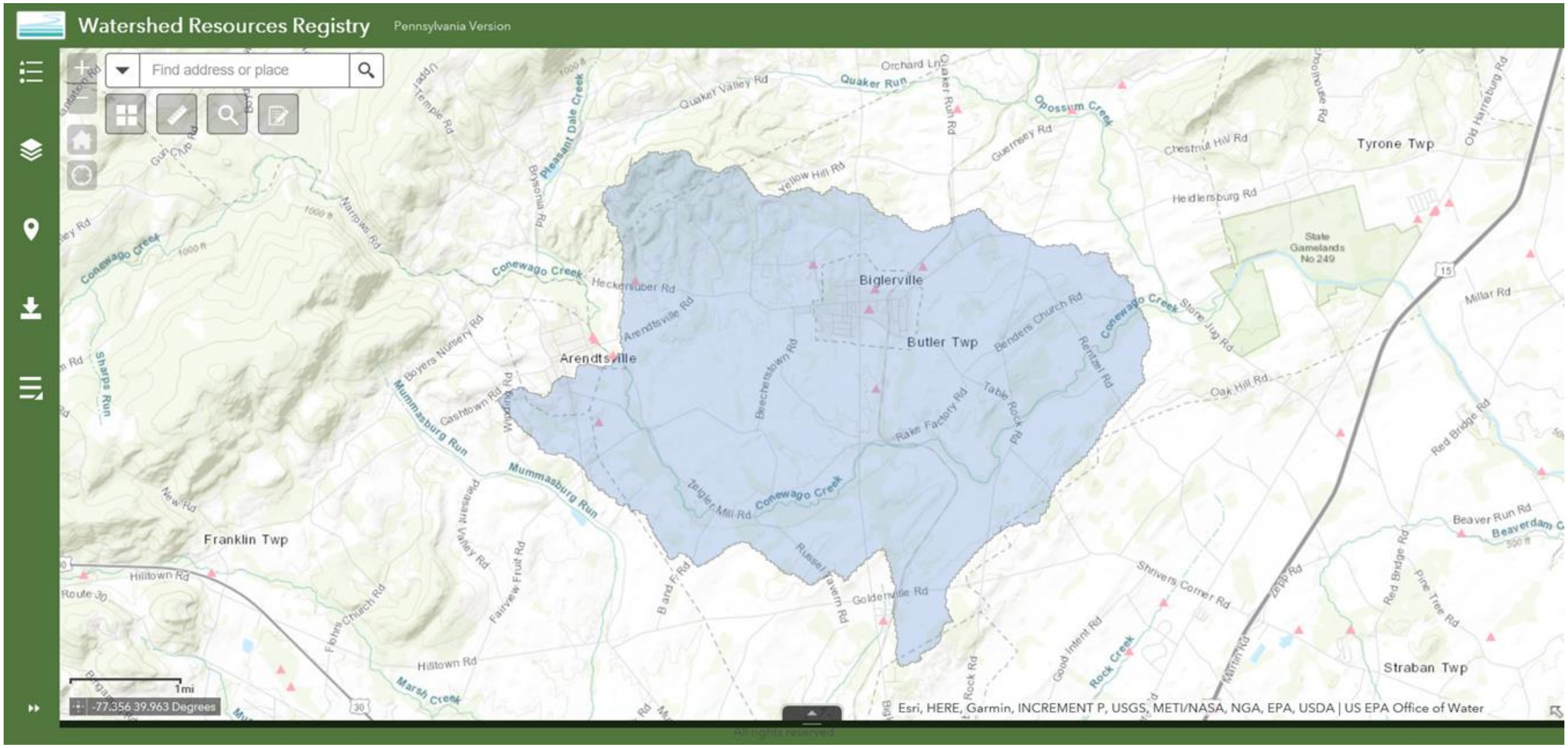

Figure 4. Permitted discharges in the Upper Conewago Impaired Subwatershed. The discharges are indicated by pink triangles, and the subwatershed is shown in blue. This Figure was created in EPA's Watershed Resource Registry for Pennsylvania, available at: https://watershedresourcesregistry.org/states/pennsylvania.html

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, the “Reference Watershed Approach” was used. This method estimates sediment loading rates in both the impaired watershed as well as a similar watershed that is not impaired for sediment. Then, the loading rate in the unimpaired watershed is 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 loading rates. Thus, selection of a reference watershed with similar natural characteristics to the impaired watershed is crucial. Failure to use an appropriate reference watershed could result in problems such as the setting of sediment reduction goals that are unattainable, or nonsensical TMDL calculations that suggest that sediment loading in the impaired watershed should be increased.

To determine the suitability of the reference site, the Department’s Integrated Report GIS-based website (available at http://www.depgis.state.pa.us/integrated_report/index.html) was used to search for potential watersheds that were of similar size as the Upper Conewago Impaired Subwatershed, but lacked stream segments listed as impaired for sediment. It was required that the reference watershed be +/-30% of the impaired watershed’s area. Model My Watershed, DEP’s internal GIS databases, and various other GIS based applications were used to consider factors such as the physiographic province, land cover/use, geology, soil drainage and slope. The suitability of the chosen watershed was also confirmed through discussions with Department staff as well as through field verification of conditions.

Because the Adams County Fruit Belt has an atypical agricultural use that is attributable to its unique geology, topography, and microclimate, we searched for a reference watershed that was as close as possible to the study watershed. Excluding the unimpaired upper watershed was necessary, because if included, the study area would be so large (42 square miles) that all potential nearby reference subwatersheds would be too small for consideration (see Figure 1). The Little Marsh Creek Watershed was an obvious candidate for the reference as it occurred only about 5 miles to the southwest as the study watershed. However, it was ultimately rejected because preliminary calculation of the prescribed sediment reduction was so small (approximately 12%), that we had little confidence that this reduction would lead to reversal of the impairments. Furthermore, this potential reference contained several stream segments listed as impaired for siltation.

