# Watershed Implementation Plan
# Bull Run – Fishing Creek Watershed

Clinton, Centre, Lycoming and Union Counties, Pennsylvania

**Trout Unlimited, Inc.**

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## List of Acronyms and Abbreviations

ALU – Aquatic Life Use
BCG – Biological Condition Gradient
BMP – Best Management Practices
BR – Buck Gap Run
CAST – Chesapeake Assessment and Scenario Tool
CBP – Chesapeake Bay Program
CCCD – Clinton County Conservation District
CHP – Coldwater Heritage Partnership
CR – Campground Road
DCNR – Department of Conservation and Natural Resources
E&S – Erosion and Sedimentation
EPA – U.S. Environmental Protection Agency
EPT – Ephemeroptera, Plecoptera, Trichoptera
FC – Fishing Creek
GIS – Geographic Information Systems
GPM – Gallons per minute
HUC – Hydrologic Unit Code
HQ-CWF – High Quality Coldwater Fishery
IBI – Index of Biotic Integrity
LHU – Lock Haven University
MC – Mill Creek
MMW – Model My Watershed
NADP – National Atmospheric Deposition Program
NFWF – National Fish and Wildlife Foundation
NHD – National Hydrography Dataset
NPDES – National Pollutant Discharge Elimination System
NRCS – Natural Resources Conservation Service
PA – Pennsylvania
PA DEP – Pennsylvania Department of Environmental Protection
PFBC – Pennsylvania Fish and Boat Commission
PAGC – Pennsylvania Game Commission
RSS – Ruhl-Seven Spring
SVWA – Sugar Valley Watershed Association
TMDL – Total Maximum Daily Load
TS – Tylersville Spring
TU – Trout Unlimited
USGS – U.S. Geological Survey
WIP – Watershed Implementation Plan
WS -Wolf Spring
ZS – Zeller Spring

## Acknowledgments

Trout Unlimited would like to sincerely thank all of those that lent their time, expertise, and guidance to the development of this 319 Watershed Management Plan for the Bull Run – Fishing Creek Watershed. The Clinton County Conservation District, USGS, PA DEP, and PFBC all provided feedback and guidance throughout the project. We would also like to extend a special thank you to the Sugar Valley Watershed Association for helping to provide initial landowner outreach and to the many landowners in the watershed that were cooperative and provided access to their land for sampling. Also thank you to the TU field crews and interns that spent many days in the watershed sampling. Finally, this project would not have been possible without the generous support of our funders.

# Executive Summary

This Section 319 Watershed Management Plan for the Bull Run – Fishing Creek Watershed was developed in response to the stream's impairment for sediment, primarily due to agricultural activities. A Total Maximum Daily Load (TMDL) was not available for this watershed. Therefore, a reference watershed approach was used to set sediment reduction goals for the watershed. The Town Creek watershed in south-central Pennsylvania was selected as the reference watershed. The targeted sediment load in the Bull Run – Fishing Creek watershed was set to 157 lbs/ac/year. The Bull Run – Fishing Creek watershed is a HUC12 (12-digit Hydrologic Unit Code) tributary of Bald Eagle Creek and the West Branch Susquehanna River. The watershed is located primarily in Clinton County, with portions extending into Centre, Lycoming, and Union Counties, Pennsylvania. The watershed is part of the larger Susquehanna River and Chesapeake Bay watersheds.

The project was led by Trout Unlimited, however several partners provided assistance and support to the project, including local, state, and federal agencies, academic institutions, and other non-profit organizations. The overall goal of the project was to develop an implementation plan that would serve as a framework to the reduction of sediment within the watershed as well as provide secondary benefits such as nutrient reduction, increase community support, and support the overall health of the watershed.

Hydrologic modeling was used to delineate the watershed into 37 subbasins to better evaluate the sources of sediment within the watershed and to develop priority areas for project implementation in the future. Physical, chemical, and biological surveys were also completed to supplement the modeling and to provide adequate baseline data that can be used to measure interim progress throughout the phased implementation plan. The implementation plan includes soil health BMPs, riparian restoration, sinkhole protection, and dirt and gravel road improvement projects in high priority areas. If fully implemented, the plan would reduce the sediment in the watershed by approximately 22% of the total load without BMPs (or a 33% reduction with current BMPs taken into account), to 5,176,117 lbs/yr, exceeding the goal of 5,788,636 lbs/year by 10.5% or 612,519 lbs/year. Or, 150 lbs/ac/yr for the sediment load, which exceeds the goal of 157 lbs/ac/yr set using the reference watershed approach. Outreach and education throughout the implementation phases will be critical to develop the landowner support needed to fully implement the outlined plan. Continued watershed monitoring will allow for an adaptive management approach to be used throughout the implementation phases as well as a method for quantifying the progress towards meeting the goals set forth in the plan.

If fully implemented, the plan should result in a healthier watershed for those that live and work in the watershed as well as the visitors that frequent this region for recreation, ensuring that the watershed is a resource that can be utilized by generations to come.

# Introduction

Trout Unlimited (TU) was funded by a Section 319(h) Nonpoint Source Management Grant to create a Section 319 Watershed Management Plan for the Bull Run – Fishing Creek watershed in 2021. TU was founded in 1959 in Grayling, Michigan on the banks of the Au Sable River by a group of anglers who successfully sought to change the state's reliance on hatchery production of trout into a program that focused on protecting and restoring fish habitat. From the beginning, TU was guided by the principle that if we "take care of the fish, then the fishing will take care of itself." Today, TU is the nation's largest grassroots coldwater conservation organization with more than 350,000 members and supporters and a mission to bring together diverse interests to care for and recover rivers and streams so that our children can experience the joy of wild and native trout and salmon. TU works to achieve this mission on a local, state, and national level through its extensive volunteer network and dedicated staff.

The Bull Run – Fishing Creek HUC 12 is a small watershed that runs through Sugar Valley and is located primarily in Clinton County, Pennsylvania and drains to waterways that eventually enter the Chesapeake Bay. Just downstream of this section of the broader Fishing Creek watershed is the 'narrows' which is a beautiful Class A trout stream with numerous wild trout tributaries. The 'narrows' section is a fly-fishing and angling destination with anglers from multiple states visiting it each year. Many sections among the narrows are considered 'trophy trout' water (PFBC 2024a). The majority of the HUC12 is underlain by karst geology where multiple surface to groundwater connections exist. Numerous sinks and springs can be found throughout and one of the springs (Ruhl-Seven Spring) is thought to be the second largest in Pennsylvania (Yamashita 2003). Groundwater upwellings and the springs can help keep stream temperatures cool in the summer and above freezing in the winter. Like many valleys in Pennsylvania that have karst geology, agricultural land use is prevalent. However, Fishing Creek is unique in that there are still brook trout and a healthy brown trout population in Fishing Creek where it flows through the agricultural land use areas.

There are two sections in the HUC12 that are considered impaired due to siltation from agricultural uses. Reducing siltation impacts with the goal of eventually de-listing the impaired sections has broad implications for the trout populations in the downstream stretches of Fishing Creek and ultimately the Chesapeake Bay. The main contributor to the impairment is siltation due to agricultural land uses, a secondary contributor to one of the sections is nutrients due to septic and other similar systems. Heavy agricultural land use occurs in Sugar Valley and the main contributor to the siltation impacts is crop land or dry land. This impact is the first listed in all of the impaired stretches of Fishing Creek that flow through Sugar Valley. Reducing the siltation and sediment impacts was determined to be the most important reduction strategy for the Bull Run – Fishing Creek HUC12.

The goal of this project was to develop an implementation plan as an outline to reducing sediment loads through restoration projects, outreach and education, continued stream monitoring, and adaptive management.

# Watershed Characterization

## *Watershed Description*

The Bull Run-Fishing Creek watershed (HUC12 - 020502040301) is located primarily in Clinton County, with small portions extending into Union, Lycoming, and Centre Counties in Pennsylvania (Figures 1 and 2). Approximately 32,357 acres are in Clinton, 4,126 acres in Centre, 506 acres in Union, and 239 acres in Lycoming County. The watershed is a part of the Susquehanna River Basin, which flows into the Chesapeake Bay. The watershed drains an area of approximately 58 square miles. Locally, Fishing Creek eventually flows into Bald Eagle Creek in the town of Mill Hall, PA. The average fall in the watershed is 22 feet per mile (RETTEW 2004). The portion of the watershed this WIP focuses on is upstream of the Narrows section of Fishing Creek within Sugar Valley; specifically, the Fishing Creek – Bull Run HUC12, within the Fishing Creek HUC10. Other HUC12's present in the Fishing Creek HUC10 include Cedar Spring – Cedar Run, Long Run, Cherry Run – Fishing Creek, and Little Fishing Creek. The main roadway in this watershed is Route 880 which runs northeast to southeast. The headwaters of Fishing Creek originate between the two lanes of Interstate 80 in Union County. This portion of the watershed experiences highway drainage impacts. In 1979, there was a styrene dump at the I80 rest area which polluted 3.5 miles of stream and killed several hundred trout (RETTEW 2004).

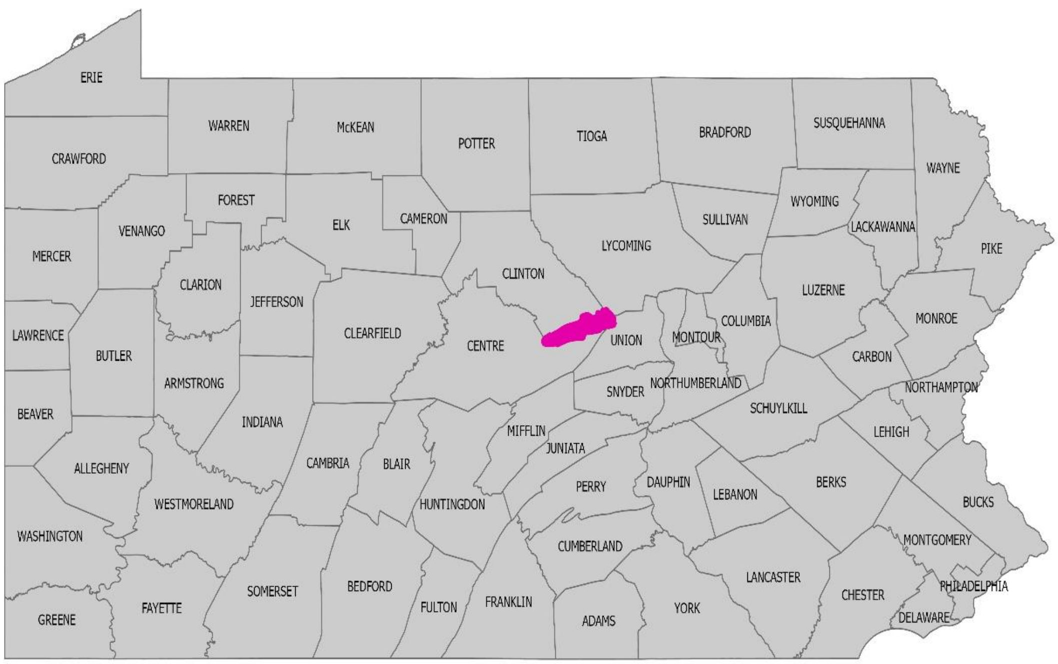


**Figure 1.** Location of the Bull Run - Fishing Creek HUC12 (highlighted in pink) in Pennsylvania.

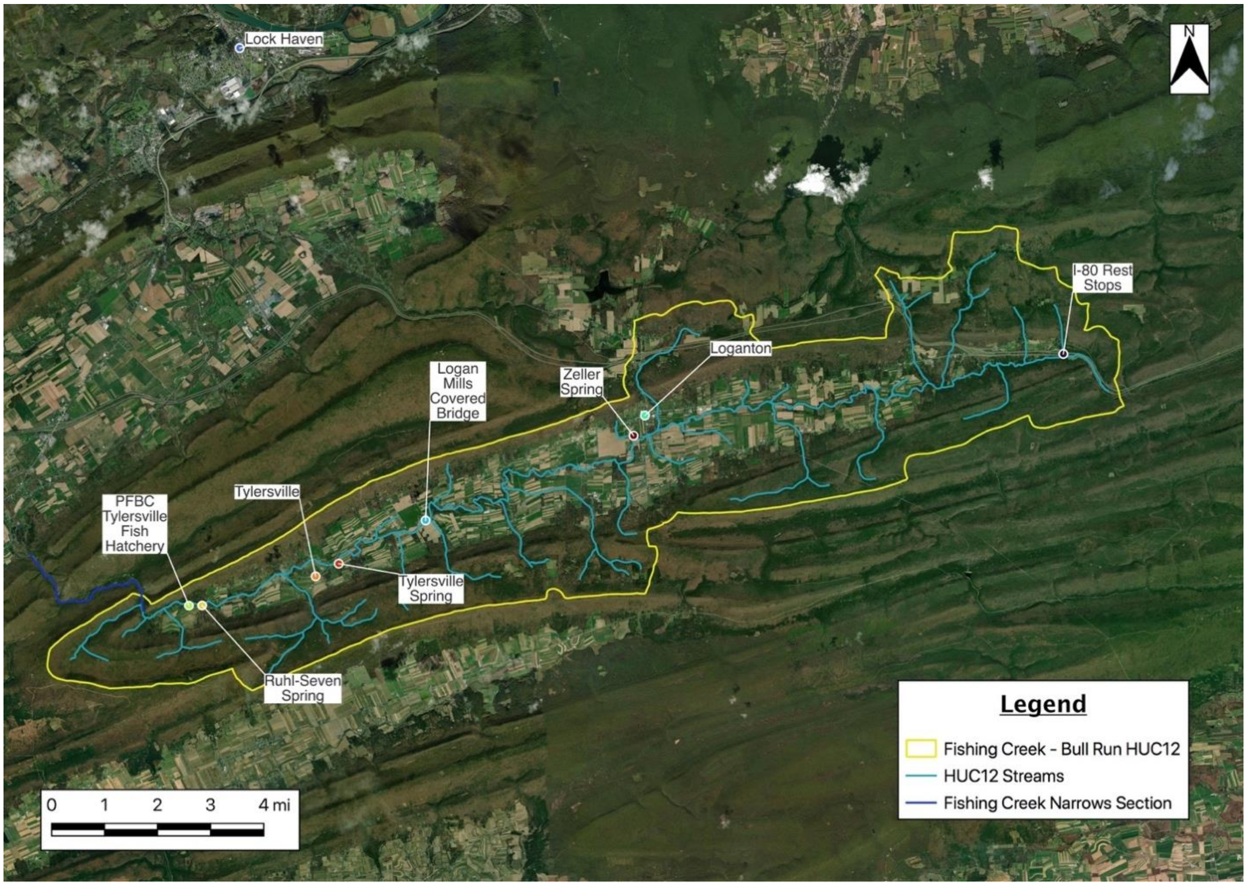


**Figure 2.** Local landmarks and towns within the Fishing Creek – Bull Run HUC12; the Fishing Creek Narrows Section is outlined on this map as well.

Point discharges in the watershed that have National Pollutant Discharge Elimination System (NPDES) permits are at rest stops 33 and 34 on I-80, the Loganton Wastewater Treatment Plan, the Tylersville Unit PA Fish & Boat Commission (PFBC) fish hatchery, Nicholas Meat LLC, and Schrack Farms. The mainstem of Fishing Creek is highly alkaline due to the underlying karst geology that includes limestone and dolomite. The Narrows section of Fishing Creek, downstream of the study area is considered a "Blue Ribbon" trout fishery with fisherman traveling from Ohio, Maryland, New York, and elsewhere in the spring to fish it, filling up the numerous fishing cabins located in the area (Yamashita 2003). Fishing Creek is a native brook trout and wild brown trout Class A fishery (PFBC 2023).

Sugar Valley's main industry is agriculture and it was the last settled valley in Central Pennsylvania (Imes 2015), it is located between Sugar Valley Mountain and Brush Valley Mountain. More than 30 years ago, Nicholas Meat LLC came to the valley and employs approximately 200 people from the area. Numerous violations from an assortment of sources have been made by Nicholas Meat LLC within the past 10 years. Landowners in the valley complain of the smell coming from the plant, and the business was notified by Pennsylvania Department of Environmental Protection (PA DEP) in 2020 that they were in violation of section 25 PA Code § 123.31(b) related to malodorous air contaminants. The company violated the Solid Waste Management Act in section 25 PA Code § 287-299 by land application of food processing residuals on snow-covered ground. The company failed to have an erosion and sedimentation plan on site, as well as not obtaining a NPDES permit for stormwater discharges associated with construction. They failed to provide temporary stabilization of an earth disturbance site, discharged sediment or another pollutant into waters of the Commonwealth, did not obtain a Chapter 105 permit, and did not obtain PA DEP approval for environmental assessment. There was also a violation of the Packers & Stockyards Act via the USDA where the company was operating without a bond or bond equivalent. Violations of Chapter 102 and 105 in the PA Code and a 401 CSL violation have all occurred. The final violation was under Occupational Safety and Health Administration and resulted in a fatality due to an accident in 1999. To date, all violations have been addressed.

