South Branch, South Fork Pine Creek TMDL
Armstrong County

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

May 2018

TABLE OF CONTENTS

South Branch, South Fork Pine Creek TMDL
Armstrong County, Pennsylvania

Executive Summary

A proposed Total Maximum Daily Load (TMDL) developed to address aquatic life use impairments in the South Branch of the South Fork Pine Creek (SBSF Pine Creek) as noted in 2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated List), initially listed in 1998 Section 303(d) impaired streams list. A separate TMDL was calculated for sediment and another for total phosphorus to address the nutrient sources. The SBSF Pine Creek joins with the North Branch of South Fork Pine Creek to form South Fork Pine Creek. It is a tributary of the greater Pine Creek and the larger Allegheny River Basin (Figure 1a.). The watershed lies north of the town of Rural Valley, within Cowanshannock and Wayne Townships (USGS quadrangle – Rural Valley), mid-eastern Armstrong County.

The impairments were originally noted during bioassessments in the watershed (SWRO May 2008). Agricultural activities have been identified as the cause of biological impairment to the High Quality Cold Water Fishery (HQ-CWF) sustainment in the SBSF Pine Creek. Because PA does not currently have water quality criteria for either sediment or total phosphorus (nutrient), a TMDL endpoint was identified using a reference watershed approach. Based on a comparison to a similar watershed in land use, yet biologically non-impaired, the maximum sediment and total phosphorus loading should still allow water quality objectives to be met. Mudlick Run, another HQ-CWF, was chosen for comparison and is a tributary to Little Mahoning Creek and the larger Mahoning Creek and Allegheny River basin, Indiana County (Figure 2.). This proposed TMDL sets allowable loadings within the specifically impaired stream segments of the SBSF Pine Creek watershed. The loading was allocated among the land uses of cropland, hay/pasture land, and associated stream banks present in the watershed. Data used in these TMDLs was generated using a watershed analysis model (MAPSHED) designed by the Penn State University. The following table shows the estimated current loadings for the watershed. Overall load reductions that are necessary are identified.

Table 1. Summary of TMDL based load reductions in the SBSF Pine Creek in lbs./yr.

Pollutant	TMDL	WLA	MOS	LA	LNR	ALA
Sediment	280,348.8	2,803.5	28,034.9	249,510.5	2,600.0	246,910.5
Phosphorus	612.2	6.1	61.2	544.9	5.7	539.2

TMDL – Total Maximum Daily Load, WLA – Waste Load Allocation, MOS – Margin of Safety
LA – Load Allocation, LNR – Loads Not Reduced, ALA – Adjusted Load Allocation

Load allocations were distributed to nonpoint sources, specifically all land use sources other than National Pollutant Discharge Elimination System (NPDES) permitted point source discharges with 10% of the TMDL reserved explicitly as a margin of safety (MOS). A search of the Pennsylvania Department of Environmental Protection's (Department) efacts permit database identified no point source discharges within the SBSF Pine Creek. 1% of the TMDL was incorporated into the WLA as a bulk reserve to take in account future permit activity. Loads not reduced (LNR) are the portion of the LA associated with nonpoint sources other than agricultural (croplands, hay/pasture), and associated stream banks. It is equal to the sum of modeled loading on forested land use, wetlands, and low development. The adjusted load allocation (ALA) represents the remaining portion of the LA distributed among agricultural land and associated stream banks. The TMDL developed for the impaired SBSF Pine Creek established a reduction in the overall, sediment loading to **59.3%** and a **29.4%** reduction in the total phosphorus loading.

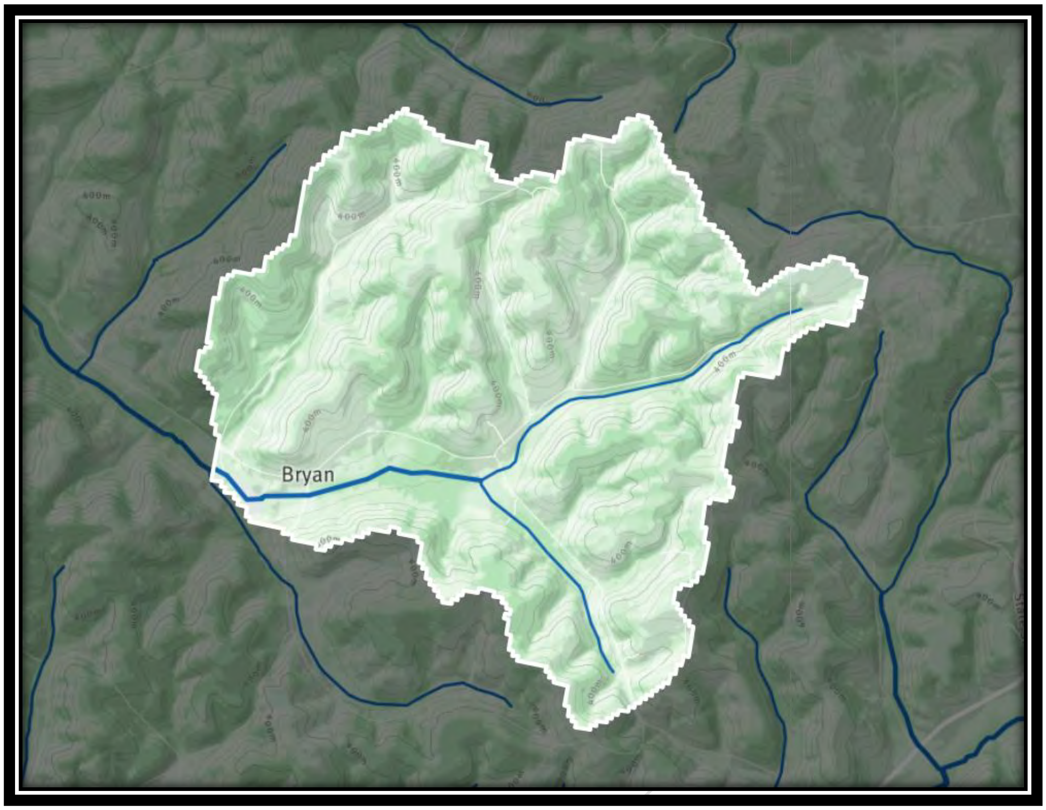
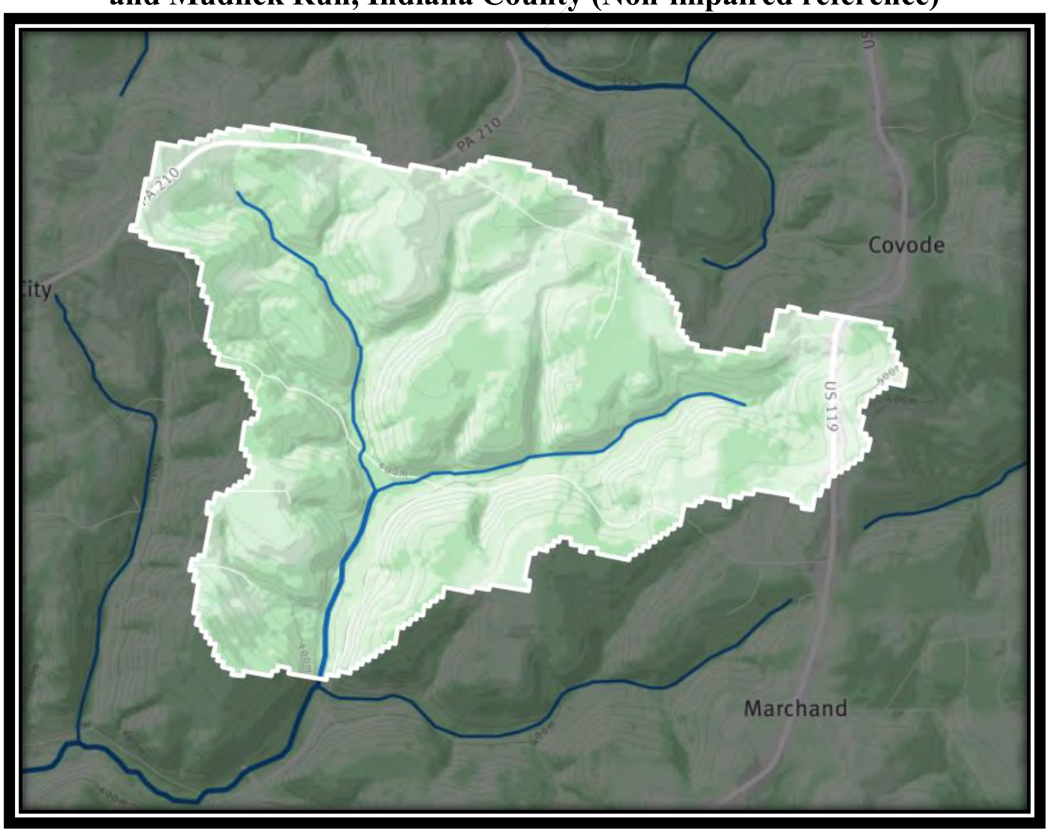


Figure 1a. and 2. Overview maps of the SBSF Pine Creek, Armstrong County (Impaired) and Mudlick Run, Indiana County (Non-impaired reference)

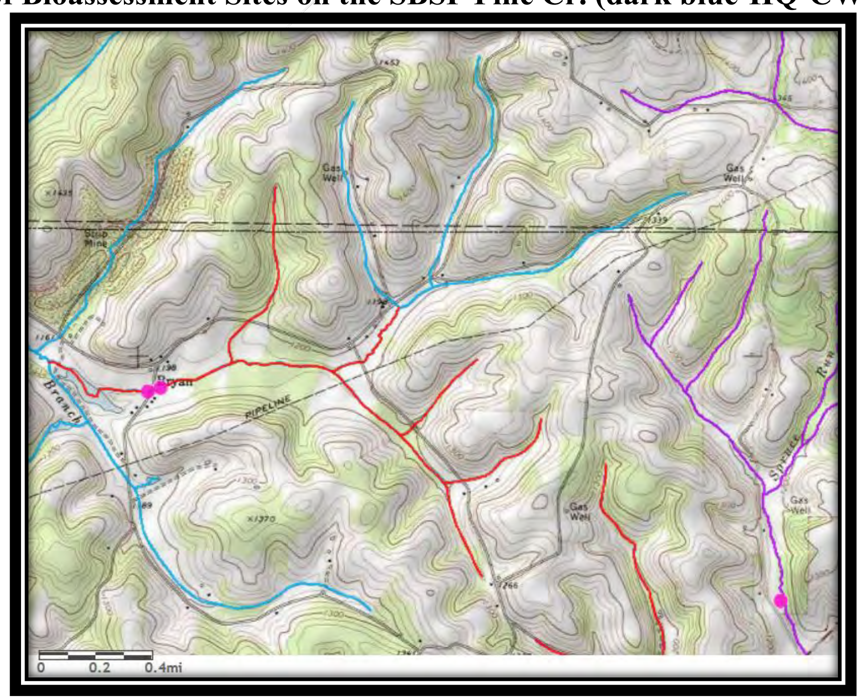


Introduction

The SBSF Pine Creek (Figures 1b. and 1c.) is High-Quality (HQ), which are waters having quality which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water (§93.4b(a)). In this case, the SBSF Pine Creek watershed is a HQ-Cold Water Fishery (CWF), which also provides for the maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold-water habitat.

Figure 1d. Satellite map of land use in the SFSB Pine Creek

Figure 1e. Map of Bioassessment Sites on the SBSF Pine Cr. (dark blue-HQ-CWF; red-impaired)



Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

Station ID 19970626-1045-RBS

Stream Name South Branch South Fork Pine Creek (Unamed Trib 12385[illegible] **Stream Code** 47210 **Strahler** 3
Survey ID 40006 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program
Collection Date **Collection Time** **Latitude** 40.8315678 **Longitude** -79.2906965
HUC8 05010006 Middle Allegheny-Redbank

Station Location Comments
Sr1039 X @ Bryan (Rural Valley Quad)

Biology / Physical Habitat Comments
stream is small ~5 ft across- has heavy silt loading and runoff from agriculture
barely holding its own
BND + other minnows observed swimming-pipes from nearby homes to creek

Land Use Comments
Mostly crops some pasture-pastures have cattle in stream

Impairment Status Comments
impairment due to agriculture (cattle in stream) farming right to edge of stream causing siltation
and nutrients

Taxa List

Taxa Name	Abundance Category	Abundance Range	PTV	FFG
Heptageniidae	Rare	<3	3	SC
Ephemeridae	Rare	<3	4	CG
Macromiinae	Rare	<3	5	
Peltoperlidae	Common	10-24	2	SH
Hydropsychidae	Present	3-9	5	FC
Elmidae	Abundant	25-100	5	CG
Chironomidae(other)	Abundant	25-100	6	
Tipulidae	Present	3-9	4	SH
Oligochaeta	Present	3-9	10	CG
Cambaridae	Rare	<3	6	CG

SSWAP metrics and IBI

	Raw Metric Value	Standardized Metric Value
Total Richness	10	45.5
EPT Richness (PTV 0 - 4)	3	27.3
Beck's Index (version 3)	1	7.1
Hilsenhoff Biotic Index	5.07	66.6
Shannon Diversitiy	1.63	61.9
SSWAP IBI		41.7

report generated Thursday, May 17, 2018 Page 1 of 2

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

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Stream Name South Branch South Fork Pine Creek (Unamed Trib 12385[illegible] **Stream Code** 47210 **Strahler** 3
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Collection Date **Collection Time** **Latitude** 40.8315678 **Longitude** -79.2906965
HUC8 05010006 Middle Allegheny-Redbank