Because there were no other separate reference watershed candidates in the area, we considered the use of a reference subwatershed that was also within the larger Conewago Watershed. Interestingly, there were clusters of attaining tributaries both directly upstream and downstream of the impaired study watershed (Figure 1). It is clear from Table 4 that the downstream potential reference was much more similar to the study watershed than the upstream potential reference. Thus, the downstream reference was chosen for further evaluation.

Table 4. Comparison of the Upper Conewago Creek Impaired Subwatershed and Downstream Reference

	Impaired Subwatershed	Downstream Reference	Upstream Reference
Phys. Province	100% Gettysburg-Newark Lowland	100% Gettysburg-Newark Lowland	86% South Mountain 15% Gettysburg-Newark Lowland
Area, ac	9,383	6,657	8,911
Land Use	66% Agriculture 21% Forest/Natural Vegetation 13% Other	48% Agriculture 42% Forest/Natural Vegetation 10% Other	33% Agriculture 58% Forest/Natural Vegetation 10% Other
Soil Infiltration	17% Group A 20% Group B 0% Group B/D 14% Group C 16% Group C/D 33% Group D	<1% Group A 16% Group B <1% Group B/D 20% Group C 36% Group C/D 28% Group D	17% Group A 64% Group B 3% Group B/D 6% Group C 9% Group C/D 3% Group D
Dominant Bedrock	49% Silty Mudstone 30% Shale 21% Quartz Conglomerate	52% Shale 25% Silty Mudstone 23% Diabase	65% Metabasalt 9% Greenstone Schist 8% Quartzite 8% Quartz Conglomerate

			6% Silty Mudstone 4% Diabase
Average Precipitation, in/yr	40.6	40.6	40.4
Average Surface Runoff, in/yr	3.63	3.9	1.73
Average Elevation (ft)	658	595	1,059
Average Slope	4.4%	4.6%	12%

Based on the summaries of landcover reported by the "Model My Watershed" application, the impaired study subwatershed had higher agricultural coverage (66%) than the downstream reference subwatershed (48%). In the downstream reference, the percent coverage of hay/pasture and croplands were approximately equal, 24% each, whereas the impaired subwatershed had a greater percent coverage of croplands (37%) than hay/pasture lands (29%) (see Appendix B, Tables B1 and B2). Both the impaired and downstream reference subwatersheds were dominated by non-carbonate sedimentary bedrock, and the average slope in both subwatersheds was nearly identical (4.4% versus 4.6%). Like the study subwatershed, the tributary stream segments within the downstream reference were designated for warm water fishes.

The permit for Tyrone Township's sewage treatment plant at the Walnut Grove Mobile Home Park was the only NPDES permitted point source discharge in the reference subwatershed with limits relevant to sedimentation (total suspended solids) (Table 5, Figure 6).

Table 5. NPDES Permitted Discharges in the Downstream Reference Subwatershed.

Permit No.	Facility Name	Load, lb/yr	Load, lb/day
PA0083551	Tyrone Twp STP at Walnut Grove MHP[1]	5,840	16
PAC010046	Rudolph Poultry Operation[2]	NA	NA
PAG123763	Hillandale Site 2/Site 5 Farm[3]	NA	NA
PAG123764	Hillandale Site 1 Farm[3]	NA	NA

[1]Their permit issued May 19, 2015 includes a 16 lbs/d monthly average total suspended solids effluent limit.

NA – Not applicable. The NPDES permit issued to the Facility does not include numeric effluent limitations relevant to sediment loading.

-[2]This permit was issued for stormwater associated with construction activities.

-[3]In Pennsylvania, routine, dry-weather discharges from concentrated animal feeding operations (CAFOs) are not allowed. Wet weather discharges are controlled through best management practices, resulting in infrequent discharges from production areas and reduced sediment loadings from lands under the control of CAFOs owner or operators, such as croplands where manure is applied. Although not quantified in this table, sediment loadings from CAFOs is accounted for in the modeling of land uses, with the assumption of no additional CAFO-related BMPs.

DEP staff travelled to both the impaired and reference subwatersheds during January 2019 to confirm the suitability of the downstream reference as well as to explore whether there were any obvious land use differences that may help to explain why one subwatershed was impaired for sediment while the other was attaining. We hypothesize that the tributary streams in the study subwatershed were impaired primarily because the high rate of agricultural landcover and the lack of adequate riparian buffering, particularly in their headwaters. With the exception that expansive riparian buffers were lacking or minimal in many cases, the agricultural practices observed in the study subwatershed appeared to incorporate erosion and sedimentation control practices. While we observed some bare soil amongst the tree rows of the orchards, this appeared to be due to herbicide use rather than tilling. Furthermore, grassy strips were left between the rows and no major erosion problems were observed. With a few small-scale exceptions, the croplands observed during DEP's winter visit were not left bare nor were pastures overgrazed to the point of leaving erosive bare soils. According to the county conservation district, adoption of conservation tillage has increased greatly within the past decade to the point that conventional tillage is rarely used (personal communication). Considering that erosion and sedimentation controls have improved greatly in recent times it may be possible that these stream impairments are due to historic agricultural practices. If so, there could be a lag time for recovery once high loading rates cease. It should also be noted that urbanization around Biglerville may also contribute to sedimentation in several of the tributaries, and an area with potential erosive legacy sediments was also observed (See Figure 7).

In contrast, the lack of impairments in the downstream reference may be in part attributable to the lower total percentage of agricultural coverage, perhaps in part due to land preservation in State Gamelands Number 249 (Figure 5). Like the impaired subwatershed, many of the tributary streams in the downstream reference originate in a hilly area, but this area on the north side of the reference subwatershed is in forest rather than orchards (Figure 5 and 8). Such headwater protection may help prevent agriculture occurring downstream from degrading to the point of impairment.