The townships within the watershed are Greene and Logan, and the only borough is Loganton. There is one conservation easement (4.8 acres) and three farm easements (328 acres) fully located within this watershed. There is also one conservation easement and one farm easement that are partially located within the watershed. There are some state forest and state game lands present in the headwaters of a number of the tributaries; and approximately 23% of the watershed is either state game or state forest land. A portion of Northcentral Region State Game Lands 295 is located in the southeastern portion of the watershed and accounts for 5.5% of state lands in the watershed. State Forests present in the watershed are Tiadaghton and Bald Eagle, mainly in the headwaters of Fishing Creek and in the headwaters of the tributaries on the south slope and account for 18.9% of state lands present.

The total population in the two townships and borough is approximately 3,110. Populations of each township are approximately 1,763 in Greene, 878 in Logan, and 469 in Loganton Borough with 20.4 %, 13.6%, and 7.8% increases in population since 2000 respectively (U.S. Census Bureau 2023).

There are currently two sections of the mainstem of Fishing Creek in Sugar Valley that are listed as impaired according to the 2022 Integrated Report by the DEP (Figure 3; PA DEP 2022). The first section begins upstream of the Logan Mills covered bridge and continues to just downstream of the confluence of Mill Creek and Fishing Creek. The second impaired section begins upstream of the PFBC Tylersville Fish Hatchery and ends upstream of the Tylersville Spring outflow. Both sections' primary listed impairment is Crop Production (Crop Land or Dry Land) – Siltation. The entirety of the first section mentioned (Logan Mills to Mill Creek) has a secondary impairment listed as On-Site Treatment Systems (Septic Systems and Similar Decentralized Systems) – Nutrients.

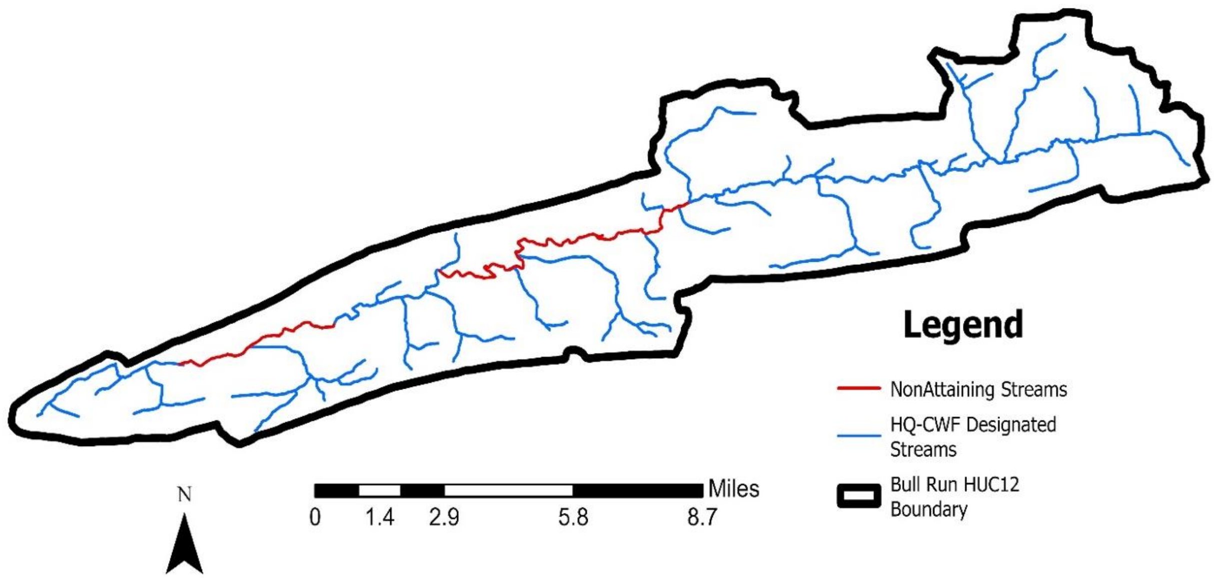


**Figure 3**. Non-attaining/Impaired stream sections and HQ-CWF (attaining) stream sections in the Bull Run - Fishing Creek watershed (PA DEP 2022).

## *Climate and Weather*

This area of the state is within a temperate region, it is within the Hot Continental Regime Mountain Division in the Humid Temperate Domain (Bailey 1995). Hot summers, cool winters, and pronounced seasons typically occur (Bailey 1995). There is a distinct summer and winter season, and all areas can develop frost (Bailey 1995). There are about 100 days where areas are frost free in northern mountains and 220 days in the southern parts of the Appalachian Highlands (Bailey 1995). Yearly snowfall is around 24" in Pennsylvania. The average annual precipitation is 45" and the max mean annual air temperature is 57.4 ºF. The majority of snowfall in this watershed occurs from December until March with an average of 47" per year from 1950-2011. Rainfall mostly occurs from May until August with a yearly average of 38" from 1899-2022. The warmest temperatures occur in the summer months with averages falling between 65º-69ºF from 1899-2022. The USDA grow zones for this watershed are 6a and 5b with the majority falling within 6a which makes the growing season May until November.

The pH of the rainfall in this area is 5.5 and contains approximately 6 kg/ha of sulfate (NADP 2021). The closest monitoring point in the Mercury Program (Mercury Deposition Network) is located west of Altoona, PA at the Allegheny Portage Railroad National Historic Site. The average mercury wet deposition from 1997-2023 is 9.88 $\mu g/m^2$ and the average mercury concentration was 8.71 ng/L. Other sites nearby were located on the Leading Ridge in Huntingdon County and at Little Pine State Park but are now inactive. Data at these sites were from 2010-2019 and 2007-2017, respectively. The average wet deposition and concentration was 7.88 $\mu g/m^2$ and 7.15 ng/L in Huntingdon County and 7.19 $\mu g/m^2$ and 7.59 ng/L at Little Pine State Park. Data can be accessed at https://nadp.slh.wisc.edu/ in the 2021 Annual Summary document.

### *Topography and Slope*

The average slope of the watershed is 8.8 degrees with a maximum elevation of 719.6 meters and a minimum elevation of 298.2 meters (Figure 4). The steepest slopes are found approximately halfway down most tributaries to Fishing Creek and near the southwestern end of the Bull Run-Fishing Creek HUC10. The majority of the watershed's slope is 10 percent or less, which accounts for approximately 45 percent of the watershed (Figure 5).

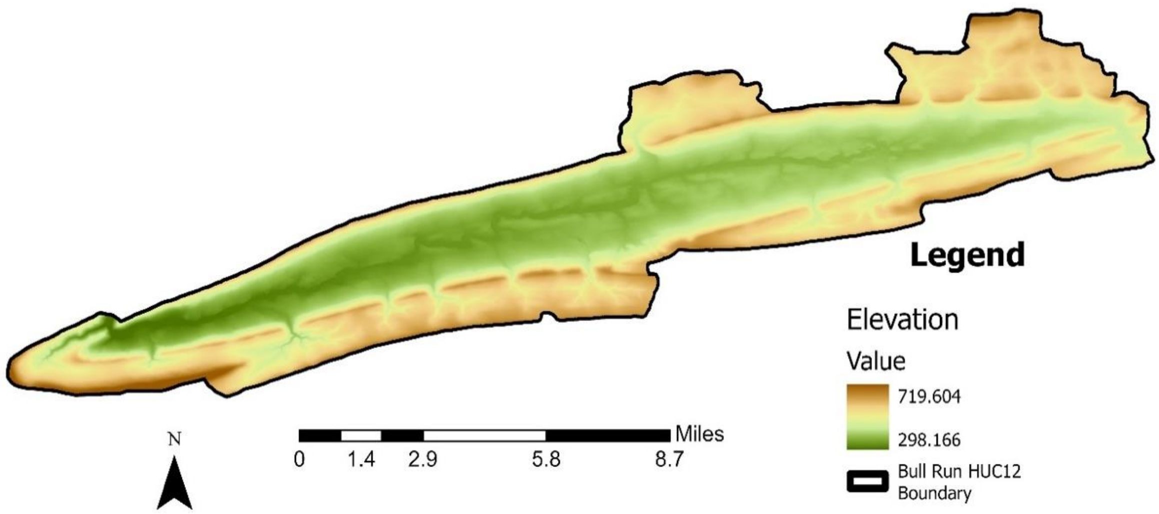


**Figure 4.** Topography of the Bull Run - Fishing Creek watershed

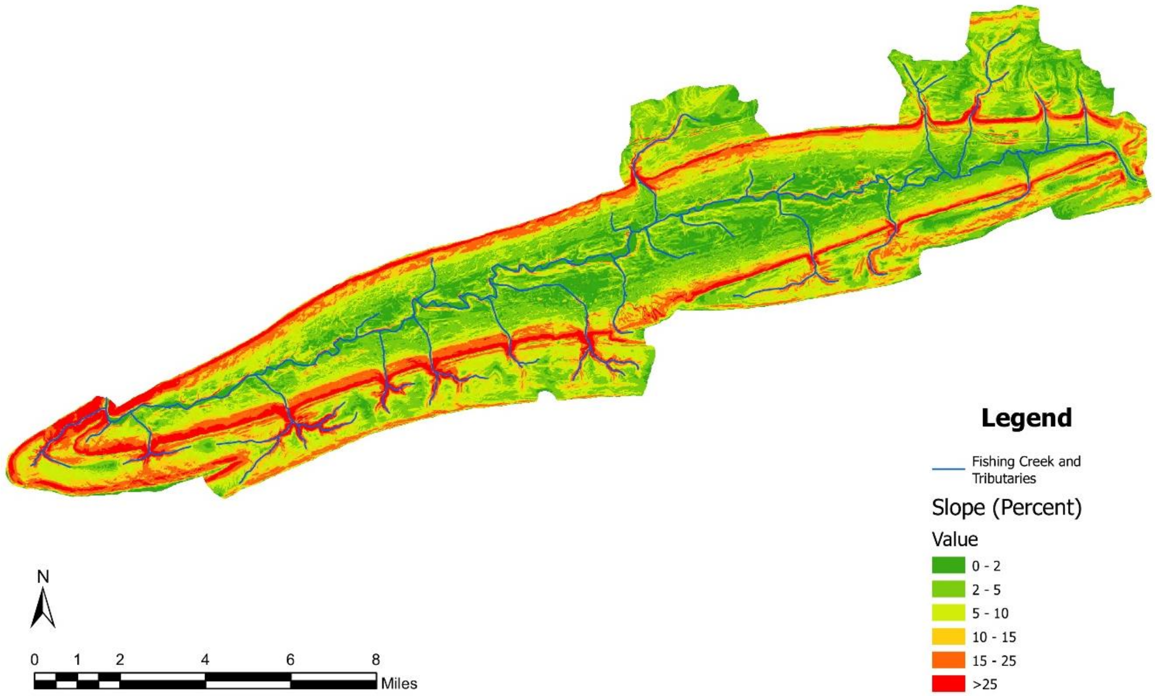


**Figure 5.** Slope of the Bull Run - Fishing Creek watershed.

## *Geology and Soils*

This watershed is located in the Ridge and Valley Province in the Appalachian Mountain Division. The majority of the watershed is karst geology and is predominately carbonate rock (Figure 6). Numerous sinks, springs, and caves are present in this area, and throughout the Ridge and Valley Province in PA. The second largest spring system in Pennsylvania (Ruhl Spring and Seven Spring) is located here with a flow of ~11,000 gallons per minute (GPM) (Yamashita 2003). Lithology present in the watershed is dolostone, limestone, sandstone, and shale. The tributaries flow mainly over sandstone and shale while the mainstem of Fishing Creek is mainly over dolostone and limestone. There are eight total geologic formations in the watershed. These include the Bald Eagle, Bellefonte, Benner through Loysburg, Coburn through Nealmont, Juniata, Reedsville, Tuscarora, and Valentine member of Benner Formation.

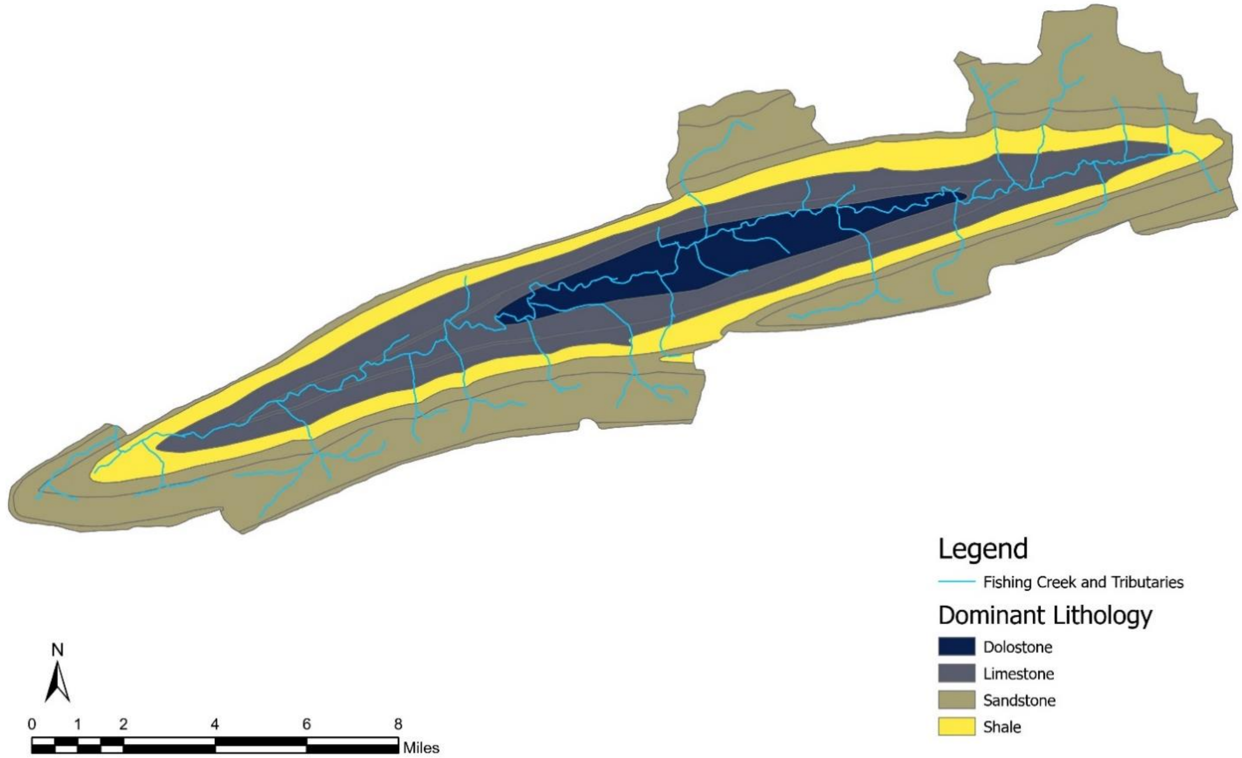


**Figure 6.** Dominant lithology of the Bull Run - Fishing Creek watershed. Data Source: PA DCNR (Bedrock Geology of Pennsylvania)

### *Sinkholes, Springs, and Karst Geology*

This watershed has numerous springs and sinks in the carbonate valley where the mainstem of Fishing Creek flows over karst features (Figure 7). Karst geological features create unique challenges when the goal is to address any pollution, including agricultural impacts. Low filtration of pollutants and high permeability in these systems makes them sensitive to pollution and surface runoff, and karst is also soluble in rainwater. Pollution and groundwater have the potential to travel long distances through karst systems. These systems are also sensitive to pollution because runoff not only flows over the surface but also enters sinkholes which are directly connected to the groundwater and aquifers. Water moves readily from the surface down through sinks and karst features, and groundwater contamination occurs easily in areas of limestone (Kochanov 2015). No soil filtration of runoff occurs if it directly enters a sinkhole. How water flows through karst systems is critical to understand and prevent pollution as these underground systems may not follow the typical delineation that is used to determine watershed area.

Not much is known about the Fishing Creek karst hydrology since no dye tracing has been completed. Dye tracing is an excellent tool to understand and determine underground connections in karst systems (Aley 1997; Dasher and Boyer 1997). A flow loss study could be another useful way to determine how water flows through karst (Barrett and Charbeneau 1997). Keeping contaminants from entering sinkholes is perhaps the most important consideration in watersheds like Fishing Creek. A buffer zone around sinkholes should be maintained and extended to protect a basin, especially in the case of multiple sinkholes located close together, which creates a larger basin (Kastning and Kastning 1997).