1. Abundance obviously low		N
2. Seven or fewer families		N
3. Three or fewer mayfly individuals (exclude Baetidae, Caenidae, Siphlonuridae)		N
4. Stoneflies collectively present	N	
5. Mayflies and caddisflies collectively abundant (exclude Baetidae, Caenidae, Siphlonuridae, Hydropsychidae, Polycentropidae)	N	
6. Jul - Sep: at least four EPT families with tolerance value of 4 or less Nov - May: at least six EPT families with tolerance value of 4 or less	N	
7. Four or more famlies with tolerance value of 3 or less	N	
8. Six or more families with tolerance value of 4 or less	N	
9. Dominant family with tolerance value of 4 or less	N	
10. Dominant family with tolerance value greater than 5 (criteria 7 and 8 negate this criterion)		N
11. Seven or more families with tolerance value of 6 or more (criteria 7 and 8 negate this criterion)		N
12. Sample dominated by families with a mean tolerance value of 5 or less	N	
13. Sample dominated by families with a mean tolerance value of 6 or more		N
14. Embeddedness (or substrate character for pool/glide) + sediment deposition = 24 or less (20 or less for warmwater, low gradient streams)		N
15. Condition of banks + bank vegetation = 24 or less (20 or less for warmwater, low gradient streams)		N
16. Total habitat score 140 or less for forested, coldwater, high gradient streams (120 or less for warmwater, low gradient streams)		N
17a. Special conditions (attaining)	N	
17b. Special conditions (impaired)		N
17c. Special conditons description		

Not impaired N **Biology impaired** Y **Habitat impaired** N **Insufficient data** N
Rock pick influenced assessment N **Impact is localized** N **Re-evaluate designated use** N

Physical Habitat Assessment

Pool/Glide Assessment N

Instream Cover	9	Substrate / Cover	0	Frequency of Riffles	13	Contition of Banks	11
Epifaunal Substrate	9	Velocity/Depth Regimes	10	Channel Sinuosity	13	Bank Vegetation	15
Embeddedness	15	Pool Variability	0	Channel Flow Status	16	Disruptive Pressure	8
Pool Substrate	0	Sediment Deposition	8	Channel Alteration	18	Riparian Zone	9

Instream Score 41 Riparian Score 35 **Total Score 141**

Field Measurements

Lab samples

Temperature (°C) 19.87 **Dissolved Oxygen (mg/L)** 8.51 **Flow (CFS)**
pH 8.51 **Alkalinity (mg/L as CaCO3)** **Conductivity** 0.01

Use Assessment Status for Stream Reach

Designated Use HQ-CWF **Existing Use**

Aquatic Life Impaired (970626-1045-RBS)
Agriculture - Nutrients, Agriculture - Siltation

Fish Consumption

Potable Water Supply

Recreation

TMDL Information (if any)

South Branch South Fork Pine Creek (Not Finalized): NONPOINT SOURCE - Nutrients, NONPOINT SOURCE - Siltation

Begin Date **Meeting Date** **Draft Date** **End Date** **Final Date**

report generated Thursday, May 17, 2018 Page 2 of 2

Figure 1f. 1997 Water Quality Bioassessment, SBSF Pine Creek, SR 1039 (Impaired)

Figure 1g. 2003 Water Quality Bioassessment, SBSF Pine Creek, SR 1039 (Impaired)

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

Station ID 20030527-0900-ALF

Stream Name South Branch South Fork Pine Creek (Unamed Trib 12385[illegible] **Stream Code** 47210 **Strahler** 3
Survey ID 51448 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program
Collection Date **Collection Time** **Latitude** 40.8317233 **Longitude** -79.28987
HUC8 05010006 Middle Allegheny-Redbank

Station Location Comments
Route 28 North, right on SR 1035, left on SR 1028, right on SR 1039 (BRYAN)
Rural Valley Quad

Biology / Physical Habitat Comments
Habitat: banks-right is good left is bad

Land Use Comments
hay fields mostly
upstream cattle and corn fields

Impairment Status Comments
dry last summer
was listed for Ag impairments in 1997-don't really see that as a problem right now

Taxa List

Taxa Name	Abundance Category	Abundance Range	PTV	FFG
Ameletidae	Present	3-9	0	CG
Baetidae	Common	10-24	6	CG
Heptageniidae	Common	10-24	3	SC
Ephemerellidae	Present	3-9	2	CG
Leptophlebiidae	Present	3-9	4	CG
Perlodidae	Abundant	25-100	2	PR
Rhyacophilidae	Present	3-9	1	SC
Elmidae	Rare	<3	5	CG
Chironomidae(other)	Present	3-9	6	
Tipulidae	Present	3-9	4	SH
Other Diptera	Rare	<3	7	
Turbellaria	Present	3-9	9	
Oligochaeta	Present	3-9	10	CG

SSWAP metrics and IBI

	Raw Metric Value	Standardized Metric Value
Total Richness	13	59.1
EPT Richness (PTV 0 - 4)	6	54.5
Beck's Index (version 3)	7	50.0
Hilsenhoff Biotic Index	3.66	85.5
Shannon Diversitiy	2.11	79.9
SSWAP IBI		65.8

report generated Thursday, May 17, 2018 Page 1 of 2

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

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Survey ID 51448 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program
Collection Date **Collection Time** **Latitude** 40.8317233 **Longitude** -79.28987
HUC8 05010006 Middle Allegheny-Redbank

1. Abundance obviously low		N
2. Seven or fewer families		N
3. Three or fewer mayfly individuals (exclude Baetidae, Caenidae, Siphlonuridae)		N
4. Stoneflies collectively present	Y	
5. Mayflies and caddisflies collectively abundant (exclude Baetidae, Caenidae, Siphlonuridae, Hydropsychidae, Polycentropidae)	N	
6. Jul - Sep: at least four EPT families with tolerance value of 4 or less Nov - May: at least six EPT families with tolerance value of 4 or less	Y	
7. Four or more famlies with tolerance value of 3 or less	Y	
8. Six or more families with tolerance value of 4 or less	Y	
9. Dominant family with tolerance value of 4 or less	Y	
10. Dominant family with tolerance value greater than 5 (criteria 7 and 8 negate this criterion)		N
11. Seven or more families with tolerance value of 6 or more (criteria 7 and 8 negate this criterion)		N
12. Sample dominated by families with a mean tolerance value of 5 or less	Y	
13. Sample dominated by families with a mean tolerance value of 6 or more		N
14. Embeddedness (or substrate character for pool/glide) + sediment deposition = 24 or less (20 or less for warmwater, low gradient streams)		N
15. Condition of banks + bank vegetation = 24 or less (20 or less for warmwater, low gradient streams)		N
16. Total habitat score 140 or less for forested, coldwater, high gradient streams (120 or less for warmwater, low gradient streams)		N
17a. Special conditions (attaining)	N	
17b. Special conditions (impaired)		N
17c. Special conditons description		

Not impaired Y **Biology impaired** N **Habitat impaired** N **Insufficient data** N
Rock pick influenced assessment N **Impact is localized** N **Re-evaluate designated use** N

Physical Habitat Assessment

Pool/Glide Assessment N

Instream Cover	12	Substrate / Cover	0	Frequency of Riffles	13	Contition of Banks	12
Epifaunal Substrate	12	Velocity/Depth Regimes	14	Channel Sinuosity	13	Bank Vegetation	13
Embeddedness	12	Pool Variability	0	Channel Flow Status	15	Disruptive Pressure	13
Pool Substrate	0	Sediment Deposition	13	Channel Alteration	15	Riparian Zone	12

Instream Score 49 Riparian Score 37 **Total Score 156**

Field Measurements

Lab samples

Temperature (°C) 12.6 **Dissolved Oxygen (mg/L)** 10.9 **Flow (CFS)**
pH 6.44 **Alkalinity (mg/L as CaCO3)** **Conductivity** 75

Use Assessment Status for Stream Reach

Designated Use HQ-CWF **Existing Use**

Aquatic Life Impaired (970626-1045-RBS)
Agriculture - Nutrients, Agriculture - Siltation

Fish Consumption

Potable Water Supply

Recreation

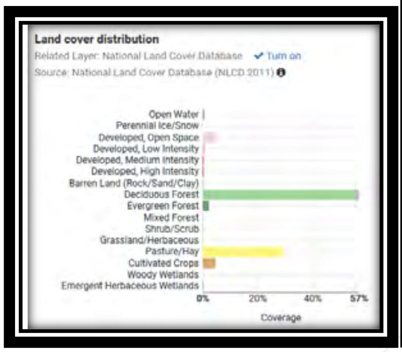
TMDL Information (if any)

South Branch South Fork Pine Creek (Not Finalized): NONPOINT SOURCE - Nutrients, NONPOINT SOURCE - Siltation

Begin Date **Meeting Date** **Draft Date** **End Date** **Final Date**

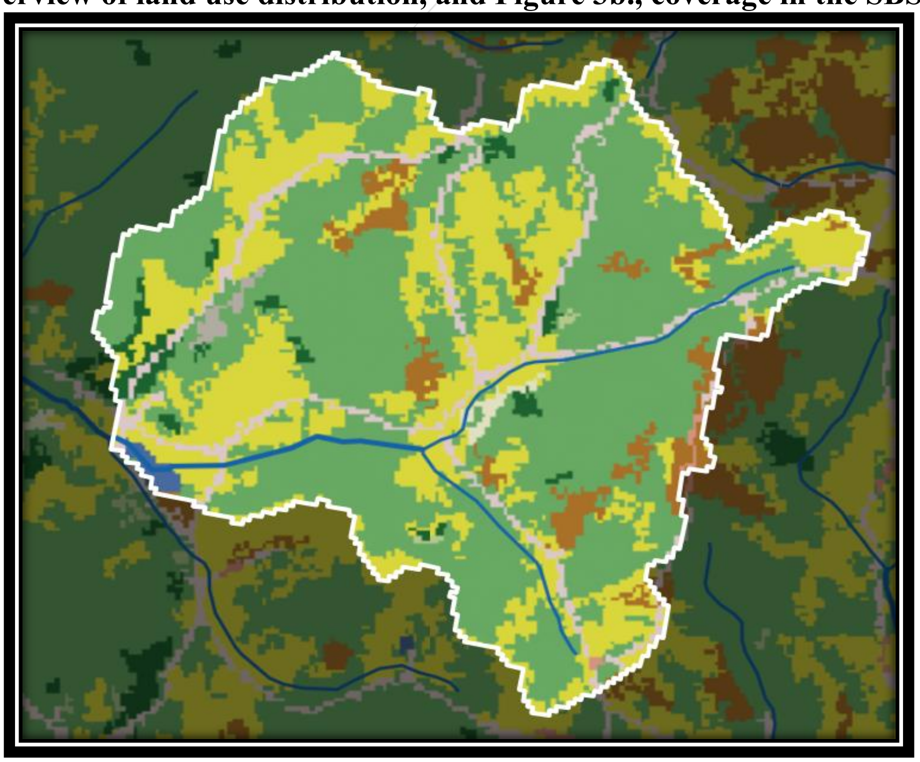
report generated Thursday, May 17, 2018 Page 2 of 2

From its headwaters, the South Branch of South Fork Pine Creek (SBSF Pine Creek) flows northwesterly for about 3.8 miles, before its confluence with the North Branch of South Fork Pine Creek to form South Fork Pine Creek. It is a tributary of the greater Pine Creek and the larger Allegheny River Basin. The SBSF Pine Creek watershed is in the townships of, Cowanshannock and Wayne in mid-eastern Armstrong County. This sediment and total phosphorus TMDL was developed for the upper section of SBSF Pine Creek. The targeted area is 2,041 acres, and encompasses about 9 miles of stream. Land use in this watershed is composed of agriculture (34%) including croplands and hay/pasture, forestland (59%), and (7%) in development, open space, and barren land (Figures 3a. and 3b.).