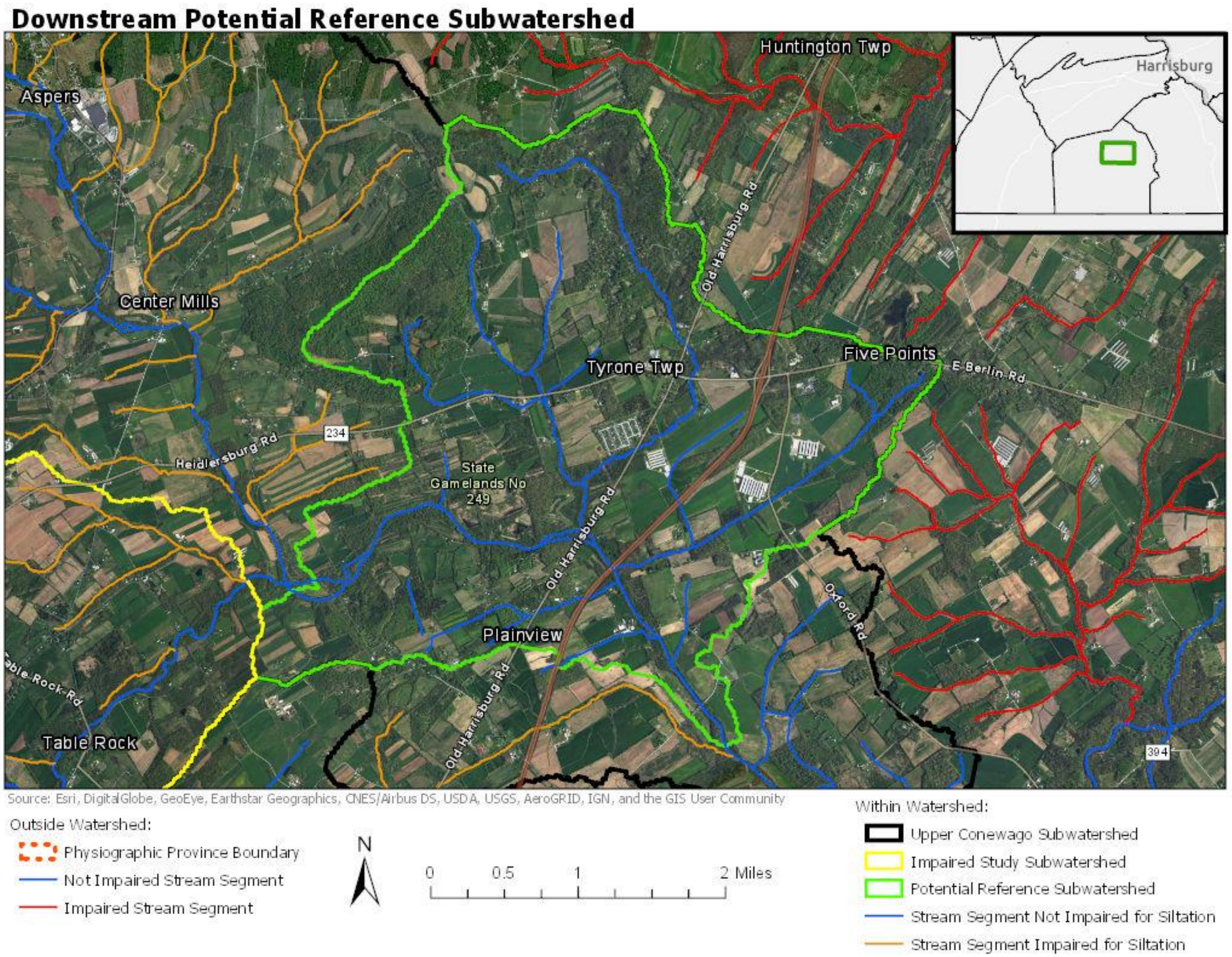

Figure 5. Downstream Reference Subwatershed in Adams County. Stream assessments correspond to the approved 2016 Integrated Report.