Due to the high agricultural land use in the Fishing Creek valley, sediment is the primary pollutant of concern and nitrates are a secondary pollutant of concern. Nitrates can remain in water until taken up by plants or other organisms, this uptake occurs less often in subsurface rivers compared to surface waters (Van Eerd et al. 2003). When karst systems are contaminated with nitrates, they do not recover quickly (Almasri and Kaluarachchi 2007). In Turkey, a study found a chemical that was banned over 30 years prior within karst fed springs (Ekmekci 2005). If the waste happens to be an organic chemical that doesn't mix well with water, like oil or gasoline, contamination can be widespread, and the substance can remain in the ground for a long time (Kochanov 2015). This area is prone to additional sinkholes forming as well. As this project was underway, new upwellings of water with a significant amount of flow appeared in a farmer's field upstream of the PFBC Tylersville Fish Hatchery. There are approximately 33 sinkholes, 848 surface depressions, and 4 surface mines (e.g. quarry) located in the Bull Run – Fishing Creek watershed (PA DCNR 2007) (Figure 7). The largest sinkhole is the Logan Mills sink, which is just downstream of a covered bridge. Twenty-four of the 33 sinkholes were investigated by RETTEW in 2003-2004 (RETTEW 2004). Sediment, which is the primary pollutant of concern in this watershed, can also be transported by sinkholes in the same manner as nitrates and other pollutants. Historically, many sinkholes were used as garbage dumps, however many were cleaned up by the SVWA in the early 2000s. This watershed also contains the second largest spring in Pennsylvania, Ruhl/Seven Spring, which has an average flow of ~11,000 GPM (Yamashita 2003). A portion of the water from this spring is currently used by the Tylersville fish hatchery that is operated by the PFBC.

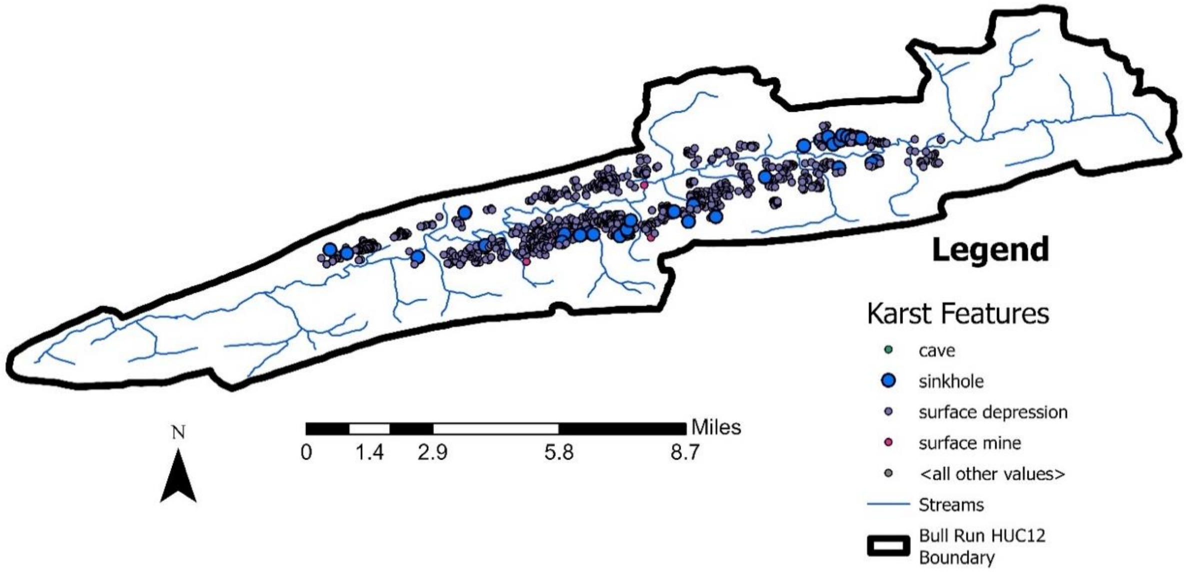


**Figure 7.** Karst features within the Bull Run - Fishing Creek watershed. Data Source: DCNR 2007.

A 30-meter-wide vegetative buffer around a sinkhole has the potential to reduce pollution by up to 80%, however a 15 meter buffer would be more cost effective while still providing benefits to the watershed (Petersen and Vondracek 2006). This would be helpful in the Bull Run – Fishing Creek watershed because sinkholes that are adjacent to row crops contribute pollutants to aquifers and surface waters. Buffers around sinkholes could also lower nitrates (Copler 2017). Overuse of groundwater can also potentially increase sinkhole frequency (Tapur 2015). A study in Florida related to strawberry growing found that there was a correlation between water extraction and minimum temperatures. They found that as air temperatures fell below 41ºF and water levels decreased by more than 20 ft that the total number of sinkholes present increases greatly (Aurit et al. 2013).

Impervious surfaces and roof runoff accelerate soil transport and further cause sinkhole development, and even replacing high grass/brush with mowed grass can accelerate sinkhole formation (White et al. 1986). A study on land use planning in local governments of West Virginia and Virginia found that most of the planning occurs in urban areas on top of karst features (Richardson 2003). Local governments in West Virginia rarely use planning and zoning in karst areas, the karst areas are predominantly rural and these communities showed the most resistance to land use planning efforts. Virginia has a mix of rapidly growing and rural communities in the karst areas, and 52% of local governments include karst provisions in their comprehensive plan. Plans to prevent pollution from reaching a sinkhole in karst landscapes are important and states seem to have little specific guidance for this type geological landscape.

The mid-Atlantic states already have policies surrounding sinkholes. Of the states in this region, New Jersey has the least amount of guidance and does not mention a buffer around the sinkhole, their policy is to just remove waste and then fill in the hole or fence it off, there is limited data on natural karst sinkholes in New Jersey. New York recommends a 35 ft fenced vegetative buffer, with no alteration of volume of surface water entering the sinkhole; it can be closed if it is causing a safety hazard with the consultation of a geologist and engineer. West Virginia recommends installing a vegetated buffer around a sink to improve runoff quality and increase the filtration of contaminants, the buffer width is seven times the sinkhole drainage area. Filling of the sinkhole should be based on the drainage area, and diversion of surface flow away from the sink is allowed if there is a safe outlet for it that will not go to another sink or cause property damage. The state of Virginia has a Karst Management Plan and they recommend a 100 ft buffer around the karst feature, a karst inventory, and related to construction: enlisting a geotechnical engineer to ensure stability of structures within 100 ft of the sinkhole, and to mitigate or separate sinkholes from construction.

Maryland's policies are aimed at public programs that limit agricultural runoff and help farmers keep livestock away from eroding stream banks, unprotected stream crossings, subsiding sinkholes, sinking streams, and natural waterways. If repairs are to be made, maintaining water quality should be a priority, consulting a geologist or engineer, minimize flow into a sinkhole, and leave a wide natural buffer of trees and vegetation around sinkholes and caves when causing a ground disturbance. Pennsylvania's guidance seemed less robust compared to other mid-Atlantic states, apart from New Jersey. Pennsylvania's guidance appears to target landowners that have a sudden sinkhole appearance; there is guidance on types of repairs and to be supervised by a geologist or geotechnical engineer. There is a manure application guideline which states that application must occur 100 ft offset from sinkholes. Each states' guidance can be found on their respective websites.

## *Land Use*

Sugar Valley is predominately agricultural land use in the valley proper with forested headwater tributaries in the surrounding hillsides. Figure 8 shows the land use in the watershed as derived from 1-meter high resolution land cover data (Chesapeake Conservancy). Pasture, hay and cultivated crops account for 22.1% of land use and most of the watershed is either deciduous, evergreen, or mixed forest (70.3%). Around 4% of the watershed is considered developed, open space. The remaining 3.6% is a combination of open water, developed land, barren rock, grassland/herbaceous, shrub/scrub, woody wetlands, and emergent herbaceous wetlands. Of the land use types, cropland accounts for the highest sediment, nitrogen, and phosphorus loads in the watershed. However, streambank erosion is the highest contributor to the sediment load in this area.

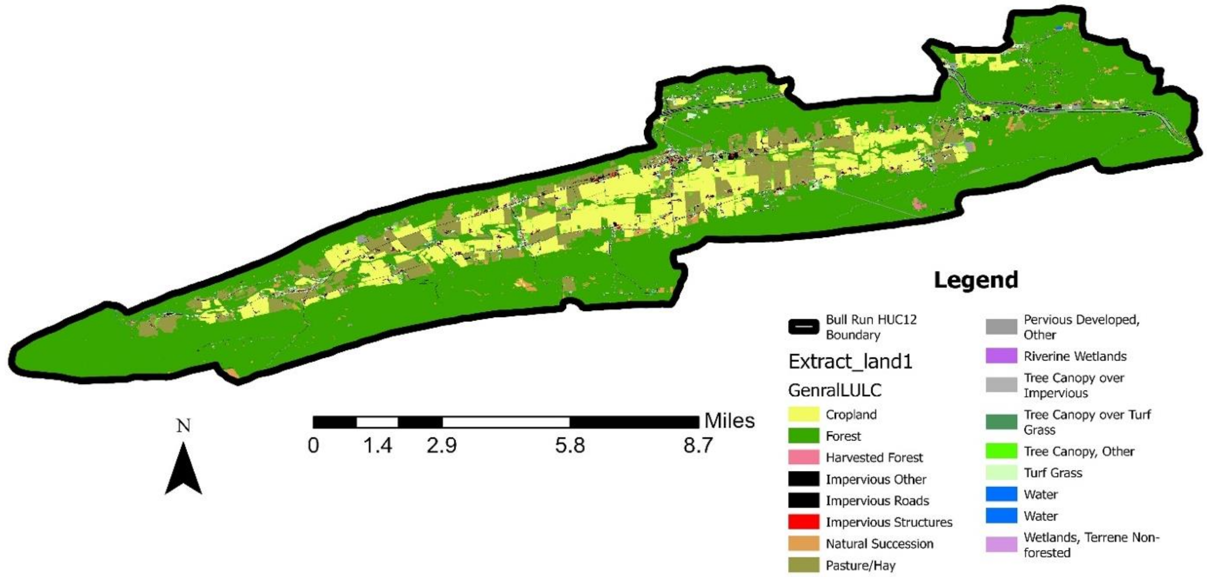


**Figure 8.** Land use in the Bull Run - Fishing Creek watershed derived from 1-meter high resolution land cover data. Data Source: Chesapeake Conservancy.

## *Hydrology and Aquatic Biota*

Fishing Creek originates as a spring in Union County, between the lanes of Interstate 80. It is also the northernmost limestone stream in Pennsylvania with public access (PA DCNR 2007; PA DCNR 2023; PAGC 2023). The drainage area of Bull Run – Fishing Creek HUC12 is approximately 57.99 $mi^2$, and is part of the greater Fishing Creek HUC10 that drains 181.48 $mi^2$. Stream density in the Bull Run – Fishing Creek HUC is 0.94 miles per square mile of land, with the majority (45.8%) of streams being Strahler $1^{st}$ order streams. The highest Strahler order is $4^{th}$ order (0.04%), and the remaining 25.8% and 24.5% are $3^{rd}$ order and $2^{nd}$ order streams respectively. The total length of all streams is approximately 76.3 miles. Of these streams, approximately 11.7% are located within agricultural areas. All of the streams in the HUC12 are classified as a high quality coldwater fishery (HQ-CWF). The majority of the length of mainstem Fishing Creek is considered a Class A brown trout fishery (Figure 9). The narrows section of Fishing Creek located just downstream of the Bull Run – Fishing Creek HUC12 is a phenomenal trout fishery with a trophy trout section that has anglers from multiple states visit it each year.

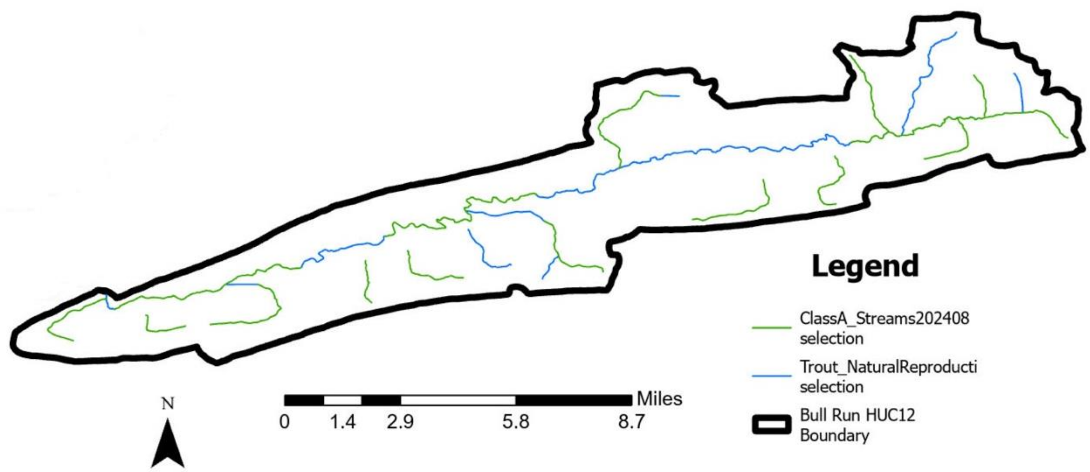


**Figure 9.** Trout Resources in the Bull Run - Fishing Creek watershed (PFBC 2024b; PFBC2024c).

## *Ecology and Terrestrial Biota*

This area is within the Central Appalachian Broadleaf Forest – Coniferous Forest – Meadow Province. The forest is considered a northeastern hardwood forest that contains birch, beech, maple, elm, red oak, basswood, hemlock and pine (Bailey 1995). Sugar maple trees are abundant in this valley and are its namesake (Imes 2015). There are very few wetlands spread out in this HUC12, only 0.12% of the land area is considered a wetland. The majority of the forest is mid-successional growth which shows legacy effects of the logging/charcoal industry. This area is dominated by winter deciduous forest which contains tall broadleaf trees that provide continuous canopy in the summer, and the lower layer of small trees and shrubs is weakly developed (Bailey 1995).

This area is considered the Northern Ridge and Valley Section which contains the Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province. Open low mountains with valleys underlain by folded weak and strong strata (Bailey 1995). Whitetail deer are very common and it is not unlikely to see black bears (Bailey 1995). Other mammals in this area are gray, red, and fox squirrels, opossums, raccoons, groundhogs, porcupines, and skunks. Some predatory mammals present are coyotes, foxes, and occasionally bobcats. In the Fishing Creek area there are pileated, downy, hairy, and red-bellied woodpeckers, common flickers, and wild turkeys (Bailey 1995). It is not uncommon to see belted kingfishers along the creek. According to the PFBC's website, 22 species of salamander, 18 species of frogs and toads, four species of lizards, 21 species of snakes, and 14 species of turtles can be found in Pennsylvania. Many of the species are likely to be found in the Fishing Creek watershed with exception of any endangered and threatened species.

## Previous Studies

Previous studies in the watershed were completed by Sugar Valley Watershed Association (SVWA) in 2003, RETTEW under the request of the SVWA in 2004, a coldwater heritage partnership project involving Clinton County Conservation District (CCCD) and Lock Haven University (LHU) in 2008, and two projects by U.S. Geological Survey (USGS) in 2017 and 2019. The first study completed in 2003 by SVWA had data collected in 2001-2003 which included monthly water quality at five sites for two years and biannual macroinvertebrate surveys over 2 years (Yamashita 2003). The water quality data results indicated that Fishing Creek is a healthy stream, but that fecal coliform was over the recreation guidelines at a few sites and that suspended solids during storm water discharge is concerning. This could be due to the underlying karst geology since it has high permeability and low filtration of pollutants. The total number of macroinvertebrates, richness, and composition varied greatly throughout the study. All macroinvertebrate sites rated as 'Fair' through the U.S. Environmental Protection Agency's (EPA's) Volunteer Stream Monitoring, and they determined that the macroinvertebrate community at both sites reflected a healthy aquatic system but recommended more sampling dates over a longer period of time to capture fluctuations.

The second study completed by RETTEW in 2004 at the request of SVWA included data collected in 2003-2004. The downstream boundary of this study was Cherry Run, so it includes some data downstream of the Bull Run – Fishing Creek HUC12. This study investigated sinkhole and spring occurrences in Sugar Valley. Macroinvertebrates were sampled at 20 sites with overlap of sites included in the 2003 study. The overlapping macroinvertebrate sites had higher Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa and greater diversity when sampled in 2003-2004 compared to the data collected in 2001-2003. Physical habitat was noted at 20 sites and electrofishing surveys occurred at 17 of the 20 total sites. The macroinvertebrate data collected by RETTEW generally supported the PA DEP impairment listings, except for the site located downstream of Ruhl Spring, which may have been incorrectly listed as impaired. Seven of the 20 sites sampled indicated a degree of impairment. Water temperatures recorded during the study indicated a coldwater fishery except in the area near Eastville. Intermittent sections of Fishing Creek exceeded coldwater temperature thresholds when flows decreased. Fish communities in the intermittent sections come and go with the water, with some species able to survive in perennial pools in these sections. The pH and alkalinity readings were consistent with the underlying geology, and nitrate, phosphate, and ammonia readings were not considered to be an issue. RETTEW found that sediment and its impacts were most concerning.