Type	Area (km²)	Coverage (%)
Open Water	0.04	0.5
Perennial Ice/Snow	0.00	0.0
Developed, Open Space	0.41	4.9
Developed, Low Intensity	0.06	0.7
Developed, Medium Intensity	0.00	0.0
Developed, High Intensity	0.00	0.0
Barren Land (Rock/Sand/Clay)	0.04	0.4
Deciduous Forest	4.74	56.9
Evergreen Forest	0.18	2.2
Mixed Forest	0.01	0.1
Shrub/Scrub	0.00	0.0
Grassland/Herbaceous	0.04	0.4
Pasture/Hay	2.44	29.3
Cultivated Crops	0.38	4.6
Woody Wetlands	0.00	0.0
Emergent Herbaceous Wetlands	0.00	0.0

Figure 3a. Overview of land use distribution, and Figure 3b., coverage in the SBSF Pine Creek

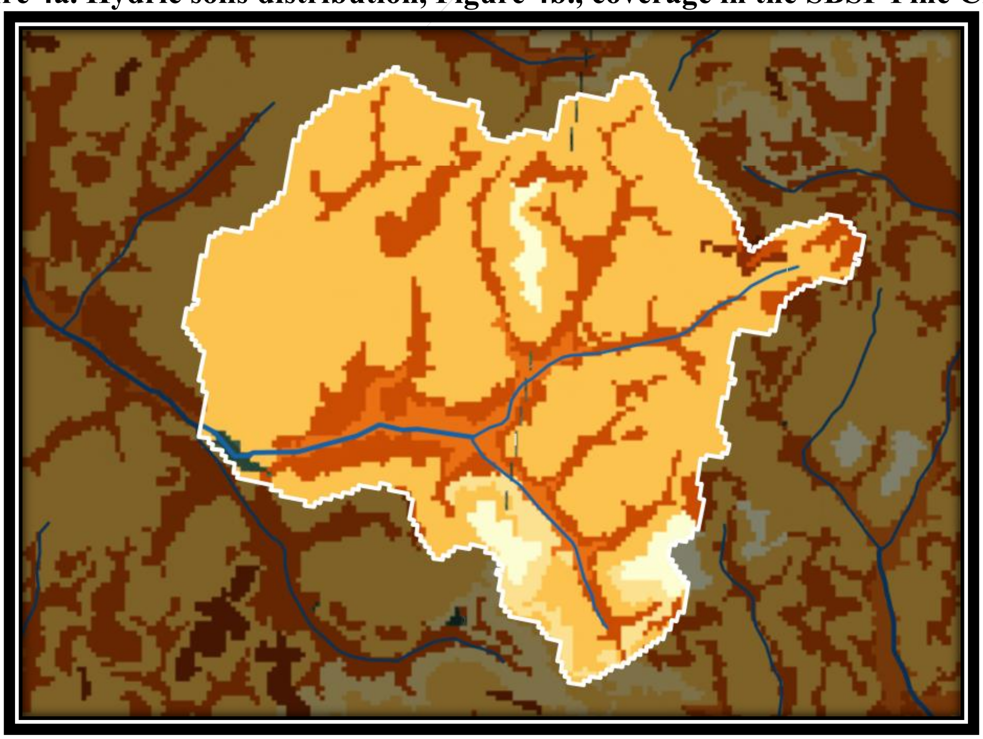


The soils are classified primarily as Hydrologic Soils Group (HSG) C and D (Figure 4a. and 4b.). These soil groups are characterized as having slow to very slow infiltration rates when thoroughly wetted and consist chiefly of soils of moderately fine to fine structure. These types of soils have a high runoff potential and must be managed as such to minimize impairments to receiving waters. The generally, low gradient drainage amongst sloping hills, with minimally vegetated agricultural areas, creates excess runoff during precipitation events. Unsuccessful sediment transport consecutively downstream causes inundation of habitat to the point of biological impairment.

Month	Precip (cm)	ET (cm)	Surface Runoff (cm)	Subsurface Flow (cm)
Jan	6.46	0.37	0.55	3.65
Feb	6.08	0.56	0.87	4.73
Mar	8.67	1.94	0.77	6.56
Apr	8.01	4.12	0.35	5.45
May	9.11	8.45	0.13	3.55
Jun	9.42	11.70	0.22	1.59
Jul	9.51	11.75	0.28	0.48
Aug	8.15	8.25	0.22	0.10
Sep	7.55	5.65	0.12	0.06
Oct	6.00	3.55	0.10	0.32
Nov	7.24	1.76	0.26	0.78
Dec	7.43	0.72	0.64	2.73
Total	93.63	58.82	4.51	30.00

Type	Area (km²)	Coverage (%)
A - High Infiltration	0.28	3.4
A/D - High/Very Slow Infiltration	0.00	0.0
B - Moderate Infiltration	0.29	3.4
B/D - Medium/Very Slow Infiltration	0.39	4.7
C - Slow Infiltration	5.75	68.9
C/D - Medium/Very Slow Infiltration	1.59	19.1
D - Very Slow Infiltration	0.03	0.4

Figure 4a. Hydric soils distribution, Figure 4b., coverage in the SBSF Pine Creek



Geographically, the South Branch of South Fork Pine Creek watershed lies within the Pittsburgh Low Plateau Section of the Appalachian Plateau Province. This section consists of a undulating upland cut by numerous, narrow and relatively, shallow valleys. Rocks within the watershed are generally interbedded sedimentary, and specifically, the two underlying bedrock groups are the lower Casselman Formation (light green, Figure 5.) and upper Glenshaw Formation (tan, Figure 5.). The Casselman's main rock type is shale. It's characterized by a few persistent red beds, claystones, freshwater limestones, thin sandstones, shales, siltstones (thin), and economically insignificant coals. The Glenshaw's main rock type is also shale. It consists of repeated sequences of sandstone, siltstone, shale, claystone (red beds), limestone, and coal.

Figure 5. General geology of the SBSF Pine Creek

The TMDL was completed to address the impairments noted on the *2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report, Streams, Category 5, Waterbodies, Pollutants Requiring a TMDL* as required under the Clean Water Act (Figure 6. non-impaired-green, impaired-purple and Table 2).

Figure 6. Impaired segments of the SBSF Pine Creek

Table 2. 2016 Integrated WQ Monitoring & Assessment Report - Impaired Streams List

2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Category 4a, 4c, and 5 Waterbodies, Pollutants Requiring a TMDL

Stream Nam / HUC / Use Assessed (Assessment ID) - Miles / Source	Cause	Date Listed	TMDL Date
Hydrologic Unit Code: 05010006-Middle Allegheny-Redbank			
South Branch South Fork Pine Creek Unnamed Of (ID:123853954) HUC: 05010006			
Aquatic Life (8357) - 0.36 miles			
Agriculture	Nutrients	1998	2011
	Siltation	1998	2011
South Branch South Fork Pine Creek Unnamed Of (ID:123853967) HUC: 05010006			
Aquatic Life (8357) - 0.39 miles			
Agriculture	Nutrients	1998	2011
	Siltation	1998	2011
South Branch South Fork Pine Creek Unnamed Of (ID:123853968) HUC: 05010006			
Aquatic Life (8357) - 1.01 miles			
Agriculture	Nutrients	1998	2011
	Siltation	1998	2011
South Branch South Fork Pine Creek Unnamed Of (ID:123853981) HUC: 05010006			
Aquatic Life (8357) - 0.7 miles			
Agriculture	Nutrients	1998	2011
	Siltation	1998	2011
South Branch South Fork Pine Creek Unnamed To (ID:123853980) HUC: 05010006			
Aquatic Life (8357) - 1.49 miles			
Agriculture	Nutrients	1998	2011
	Siltation	1998	2011

Page 1 of 1

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.

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

Pennsylvania Clean Streams Law Requirements and Agricultural Operations

All Pennsylvania farmers are subject to the water quality regulations authorized under the Pennsylvania Clean Streams Law, Title 25 Environmental Protection, and found within Chapters 91-93, 96, 102 and 105. These regulations include topics such as manure management, Concentrated Animal Operations (CAOs), Concentrated Animal Feeding Operations (CAFOs), Pollution Control and Prevention at Agricultural Operations, Water Quality Standards, Water Quality Standards Implementation, Erosion and Sediment Control Requirements, and Dam Safety and Waterway Management. To review these regulations, please refer to http://pacode.com/ or the Pennsylvania Water Quality Action Packet for Agriculture which is supplied by the County Conservation Districts. To find your County Conservation District’s contact information, please refer to http://pacd.org/ or call any DEP office or the Pennsylvania Conservation Districts Headquarters at 717-238-7223.

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

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. Please see Table 3 below for a breakdown of the changes to listing documents and assessment methods through 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 selected as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. All the biological surveys 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 SSWAP protocol that preceded the ICE protocol, the method requires selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. All the biological surveys include D-frame kick-net sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples are returned to the laboratory where the samples are then subsampled to obtain a benthic macroinvertebrate sample of 200 + or – 20% (160 to 240). The benthic macroinvertebrates in this subsample were then 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

Once a stream segment is listed as impaired, a TMDL must be developed for it. A TMDL addresses only one pollutant. If a stream segment is impaired by multiple pollutants, all those pollutants receive separate and specific TMDLs within that stream segment. For the TMDL process to be most effective, adjoining stream segments with the same source and impairment causes listing are addressed

Table 3. 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**

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, there are basic processes or steps 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. Calculate TMDL for the waterbody using EPA approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Submit draft report for public review and comments; and
6. EPA approval of the TMDL.

TMDL Elements (WLA, LA, MOS)

A TMDL equation consists of a waste load allocation, load allocation and a margin of safety. The waste load allocation (WLA) is the portion of the load assigned to point sources (National Pollutant Discharge Elimination System (NPDES) permitted discharges). The load allocation (LA) is the portion of the load assigned to nonpoint sources (non-permitted). The margin of safety (MOS) is applied to account for uncertainties in the computational process. The MOS may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Future TMDL Modifications

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

Changes in TMDLs That May Require EPA Approval

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

Changes in TMDLs That May Not Require EPA Approval

- Changes among individual WLAs but not the total sum of the WLA with no other changes in the TMDL; TMDL public notice concurrent with permit public notice.
- Removal of a pollutant source that will not be reallocated.
- Reallocation between LAs.
- Changes in land use.

TMDL Endpoints

Pennsylvania does not currently have specific numeric criteria for sediment or nutrient loading requirements. Therefore, to establish endpoints such that the designated uses of the SBSF Pine Creek watershed are attained and maintained, for all waterbodies, Pennsylvania utilizes its narrative water quality criteria, which state that:

> *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)).*

In an effort to address sediment and nutrient impairments found in the SBSF Pine Creek watershed, Total Maximum Daily Loads (TMDLs) were developed. Based on a reference watershed approach, a total load capacity (or endpoint) of 280,348.8 lbs./yr. of sediment loading and 438.0 lbs./yr. phosphorus loading in the SBSF Pine Creek watershed was determined sufficient in order to be protective of all High Quality Cold Water Fishery uses as it is maintained in the reference watershed, Mudlick Run.

Defining Excess Sedimentation and Nutrient Contribution

Sedimentation and nutrient contribution is an essential component of aquatic ecosystems, as it often contains minerals used by many aquatic organisms, and provides habitat. Sedimentation is a natural process that is caused by the weathering of landscape, whereby wind and water erode the surfaces of rocks and soils creating small particles. When these particles enter streams, they may flow with the current (suspended solids), or be deposited on the streambed.

Typically, natural inputs of sediment and the nutrient components do not cause problems, rather influence the dynamics and biology of hydrologic systems; however, when landscape is modified, excessive amounts of sediment can enter streams or erode from streams and cause undesirable effects, related to unbalanced uptake of total phosphorus (Bryan and Rutherford 1995).

Agricultural practices such as row cropping involve the tilling of landscapes to make the soil porous and fertile, which consequently loosens soil directly, as well as indirectly by removing plants whose roots once held soil in place. During rain events, loosened soil is directed toward nearby streams via overland runoff, and depending upon the density of vegetation along the shoreline, sediment enters into the water. The soil of pasture land is often more stable than that of cropland, yet in-stream sedimentation issues arise from the surface runoff associated with this land use. If the pasture land is grazed, the soil becomes compacted from the constant trampling by livestock, and therefore precipitation leaves the area via surface runoff and enters streams instead of infiltrating into the soil.

In addition, because vegetation within pasture land typically has shallow roots and little water retention ability, precipitation that does infiltrate the soil saturates the soil quickly, which consequently reduces absorbance and increases surface runoff. The sudden increase in water volume in a stream raises the velocity of the flow to a point where soil from the stream banks begins to erode into the channel. Runoff volume from this land use is further increased in areas with steep topography, and areas in which cattle have overgrazed the vegetation. In addition to facilitating hydrology-related sedimentation issues, the overgrazing and trampling of vegetation in riparian zones leads to loosened soil that directly enters streams.

Eroded sediment can cause numerous problems for aquatic organisms. Suspended sediment causes turbidity, which can interfere with predation efficiency; cause respiration problems by clogging gills of aquatic organisms (Horne and Goldman 1994); and also reduces sunlight penetration, which affects plant photosynthesis (Waters 1995). Causing a higher magnitude of problems, deposited sediment can 1) suffocate eggs of fish and other organisms, 2) suffocate small organisms, 3) severely reduce habitat and habitat diversity, and 4) alter flow patterns (USEPA 1999). Because neither Pennsylvania nor EPA has water quality criteria for siltation and total phosphorus (nutrients), a method was developed to determine water quality objectives for this pollutant that should result in the impaired stream segments attaining their designated uses. The method employed for this TMDL is termed the "Reference Watershed Approach".

Selection of the Reference Watershed

The reference watershed approach was used to estimate the appropriate sediment and total phosphorus (nutrient) loading reduction necessary to restore healthy aquatic communities to the SBSF Pine Creek. This approach is based on selecting a non-impaired, or reference, watershed and estimating its current loading rates for the pollutants of interest. The objective of the process is to reduce loading rates of those pollutants identified as causing impairment to a level equivalent to or lower than the loading rates in the reference watershed. Achieving the appropriate load reductions should allow the return of a healthy biological community to affected stream segments.

First, there are three factors that should be considered when selecting a suitable reference watershed: impairment status, similarity of physical properties, and size of the watershed. A watershed that the

Department has assessed and determined to be attaining water quality standards should be used as the reference. Second, a watershed that closely resembles the impaired watershed in physical properties such as land use/land cover, physiographic province, elevation, slope and geology should be chosen. Finally, the size of the reference watershed should be within 20-30% of the impaired. The search for a reference watershed that would satisfy the above characteristics was done by means of a desktop screening using several GIS shapefiles, including a watershed layer, geologic formations layer, physiographic province layer, soils layer, Landsat-derived land cover/use grid, and the stream assessment information found on the Department's Instream Comprehensive Evaluation Protocol (ICE) GIS-based website.