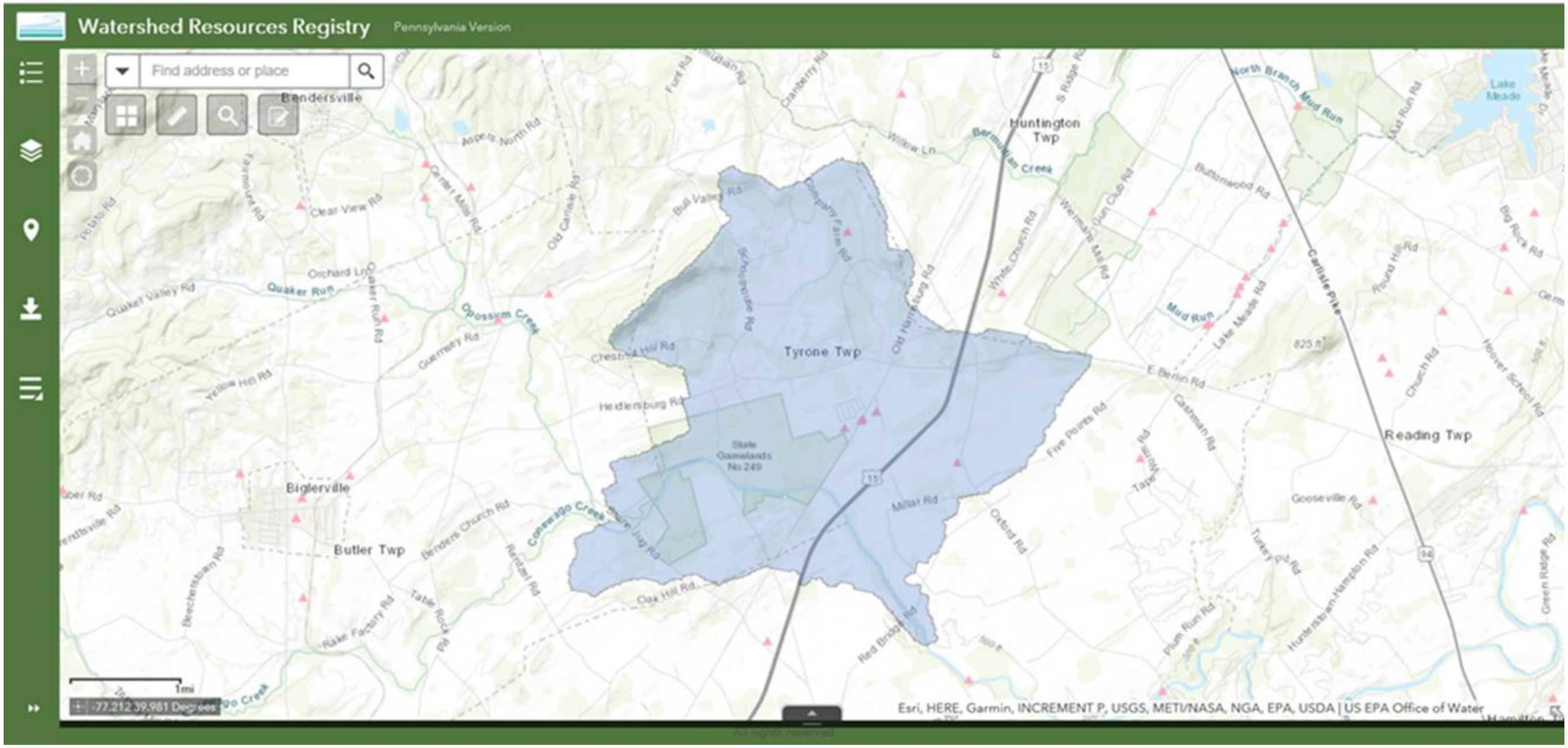

Figure 6. Permitted discharges in the Downstream Reference Subwatershed. The discharges are indicated by pink triangles, and the subwatershed is shown in blue. This Figure was created in EPA's Watershed Resource Registry for Pennsylvania, available at: https://watershedresourcesregistry.org/states/pennsylvania.html

Figure 7. Example stream segments in the Upper Conewago Creek Impaired Subwatershed. The mainstem (Photograph A) commonly had forested buffers and was not listed as impaired for sediment. Photographs B through D show examples of tributaries in the lower portion of the subwatershed that were listed as impaired for sediment. These tributaries tended to originate in hilly agricultural areas (see Figure 2 also). Photograph E shows a stream segment flowing out of an industrialized area and the erosion of what may be legacy sediments. Photograph F shows the beneficial use of streambank fencing and the establishment of a riparian buffer on one of the small tributaries.

Figure 8. Example stream segments in the Downstream Reference Subwatershed. Much of the mainstem flowed through a State Game Lands, and as was the case in the study subwatershed, it tended to be well buffered and not impaired (Photograph A). Unlike the study subwatershed, many of the first-order tributaries originated in forested areas (Photographs B and C). Photograph D shows a small tributary stream originating from a forested area (in the background) but then flowing through an agricultural area. Photographs E and F show tributaries in the lower lying agricultural areas. In some cases riparian buffers were minimal (E), but in other cases they were expansive (F).

Hydrologic / Water Quality Modeling

The TMDL for this subwatershed was 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 that has been used to derive approved sediment TMDLs in Pennsylvania. 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.

MMW provides the ability to simulate runoff and sediment load from a watershed given variable-size source areas (i.e., agricultural, forested, and developed land). The model used in MMW, GWLF-E, is a continuous simulation model that 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.

GWLF-E is a combined distributed/lumped parameter watershed model that simulates 30-years of daily water, nitrogen, phosphorus and sediment fluxes. 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 with regard to various 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 sub-surface 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 sub-surface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

With respect to the major processes simulated, GWLF-E models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather inputs of temperature and precipitation. 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 (i.e., 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 the conservation practices factor (P). 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. 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.

For a detailed discussion of this modelling program, including a description of the data input sources, see https://wikiwatershed.org/documentation/mmw-tech/.

Model My Watershed Version 1.24.0 allows the user to adjust model parameters, such as the area of land coverage types, the use of conservation practices and the efficiencies of those conservation practices, the watershed's sediment delivery ratio, etc. With the exception that flow from the wastewater treatment plants shown in Tables 3 and 5 were entered into Model My Watershed, default values were used for the modelling run. However, a correction for the presence of existing riparian buffers was made in the BMP Spreadsheet Tool provided by Model My Watershed following the model run. The following paragraphs describe the riparian buffer correction 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. 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 51% in the the impaired watershed versus 73% in the reference watershed.

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 this, the length of streams reported by Model My Watershed was multiplied by the proportion of landcover that was croplands, and then by the estimated proportion of riparian buffers, 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 Bay CAST Model. The length of riparian buffers is converted to acres, assuming that the buffers are 100 feet wide. For sediment loading the model assumes that 2 acres of croplands are treated per acre of buffer. Thus, twice the acreage of buffer is multiplied by the sediment loading rate calculated for croplands and then by a reduction coefficient of 0.54. This calculated reduction was then subtracted from the watershed-wide yearly loading rate for croplands. 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 we sought to account for historic rather than proposed buffers. While the BMP spreadsheet tool did not account for riparian buffers along hay/pasture lands, the present study estimated these load reductions using the same logic and methodology as was described for croplands.