The third study was a Coldwater Conservation Plan written with funding from the Coldwater Heritage Partnership (CHP) grant program by the CCCD in partnership with LHU in 2008. This study included Fishing Creek and Cedar Run with some of the work occurring outside of this project's study area. Water chemistry was monitored from 2002-2007 at 14 sites, and two of these sites were located within Sugar Valley. Habitat assessments occurred at 10 sites, but none were within Sugar Valley. Macroinvertebrates were sampled at 11 sites, with one in Sugar Valley. And none of the three electrofishing sites were in Sugar Valley. The main recommendations from this CHP report were centered around agriculture and minimizing its effects. Some of the suggestions were agricultural conservation plans, riparian plantings, no till/conservation tillage, cover crops, and nutrient management plans. Another recommendation was to improve fish habitat through bank stabilization structures, some of which were planned to be constructed in 2010. Cedar Run sites in this study had the worst results in terms of water chemistry for total suspended solids, total dissolved solids, and nitrate-N. A public meeting about this project was also held in 2009 and additional recommendations came from it. These included upgrading Fishing Creek to Exceptional Value, additional water chemistry sampling during storm events, securing easements in Fishing Creek, and nutrient management and Best Management Practices (BMPs) targeting these areas.

The first study by the USGS was published in 2020, where they studied the groundwater quality of 54 domestic wells in Clinton County in 2017. Of the total number of domestic wells, eight were located within the Bull Run – Fishing Creek watershed. Samples from the carbonate aquifer frequently had elevated levels of coliform bacteria and nitrate concentrations. One of the samples had a nitrate concentration of 49.3 mg/L that well exceeded the drinking water standard of 10 mg/L (Clune and Cravotta 2020). This is important to note since the majority of the Bull Run – Fishing Creek watershed lies over carbonate and dolomite geology. USGS recently completed synoptic sampling of the watershed to inform nitrogen reduction strategies. The study concluded that the main sources of nitrogen included manure, fertilizer, and wastewater (Clune et al. 2024). In addition, the nitrogen load shifted among losing and gaining stream sections depending on season and location (Clune et al. 2024). Finally, this study concluded that high nitrogen inputs, effectiveness of conservation practices, and release of legacy nutrients within the karst cavities could confound progress of water quality goals and recommended fixed monitoring sites that incorporate synoptic water sampling to monitor long-term progress from management actions in the watershed (Clune et al. 2024).

## Watershed Analysis

### *Hydrologic/Water Quality Modeling*

An estimate of sediment loading for the Bull Run – Fishing Creek HUC12 was calculated using the "Model My Watershed" (MMW) version 1.35.0 application developed by Stroud Water Research Center (Stroud Water Research Center 2023). MMW uses several applicable datasets at the local scale (slope, soil permeability, climate, geology, etc.) to determine loading coefficients to a specified watershed. Although MMW allows for the input of BMPs, only baseline models (excluding current BMPs) were used. The Chesapeake Assessment and Scenario Tool (CAST) was used to calculate sediment reductions for both current and proposed BMPs as discussed in the Existing Best Management Practices and Current Load Reduction section. The entire Bull Run – Fishing Creek HUC12 watershed was used in the initial MMW model run to determine baseline sediment loads for the entire watershed. This model run resulted in a total watershed area of 37,084 acres and a total sediment load of 7,718,182 lbs/year.

In addition to the full HUC12 model run, sediment loading for individual subbasins were also calculated using the MMW approach. Subbasins were delineated using a flow path analysis of the watershed. A digital elevation model of the Bull Run – Fishing Creek HUC12 was compiled using lidar-derived data available through the PAMAP program and used to create flow accumulation paths. Drainage points were created at key intersections of the flow paths and were identified as the outflow location for each subbasin. A total of 37 subbasins were delineated through this process (Figure 10). MMW was run for each subbasin to determine the sediment load contribution of each subbasin to identify priority areas for project implementation (Figure 11). Sediment loading (lbs/yr) were converted to sediment yields (lbs/(acre*year)) to account for variations in the size of the subbasins.

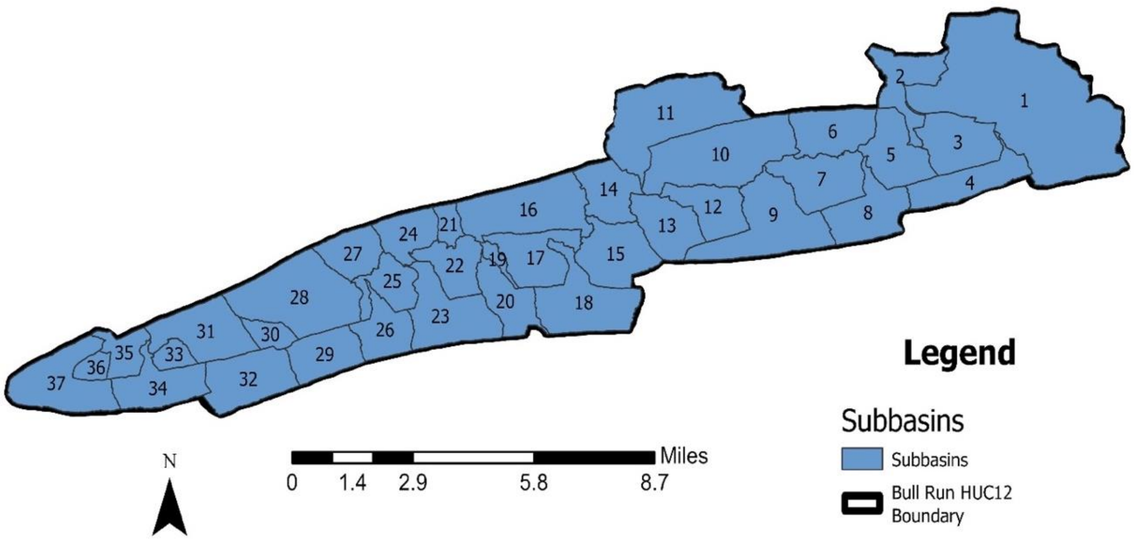


**Figure 10.** Map of the 37 subbasin delineations for the Bull Run - Fishing Creek watershed.

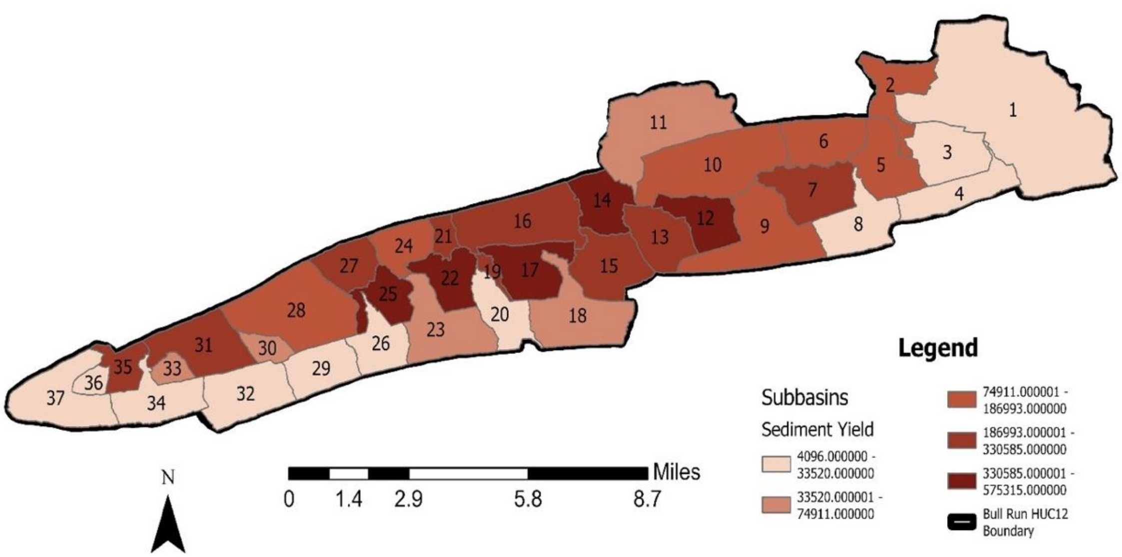


**Figure 11.** Sediment yield (lbs/acre*year) as quantified by Model My Watershed for each subbasin. Darker colors indicate higher sediment yields.

### *Stream Monitoring*

There were a total of 13 monitoring locations determined for water quality monitoring, benthic macroinvertebrates were sampled at 15 locations, and fishery surveys occurred at 10 locations. A list of sampling locations and what was sampled at each one can be found in Table 1. A total of seven macroinvertebrate samples were sent to the lab for identification, however the remaining eight samples are being held in case additional future funding becomes available to identify the macroinvertebrates in those samples. Fishery surveys occurred at any in-stream site, and a supplemental site (TU_CR) was added to the fishery surveys. None of the spring sites (TU_ZS, TU_WS, TU_TS, TU_RSS) had macroinvertebrates collected or a fishery survey performed due to the flow coming out of a small area and water depth in some cases. More detail on this sampling can be found in the following 3 sections of this document (Water Quality, Benthic Macroinvertebrate Surveys, and
Fishery **Surveys**).

**Table 1.** List of sampling locations in the Fishing Creek watershed. Supplemental sampling locations are below the horizontal line and begin with site TU_CR. Columns with an ✓ indicate a sample was taken and columns with an ✓* indicate a sample was taken but is being held for processing in the event future funding becomes available for macroinvertebrate identification. WS=water sample sent to lab on both sampling events.

| Site | Lat | Long | Fish | Benthic Macros | WS |
|---|---|---|---|---|---|
| TU_FC0 | 41.05010 | -77.15451 | ✓ | ✓ | ✓ |
| TU_FC1 | 41.05001 | -77.15511 | ✓ | ✓ | ✓ |
| TU_BR | 41.05021 | -77.15610 | ✓ | ✓* | ✓ |
| TU_FC2 | 41.03958 | -77.21797 | ✓ |  | ✓ |
| TU_MC | 41.03067 | -77.30214 | ✓ | ✓ | ✓ |
| TU_ZS | 41.02806 | -77.31026 |  |  | ✓ |
| TU_FC3 | 41.02721 | -77.31094 | ✓ | ✓ | ✓ |
| TU_WS | 41.02027 | -77.33041 |  |  | ✓ |
| TU_FC4 | 41.00559 | -77.38595 | ✓ | ✓ | ✓ |
| TU_TS | 40.99404 | -77.41740 |  |  | ✓ |
| TU_FC5 | 40.99368 | -77.41956 | ✓ | ✓ | ✓ |
| TU_RSS | 40.98266 | -77.46652 |  |  | ✓ |
| TU_FC6 | 40.98045 | -77.48252 | ✓ | ✓ | ✓ |
| TU_CR | 41.01537 | -77.35756 | ✓ | ✓* |  |
| TU_SR | 41.03742 | -77.26060 |  | ✓* |  |
| TU_SS1 | 41.05183 | -77.15611 |  | ✓* |  |
| TU_SS2 | 41.04994 | -77.15710 |  | ✓* |  |
| TU_SS3 | 41.02785 | -77.30962 |  | ✓* |  |
| TU_SS4 | 40.99436 | -77.41751 |  | ✓* |  |
| TU_LG | 41.02868 | -77.30636 |  | ✓* |  |

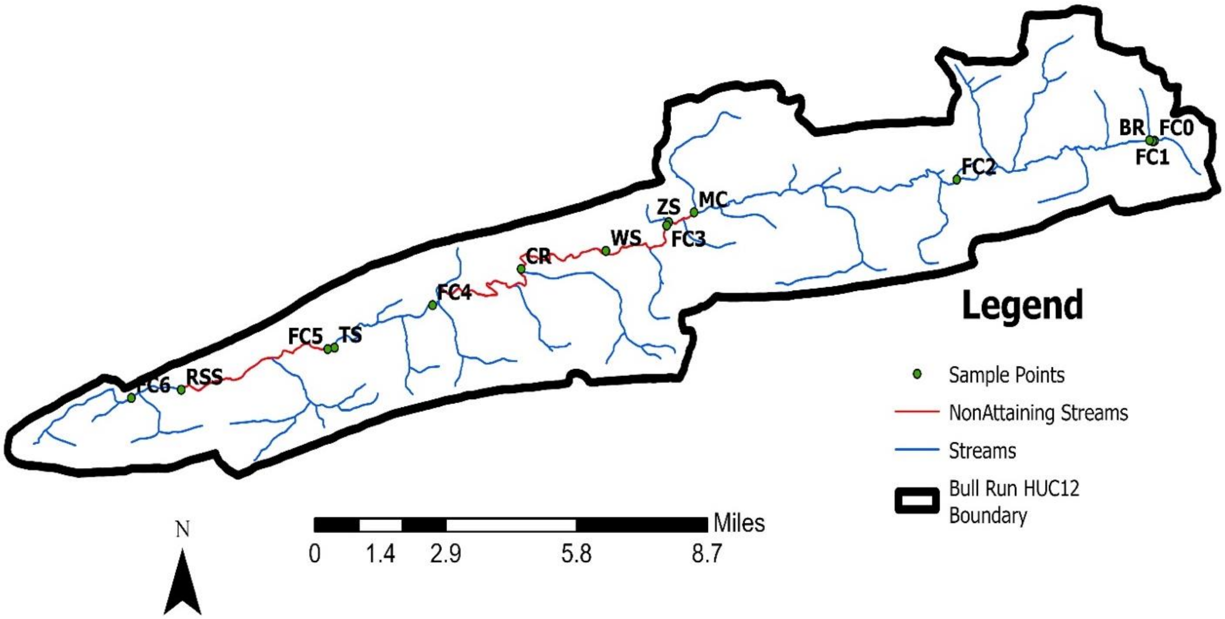


**Figure 12.** Sample sites map. More detailed information on sample locations is provided in Table 1. Supplemental sampling locations are not depicted, with the exception of the Campground Road (CR) site.

### *Water Quality*

Two storm events were targeted for this sampling at various sites in the watershed. Both sampling events had a total of 13 sites collected (Figure 12), excluding the CR site on the map due to that location being a supplemental fishery location. The laboratory measured parameters for both sampling events were lab pH, total Kjeldahl nitrogen (TKN), nitrite (NO2), nitrate (NO3), total phosphorus (P), potassium (K), sulfate (SO4), total suspended solids (TSS), and total dissolved solids (TDS), Calcium (Ca), Magnesium (Mg), Chloride (Cl), Sodium (Na), and total alkalinity. Multiple studies have mentioned the need to understand contaminants in this watershed during a storm or have found concerning results during a storm event (Clinton County Conservation District 2009; Yamashita 2003; Clune et al. 2024). Field measurements recorded were stream temperature (ºC), pH, and specific conductance. Flows were estimated using a nearby stream USGS gage (USGS- 01547700) and the USGS StreamStats application (USGS 2023).

Water samples were collected in 1 L (unpreserved samples) or pre-acidified 250 mL (preserved samples) polyethylene bottles obtained from Pace Analytical. Samples were preserved immediately upon collection in pre-acidified bottles from the lab (1:1 nitric acid or sulfuric acid to an amount where the pH is falls below 2.0). All sample bottles were cooled and held at ≤6°C

until receipt by the laboratory. Water samples were delivered on ice to the laboratory within 24 hours of collection. Collectors also kept a field notebook of all samples for later reference.
To collect a grab sample, the collector faced upstream, taking care to not alter flow patterns or disturb substrate sediments upstream of where they collected the sample. Collection bottles were inserted into the water column vertically, facing down to avoid contamination. The samples were collected at mid-depth in the thalweg. The collector removed the lid from the bottle just before sampling, taking care not to contaminate the cap, neck, or the inside of the bottle. All bottles were rinsed 3 times with stream water before filling the bottle, unless pre-acidified bottles for preserved sample parameters were being used. Rinsing waste was discarded downstream of the collector to ensure no contamination reentered the sample bottle. Each sample container was filled to the neck of the bottle. All water sampling collection followed PA DEP recommendations (Shull and Pulket 2021).

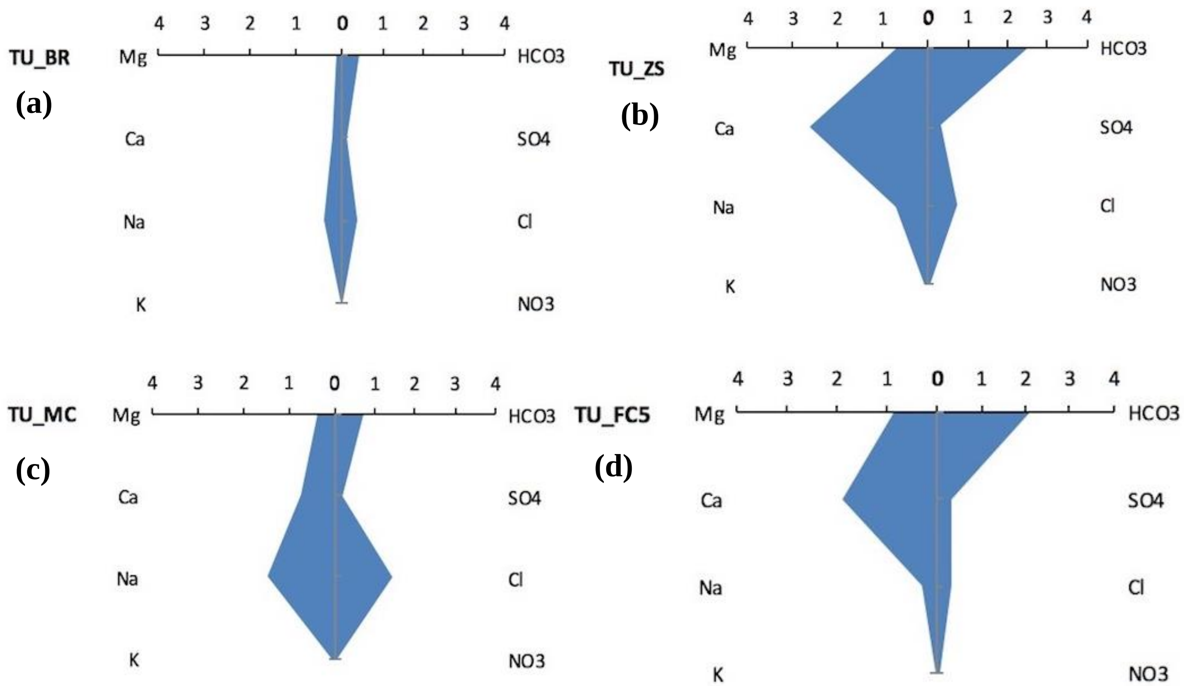


**Figure 13.** Select stiff plots from water quality data. Stiff plot of a tributary with few anthropogenic impacts (a), stiff plots illustrating the underlying geology of dolomite and limestone (b, d), and a stiff plot of a site that potentially has sewage or road salt impacts (c).