The suitability of the chosen watershed was confirmed through discussions with Department staff as well as through field verification of conditions. Mudlick Run was selected as the reference for developing the SBSF Pine Creek TMDL (see Figures 7. To 10.). It has a total drainage area of 1816.2 acres. Mudlick Run is a tributary to Little Mahoning Creek and the larger Mahoning Creek and Allegheny River basin.

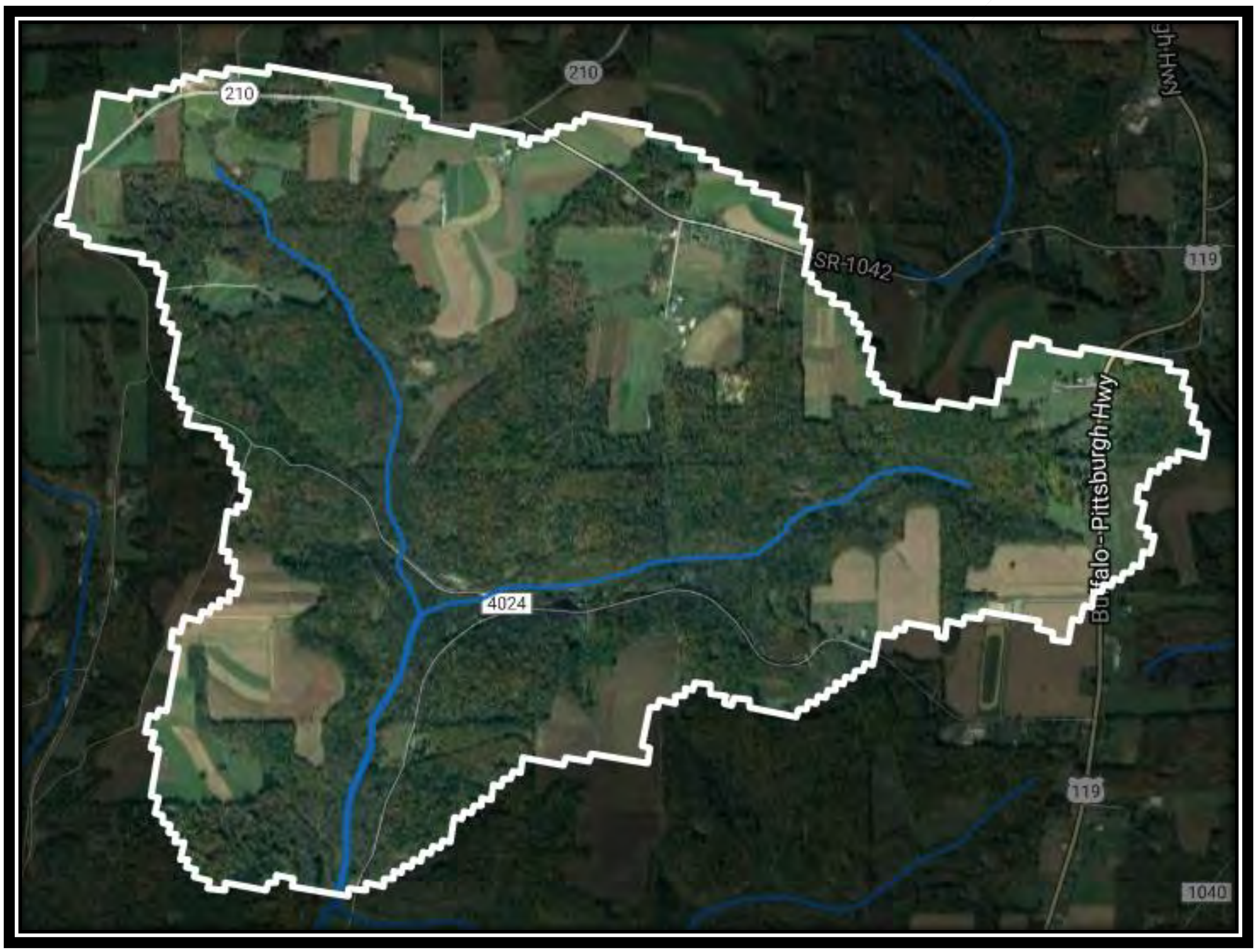


Figure 7a. Map of Bioassessment Sites on Mudlick Run (dark blue-HQ-CWF)

Mudlick Run is also designated as a High Quality, Cold Water Fishery like the SBSF Pine Creek, but is attaining its designated aquatic life uses based on biological sampling done by the Department in 2005 (Figure 10. non-impaired-green, impaired-purple).

Figure 7b. Map of Bioassessment Sites on Mudlick Run (dark blue-HQ-CWF)

Figure 7c. 2005 WQ Bioassessment, Mudlick Run, Foose and Beaverdam Rds (Not Impaired)

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

Station ID 20050608-1200-TAS

Stream Name Mudlick Run (01182065) **Stream Code** 47516 **Strahler** 1

Survey ID 54752 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program

Collection Date **Collection Time** **Latitude** 40.8684916 **Longitude** -79.0490416

HUC8 05010006 Middle Allegheny-Redbank

Station Location Comments

Mudlick Run adjacent to T 652 approximately 200 meters downstream SR 4024.

Biology / Physical Habitat Comments

Other 1% gas wells in watershed.

Land Use Comments

Upper watershed was primarily forested.

Impairment Status Comments

Lower diversity and abundance than expected. Excellent riparian corridor.

Taxa List

Taxa Name	Abundance Category	Abundance Range	PTV	FFG
Baetidae	Present	3-9	6	CG
Heptageniidae	Rare	<3	3	SC
Ephemerellidae	Rare	<3	2	CG
Leptophlebiidae	Common	10-24	4	CG
Gomphidae	Rare	<3	4	PR
Hydropsychidae	Present	3-9	5	FC
Glossosomatidae	Rare	<3	0	SC
Limnephilidae	Present	3-9	4	SH
Uenoidae	Present	3-9	3	SC
Elmidae	Present	3-9	5	CG
Tipulidae	Rare	<3	4	SH
Cambaridae	Present	3-9	6	CG

SSWAP metrics and IBI

	Raw Metric Value	Standardized Metric Value
Total Richness	12	54.5
EPT Richness (PTV 0 - 4)	6	54.5
Beck's Index (version 3)	4	28.6
Hilsenhoff Biotic Index	4.24	77.7
Shannon Diversitiy	2.20	83.3
	SSWAP IBI	59.7

report generated Thursday, May 17, 2018 Page 1 of 2

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

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Collection Date **Collection Time** **Latitude** 40.8684916 **Longitude** -79.0490416

HUC8 05010006 Middle Allegheny-Redbank

1. Abundance obviously low	N
2. Seven or fewer families	N
3. Three or fewer mayfly individuals (exclude Baetidae, Caenidae, Siphlonuridae)	N
4. Stoneflies collectively present	N
5. Mayflies and caddisflies collectively abundant (exclude Baetidae, Caenidae, Siphlonuridae, Hydropsychidae, Polycentropidae)	Y
6. Jul - Sep: at least four EPT families with tolerance value of 4 or less Nov - May: at least six EPT families with tolerance value of 4 or less	Y
7. Four or more famlies with tolerance value of 3 or less	Y
8. Six or more families with tolerance value of 4 or less	Y
9. Dominant family with tolerance value of 4 or less	Y
10. Dominant family with tolerance value greater than 5 (criteria 7 and 8 negate this criterion)	N
11. Seven or more families with tolerance value of 6 or more (criteria 7 and 8 negate this criterion)	N
12. Sample dominated by families with a mean tolerance value of 5 or less	Y
13. Sample dominated by families with a mean tolerance value of 6 or more	N
14. Embeddedness (or substrate character for pool/glide) + sediment deposition = 24 or less (20 or less for warmwater, low gradient streams)	N
15. Condition of banks + bank vegetation = 24 or less (20 or less for warmwater, low gradient streams)	N
16. Total habitat score 140 or less for forested, coldwater, high gradient streams (120 or less for warmwater, low gradient streams)	N
17a. Special conditions (attaining)	N
17b. Special conditions (impaired)	N
17c. Special conditons description	

Not impaired Y **Biology impaired** N **Habitat impaired** N **Insufficient data** N

Rock pick influenced assessment N **Impact is localized** N **Re-evaluate designated use** N

Physical Habitat Assessment **Pool/Glide Assessment** N

Instream Cover	14	Substrate / Cover	0	Frequency of Riffles	16	Contition of Banks	13
Epifaunal Substrate	14	Velocity/Depth Regimes	10	Channel Sinuosity	16	Bank Vegetation	16
Embeddedness	13	Pool Variability	0	Channel Flow Status	8	Disruptive Pressure	20
Pool Substrate	0	Sediment Deposition	13	Channel Alteration	18	Riparian Zone	18

Instream Score 54 **Riparian Score** 47 **Total Score** 173

Field Measurements **Lab samples**

Temperature (°C) **Dissolved Oxygen (mg/L)** **Flow (CFS)**

pH **Alkalinity (mg/L as CaCO3)** **Conductivity**

Use Assessment Status for Stream Reach **Designated Use** HQ-CWF **Existing Use**

Aquatic Life Attaining (20050608-1200-tshervinsk)

Fish Consumption

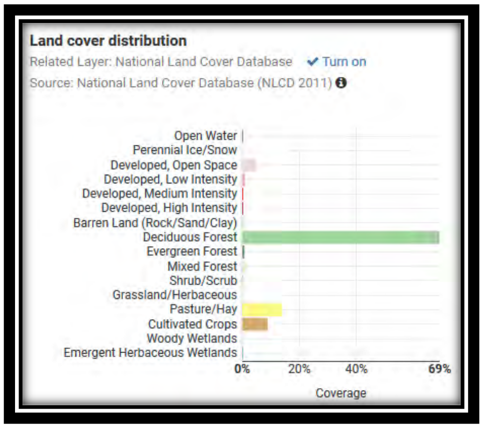
Potable Water Supply

Recreation

TMDL Information (if any)

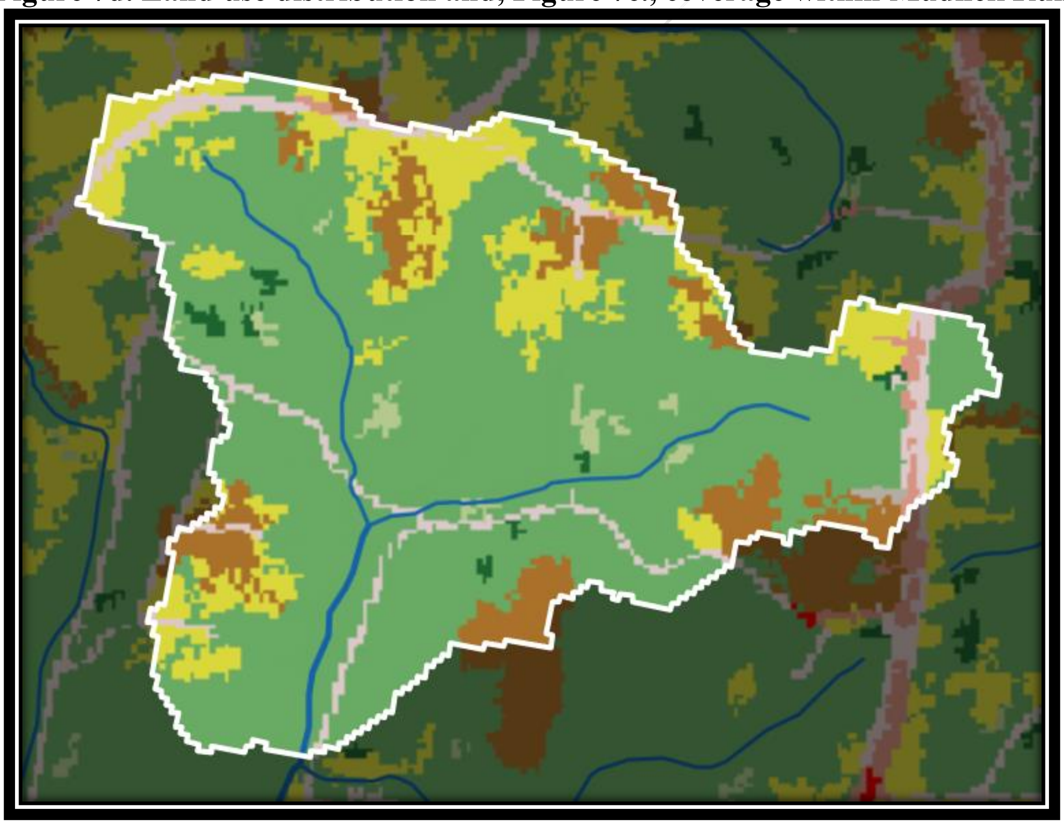
Begin Date **Meeting Date** **Draft Date** **End Date** **Final Date**

report generated Thursday, May 17, 2018 Page 2 of 2



Type	Area (km²)	Coverage (%)
Open Water	0.00	0.0
Perennial Ice/Snow	0.00	0.0
Developed, Open Space	0.35	4.8
Developed, Low Intensity	0.07	0.9
Developed, Medium Intensity	0.00	0.0
Developed, High Intensity	0.00	0.0
Barren Land (Rock/Sand/Clay)	0.01	0.2
Deciduous Forest	5.08	69.1
Evergreen Forest	0.06	0.8
Mixed Forest	0.09	1.2
Shrub/Scrub	0.00	0.0
Grassland/Herbaceous	0.00	0.0
Pasture/Hay	1.04	14.2
Cultivated Crops	0.65	8.8
Woody Wetlands	0.00	0.0
Emergent Herbaceous Wetlands	0.00	0.0

Figure 7d. Land use distribution and, Figure 7e., coverage within Mudlick Run



Type	Area (km^2)	Coverage (%)
A - High Infiltration	1.86	25.3
A/D - High/Very Slow Infiltration	0.00	0.0
B - Moderate Infiltration	0.64	8.7
B/D - Medium/Very Slow Infiltration	0.25	3.4
C - Slow Infiltration	2.08	28.3
C/D - Medium/Very Slow Infiltration	1.98	26.9
D - Very Slow Infiltration	0.53	7.3

Figure 8a. Hydric soils distribution and Figure 8b., coverage within Mudlick Run

Geographically, the Mudlick Run watershed lies within the Pittsburgh Low Plateau Section of the Appalachian Plateau Province. This section consists of undulating upland cut by numerous, narrow and relatively, shallow valleys. Rocks within the watershed are generally interbedded sedimentary, and specifically, the underlying bedrock group is the upper Glenshaw Formation (tan, Figure 9.). The Glenshaw's main rock type is also shale. It consists of repeated sequences of sandstone, siltstone, shale, claystone (red beds), limestone, and coal.