Calculation of the TMDL

The mean watershed-wide sediment loading rate for the unimpaired downstream reference subwatershed was estimated to be 416 pounds per acre per year (Table 6). This was substantially lower than the estimated loading rate in the impaired subwatershed (615 pounds per acre per year, Table 7). Thus, to achieve the loading rate of the unimpaired subwatershed, sediment loading in the impaired subwatershed should be reduced to 3,904,307 pounds per year, or 10,697 pounds per day, or less (Table 8).

Table 6. Existing loading values for the Downstream Reference Subwatershed			
Source	Area, ac	Sediment, lbs/yr	Unit Area Load, lb/ac/yr
Hay/Pasture	1,575	93,728	59
Cropland	1,620	1,873,888	1,157
Forest and Shrub/Scrub	2,469	6,585	3
Wetland	306	884	3
Herbaceous/Grassland	30	2,016	68
Low Intensity Mixed Development	602	6,514	11
Medium Intensity Mixed Development	52	3,584	69
High Intensity Mixed Development	2	234	95
Streambank		776,729	
Point Sources		5,840	
Total	6,657	2,770,003	416

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

Table 7. Existing loading values for the Upper Conewago Impaired Subwatershed			
Source	Area ac	Sediment, lbs/yr	Unit Area Load, lbs/ac/yr
Hay/Pasture	2,699	140,186	52
Cropland	3,489	3,804,057	1,090
Forest and Shrub/Scrub	1,494	3,434	2
Wetland	444	1,228	3
Herbaceous/Grassland	64	2,640	41
Low Intensity Mixed Development	980	10,841	11
Medium Intensity Mixed Development	123	7,263	59

High Intensity Mixed Development	54	3,209	59
Bare Rock	35	60	2
Streambank		1,760,051	
Point Sources		33,580	
total	9,383	5,766,550	615

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

Table 8. TMDL values for the Upper Conewago Impaired Subwatershed

Pollutant	Loading Rate in Reference, lb/ac/yr	Total Area in Impaired Watershed, ac	Target TMDL Value, lb/yr	Target TMDL Value, lb/day
Sediment	416	9,383	3,904,307	10,697

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 allocation, the margin of safety and wasteload allocation 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 was explicitly designated as ten-percent of the TMDL based on professional judgment. Thus:

3,904,307 lbs/yr TMDL * 0.1 = 390,431 lbs/yr MOS

Wasteload Allocation

The wasteload allocation (WLA) is the pollutant loading assigned to existing permitted point sources as well future point sources. There were several National Pollutant Discharge Elimination System (NPDES) point source discharges, but only one of them, the Biglerville wastewater treatment plant, had significant permit limits for sediment (Table 3, Figure 4). A bulk reserve was also included to allow for insignificant dischargers and minor increases from point sources as a result of future growth of existing or new sources.

Thus, the WLA was comprised of the bulk reserve, which we defined as one percent of the targeted TMDL, plus the permitted sediment loading from the Biglersville wastewater treatment plant. Therefore:

3,904,307 lbs/yr TMDL * 0.01 = 39,043 lbs/yr bulk reserve + 33,580 lbs/yr permitted loads = 72,623 lbs/yr WLA

It should be noted that the concentrated animal feeding operations (CAFOs) listed in Table 3 were not provided individual wasteload allocations. Runoff from land application areas of CAFOs is typically considered nonpoint source pollution when permittees are operating in compliance with their permits. Furthermore, Pennsylvania does not allow routine point source discharges from CAFO production areas. If however effluent limits are necessary in the future, capacity would be available in the bulk reserve.

Load Allocation

Now that the margin of safety and wasteload allocation have been defined, the load allocation (LA) is calculated as:

3,904,307 lbs/yr TMDL – (390,431 lbs/yr MOS + 72,623 lbs/yr WLA) = 3,441,253 lbs/yr LA

Loads Not Reduced and Adjusted Load Allocation

Since the impairment addressed by this TMDL is for sedimentation due to agriculture, sediment contributions from forests, wetlands, non-agricultural herbaceous/grasslands and developed lands within the impaired study subwatershed were considered loads not reduced (LNR). LNR was calculated to be 28,676 lbs/yr (Table 9).

The LNR is subtracted from the LA to determine the ALA:

3,441,253 lbs/yr LA – 28,676 lbs/yr LNR = 3,412,577 lbs/yr ALA

Table 9. Load allocation, loads not reduced and adjusted load allocation

	Sediment, lbs/yr	Sediment, lbs/d
Load Allocation (LA)	**3,441,253**	**9,428**
Loads Not Reduced (LNR):	**28,676**	**79**
Forest	3,434	9
Wetlands	1,228	3
Non-Agricultural Herbaceous/Grasslands	2,640	7
Low Intensity Mixed Development	10,841	30
Medium Intensity Mixed Development	7,263	20
High Density Mixed Development	3,209	9
Bare Rock	60	0.2
Adjusted Load Allocation (ALA)	**3,412,577**	**9,350**

Sediment loads associated with stormwater sources not currently regulated by an NPDES permit are included in the calculated LA. These loads were modeled and are a component of the total load for the watershed, but will remain part of the LA contingent upon the source remaining unpermitted.

Calculation of Sediment Load Reductions

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

In this evaluation, cropland exceeded the adjusted loads allocation by itself. Thus, it received a greater assigned reduction goal (42%) than hay/pasture and streambanks (both 36%) (Tables 10 and 11).