Anion and cation chemistry was visualized using Stiff plots (Stiff 1951), which shows water composition differences and similarities. Stiff plots use four horizontal axes on each side of a vertical axis, with cations on the left and anions on the right. Concentrations from the lab were reported in mg/L and were transformed to milliequivalents per liter (meqL) for the Stiff plots. Pie diagrams were also created using the anions and cations to show proportions of each ion within the total ionic concentration. Some sites (FC0, FC1, and MC) showed potential sewage or road salt impacts due to spikes on Na and Cl, others indicated the underlying geology of dolomite and limestone due to spikes on Mg, HC03, and Ca (Spring sites, FC3-FC6), others showed little impacts or that a site was close to pure water (BR) (Figure 13). All stiff plots can be found in Appendix 1. Loadings (lbs/day) were calculated for each parameter sampled at the lab. By calculating loadings, it not only accounts for concentrations (mg/L), but amount of flow (gallons per minute) on the particular sampling date and is a way to compare parameters across multiple sites and sampling events. Field chemistry conductivity readings were used to estimate Nitrate as N (mg/L) at the sites based on the mathematical relationship in Clune et al. 2024 to compare to the lab readings. The NO3/Cl ratio was plotted against NO3 to assist with determining where the impacts from these parameters came from (i.e. agricultural/wastewater, mixed, natural). The majority of sites showed mixed sources, however Zeller Spring showed agricultural sources.

### *Benthic Macroinvertebrate Surveys*

Macroinvertebrate surveys were conducted at 15 sites, seven of which were analyzed by the lab, and the remaining eight are being held by the lab in case additional funding becomes available to have those analyzed at a future date. The Wadeable Riffle-Run and Wadeable Limestone Stream Macroinvertebrate Data Collection Protocols from PA DEP’s Water Quality Monitoring Protocols for Streams and Rivers was followed for this sampling (Shull and Lookenbill 2021). Due to the nature of Fishing Creek and its tributaries, the assessment methods for wadeable freestone riffle-run and wadeable limestone streams were followed based on stream conditions at each site. These surveys took place in March, which was between the sampling timeframe of January to May. Each site involved of a combination of six kick efforts within a 100-meter section of stream. Areas with varying depths in the best riffle habitat areas were chosen at each site. A 12-inch diameter D-frame kick net with 500 or 800-900 micron mesh was used to collect samples; limestone and spring influenced stream sections sometimes require a larger mesh size than freestone streams if substrate has the potential to clog the net. Each sampling kick disturbed an area of $1m^2$ to an approximate depth of 4 inches directly upstream of the net and was done for a duration of 1 minute for each kick.

The six individual kicks were composited and preserved with at least 70% ethanol in the field before being sent to the lab for processing. Individuals were identified by Society for Freshwater Science-certified taxonomists at Cole Ecological to genus or the next highest taxonomic level. Samples containing 180 to 220 organisms (freestone sites), or 270 to 330 organisms (limestone sites) were evaluated according to the six metrics comprising the PA DEP’s Index of Biological Integrity (IBI) (Total Taxa Richness, EPT Taxa Richness, Beck’s Index V.3, Shannon Diversity, Hilsenhoff Biotic Index, Ratio of Biological Condition Gradient (BCG) Attribute, Percent Sensitive Individuals (Freestone stream only), and Percent Tolerant Individuals (Limestone stream only)). Appendix 2 contains a description of each of these eight metrics. These metrics were standardized and used to determine if the stream meets the Aquatic Life Use (ALU) attainment (Shull and Pulket 2021). Definitions of these ALU’s can be found in Appendix 3. The IBI and associated benchmarks are calibrated for use with sub-samples containing 180-220 organisms (freestone sites) or 270-330 organisms (limestone sites), so applications of the IBI to samples containing less or more than the target number of organisms cannot accurately be assessed using the procedures and benchmarks. In instances where more than 220 or 330 individuals are present in a sample, subsampling procedures as outlined in PA DEP’s Water Quality Monitoring Protocols for Streams and Rivers were followed (Shull and Lookenbill 2021). Raw macroinvertebrate results can be found in Appendix 4.

All sites were attaining ALU for limestone streams and for freestone streams at the Mill Creek site (Table 2). Collector (filtering, gathering) macroinvertebrates began to make up the majority of sample sites lower in the watershed compared to the headwater sites (FC1, FC0) and the site on the Mill Creek tributary (Figure 14).

**Table 2.** Benthic macroinvertebrate metric scores for all sampling locations. All sites were found to be attaining ALU.

| Metric | FC0 | FC1 | MC | FC3 | FC4 | FC5 | FC6 |
|---|---|---|---|---|---|---|---|
| Number of Individuals | 331 | 326 | 192 | 325 | 318 | 325 | 317 |
| Taxa Richness | 34 | 35 | 23 | 20 | 23 | 15 | 23 |
| EPT Richness | 17 | 16 | 9 | 8 | 7 | 4 | 10 |
| Beck's | 32 | 29 | 12 | 14 | 15 | 8 | 20 |
| Hilsenhoff | 3.25 | 3.76 | 3.9 | 2.6 | 3.97 | 3.58 | 3.86 |
| Shannon | 2.48 | 2.74 | 2.45 | 1.79 | 2.33 | 1.58 | 2.27 |
| Percent Sensitive Taxa | 51.7 | 34 | 46.4 | 81.5 | 34.3 | 30.2 | 35.6 |
| Percent Tolerant Taxa | 2.42 | 2.15 | 3.6 | 5.23 | 7.23 | 5.54 | 1.89 |
| BCG | 1.5 | 1.4 | 2.1 | 5.3 | 0.5 | 0.4 | 0.7 |
| **IBI Score** | **83.3** | **83.4** | **60.7** | **96.7** | **96.6** | **78.3** | **83.4** |

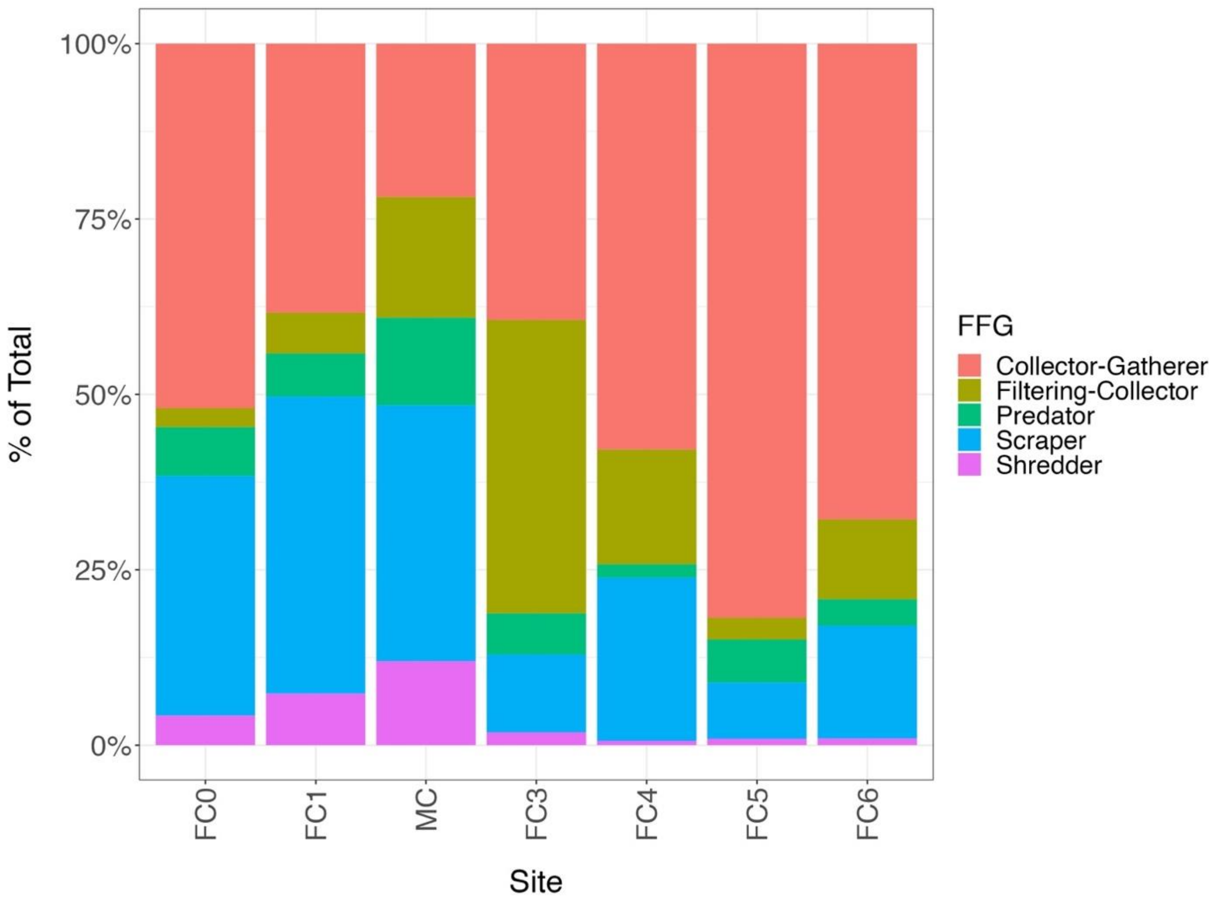


**Figure 14.** Functional feeding group composition (percent of total count) of macroinvertebrates at each sampling location.

### *Fishery Surveys*

All sites had a fishery sample completed during the summer of 2023 except a majority of the supplemental sites, spring sites, and sites deemed too deep for a backpack electrofisher. A total of 10 sites had a fishery survey completed. One of the supplemental sites (TU_CR) was added to the fishery locations at the discretion of the field crew. Fishery sampling was conducted between June and September in accordance with the PFBC sampling timeframe for trout (Weber et al. 2019). Multiple pass electrofishing methods were utilized to determine the presence of salmonids and other fish species in a 100-meter section at each location and to estimate the total population and biomass at each site. Each sample reach began and ended at a shallow riffle or other barrier sufficient to prevent fish movement beyond the sample reach. If such barriers are not present, block nets were used to prevent movement outside of the sample reach.

All fish collected within the sample reach were identified to species. Any species that were unable to be identified in the field had pictures taken of them for later identification by a fishery professional within TU or at PFBC. The total length of each salmonid was measured to the nearest millimeter. Following processing, salmonids were released throughout the sample reach where they were captured. All other species were released immediately following capture and identification. Relative abundance of non-salmonid species was recorded based on a count of all species found at each sample site per the PFBC protocols. The rating criteria are as follows:

< 2 individuals = Rare
2-8 individuals = Present
9-33 individuals = Common
>33 individuals = Abundant

Brown trout biomass was high at most sites, except for the Campground Road (CR) site and the site directly downstream of the Zeller Spring outflow. Only one brown trout was documented in Buck Gap Run and low numbers of brook trout were found; this is likely due to the tributary's small size and low water levels. Many of the trout captured in Buck Gap Run were young of the year (< 99 mm total length) so this tributary likely serves as nursery habitat for young trout. Brook trout biomass was higher than brown trout biomass at one site (FC1) which is forested and had cooler stream temperatures than FC0 which was located between the lanes of I80 upstream of culverts and had no forest but did have some shading over the stream. No brook trout were captured at sites FC2 (Eastville) and FC6 (Narrows Rd bridge). Condition scores of the trout had a large variance and many outliers in the upper sites FC0, FC1, and BR (Figure 15). The FC5 site located below the Tylersville spring outflow had a few low condition scores that were outliers. Overall, the condition scores of brook and brown trout indicate that the majority of the trout are in good condition based on length and weight relationships, any score above 1.0 is considered above average and 1.0 is considered normal (Zale et al. 2012). The lowest trout condition score average for brown trout occurred at FC3 (0.84) which is directly downstream of the Zeller Spring outflow and this site also had very few trout compared to the other sites. A value around 0.8 can indicate an unhealthy fish (Zale et al. 2012).

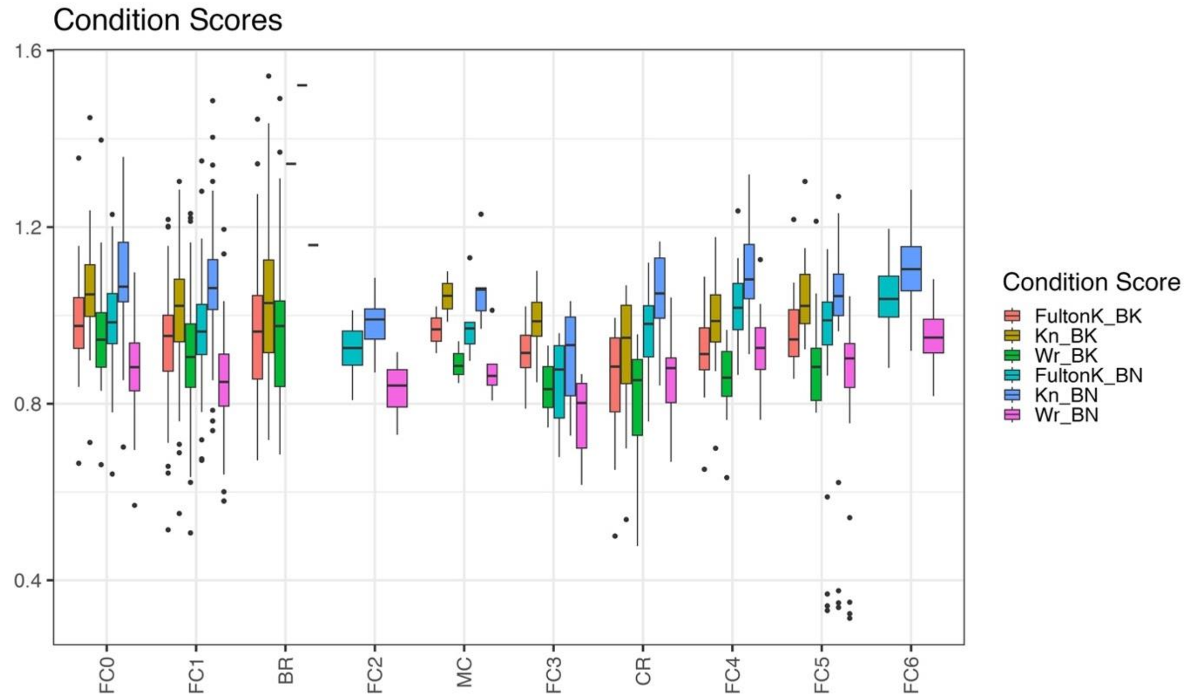


**Figure 15.** Condition scores (Fulton's K, Relative Condition (Kn), Relative Weight (Wr)) for brook (BK) and brown (BN) trout at all fishery sampling locations.

All sites except FC3 and Campground Rd (CR) were above the PFBC Class A designation for brown trout which is > 40 kg/ha (Figure 16). Only one site, FC1, was above the PA Fish & Boat Commission Class A designation for brook trout (> 30 kg/ha) (Figure 16). Brook trout numbers were low compared to brown trout. Multiple factors could be influencing this such as water temperature, competition, contaminant levels, habitat, and food availability. All sites had at least one trout present. The number of size classes represented was high at most sites, except for sites on Buck Gap Run, Mill Creek and FC3 downstream of the Zeller Spring outflow (Figure 17).