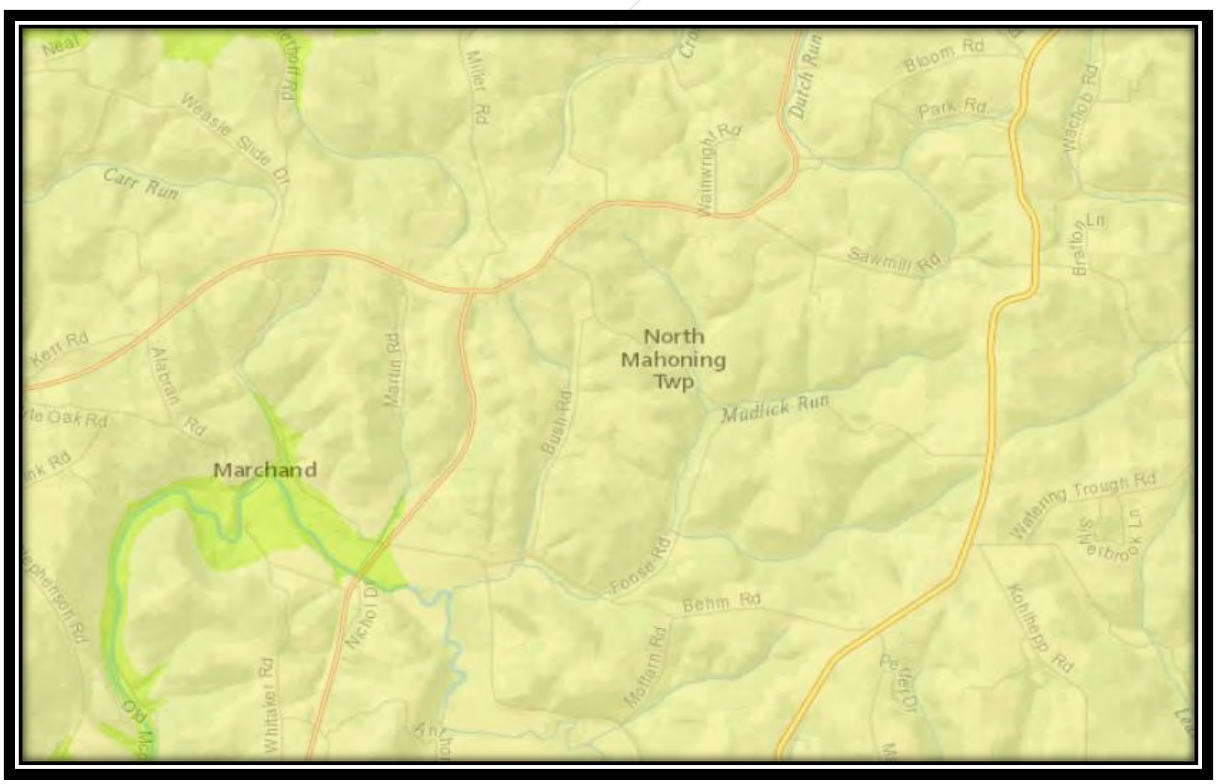


Figure 9. General geology of Mudlick Run

Table 4. compares the respective impaired and reference headwaters in terms of size, location, and other physical characteristics.

Table 4. Comparison of SBSF Pine Creek (impaired) and Mudlick Run (reference)		
	SBSF Pine Creek	**Mudlick Run**
Physiographic Province	Appalachian Plateau Province (Pittsburgh Low Plateau Section)	Appalachian Plateau Province (Pittsburgh Low Plateau Section)
Area (acres)	2,041.1	1,816.2
Land Use Distribution		
% Agriculture	34	27
% Forest	59	67
% Development	7	1
Surface Geology:		
Interbedded Sedimentary	100	100
Hydric Soils:		
Group A	3.4	25.3
Group A/D	0.0	0.0
Group B	3.4	8.7
Group B/D	4.7	3.4
Group C	68.9	28.3
Group C/D	19.1	26.9
Group D	0.4	7.3
Average Rainfall (in.)	36.9	44.8
Average Runoff (in.)	1.5	2.4

Hydrologic / Water Quality Modeling

Part 1. Model Overview & Data Compilation

The core watershed simulation model for the MAPSHED software application is the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker. The original DOS version of the model was re-written in Visual Basic by Evans et al. (2002) to facilitate integration with ArcView, and tested extensively in the U.S. and elsewhere.

The GWLF model provides the ability to simulate runoff and corresponding sediment and total phosphorus (nutrient) loading from a watershed given variable-size source areas (i.e., agricultural, forested, and developed land). It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment/total phosphorus (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 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 models surface runoff using the Soil Conservation Service Curve Number, or SCS-CN, approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (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 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. For execution, the model requires two separate input files containing transport and weather-related data. The transport (transport.dat) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The weather (weather.dat) file contains daily average temperature and total precipitation values for each year simulated.

Since its initial incorporation into MAPSHED, the GWLF model has been revised to include a number of routines and functions not found in the original model. For example, a significant revision in one of the earlier versions of MAPSHED was the inclusion of a streambank erosion routine. This routine is based on an approach often used in the field of geomorphology in which monthly streambank erosion is estimated by first calculating a watershed-specific lateral erosion rate (LER). After a value for LER has been computed, the total sediment load generated via streambank erosion is then calculated by multiplying the above erosion rate by the total length of streams in the watershed (in meters), the average streambank height (in meters), and the average soil bulk density (in kg/m3). The inclusion of the various model enhancements mentioned above has necessitated the need for several more input files than required by the original GWLF model, including a "scenario" (*.scn) file, an animal data (animal.dat) file. Also, given all of the new and recent revisions to the model, it has been renamed "GWLF-E" to differentiate it from the original model. In utilizing this interface, the user is prompted to load required GIS files and to provide other information related to various "non-spatial" model parameters (e.g., beginning and end of the growing season; the months during which manure is spread on agricultural land, etc.). This information is subsequently used to automatically derive values for required model input parameters which are then written to the appropriate input files needed to execute the GWLF-E model.

Also accessed through the interface are Excel-formatted weather files containing daily temperature and precipitation information. (In the version of MAPSHED used in Pennsylvania, a statewide weather database was developed that contains about twenty-five (25) years of temperature and precipitation data for seventy-eight (78) weather stations around the state).

Part 2. GIS Based Derivation of Input Data

The primary sources of data for this analysis were geographic information system (GIS) formatted databases and shapefiles. In using the MAPSHED interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g. beginning and end of growing season, manure spreading period, etc.). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, MAPSHED has been linked with statewide GIS data layers such as land use/cover, soils, topography and physiography; and includes location-specific default information such as cropping practices. Complete GWLF-formatted weather files are also included for the seventy-eight weather stations around the state. Table 5. lists GIS datasets and shapefiles used for the SBSF Pine Creek TMDL calculations via MAPSHED and provides explanations of how they were used for development of the input files.

Table 5. GIS Datasets

DATASET	DESCRIPTION
county.shp	The county boundaries coverage lists data on conservation practices which provides C and P values in the Universal Soil Loss Equation (USLE).
padem	100-meter digital elevation model; this is used to calculate land slope and slope length.
palumrlc	A satellite image derived land cover grid which is classified into 15 different landcover categories. This dataset provides landcover loading rates for the different categories in the model.
physprov.shp	A shapefile of physiographic provinces. This is used in rainfall erosivity calculations.
smallsheds.shp	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
streams.shp	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
PAgeo	A shapefile of the surface geology used to compare watersheds of similar qualities.
weathersta.shp	Historical weather files for stations around Pennsylvania to simulate flow.
soils.shp	A shapefile providing soil characteristics data. This is used in multiple calculations.
zipcodes.shp	This shapefile provides animal density numbers used in the LER calculation.

In the GWLF model, the nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It is also affected by farming practices utilized in the area. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

Areal extent of different land use/cover categories: This is calculated directly from a GIS layer of land use/cover.

Curve number: This determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type, and is calculated directly using digital land use/cover and soils layers.

K factor: This factor relates to inherent soil erodibility, and affects the amount of soil erosion taking place on a given unit of land.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, the crops grown and the cultivation practices utilized largely control this factor. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

P factor: This factor is directly related to the conservation practices utilized in agricultural areas. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment that is delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This relates to the amount of water that can be stored in the soil and affects runoff and infiltration. It is calculated using a digital soils layer.

Watershed Assessment and Modeling

The MAPSHED model was used to establish existing loading conditions for the impaired (siltation and total phosphorus (nutrients) the SBSF Pine Creek and the corresponding non-impaired, reference of Mudlick Run. All MAPSHED data and outputs have been attached to this TMDL as Attachment A.

Department staff visited the listed watersheds to get a better understanding of existing conditions that might influence the MAPSHED model (2005, 2008, and 2017). The following are general observations (as detailed with photos and descriptions) of the reference of Mudlick Run (Figures 9. to 21.). and biologically impaired, SBSF Pine Creek (Figures 22. to 35.). Special attention was given to what BMPs were implemented in Mudlick Run in comparison with the SBSF Pine Creek being that many land uses were relatively similar.

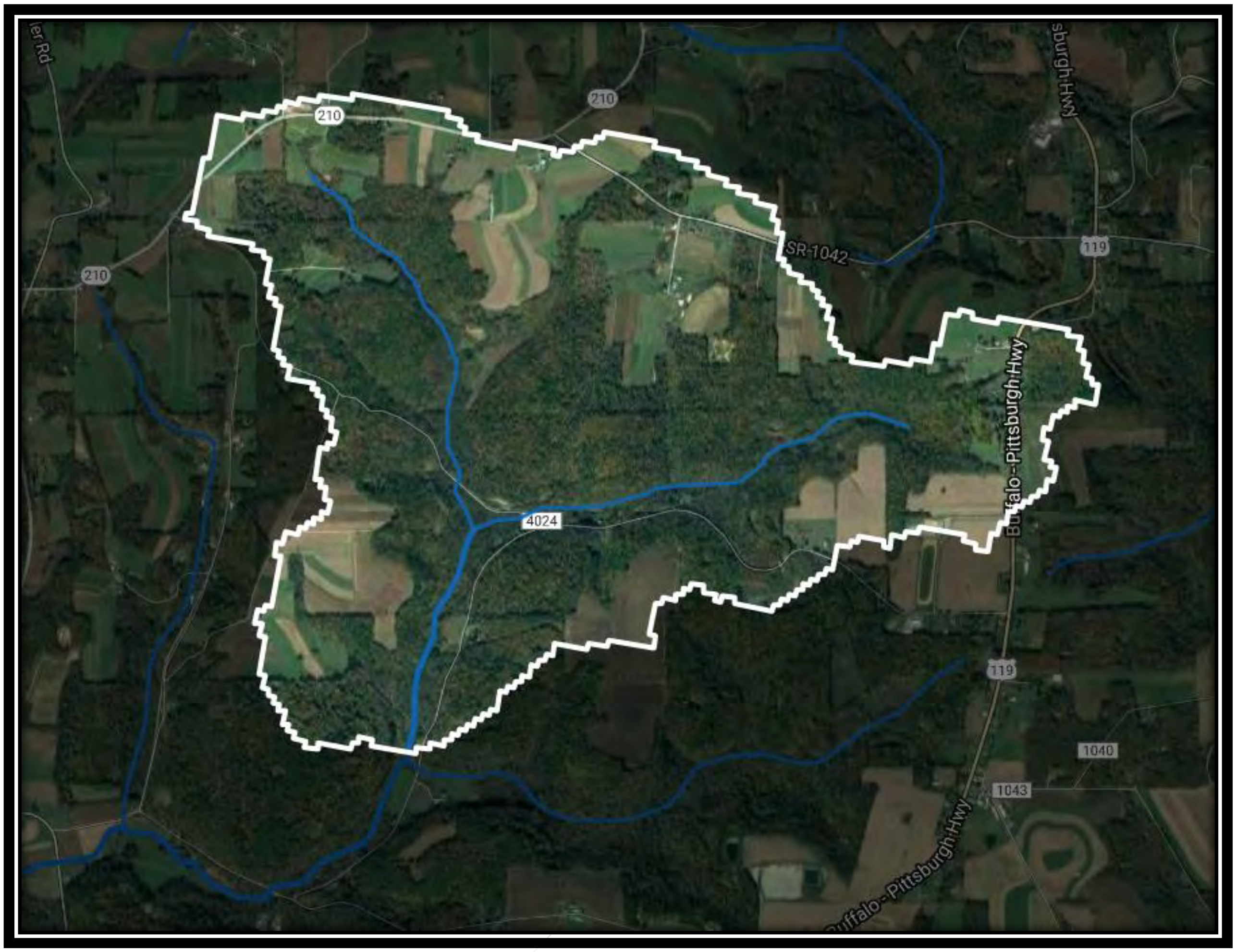


Figure 10a. Overview of on the ground land uses in Mudlick Run (reference)