Table 10. Sediment load allocations for source sectors in the Upper Conewago Impaired Subwatershed, annual values						
		Allowable Loading	Load Allocation	Current Loading	Current Load	Reduction Goal
Land Use	Acres	lbs/ac/yr	lbs/yr	lbs/ac/yr	lbs/yr	
CROPLAND	3,489	628	2,191,999	1,090	3,804,057	42%
HAY/PASTURE	2,699	33	90,046	52	140,186	36%
STREAMBANK			1,130,533		1,760,051	36%
AGGREGATE		ALA	3,412,577		5,704,294	40%

Table 11. Sediment load allocations for source sectors in the Upper Conewago Impaired Subwatershed, daily values						
		Allowable Loading	Load Allocation	Current Loading	Current Load	Reduction Goal
Land Use	Acres	lbs/ac/d	lbs/d	lbs/ac/d	lbs/d	
CROPLAND	3,489	1.7	6,005	3.0	10,422	42%
HAY/PASTURE	2,699	0.1	247	0.1	384	36%
STREAMBANK			3,097		4,822	36%
AGGREGATE		ALA	9,350		15,628	40%

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 1960-1990 (Stroud Water Research Center 2018). It should be noted however that the dataset is not complete for all years at all locations. The evapotranspiration calculations also take into account the length of the growing season and changing day length. Monthly calculations are made for sediment 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. Because there is generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective for the waterbody.

Recommendations

This document proposes a 32% reduction in sediment loading for the Upper Conewago Impaired Subwatershed. To achieve this goal while maintaining a 10% margin of safety and minor allowance for point sources, sediment loading from croplands by 42% and hay/pasture lands and streambanks should be reduced by by 36% each. Reductions in stream sediment loading due to agricultural activities can be made through the implementation of required Erosion and Sediment Control Plans (Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Chapter 102.4, see also Appendix E) and through the use of BMPs such as conservation tillage, cover crops, vegetated filter strips, rotational grazing, livestock exclusion fencing, riparian buffers, etc.

As explained previously in the "Selection of the Reference Watershed" section, it appears that progress has already been made towards modernizing agricultural practices in the impaired study subwatershed (Figure 7), and the specific cause of the impairments was not obvious during our site visit. However, a common feature of many of the impaired tributaries, particularly those originating on the north side of Arendtsville Road, were that their headwater reaches flowed through steeply sloping orchard land. In contrast, the downstream reference subwatershed lacked substantial orchard landcover, and the headwater streams typically originated in hilly forested area. Soils on steeply sloping areas may be particularly prone to erosion. While the mature orchards that we observed lacked obvious signs of erosion problems, the county conservation district speculated that problems may occur when orchards are periodically cleared (personal communication). It was explained that trees are removed after 15 to 20 years and replaced with other crops for several years before trees are replanted. We observed some sites where trees were being removed, and it appeared that the typical practice was to simply uproot the trees but leave the grassy strips between the tree rows intact. This wasn't obviously problematic during our winter visit, but the sites might become problematic if they are then plowed to accommodate other crops. However, we found a site outside of the subwatershed, where an old, overgrown orchard appeared to have been bulldozed leaving a large area of bare soils (Figure 9). Considering the steep slopes, this practice could be very degrading without proper erosion and sedimentation controls. Fortunately, the site that we observed was not located near a stream, and a line of uprooted trees was apparently being used to prevent erosion from part of the site. At another location we observed an area with new orchard plantings on steep slopes (Figure 9). Small strips had been plowed on on-contour to accommodate the new plantings. However, grassy strips were left between the rows. Considering the erosion risk on the steep slopes typical of orchards in this region, we recommend that orchard management practices and the need for erosion and sedimentation controls be evaluated over the entire orchard rotation cycle. We note that headwater streams in the upper potential reference subwatershed were not impaired, despite the presence of orchards (Figure 1). Perhaps this was because there was a much greater area of forest cover (see Table 4), but it may also be that streams coming off South Mountain are less vulnerable to sediment deposition impairments due to their high gradient.

Use of riparian buffers is widely recognized as one of the best ways to promote stream health. Riparian buffers protect streams from sedimentation impairments by filtering sediment 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. For instance, riparian buffers may: filter out other pollutants, such as nutrients; provide habitat and nutrition for aquatic, semi-aquatic and terrestrial organisms; and moderate stream temperature. While some sites had extensive and mature riparian buffers, particularly on the mainstem, many areas along the impaired small tributaries had minimal or no buffers (Figure 7). Riparian buffers may be especially beneficial in orchard lands where soils on steep slopes are at greater risk of erosion.

Research over the past decade has led to a growing awareness that the high rates of sediment loading occurring in Pennsylvania during modern times may be in part attributable to the erosion of “legacy sediments” that had accumulated behind historic mill dams. In addition to being a long term source of sediments, these legacy sediments may cut off a stream from its former floodplain and inhibit the growth of some riparian species. In some cases, planting riparian trees directly on legacy sediments with entrenched banks may enhance erosion. While it wasn’t obviously a major problem in the impaired subwatershed, legacy sediments may have been observed at some sites. Thus, if further investigation reveals significant problems with legacy sediments, then their removal, or at least bank grading, may be important for preventing sediment loading and establishing riparian buffers.

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 BMPs required for meeting the required sediment reductions. Key personnel from the regional DEP office, the County Conservation District, Susquehanna River Basin Commission (SRBC) and other state and local agencies and/or watershed groups should be involved in developing a restoration strategy.

Figure 9. Example orchard management practices in Adams County. In mature orchards, weeds within the tree rows appeared to be managed with herbicides and the rows were separated by vegetated swaths (Photograph A). Photograph B shows new plantings on steep slopes within strips plowed on contour, but the tree rows were separated by vegetated strips. Photographs C and D show tree removal. In C, trees were uprooted, leaving only bare patches within the vegetated strips. Photograph D shows extensive bare soils on steep slopes where an old overgrown orchard was cleared. Photograph A is from the impaired study subwatershed, Photographs B and C are from the potential upstream reference, and Photograph D was taken outside of the Conewago Watershed.

Public Participation

Public notice of the draft TMDL was published in the Pennsylvania Bulletin on 6/29/2019 to foster public comment. A 30-day period was provided for the submittal of comments.