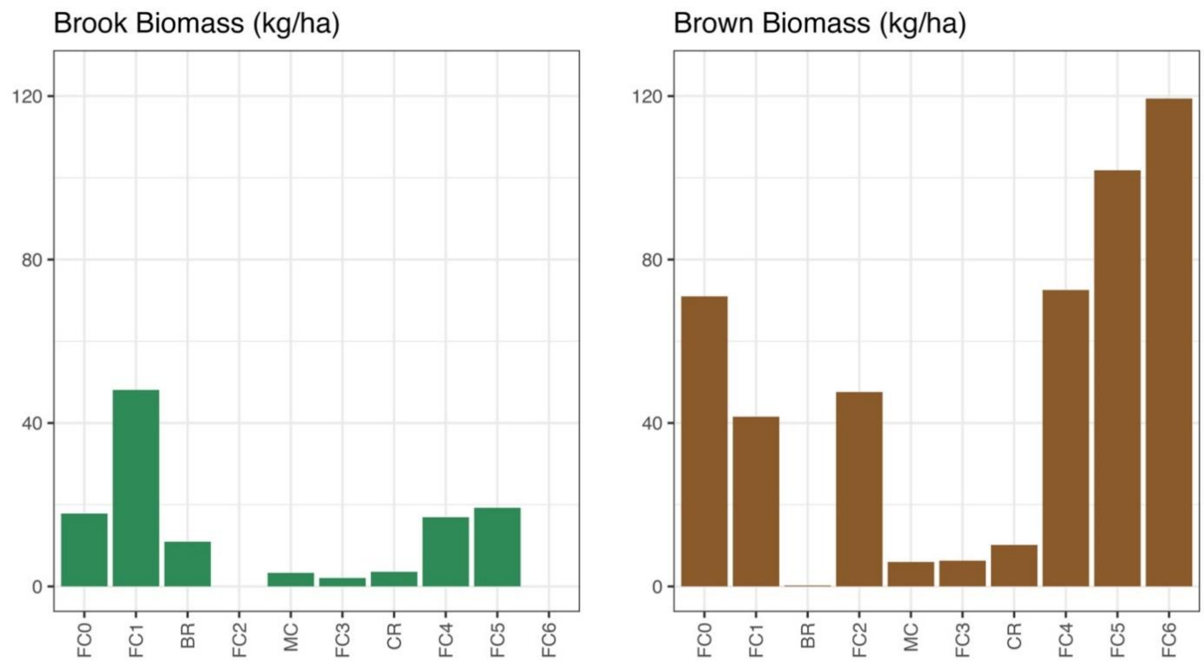


**Figure 16.** Brook and brown trout biomass at all sampling locations in kg/ha.

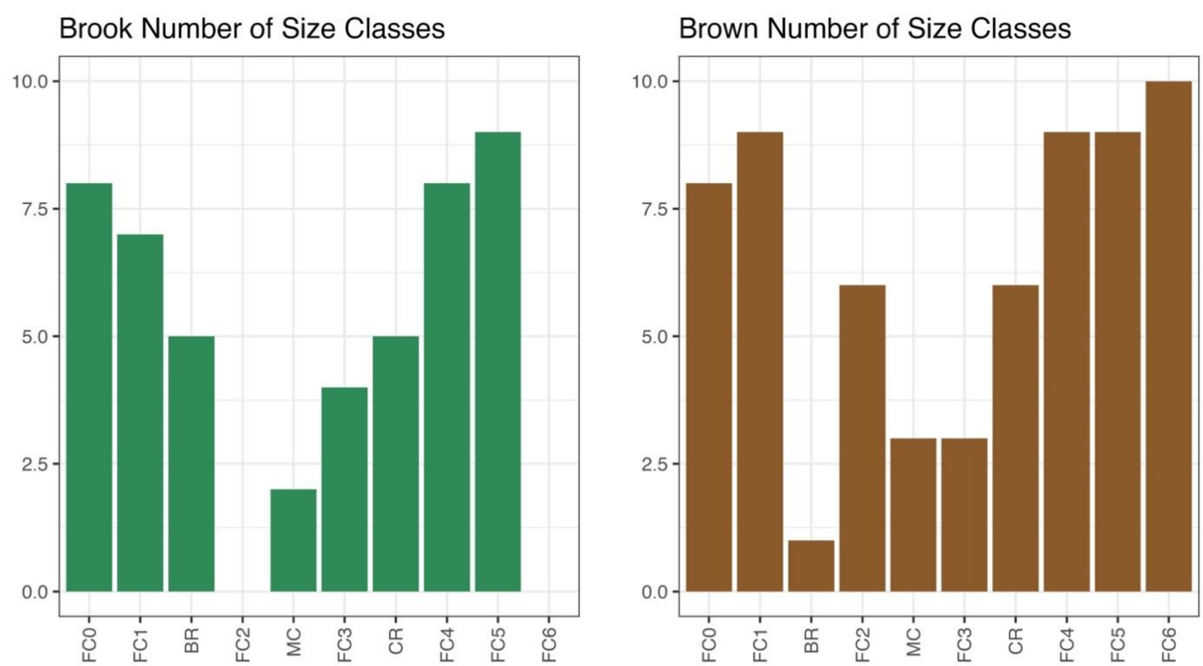


**Figure 17.** Count of brook and brown trout size classes at all fishery sampling locations.

### *Existing Best Management Practices and Current Load Reduction*

Numerous BMPs have already been implemented throughout the watershed and it is important to recognize the progress that has been made in sediment reduction when setting goals for future sediment load reductions in the watershed. Current BMP data were obtained through the CCCD, compiled into a single database, and visualized spatially using ArcGIS Pro (Figure 18).

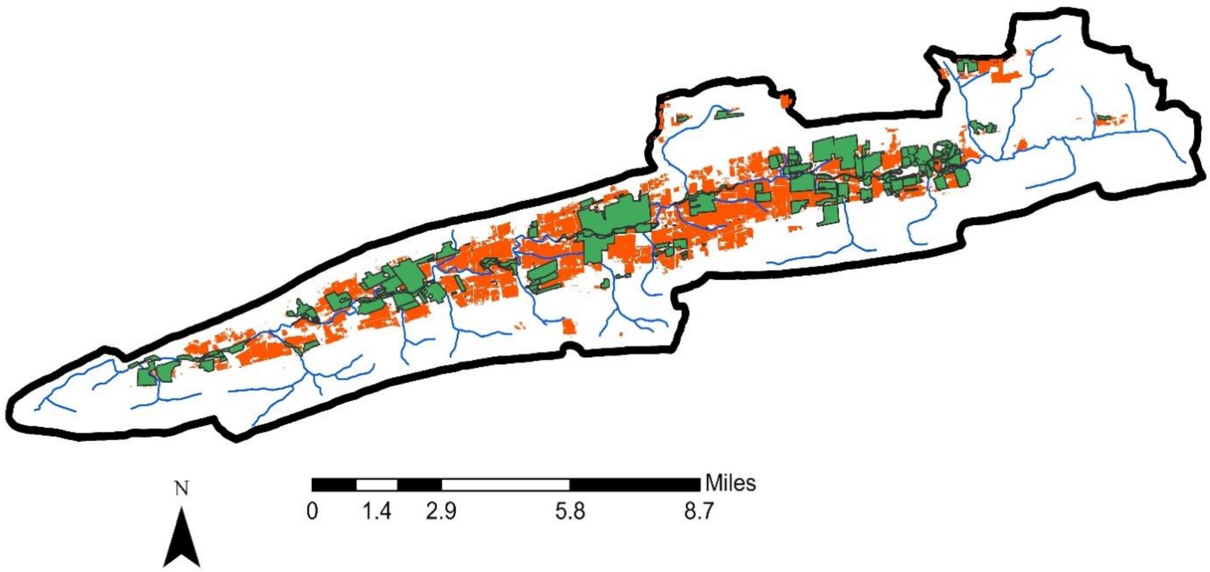


**Figure 18.** Current BMPs (green) throughout the watershed. Other agricultural land use areas are shown in orange.

Common BMPs that have been implemented throughout the watershed include conservation tillage, cover crops, riparian forest buffers, streambank fencing, erosion and sedimentation plans, grazing land management, and nutrient management practices. In total, approximately 63% of the agricultural land use area in the HUC12 currently has a BMP implemented. The existing BMPs were used to calculate the sediment load reduction using the CAST model. The results of this modeling scenario showed an 11% reduction in sediment load due to the current BMPs in place throughout the watershed. The 11% reduction in sediment load is included in the proposed implementation plan as discussed below.

# Implementation Plan

## *Reference Watershed Selection*

In addition to anthropogenic influences, there are many other natural factors affecting sediment loading rates and accumulation. Thus, selection of a reference watershed with similar natural characteristics as the impaired watershed is crucial. Failure to use an appropriate reference watershed could result in problems such as the setting of sediment reduction goals that are unattainable, or nonsensical calculations that suggest that sediment loading in the impaired watershed should be increased. The impaired watershed used in this was the Fishing Creek – Bull Run HUC12.

To find a reference, GIS data layers largely consistent with DEP's Integrated Report (PA DEP 2022) were used to search for other special protection (High-Quality or Exceptional Value) watersheds within the Appalachian Mountain section of the Ridge and Valley Physiographic Province that were of similar size as the size as the Fishing Creek -Bull Run HUC12  but lacked stream segments impaired for Aquatic Life Use. Given these factors, and the large size of the Fishing Creek – Bull Run HUC12, there were few potential references. Once potential references were identified, they were screened to determine which ones were most like the impaired watershed with regard to factors such as landscape position, topography, hydrology, soil drainage types, landuse etc. Furthermore, benthic macroinvertebrate and physical habitat assessment scores were reviewed to confirm that a reference was acceptable. Preliminary modelling was conducted to make sure that use of a particular reference would result in a reasonable pollution reduction.

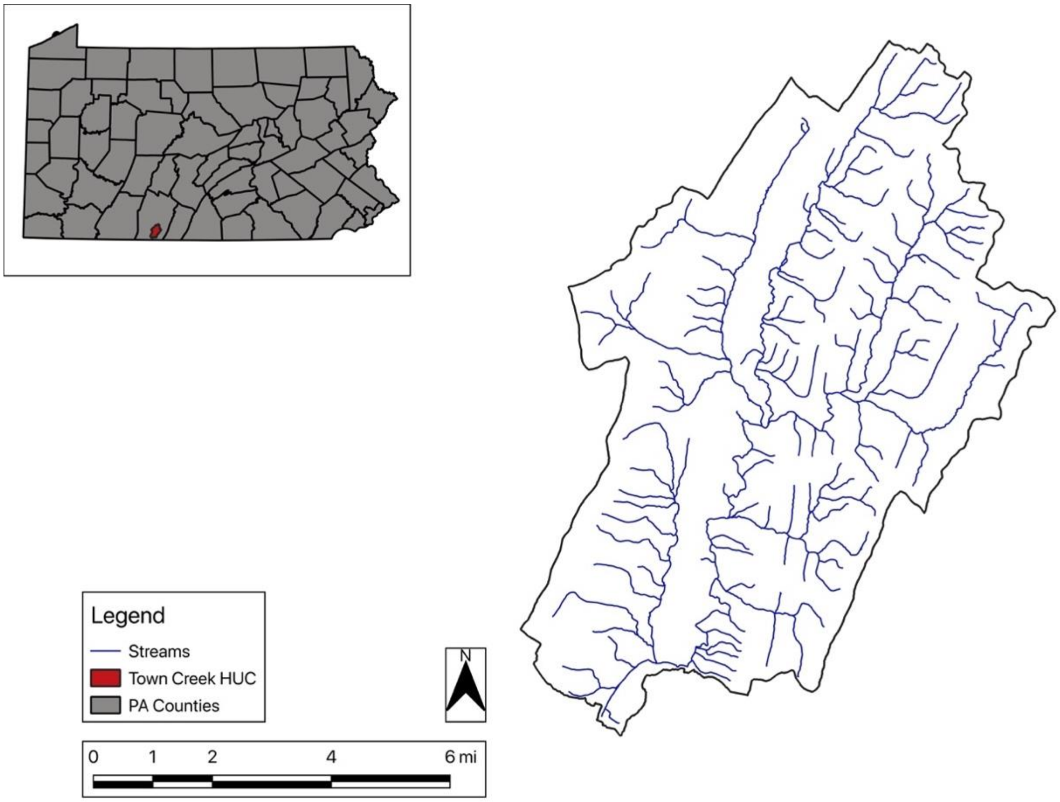


**Figure 19.** Location of the Town Creek watershed in Pennsylvania and streams within the watershed.

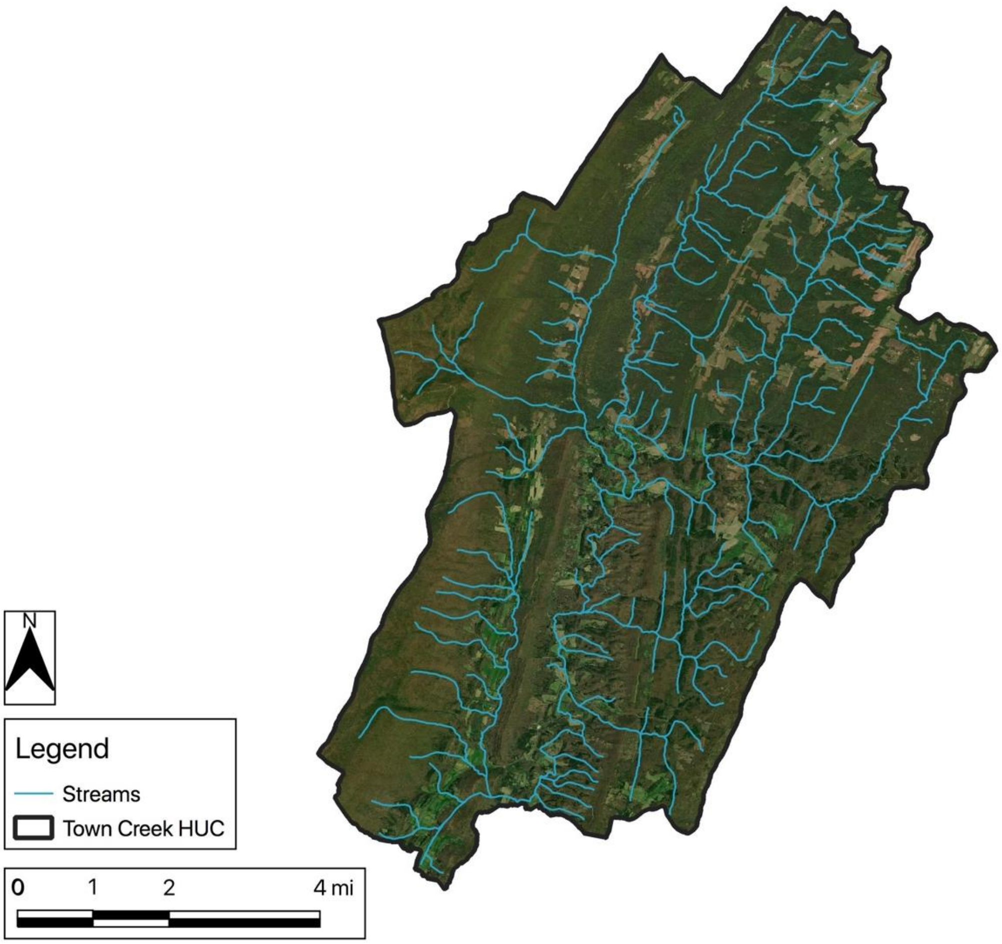


**Figure 20.** Satellite imagery of the Town Creek watershed showing rough land use. There is more forested land and less agricultural land use compared to the Bull Run – Fishing Creek HUC12, see Table 3.

A subwatershed of Town Creek (Figure 19, Figure 20) in Bedford County appeared to be a good match based on these criteria. All stream segments within this watershed were designated as High-Quality. Like the Fishing Creek – Bull Run HUC12, its landcover was dominated by forest/other natural vegetation, and there were few developed lands (Table 3). While both watersheds had significant agricultural land area as well, the amount in the Fishing Creek – Bull Run HUC12 was more than double that of the Town Creek subwatershed (24% vs 10%). The distribution of soil drainage classes were similar in both watersheds, and estimated hydrological variables were also similar (Table 3). The average slope of both watersheds was fairly high (14% and 19%), as may be expected in such ridge and valley systems. Thus, first order stream segments tended to be high gradient in both watersheds, while the highest order channels running through the valley of both watersheds were similarly moderate to low gradient (Table 3).