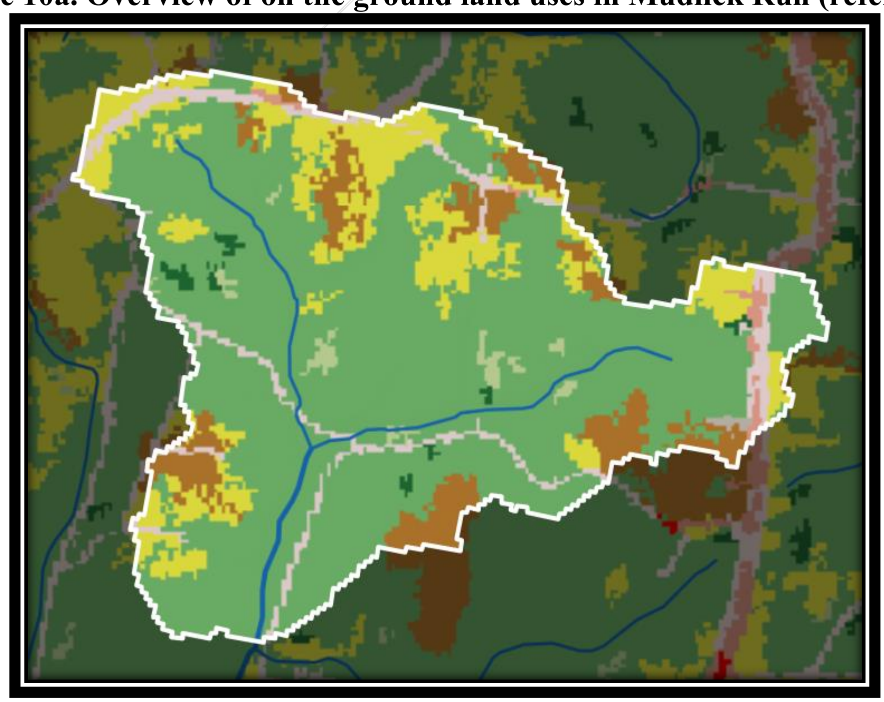


Figure 10b. Mudlick Run starts west of I-119 and south of Sawmill Rd. (NW of Marchant)

Figure 11. The headwaters flow approximately a mile and half through forest

Figure 12. The stream is generally shaded and opens up adjacent to Beaver Road and crossings

Figure 13. Stable banks and adequate flushing allow minimize siltation and turbidity

Figure 14. Benthic environment has snags, variety of substrate, leaf packs, and pools

Figure 15. Small tributary originating as a spring and pool with retention

Figure 16. Riparian vegetation provides a tighter stream bed with fluvial clarity

Figure 17. The first major tributary enters from the northwest (up from Beaver Drive) Contour cropping and other practices allow more retention for storm water

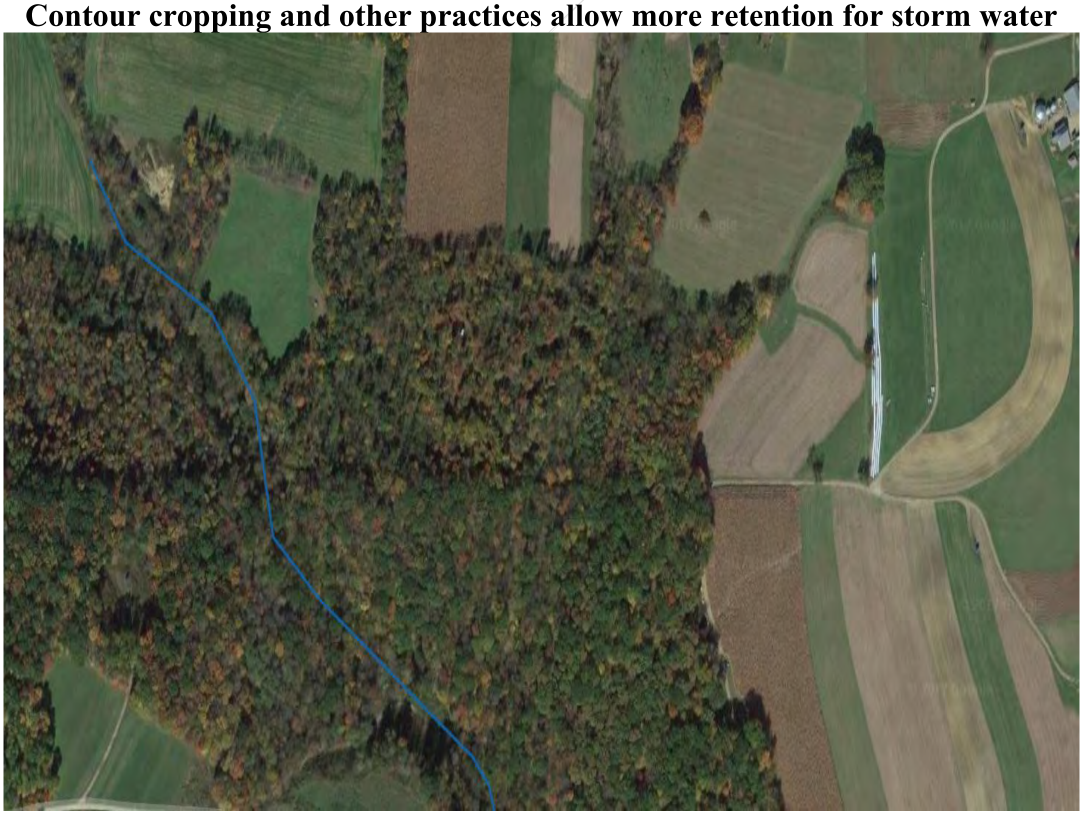


Figure 18. Mudlick flows south for approximately a half mile adjacent to Foose Road

Figure 19. Excellent frequency of riffle and run habitat

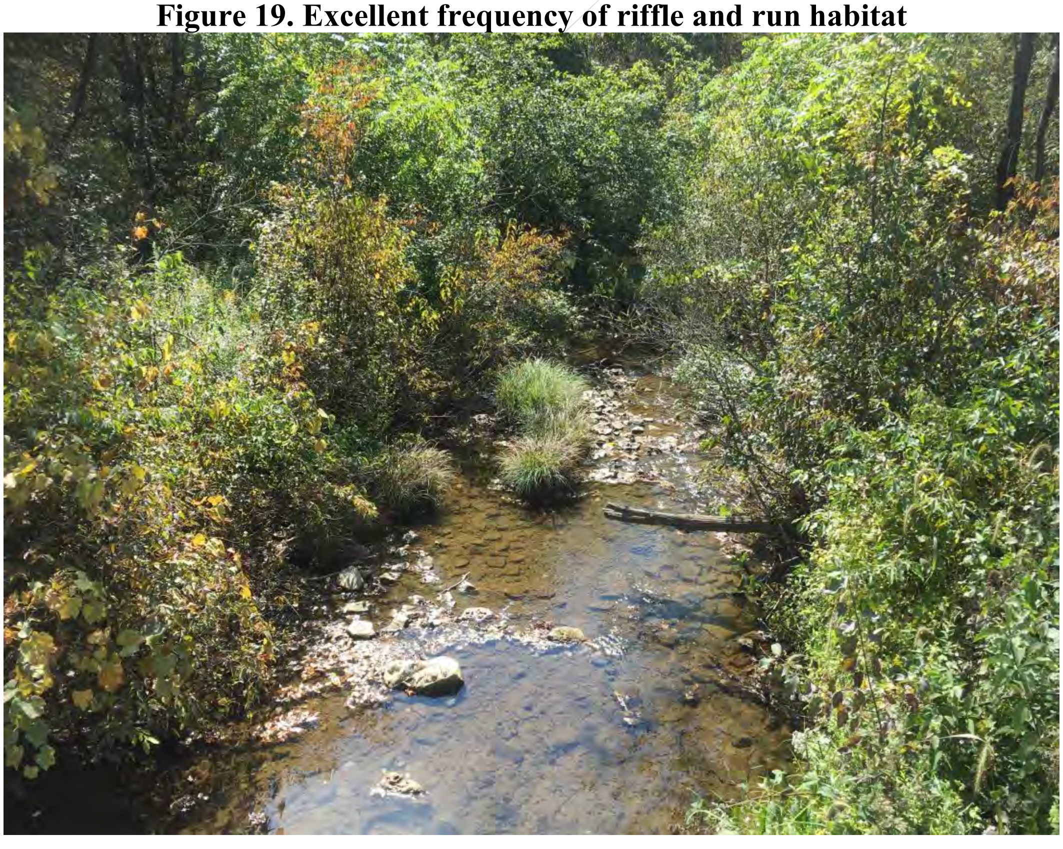


Figure 20. Cropland and low cropped vegetation excludes the stream plain

Figure 21. Bank with rooted vegetation encourages successful storm water flushing

Figure 22. Overview of on the ground land uses in SBSF Pine Creek

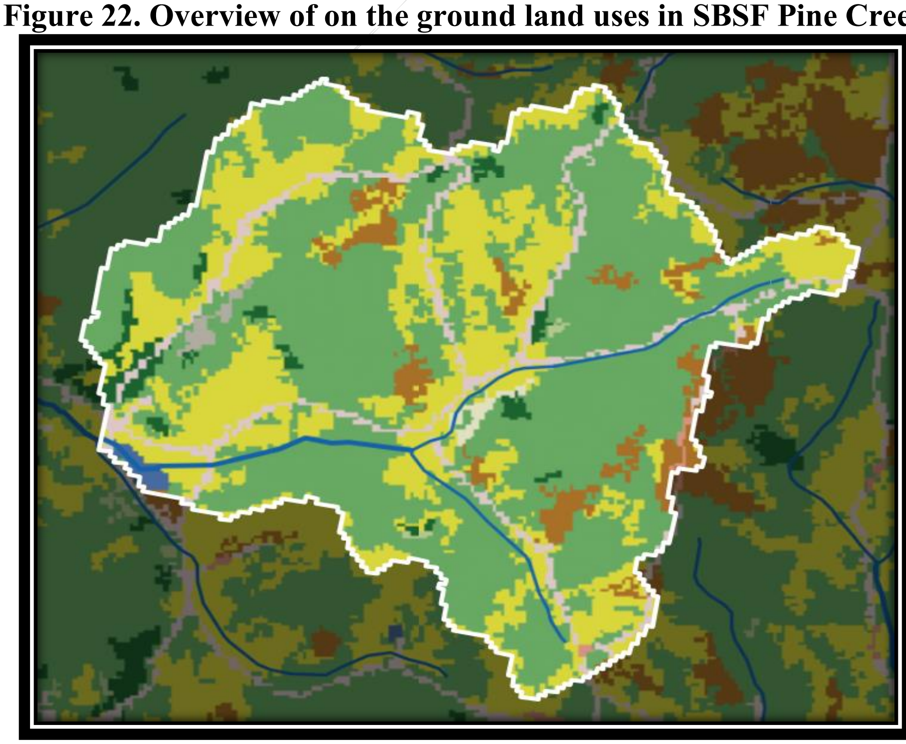


Figure 23. The headwaters of the SBSF Pine Creek consist of two tributaries and flows approximately a mile adjacent to Logan Road through generally forested riparian tracts

Figure 24. Impaired segments (purple) have both grazing and cropland

Figure 25. Grazing land has a variety of animal influences

Figure 26. Excessive algal growth is found in the shallow pools

Figure 27. Stream bank instability and storm water incision

Figure 28. Instream slumping and benthic inundation

Figure 29. Extensive lack of rooted vegetation and land use

Figure 30. Extensive deuteriation of stream bed and flood zone

Figure 31. Livestock staging area and run off in proximity to the SBSF Pine Creek

Figure 32. Several tributaries have either good bank or heavy impacts to existing stream

Figure 33. Elevated stream banks of silt cause in place pooling and downstream flooding

Figure 34. The lower stretch of the SBSF Pine Creek (adjacent to SR 1028) show pooling and instream development of wetlands

Figure 35. The SBSF Pine empties into a pond and lacks production habitat

To summarize some of the visual comparisons, both the impaired and reference watersheds are similar; however, differences were found that likely explain why streams within the Mudlick Run watershed are not impaired, whereas SBSF Pine Creek and its tributaries are. It should be noted that some areas in the Mudlick Run watershed could be improved; however, there are more areas in this watershed that are protective of the streams relative to the Mudlick Run watershed.