Citations

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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 required selecting 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 generally included kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates were 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 generally included 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 identified to the generic level where feasible. 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 any 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 (km²)	Coverage (%)
Open Water	11	0.04	0.1
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	2.72	7.1
Developed, Low Intensity	22	1.25	3.3
Developed, Medium Intensity	23	0.5	1.3
Developed, High Intensity	24	0.22	0.6
Barren Land (Rock/Sand/Clay)	31	0.14	0.4
Deciduous Forest	41	3.26	8.6
Evergreen Forest	42	0.35	0.9
Mixed Forest	43	0.26	0.7
Shrub/Scrub	52	2.18	5.7
Grassland/Herbaceous	71	0.26	0.7
Pasture/Hay	81	10.93	28.7
Cultivated Crops	82	14.13	37.1
Woody Wetlands	90	1.64	4.3
Emergent Herbaceous Wetlands	95	0.16	0.4

Table B1. "Model My Watershed" land cover outputs for the Upper Conewago Creek Impaired Subwatershed

Type	NLCD Code	Area (km²)	Coverage (%)
Open Water	11	0.01	0
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	1.78	6.6
Developed, Low Intensity	22	0.66	2.4
Developed, Medium Intensity	23	0.21	0.8
Developed, High Intensity	24	0.01	0.1
Barren Land (Rock/Sand/Clay)	31	0	0
Deciduous Forest	41	7.2	26.7
Evergreen Forest	42	0.25	0.9
Mixed Forest	43	0.11	0.4
Shrub/Scrub	52	2.44	9
Grassland/Herbaceous	71	0.12	0.5
Pasture/Hay	81	6.38	23.7
Cultivated Crops	82	6.56	24.3
Woody Wetlands	90	1.16	4.3
Emergent Herbaceous Wetlands	95	0.08	0.3

Table B2. "Model My Watershed" land cover outputs for the Downstream Reference Subwatershed

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	5.47	1.45	3.91	0.11	0.5	7.48
Feb	6.19	1.37	4.72	0.1	0.77	7.68
Mar	6.77	0.81	5.85	0.11	2.27	8.46
Apr	5.53	0.17	5.25	0.11	5.18	8.04
May	4.01	0.36	3.54	0.11	9.76	10.14
Jun	2.91	0.83	1.96	0.11	12.94	9.55
Jul	1.39	0.43	0.84	0.11	10.77	9.26
Aug	0.81	0.41	0.29	0.11	8.51	9.17
Sep	1.27	1.06	0.11	0.11	5.78	8.79
Oct	1.09	0.57	0.4	0.11	3.9	7.51
Nov	1.73	0.75	0.87	0.11	2.09	8.7
Dec	3.69	1	2.58	0.11	0.99	8.44
Total	40.86	9.21	30.32	1.31	63.46	103.22

Table B3. “Model My Watershed” hydrology outputs for the Upper Conewago Impaired Subwatershed.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	4.44	1.54	2.87	0.03	0.51	7.48
Feb	5.54	1.46	4.05	0.03	0.78	7.68
Mar	6.37	0.87	5.47	0.03	2.3	8.46
Apr	5.31	0.19	5.09	0.03	5.17	8.04
May	3.91	0.39	3.49	0.03	9.68	10.14
Jun	2.86	0.88	1.96	0.03	13.7	9.55
Jul	1.35	0.48	0.84	0.03	12.63	9.26
Aug	0.77	0.45	0.29	0.03	9.21	9.17
Sep	1.27	1.15	0.1	0.03	5.74	8.79
Oct	0.78	0.62	0.13	0.03	3.88	7.51
Nov	1.23	0.81	0.39	0.03	2.09	8.7
Dec	2.74	1.07	1.65	0.03	1	8.44
Total	36.57	9.91	26.33	0.36	66.69	103.22

Table B4. “Model My Watershed” hydrology outputs for the Downstream Reference Subwatershed

Sources	Sediment (kg)
Hay/Pasture	66,173.80
Cropland	1,795,676.40
Wooded Areas	1,557.20
Wetlands	556.9
Open Land	1,197.50
Barren Areas	27.3
Low-Density Mixed	1,549.60
Medium-Density Mixed	3,294.10
High-Density Mixed	1,455.20
Low-Density Open Space	3,367.10
Farm Animals	0
Stream Bank Erosion	798,209.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

Table B5. Model My Watershed outputs for Sediment in the Upper Conewago Impaired Subwatershed. Note that sediment contributions from point sources were added manually to the BMP Spreadsheet Tool and EMPR spreadsheet. Also, the values for hay/pasture and cropland shown above are prior to correction for existing riparian buffers.

Sources	Sediment (kg)
Hay/Pasture	44,964.10
Cropland	898,963.70
Wooded Areas	2,986.40
Wetlands	400.9
Open Land	914.5
Barren Areas	0
Low-Density Mixed	797.9
Medium-Density Mixed	1,625.50
High-Density Mixed	106.3
Low-Density Open Space	2,156.40
Farm Animals	0
Stream Bank Erosion	352,258.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

Table B6. Model My Watershed outputs for Sediment in the Downstream Reference Subwatershed. Note that sediment contributions from point sources were added manually to the BMP Spreadsheet Tool and EMPR spreadsheet. Also, the values for hay/pasture and cropland shown above are prior to correction for existing riparian buffers.