**Table 3.** Comparison of watershed characteristics in the Fishing Creek – Bull Run HUC12 and the Town Creek HUC12. Sources of information in this table are the DCNR GEODE[1] (DCNR 2024) datasets, Model My Watershed[2] (Strout Water Research Center 2023), and NHD High Resolution[3] data.

| Metric | Fishing Creek | Town Creek |
|---|---|---|
| Physiographic Province[1] | Appalachian Mountain Section of the Ridge and Valley Province | Appalachian Mountain Section of the Ridge and Valley Province |
| Area ($km^2$)[2] | 150 | 147 |
| Land Cover[2] | 22% Agriculture<br>72% Forest/Natural Vegetation<br>6% Developed | 10% Agriculture<br>85% Forest/Natural Vegetation<br>4% Developed |
| Soil Infiltration[2] | 31% Group A<br>41% Group B<br>2% Group B/D<br>3% Group C<br>1% Group C/D<br>21% Group D | 14% Group A<br>37% Group B<br>5% Group B/D<br>11% Group C<br>4% Group C/D<br>29% Group D |
| Dominant Lithology[1] | 46% Sandstone<br>25% Limestone<br>18% Shale<br>9% Dolomite<br>1% Quartzite<br>0.8% High Calcium Limestone | 37% Sandstone<br>21% Siltstone<br>17% Shale<br>13% Quartzite<br>7% Calcareous Shale<br>5% Limestone |
| Average Precipitation (in/year)[2] | 41.5 | 42.5 |
| Average Surface Runoff, in/year[2] | 2.2 | 1.8 |
| Average Elevation (ft)[2] | 1,543 | 1,409 |
| Average Slope[2] | 15% | 19% |
| Average Stream Channel Slope (NHD High Resolution)[3] | 1st order: 5%<br>2nd order: 3.7%<br>3rd order: 0.4%<br>4th order: 0.5% | 1st order: 6.4%<br>2nd order: 2.7%<br>3rd order: 1.6%<br>4th order: 1.32%<br>5th order: 0.34% |

There were however two major areas where these watersheds differed. The first was topographic configuration. Whereas the Fishing Creek – Bull Run HUC12 had one major valley, the Town Creek subwatershed consisted of a network of smaller valleys. Secondly, while there were minor amounts of limestone and calcareous shale in the Town Creek subwatershed, karst geology was a major component of the Fishing Creek – Bull Run HUC12 (Table 3). These differences are concerning, as both may exert significant control over the hydrologic and sediment transport dynamics within watersheds. However, finding a similar reference with a large central limestone valley is not possible, these watersheds commonly harbor intensive agriculture and experience similar water quality problems. With the understanding that compromises are necessary when using the reference watershed approach, the Town Creek subwatershed was selected. Furthermore, the sediment pollution reductions prescribed later will include a 10% margin of safety factor to help account for such uncertainties.

## *Target Load Reduction*

MMW was used to calculate the sediment loading rates in the Town Creek reference watershed and compared to the results from the baseline model for the Bull Run – Fishing Creek watershed, as outlined in the Watershed Analysis section. The annual sediment loading rate in the Town Creek reference watershed was estimated to be 157 lbs/(acre*yr) (Table 4). The estimated mean annual sediment loading rate in the impaired Bull Run – Fishing Creek watershed was 207 lbs/(acre*yr). Thus, to achieve the loading rate of the unimpaired reference watershed at 157 lbs/(acre*yr), the sediment loading in the Bull Run – Fishing Creek watershed should be reduced by 25% to 5,788,636.

**Table 4.** Annual average loading rates and yields in the Fishing Creek – Bull Run and Town Creek watersheds. Data was obtained from Model My Watershed for Fishing Creek and Mike Morris for Town Creek.

| Land Cover Type | Fishing Creek | | | Town Creek | | |
|---|---|---|---|---|---|---|
| | Landcover (ac) | Sediment (lbs/yr) | Sediment (lbs/ac*yr) | Landcover (ac) | Sediment (lbs/yr) | Sediment (lbs/ac*yr) |
| **Hay/Pasture** | 4,244 | 355,192 | 83 | 3,104 | 323,158 | 104 |
| **Cropland** | 3,940 | 3,480,879 | 880 | 630 | 359,009 | 570 |
| **Forest** | 26,410 | 34,219 | 1 | 30,756 | 70,366 | 2 |
| **Wetland** | 44 | 57 | 1 | 37 | 64 | 2 |
| **Open Land** | 111 | 16,331 | 147 | 264 | 19,393 | 73 |
| **Bare Rock** | 52 | 109 | 2 | 52 | 195 | 4 |
| **Low Density Mixed Dev** | 2,047 | 6,209 | 11 | 1,516 | 16,242 | 11 |
| **Medium Density Mixed Dev** | 190 | 12,832 | 67 | 15 | 1,293 | 87 |
| **High Density Mixed Dev** | 44 | 3,017 | 67 | - | 108 | - |
| **Stream Bank** | - | 3,809,336 | - | - | 5,046,577 | - |
| **Point Sources** | - | - | - | - | 24 | - |
| **Riparian Buffer Discount** | - | - | - | - | -123,397 | - |
| ***Total*** | **37,084** | **7,718,181** | **207** | **36,373** | **5,713,032** | **157** |

## *Implementation Plan*

As previously described, the total sediment load reduction goal for the Bull Run – Fishing Creek watershed is a 25% reduction from the baseline (without current BMPs) model conditions. Current BMPs in the watershed account for an 11% reduction in sediment load, bringing the total estimated sediment load in the Bull Run – Fishing Creek HUC12 watershed to 6,869,181 lbs/yr. The estimated existing 11% reduction was modeled by the Model My Watershed tool, also described in the Existing Best Management Practices and Current Load Reduction section. The BMPs were obtained from the Clinton County Conservation District, we were warned that the BMP dates may be incorrect, but we wanted to utilize what the district had on file for BMPs in the HUC12. The majority of BMPs were land management types, therefore as long as the land remains in the management (i.e. conservation tillage, cover crops, etc.) the reductions are active and there are no maintenance activities other than keeping the land in the BMP. Age also isn't a factor for land management like it would be for in-stream restoration structures, which can degrade over time. The margin of safety factor of 10%, in our professional opinions, would adequately cover any discrepancies between the Clinton County Conservation District's data on the BMPs and the status of current BMPs. The target reduction in the watershed, for it to become comparable to the reference Town Run watershed, was a 14% reduction in sediment load after accounting for the current estimated 11% reduction achieved by current BMPs.

A total of four sets of BMP implementation scenarios were evaluated for sediment load reduction and cost estimation using the CAST model (Appendix 5). Based on the results of the CAST modelling, a BMP implementation scenario was chosen that would exceed the needed 14% reduction and was also a cost-effective strategy. The proposed implementation plan is shown in Tables 5 and 6 for the Bull Run -Fishing Creek watershed. If fully implemented, the plan would reduce the sediment in the watershed by approximately 22% of the total load without BMPs (or a 33% reduction with current BMPs taken into account), to 5,176,117 lbs/year, exceeding the goal of 5,788,636 lbs/year by 10.5% or 612,519 lbs/year. Secondary benefits to this implementation plan include additional reductions in nitrogen and phosphorus. Nitrogen and phosphorus are estimated to be reduced by approximately 145,629 lbs/yr and 45,922 lbs/yr, respectively, according to the CAST model.

**Table 5.** Proposed implementation plan for the Bull Run – Fishing Creek watershed. Sediment load reductions are based on modeled results from the CAST model as described in text.

| BMP | Amount | Load Reduction (lbs/yr) |
|---|---|---|
| **Stream Restoration (ft)** | 11,060 | 705,628 |
| **Wetland Floodplain Restoration (acres)** | 30 | 31,224 |
| **Ag E&S Plans (acres, 80% Compliance)** | 6,446 | 654,138 |
| **Cover Crops (acres)** | 200 | 18,130 |
| **Conservation Tillage (acres)** | 200 | 74,266 |
| **Riparian Buffers (acres)** | 90 | 76,647 |
| **Sinkhole Riparian Buffers (acres)** | 25 | 21,291 |
| **Grass Filter Strips (acres)** | 30 | 93,323 |
| **Dirt and Gravel Road Improvements (ft)** | 6,222 | 18,417 |
| ***Total*** | | ***1,693,064*** |
| ***% Reduction*** | | ***21.9%*** |

**Table 6.** Reduction estimates for BMPs in the proposed implementation plan, organized by land cover type that the BMPs would influence.

| Land Cover Type | Land Cover Sediment (lbs/yr) | BMPs from Selected Scenario | Load Reduction (lbs/yr) |
|---|---|---|---|
| Agriculture | 3,836,071 | Ag E&S Plans (acres, 80% Compliance) | 654,138 |
| | | Cover Crops (acres) | 18,130 |
| | | Conservation Tillage (acres) | 74,266 |
| | | Grass Filter Strips (acres) | 93,323 |
| | | Riparian Buffers (acres) | 76,647 |
| | | Sinkhole Riparian Buffers (acres) | 21,291 |
| Wetland | 57 | Wetland Floodplain Restoration (acres) | 31,224 |
| Stream Bank | 3,809,336 | Stream Restoration (ft) | 705,628 |
| Development (Low, Med, High) | 22,058 | Dirt and Gravel Road Improvements (ft) | 18,417 |
| Open Land | 16,331 | - | - |
| Forest | 34,219 | - | - |
| Bare Rock | 109 | - | - |
| ***No BMP Total:*** | 7,718,181 | ***Total Reduction from Scenario BMPs:*** | 1,693,064 |
| ***11% Reduction with Current BMPs Total:*** | 6,869,181 | | |

### *Priority Subbasins for Implementation*

The 37 subbasins identified for this project were categorized into three tiers of priorities for the implementation of the proposed BMPs. The prioritization tiers were based on the sediment yield for each subbasin, with Tier 1 priorities contributing the most sediment to the watershed and Tier 3 priorities, the least. The 319 program will primarily fund BMP implementation in Tier 1 subwatersheds first, until all BMP opportunities are exhausted. However, Tier 2 projects could be funded if there is significant justification for a new/unforeseen opportunity or environmental benefit. Tier 3 priorities were primarily forested subbasins, with fewer opportunities for BMP implementation. Therefore, BMP implementation should primarily focus within Tier 1 and Tier 2 subbasins. Figure 21 shows the location of each prioritization tier within the Bull Run – Fishing Creek HUC12 watershed.

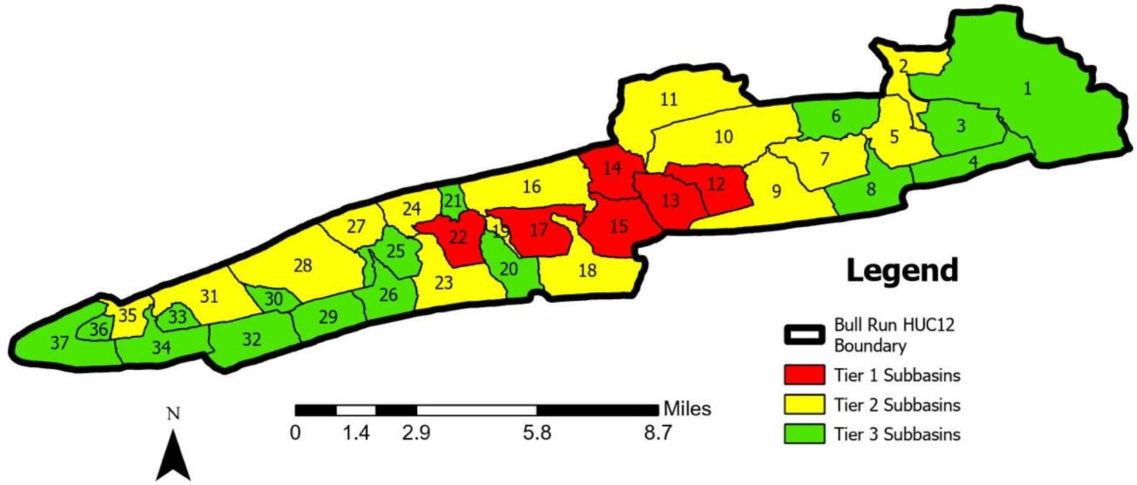


**Figure 21**. Prioritization of subbasins for sediment reduction implementation projects.

BMP opportunities were evaluated throughout the watershed (see Figure 22, Figure 23, Figure 24, Figure 25, and Figure 26). Riparian restoration opportunities included forested riparian buffers, precision grass filters, and livestock exclusion fencing (Figure 22). Stream corridors that lacked forested riparian vegetaion, primarily along the mainstem of Fishing Creek, were identified using the 1-meter high resolution land cover dataset (Chesapeake Conservancy). Similar methods were used to identify areas for precision grass filters and identify sinkholes that lacked riparian buffers (Figure 26). Sinkhole protection is not credited under CAST methodology, however in watersheds that have karst geology, protecting these sinkholes could greatly reduce sediment and nutrients, therefore it is a critical BMP. Soil health BMPs include cover crops, conservation tillage, and Agricultural Erosion and Sedimentation Plans (Figure 23). Areas of opportunity for soil health BMPs include agricultural land use areas that are not currently under a BMP. Areas that currently have a BMP may also have opportunities for the implementation of additional BMPs and should be evaluated during the initial outreach stages of the implementation plan.

Instream restoration opportunites, including wetland restoration, were prioritized to areas of Fishing Creek that have the lowest percent slope, as these areas tend to accumulate sediment at a greater rate than high gradient sections (Figure 24). Dirt and gravel road and farm lane improvement opportunity areas were identfied through aerial imaging and site visits by TU staff (Figure 25). Each of the BMP implementation opportunities should be directed at the Tier 1 and Tier 2 priority areas, with most implementation projects targeting Tier 1 priority areas. The 319 program funding will be focused in Tier 1 priority areas. Few opportunities exist in the Tier 3 priority areas, which tend to be primarily forested. Tier 3 should be protection focused instead of restoration focused as well. Based on the opportunity analyses presented in the figures below, we recommend that at least 60% of the implementation projects be targeted to Tier 1 subbasins (Table 7).

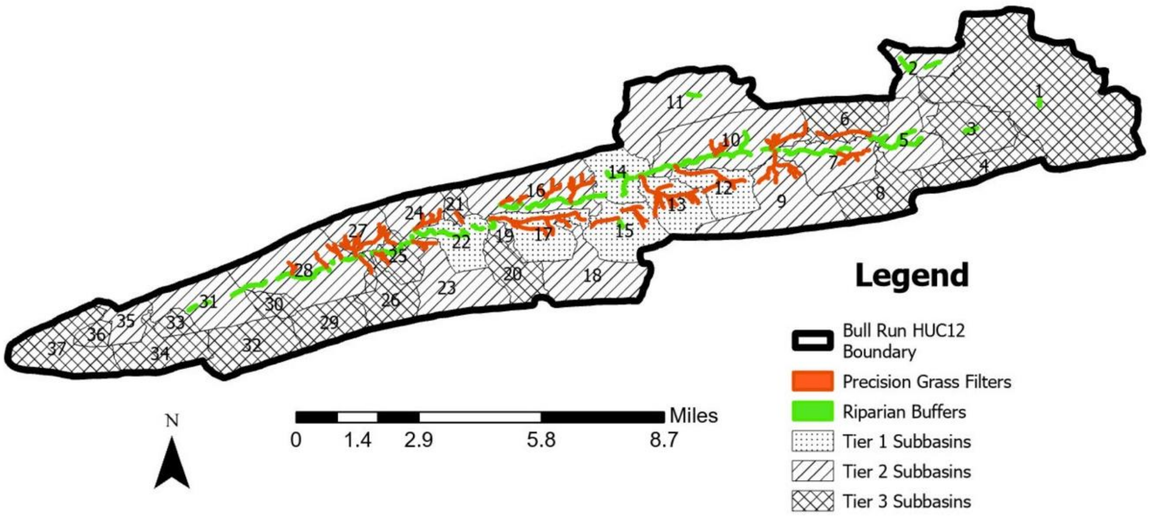


**Figure 22.** Riparian restoration opportunities within the Bull Run - Fishing Creek watershed.

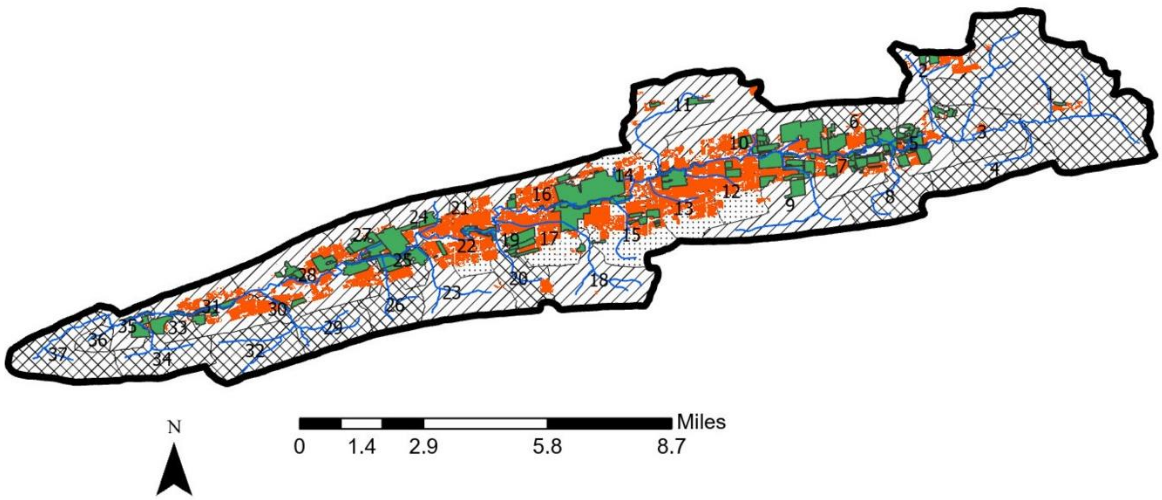


**Figure 23.** Soil health BMP opportunities in the Bull Run - Fishing Creek watershed. Opportunity areas are shown in orange. Areas highlighted in green currently have BMPs in place, although additional opportunities may exist in these areas.