Because most of the sediment impairments within the SBSF Pine Creek watershed arise from within agricultural land, attention was given to such areas that exist within the reference watershed. The two major sedimentation issues in the SBSF Pine Creek watershed are 1) direct sediment runoff and stream bank decay resulting from overgrazed and trampled riparian areas, and 2) in-stream erosion caused by accelerated flow resulting from large volumes of overland runoff during rain events.

Table 6. Sediment & phosphorus loads in the SBSF Pine Creek, and Mudlick Run

	SBSF Pine Creek			Mudlick Run (Reference)		
Pollutant Source	**Area (Acres)**	**Sediment (lbs./yr.)**	**Total P (lbs./yr.)**	**Area (Acres)**	**Sediment (lbs./yr.)**	**Total P (lbs./yr.)**
Hay/Past	606	473,000.0	449.5	258	54,800.0	156.9
Cropland	95	100,800.0	102.6	161	108,800.0	194.7
Forest	1,224	1,200.0	2.2	1,296	4,600.0	16.4
Open Space	9	600.0	0.6	0	0.0	0.0
Barren Land	9	0.0	0.1	3	0.0	0.2
Low Dev.	115	800.0	2.8	104	2,200.0	7.1
Stream Bank	-	33,000.0	6.9	-	77,800.0	12.8
Farm Animals	-	-	204.3	-	-	**154.2**
TOTAL	**2,058**	**608,400.0**	**769.2**	**1,822**	**248,200.0**	**542.0**

For Table 6 the "stream bank" sediment loads are calculated by MAPSHED's stream bank routine. This routine uses stream bank (linear) miles rather than area. Loading is based on surface hydrology (precipitation, erosion, runoff) computation.

Development of Sediment and Total PhosphorusTMDL

The target TMDL value for the biologically impaired SBSF Pine Creek was established based on current loading rates for sediment and total phosphorus (nutrient) in the reference, Mudlick Run watershed. Reducing the loading rates in SBSF Pine Creek to levels equal to, or less than, the reference watershed should allow for the reversal of current use impairments and maintain its HQ-CWF aquatic life use value. As described in the previous section, sediment and total phosphorus (nutrient) loading rates were computed for the reference stream using the MAPSHED model. The target TMDL value was determined by multiplying the unit area loading rates for the reference stream by the total area of the biologically impaired one (Table 7.).

Table 7. Target TMDL = Reference Loading Rate by Area of Impairment

Pollutant	**Loading Rate in Reference (lb./ac-yr.)**	**Total Area Impaired Watershed (ac)**	**Target TMDL Value (lb./yr.)**
Sediment	**136.2**	**2,058.0**	**280,348.8**
Phosphorus	**0.3**	**2,058.0**	**612.2**

The TMDL value was used for load allocations and reductions using the following two equations:
TMDL = WLA + LA + MOS, TMDL = Total Maximum Daily Load, WLA = Waste Load Allocation (Point Sources), MOS = Margin of Safety, LA = Load Allocation (Nonpoint Sources) = ALA + LNR
ALA = Adjusted Load Allocation, LNR = Loads Not Reduced

Waste Load Allocation

The waste load allocation (WLA) portion of the sediment TMDL equation is the total loading of a pollutant that is assigned to point sources. A search of the Pennsylvania Department of Environmental Protection's (Department) efacts permit database identified no point source discharges within the SBSF Pine Creek watershed. A WLA allocation of 1% of the Sediment TMDL (280,348.8 lbs./yr.) was incorporated as a bulk reserve (2,803.5 lbs./yr.) for the dynamic nature of future permit activity.

SBSF Pine Creek Sediment TMDL:
WLA = 2,803.5 lbs./yr. or 7.7 lbs./d.

A WLA allocation of 1% of the Total Phosphorus (nutrient) TMDL (612.2 lbs./yr.) was incorporated as a bulk reserve (6.1 lbs./yr.) for the dynamic nature of future permit activity.

SBSF Pine Creek Total Phosphorus (nutrient) TMDL:
WLA = 6.1 lbs./yr. or 0.02 lbs./d.

Margin of Safety

The margin of safety (MOS) is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment was reserved as the MOS. Using 10% of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of SBSF Pine Creek Run. The MOS used for the Sediment TMDL was set at 28,034.9 lbs./yr. and at 61.2 lbs./yr. for the Total Phosphorus (nutrient) TMDL.

SBSF Pine Creek Sediment TMDL:
MOS = 280,348.8 lbs./yr. (TMDL) * 0.1 = 28,034.9 lbs./yr. or 76.8 lbs./d.

SBSF Pine Creek Total Phosphorus (nutrient) TMDL:
MOS = 612.2 lbs./yr. (TMDL) * 0.1 = 61.2 lbs./yr. or 0.2 lbs./d.

Load Allocation

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. The LA for the Sediment TMDL and Total Phosphorus (nutrient) TMDL was computed by subtracting the MOS value and the WLA from the TMDL value. The LA for Sediment TMDL was set at 249,510.5 lbs./yr. and at 544.9 lbs./yr. for the Total Phosphorus (nutrient) TMDL.

SBSF Pine Creek Sediment TMDL:
LA = 280,348.8 lbs./yr. (TMDL) – 28,034.9 lbs./yr. (MOS) – 2,803.5 lbs./yr. (WLA) = 249,510.5 lbs./yr. or 683.6 lbs./d

SBSF Pine Creek Total Phosphorus (nutrient):
LA = 612.2 lbs./yr. (TMDL) – 61.2 lbs./yr. (MOS) – 6.1 lbs./yr. (WLA) = 544.9 lbs./yr. or 1.5 lbs./d.

Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced (LNR)) from the LA. The SBSF Pine Creek TMDLs was developed to address impairments caused by agricultural activities, including hay/pastureland and cropland. Transitional land and stream banks are also considered a contributor to the sediment and phosphorus loading in the watershed. Land uses/source loads not reduced (LNR) were carried through at their existing loading values (Table 8.).

Table 8. Load Allocations, Loads Not Reduced, Adjusted Load Allocations

	Sediment (lbs./yr.)	Total Phosphorus (lbs./yr.)
Load Allocation	**249,510.5**	**544.9**
Loads Not Reduced:	**2,600.0**	**5.7**
Forest	1,200.0	2.2
Open Space	600.0	0.6
Barren Land	0.0	0.1
Low Dev.	800.0	2.8
Adjusted Load Allocation	**246,910.5 (676.5)**	**539.2 (1.5 lbs./d.)**

TMDL Summary

The sediment and total phosphorus (nutrient) TMDLs established for the SBSF Pine Creek consists of a Load Allocation (LA) and a Margin of Safety (MOS). The individual components of SBSF Pine Creek TMDLs are summarized in Table 9.

Table 9. TMDL Components for the SBSF Pine Creek TMDL

	Sediment (lbs./yr.)	Sediment (lbs./d.)	Total Phosphorus (lbs./yr.)	Total Phosphorus (lbs./d.)
TMDL (Total Maximum Daily Load)	280,348.8	768.1	**612.2**	**1.7**
WLA (Waste Load Allocation)	2,803.5	7.7	**6.1**	**0.02**
MOS (Margin of Safety)	28,034.9	76.8	**61.2**	**0.2**
LA (Load Allocation)	249,510.5	683.6	**544.9**	**1.5**
LNR Loads Not Reduced)	2,600.0	7.1	**5.7**	**0.0**
ALA (Adjusted Load Allocation)	246,910.5	676.5	**539.2**	**1.5**

Calculation of Sediment and Total P Load Reductions

The adjusted load allocation established in the previous section represents the sediment and total phosphorus (nutrient) loads that is available for allocation between agricultural activities (cropland and hay/pastureland) and associated stream banks in the SBSF Pine Creek. Data needed for load reduction analyses, including land use distribution, were obtained by GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method, Attachment B, was used to distribute the ALA between the two land use types and stream banks. The process is summarized below:

1. Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR. For this evaluation Cropland was in excess of the adjusted load allocation (ALA).

2. After any necessary reductions, have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the total allocable load. If the allocable load 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. For this evaluation, the allocable load was exceeded. The equal percent reduction, i.e., the ALA divided by the summation of the baselines, worked out to a reduction in the overall, sediment loading to **59%** and a **29.4%** reduction in the total phosphorus loading.

Tables 10. (Annual Values), and Table 11. (Daily Values) contain the results of the EMPR in sediment loading and Table 12. (Annual Values), and Table 13. (Daily Values) contains the results of the EMPR in current phosphorus loading (nutrient) for the respective land use in the SBSF Pine Creek. The load allocation for each land use is shown along with the percent reduction of current loads necessary to reach the targeted LA.

Table 10. Sediment Load Allocations/Reductions for Land Uses and Stream Banks In the SBSF Pine Creek (Annual Values)

Pollutant Source	Current Loading Rate (lbs./yr./acre)	Allowable Loading Rate (lbs. /yr./acre)	Current Load (lbs./yr.))	Allowable Load (lbs./yr.)	Percent Load Reduction
Cropland	**1,061.1**	**690.0**	**100,800.0**	**65,546.2**	**35.1%**
Hay/Pasture	**780.5**	**264.9**	**473,000.0**	**160,556.0**	**66.1%**
Stream bank	**-**	**-**	**32,000.0**	**20,808.3**	**35.1%**

Table 11. Sediment Load Allocations/Reductions for Land Uses and Stream Banks In the SBSF Pine Creek (Daily Values)

Pollutant Source	Current Loading Rate (lbs./d./acre)	Allowable Loading Rate (lbs. /d./acre)	Current Load (lbs./d.)	Allowable Load (lbs./d.)	Percent Load Reduction
Cropland	2.9	1.9	276.2	179.6	35.1%
Hay/Pasture	2.1	0.7	1,295.9	439.8	66.1%
Stream bank	-	-	87.7	57.0	35.1%

Table 12. Total Phosphorus Load Allocations/Reductions for Land Uses and Stream Banks In the SBSF Pine Creek (Annual Values)

Pollutant Source	Current Loading Rate (lbs./yr./acre)	Allowable Loading Rate (lbs./yr./acre)	Current Load (lbs./yr.))	Allowable Load (lbs./yr.)	Percent Load Reduction
Cropland	1.1	0.8	102.6	72.5	29.4%
Hay/Pasture	0.7	0.5	449.5	317.4	29.4%
Stream bank	-	-	7.1	5.0	29.4%
Farm Animals	-	-	204.3	144.3	29.4%

Table 13. Total Phosphorus Load Allocations/Reductions for Land Uses and Stream Banks In the SBSF Pine Creek (Daily Values)

Pollutant Source	Current Loading Rate (lbs./d./acre)	Allowable Loading Rate (lbs./d./acre)	Current Load (lbs./d.)	Allowable Load (lbs./d.)	Percent Load Reduction
Cropland	0.003	0.002	0.281	0.199	29.4%
Hay/Pasture	0.002	0.001	1.232	0.870	29.4%
Stream bank	-	-	0.019	0.014	29.4%
Farm Animals	-	-	0.560	0.395	29.4%

Consideration of Critical Conditions

The MAPSHED model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance accumulated in monthly values. Therefore, all flow conditions are considered for loading calculations. Because there is generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

Consideration of Background Contributions

The MAPSHED model accounts for all land uses within the watershed and their respective contributions to the sediment load. The only background sources of sediment and phosphorus loading (nutrient) within the watershed would be from forested areas. There are no additional "upstream" these non-point sources to this watershed. The remaining land uses are anthropogenic sources of sediment and phosphorus loading (nutrient) to the watershed, thus will not be considered background.

Recommendations

Sediment and phosphorus loading (nutrient) reductions in the TMDL are allocated to nonpoint sources in the watershed including: agricultural activities, transitional lands and stream banks. Implementation of best management practices (BMPs) in these affected areas are called for according to this TMDL document. The proper implementation of these BMPs should achieve the loading reduction goals established in the TMDL.

From an agricultural perspective, reductions in the amount of sediment reaching the streams in the watershed can be made through the right combination of BMPs including, but not limited to: establishment of cover crops, strip cropping, residue management, no till, crop rotation, contour farming, terracing, stabilizing heavy use areas and proper management of storm water. Vegetated or forested buffers are acceptable BMPs to intercept any runoff from farm fields. For the pasturing of farm animals and animal heavy use areas, acceptable BMPs may include: manure storage, rotational grazing, livestock exclusion fencing and forested riparian buffers. Some of these BMPs were observed in the biologically impaired SBSF Pine Creek; however, they were more extensively used in the unimpaired, reference Mudlick Run watershed, with forested riparian buffers being the predominant BMP in use. Since both watersheds have a considerable amount of agricultural activities, it is apparent that the greater use of BMPs, especially forested riparian buffers, in the reference watershed has contributed to its ability to maintain its attainment status as a HQ-CWF stream.

Stream banks contribute to the sediment load and phosphorus loading (nutrient) in SBSF Pine Creek. Stream bank stabilization projects would be acceptable BMPs for the eroded stream banks in the area. However, the establishment of forested riparian buffers is the most economical and effective BMP at providing stream bank stabilization and protection of the banks from freeze/thaw erosion and scouring flows. Forested riparian buffers are also essential to maintaining the biologically rich yet sensitive HQ-CWF habitat. Forested riparian buffers also provide important natural and durable connectivity of land and water. This connectivity is necessary to provide cover, nesting and nursery sites, shade and stable temperatures, and viable substrate for aquatic organisms of all layers of the food web protected under the HQ-CWF use designation.