Appendix C: Stream Segments in the Upper Conewago Impaired Subwatershed with Siltation Impairments

Assessed Use:	Status:	Impairment Source:	Impairment Cause:	Date Listed:	COMID:	Length (mi):
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471555	0.02
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471567	0.01
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471571	0.11
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471581	0.10
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471599	0.06
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471621	0.70
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471629	0.09
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471661	0.14
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471679	0.54
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471719	0.27
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471735	0.05
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471757	0.57
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471781	0.24
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471789	0.08
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471837	0.02
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471839	0.03
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471855	1.01
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471857	0.07
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471893	0.71
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471895	0.14
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471913	0.05
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471967	0.75
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471983	0.43
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471987	0.47
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471993	0.32
Aquatic Life	Impaired	Agriculture	Siltation	2008	57471997	0.01
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472019	0.99
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472027	0.03
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472029	0.01
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472033	0.03
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472175	0.60
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472199	0.59
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472201	1.31
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472213	0.07
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472257	0.66
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472279	0.62
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472281	0.66
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472287	0.17
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472315	0.70

Aquatic Life	Impaired	Agriculture	Siltation	2008	57472331	0.64
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472335	1.25
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472347	2.12
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472349	0.36
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472351	0.01
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472429	0.04
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472515	0.35
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472549	0.41
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472551	0.25
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472573	0.66
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472575	0.82
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472583	1.03
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472645	0.51
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472647	1.20
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472663	0.71
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472691	0.25
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472693	0.22
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472701	0.62
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472837	0.58
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472877	0.25
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472893	0.04
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472901	0.51
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472907	0.23
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472915	0.30
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472925	0.05
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472975	1.31
Aquatic Life	Impaired	Agriculture	Siltation	2008	57472985	0.12
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473063	0.13
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473077	1.10
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473135	0.83
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473153	0.82
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473195	0.35
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473437	0.93
Aquatic Life	Impaired	Agriculture	Siltation	2008	57473601	1.73
Aquatic Life	Impaired	Agriculture	Siltation	2008	133624888	0.52
Aquatic Life	Impaired	Agriculture	Siltation	2008	133624890	0.28
Aquatic Life	Impaired	Agriculture	Siltation	2008	133624892	0.33

Note: This table only shows impairments for siltation.

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

	TMDL				2	ALA = TMDL total load - (MOS + WLA + loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					3412577.4	3412577.4					
	3904307.0											
		Annual				Recheck	% reduction	Load			Allowable	%
3		Avg. Load	Load Sum	Check	Initial Adjust	Adjust	allocation	Reduction	Initial LA	Acres	Loading Rate	Reduction
	CROPLAND	3804057.4	5704294.4	bad	3412577.4		0.6	1220578.3	2191999.1	3488.9	628.3	42.4%
	HAY/PASTURE	140186.1		good	140186.1	1900237.0	0.0	50140.4	90045.7	2698.8	33.4	35.77%
	STREAMBANK	1760050.8		good	1760050.8		0.3	629518.3	1130532.6			35.8%
					5312814.4		1.0		3412577.4			
4	All Ag. Loading Rate	368.81										
			Allowable		Current	Current	**Reduction**					
	Land Use	Acres	loading rate	Final LA	Loading Rate	Load	**Goal**			CURRENT LOAD	FINAL LOAD ALLOCATION	
5	CROPLAND	3,489	628	2,191,999	1,090	3,804,057	**42%**		HAY/PASTURE	140,186	90,046	
	HAY/PASTURE	2,699	33	90,046	52	140,186	**36%**		STREAMBANK	1,760,051	1,130,533	
	STREAMBANK			1,130,533		1,760,051	**36%**		CROPLAND	3,804,057	2,191,999	
	AGGREGATE		ALA	3,412,577		5,704,294	**40%**		AGGREGATE	5,704,294	3,412,577	

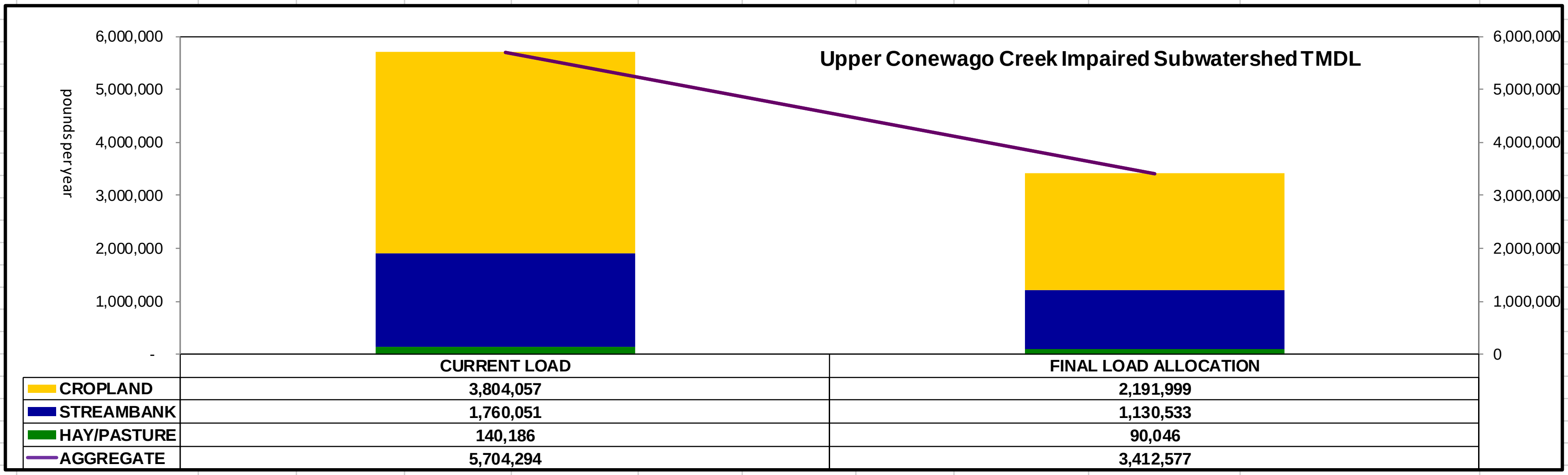

Table D1. Equal Marginal Percent Reduction calculations for the Upper Conewago Impaired Subwatershed

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.

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

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.