Important to TMDLs, established forested riparian buffers act as sediment and phosphorus loading (nutrient) sinks. This is because the highly active and concentrated biological communities they maintain will assimilate and remove sediment and phosphorus loading (nutrient) from the water column instead of allowing them to pass downstream, thus forested riparian buffers work directly toward attaining the goals of the TMDL by reducing pollutant loads. These forested riparian buffers also provide the essential conditions necessary to meet the HQ-CWF designated use of the waterway. Forested riparian buffers also provide critical habitat to rare and sensitive amphibious and terrestrial organisms as well as migratory species. While forested riparian buffers are considered the most effective BMP, other possibilities for attaining the desired reductions may exist for the agricultural usages, as well as for the stream banks.

Funding Sources

The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act) is one funding source for nonpoint source pollution reduction BMPs, such as those described above. This grant program provides funding to assist in implementing Pennsylvania's Nonpoint Source Management Program. This includes funding for abandoned mine drainage, agricultural and urban run-off, and natural channel design/stream bank stabilization projects.

Information on Pennsylvania's Nonpoint Source Management Program can be found at:
http://www.portal.state.pa.us/portal/server.pt/community/nonpoint_source_management/10615
As mentioned before, a second funding source is Pennsylvania's Growing Greener Watershed Grants, which provides nearly $547 million in funding to clean up non-point sources of pollution throughout Pennsylvania. The grants were established by the Environmental Stewardship & Watershed Protection Act. Information on Pennsylvania's Growing Greener Watershed Grants
http://www.depweb.state.pa.us/portal/server.pt/community/growing_greener/13958
Information on these and other programs and additional funding sources can be found at:
http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Grants

Public Participation

Public notice of the TMDL will be published in the Pennsylvania Bulletin on May 26, 2018 to foster public comment on the allowable loads calculated. A 30-day period will be provided for the submittal of comments and notice. Any public contribution will be placed in the Comments and Response, Section B, Pg. 55.

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Attachment A.

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 Adjusted Load Allocations (ALAs) among the appropriate contributing non-point sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix E. 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, Margin of Safety, and existing loads not reduced.

Step 3: Actual EMPR Process.

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

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

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

Appendix A1. - GWLF Output for the South Branch South Fork Pine Creek

GWLF Total Loads for file: SBSFPineWithAnimalNumb Period of analysis: 30 years from 1961 to 1990

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	606	0.9	1267.3	236.5	114.0	1060.0	41.8	449.5
Cropland	95	2.2	270.2	50.4	137.7	339.5	15.6	102.6
Forest	1224	0.4	3.2	0.6	23.5	25.9	1.2	2.2
Wetland	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disturbed	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turfgrass	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	9	4.1	1.6	0.3	4.3	5.5	0.1	0.6
Bare Rock	9	4.1	0.0	0.0	2.5	2.5	0.1	0.1
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LD Mixed	115	1.5	0.0	0.4	8.7	26.4	1.1	2.8
MD Mixed	0	6.6	0.0	0.0	0.2	0.5	0.0	0.0
HD Mixed	0	10.1	0.0	0.0	0.0	0.0	0.0	0.0
LD Residential	0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
MD Residential	0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
HD Residential	0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Farm Animals						992.4		204.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				16.5		16.4		7.1
Groundwater					1895.6	1895.6	76.9	76.9
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					0.0	0.0	0.0	0.0
Totals	2058.1	1.7	1542.3	304.8	2186.6	4364.8	137.0	846.3

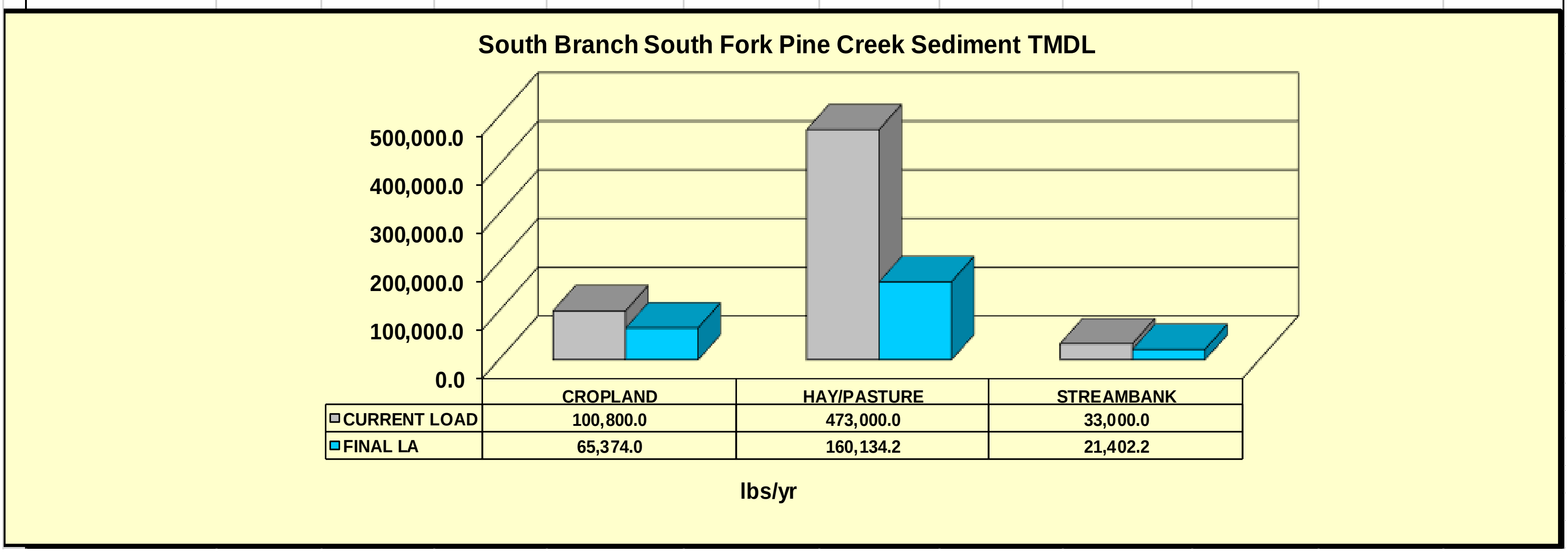
Appendix A2. - GWLF Output for Mudlick Run

GWLF Total Loads for file: MudlickRunRefForSBSFPin **Period of analysis:** 30 years from 1961 to 1990

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	258	7.3	145.7	27.4	435.2	544.7	120.9	156.9
Cropland	161	11.9	289.6	54.4	1236.9	1454.6	123.0	194.7
Forest	1296	4.6	12.1	2.3	254.5	263.6	13.4	16.4
Wetland	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disturbed	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turfgrass	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	3	19.9	0.0	0.0	4.7	4.7	0.2	0.2
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LD Mixed	104	8.8	0.0	1.1	19.6	59.3	2.7	6.8
MD Mixed	0	22.9	0.0	0.0	0.2	0.4	0.0	0.0
HD Mixed	0	32.1	0.0	0.0	0.0	0.0	0.0	0.0
LD Residential	0	8.8	0.0	0.0	0.0	0.0	0.0	0.0
MD Residential	0	14.5	0.0	0.0	0.0	0.0	0.0	0.0
HD Residential	0	19.8	0.0	0.0	0.0	0.0	0.0	0.0
Farm Animals						693.2		154.2
Tile Drainage				0.0		0.0		0.0
Stream Bank				38.9		38.9		12.8
Groundwater					4944.6	4944.6	205.9	205.9
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					0.0	0.0	0.0	0.0
Totals	1823.4	13.3	447.4	124.1	6895.6	8004.1	466.1	747.8

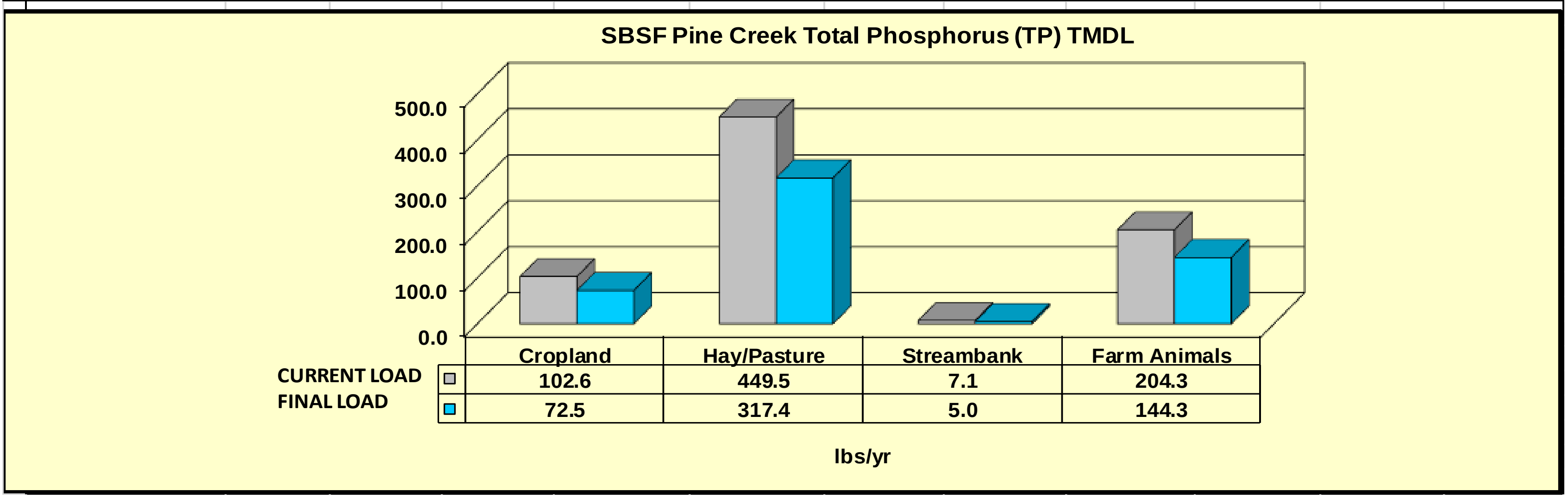
Appendix A3 - Equal Marginal Percent Reduction Calculations for the South Branch South Fork Pine Creek for Sediment

1	TMDL				2	Adjusted LA = TMDL total load - ((MOS) - loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					246910.5	246910.5					
	280348.8											
		Annual				Recheck	% reduction	Load			Allowable	%
3		Avg. Load	Load Sum	Check	Initial Adjust	Adjust	allocation	Reduction	Initial LA	Acres	Loading Rate	Reduction
	CROPLAND	100800.0	606800.0	good	100800.0		0.3	35426.0	65374.0	95.0	688.1	35.1%
	HAY/PASTURE	473000.0		bad	246910.5	133800.0	0.6	86776.2	160134.2	606.0	264.2	66.1%
	STREAMBANK	33000.0		good	33000.0		0.1	11597.8	21402.2			35.1%
					380710.5		1.0		246910.5			
4	All Ag. Loading Rate	321.70										
			Allowable		Current	Current						
		Acres	loading rate	Final LA	Loading Rate	Load	% Red.			CURRENT LOAD	FINAL LA	
5	CROPLAND	95.0	688.1	65374.0	1061.1	100800.0	35.1%		CROPLAND	100,800.0	65,374.0	
	HAY/PASTURE	606.0	264.2	160134.2	780.5	473000.0	66.1%		HAY/PASTURE	473,000.0	160,134.2	
	STREAMBANK			21402.2		33000.0	35.1%		STREAMBANK	33,000.0	21,402.2	
				246910.5		606800.0	59.3%					



Appendix A4. - Equal Marginal Percent Reduction Calculations for the South Branch South Fork Pine Creek for Phosphorus

1	TMDL				2	Adjusted LA = TMDL total load - ((MOS) - loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					539.2	539.2					
	612.2											
		Annual				Recheck	% reduction	Load			Allowable	%
3		Avg. Load	Load Sum	Check	Initial Adjust	Adjust	allocation	Reduction	Initial LA	Acres	Loading Rate	Reduction
	CROPLAND	102.6	763.5	good	102.6		0.1	30.1	72.5	95.0	0.8	29.4%
	HAY/PASTURE	449.5		good	449.5	224.3	0.6	132.1	317.4	606.0	0.5	29.4%
	STREAMBANK	7.1		good	7.1		0.0	2.1	5.0			29.4%
	FARM ANIMALS	204.30		good	204.3		0.3	60.0	144.3			29.4%
					763.5		1.0		539.2			
4	All Ag. Loading Rate	0.56										
			Allowable		Current	Current						
		Acres	loading rate	Final LA	Loading Rate	Load	% Red.			CURRENT LOAD	FINAL LA	
5	CROPLAND	95.0	0.8	72.5	1.1	102.6	29.4%		Cropland	102.6	72.5	
	HAY/PASTURE	606.0	0.5	317.4	0.7	449.5	29.4%		Hay/Pasture	449.5	317.4	
	STREAMBANK			5.0		7.1	29.4%		Streambank	7.1	5.0	
	FARM ANIMALS			144.3		204.3	29.4%		Farm Animals	204.3	144.3	
				539.2		763.5	29.4%					



Attachment B.

Comment and Response

Any public notice contribution for the SBSF Pine Creek TMDL will be placed in this section upon completion of the 30-day comment period after **May 26, 2018.**