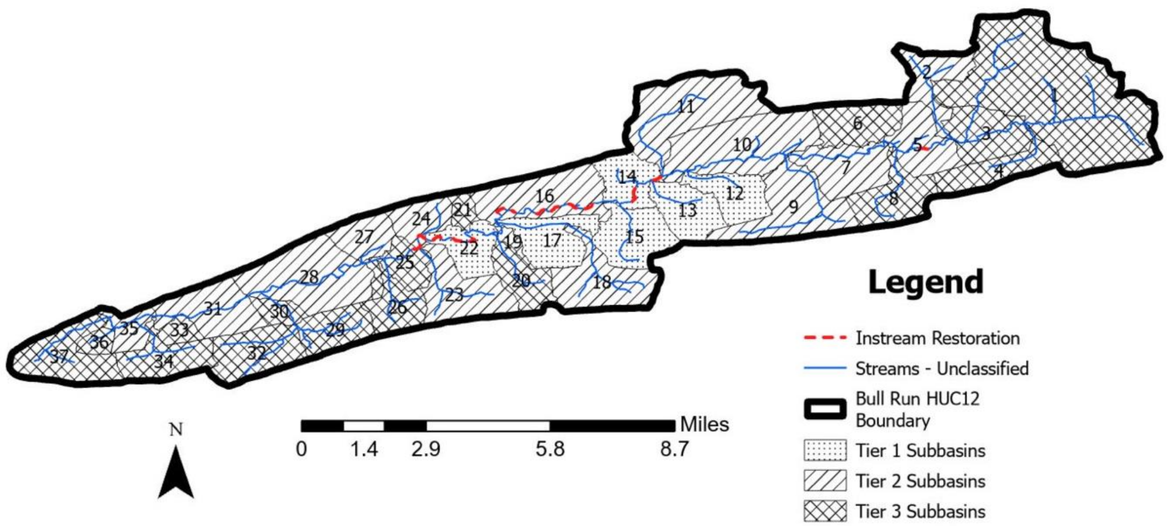


**Figure 24**. Instream restoration opportunities (including wetland restoration) within tiered restoration priorities of the Bull Run - Fishing Creek watershed.

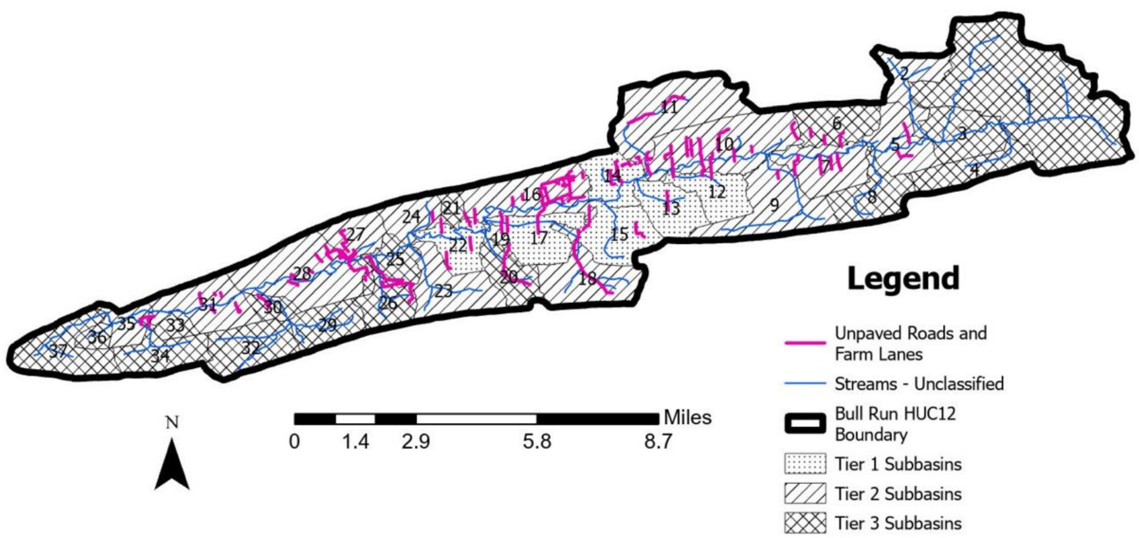


**Figure 25.** Unpaved road and farm lane improvement opportunities within the Bull Run - Fishing Creek watershed.

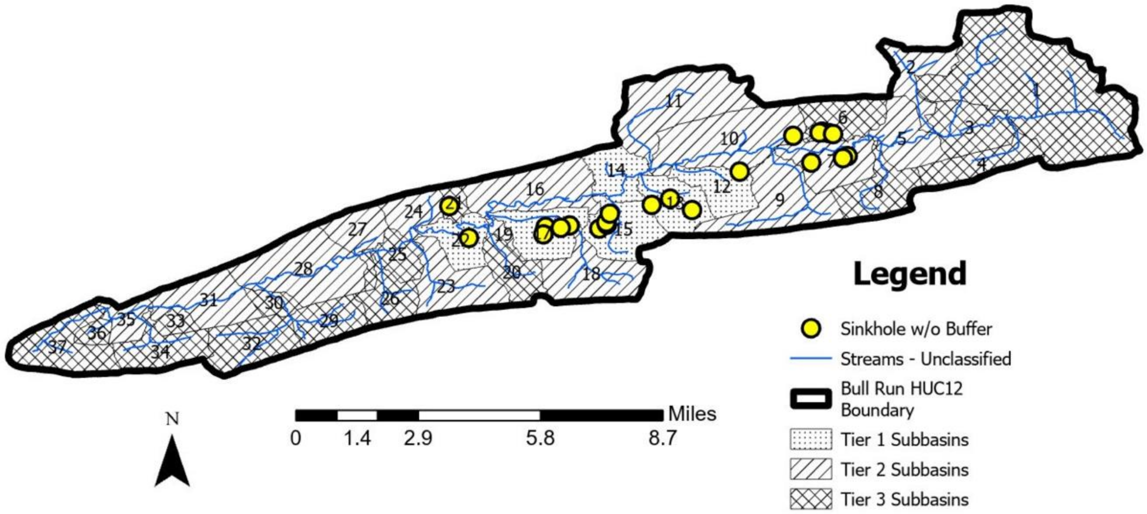


**Figure 26.** Sinkhole features that are currently lacking a forested buffer within the Bull Run – Fishing Creek watershed.

**Table 7**. Proposed BMPs for Tier 1 and Tier 2 priority subbasins.

| BMP | Total | Tier 1 Subbasins | Tier 2 Subbasins |
|---|---|---|---|
| Stream Restoration (ft) | 11,060 | 6,636 | 4,424 |
| Wetland Floodplain Restoration (acres) | 30 | 18 | 12 |
| Ag E&S Plans (acres, 80% Compliance) | 6,446 | 3,867 | 2,578 |
| Cover Crops (acres) | 200 | 120 | 80 |
| Conservation Tillage (acres) | 200 | 120 | 80 |
| Riparian Buffers (acres) | 90 | 54 | 36 |
| Sinkhole Riparian Buffers (acres) | 25 | 15 | 10 |
| Grass Filter Strips (acres) | 30 | 18 | 12 |
| Dirt and Gravel Road Improvements (ft) | 6,222 | 3,733 | 2,489 |


### *Public Outreach and Education*

Trout Unlimited and the CCCD have worked with the community in Sugar Valley in the past and have fostered relationships during the past decade. Using past relationships and areas where implementation has been successful, this implementation plan was written around local knowledge of the watershed. Targeting areas where landowners have been interested in the past was the first step, further outreach will target areas where projects may have not been successful in the past. Farmer to farmer outreach through showing successful BMPs will be important to use in the future.

A farm field day will be hosted by either TU or the CCCD within the first two years of WIP implementation where local farm owners show successful BMPs implemented on their land. Subsequent farm field days will be hosted by TU or the CCCD every two years to highlight more recent projects completed through WIP implementation. Farmers trust the judgement of other farmers, and if they are shown successful BMPs by another farmer they will be more likely to implement them. This would also be an opportunity to educate other landowners in the watershed about agricultural BMPs, riparian buffers, soil health, and how they can be used to improve the health of the agricultural landscape and the stream corridor. How BMPs can be implemented at no cost to the landowner would be discussed at this field day, and contacts at TU and CCCD would be given to the farmers to assist with BMP implementation. Working together with the SVWA to organize this and reach out to landowners would be beneficial due to the number of farmers who attend SVWA meetings. A flier about the event could be given to local businesses to display and it could also be put on the Clinton County calendar of events to reach other potential interested parties.

A public meeting hosted by TU to discuss the results of the WIP would be also beneficial for the community upon completion of the WIP. Any interested stakeholders would be invited and coordination with the SVWA for a potential date/time would occur. After the meeting is scheduled, the meeting would be announced at a SVWA meeting. Trout Unlimited would invite USGS, CCCD, LHU, and any other stakeholders to this meeting as well. Continued engagement with SVWA moving forward will be helpful in this valley. Installing informational signs about BMPs and stream health in public locations in the watershed would help reach more residents as well.

This watershed is underlain by karst geology, a general workshop about karst geology would be beneficial. TU and CCCD will work to organize a karst workshop within the first three years of WIP implementation in partnership with experts from federal and/or state agencies. Sinkhole protection is not credited under CAST methodology, however in watersheds that have karst, protecting these sinkholes could greatly reduce sediment and nutrients, therefore it is a critical BMP. It is important to educate the public how each sinkhole is connected to the entire watershed. This could have broader implications for reducing contaminants in drinking water since the majority of residents get their water from private wells. Sinkholes can create direct connections to wells and other groundwater, making sure residents understand this is crucial to watershed health in areas with karst geology.

**Main goals**

- Increase public knowledge of agricultural BMPs, riparian buffers, and soil health.
- Increase landowner knowledge of BMP implementation at no cost to them and who to contact for assistance with BMP implementation.
- Foster community engagement around this management plan.

**Outreach strategies**

- One-on-one landowner outreach.
- Host farm field days and farm tours periodically.
- Host soil health workshops.
- Attend small events and SVWA meetings, continued presence in this watershed.
- Attend other local events to create community connections.
- Signs in public locations in the watershed about BMPs, stream health, and karst geology.
- Encourage farmland and open space preservation.
- Increase access to project information, distribute the final document to stakeholders.

**How is success measured?**

- Minimum attendance of 10 individuals at annual project meetings and community events
- Implement BMP on one new property (that does not currently have BMPs established) within the first five years of the Watershed Implementation Plan.

- A minimum of 3 new landowners (currently without BMP implementation) implementing BMPs on their property by year 10 of the Watershed Implementation Plan.
- Engage one landowner currently implementing BMPs to evaluate and implement additional BMPs on property within the first five years of the Watershed Implementation Plan and engage three landowners currently implementing BMPs on their property by year 10 of the Watershed Implementation Plan.
- Positive feedback through interactions with the community and landowners.

### *Cost Estimate*

The cost estimates for the individual BMPs proposed were taken from CAST (Chesapeake Bay Program 2022; Chesapeake Bay Program 2023), with the exception of the Agricultural Erosion and Sedimentation (E&S) Plans. Internal discussions at PA DEP determined that the CAST estimate of $24.91 per year for "Soil Conservation and Water Quality Plans" does not reflect typical costs and longevity for Agricultural E&S Plans in Pennsylvania; a prior CAST estimate from 2010 of $15.00 per year was used for this BMP (Chesapeake Bay Program 2010). The total cost for the proposed implementation plan is $6,377,044. The total cost of stream restoration and wetland restoration could be much less considering that some wetland restoration could happen as stream restoration projects are implemented. For simplicity's sake the 2022 CAST cost estimates were used for each individual BMP (stream restoration and wetland restoration). Some assumptions were made for each BMP for cost estimation purposes: riparian buffers (forest and sinkhole) were 100 feet wide on both sides of waterways, and grass strips were 35 feet wide. These costs would be spread out over a 20 year time frame as detailed in the Implementation Timeline section. Table 8 details the costs of each proposed BMP.

**Table 8.** Cost estimates and operation and maintenance costs over time for each BMP proposed. The cost estimates were determined using CAST estimates from 2022 and 2010*. Abbreviations ft=feet, ac=acre.

| BMP | Amount | Lifespan (yrs) | Capital Cost/Unit | Annual O&M Cost/Unit | One time opportunity cost/unit (land cost) | Total Annualized cost/unit | Total Capital Cost | Total Capital Cost + Land Cost | Total Annualized Cost | Total Annualized Cost/(lb of Sediment*yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Stream Restoration (ft) | 11,060 | 20 | 513.24 | 64.16 | 0 | 105.34 | 5,676,434 | 5,677,406 | 309,680 | 0.439 |
| Wetland Restoration (ac) | 30 | 15 | 544.56 | 52.11 | 1,770.23 | 193.09 | 16,337 | 18,107 | 5,793 | 0.029 |
| Erosion and Sedimentation Plans (ac)* | 6,446 | 10 | 15 | 0 | 0 | 1.94 | 96,684 | 96,684 | 12,504 | 0.019 |
| Cover Crops (ac) | 200 | 1 | 0 | 75.5 | 0 | 75.5 | 0 | 0 | 15,100 | 0.833 |
| Conservation Tillage (ac) | 200 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Forested Riparian Buffer w/o Fence (ac) | 90 | 40 | 4,064.42 | 81.25 | 1,770.23 | 406.51 | 365,798 | 367,568 | 36,586 | 0.477 |
| Sinkhole Riparian Buffer w/o Fence (ac) | 25 | 40 | 4,062.42 | 81.25 | 1,770.23 | 406.51 | 101,611 | 103,381 | 10,163 | 0.477 |
| Grass Filter Strips w/o Fence (ac) | 30 | 10 | 899.15 | 35.97 | 1,770.23 | 240.93 | 26,975 | 28,745 | 7,228 | 0.077 |
| Dirt and Gravel Road Improvement (ft) | 6,222 | 25 | 14.98 | 0.3 | 0 | 1.36 | 93,206 | 93,206 | 8,462 | 0.106 |
| ***Total*** | | | | | | | 6,377,044 | | | |


## *Implementation Timeline*

| Phase 1 (Years 1-5) | Phase 2 (Years 6-10) | Phase 3 (Years 11-15) | Phase 4 (Years 16-20) |
|---|---|---|---|
| **Implementation:**<br>50% Tier 1 Projects<br>**Outreach:** in all tiers: one-on-one landowner outreach, annual public meeting, community events, host field days | **Implementation:**<br>100% Tier 1 Projects<br>50% Tier 2 Projects<br>**Outreach:** in all tiers: one-on-one landowner outreach, annual public meeting, community events, host farm tours at restoration sites | **Implementation:**<br>100% Tier 1 Projects<br>75% Tier 2 Projects<br>**Outreach:** in all tiers: one-on-one landowner outreach, annual public meeting, community events, host farm tours at restoration sites | **Implementation:**<br>100% of Implementation Plan<br>**Outreach:** in all tiers: one-on-one landowner outreach, annual public meeting, community events, host farm tours at restoration sites |
| **Sediment Reduction:**<br>507,919 lbs/yr | **Sediment Reduction:**<br>1,354,451 lbs/yr | **Sediment Reduction:**<br>1,523,758 lbs/yr | **Sediment Reduction:**<br>1,693,064 lbs/yr |

### *Technical and Financial Assistance*

**Table 9.** Potential sources of technical and/or financial assistance for various stages of the proposed implementation plan.

| Coordination | Implementation | Outreach/Education | Monitoring |
|---|---|---|---|
| Trout Unlimited | Trout Unlimited | Trout Unlimited | Trout Unlimited |
| Clinton County Conservation District | Clinton County Conservation District (CAP and ACAP) | Clinton County Conservation District (CAP and ACAP) | Clinton County Conservation District |
| Chesapeake Conservancy | NRCS (EQIP) | SVWA | USGS |
| Chesapeake Bay Foundation | NFWF (Chesapeake Bay Small Watersheds Grants, Central Appalachian Stewardship Grants) | NFWF (Chesapeake Bay Small Watersheds Grants, Central Appalachian Stewardship Grants) | PFBC |
| | DEP (319 Program and Growing Greener) | DEP (319 Program and Growing Greener) | DEP (319 Program and Growing Greener) |
| | Chesapeake Bay Foundation | Landowners | SRBC |
| | SVWA | | SVWA |
| | Chesapeake Conservancy | | Lock Haven University |
| | DCNR (Riparian Buffer Forest Program, C2P2) | | NFWF (Chesapeake Bay Small Watersheds Grants, Central Appalachian Stewardship Grants) |
| | Keystone 10 Million Tree Partnership | | |
| | Farm Service Agency (CREP ) | | |
| | PSU Center for Dirt and Gravel Road Studies | | |

# Monitoring Progress

## *Implementation Tracking*

The phased schedule outlined in the Implementation Timeline section will allow for the tracking of interim progress towards the full implementation of the outlined plan. The milestones through each phase of the project will be quantified in terms of the amount of BMPs implemented (acres, linear feet, etc.). Similar to the methodology used is setting sediment load reduction goals, the CAST model will be used to model sediment load reductions based on the actual BMPs implemented during each phase of the project and track progress towards the goals outlined in the Implementation Timeline section.

## *Stream Monitoring*

Continued stream monitoring for physical, chemical, and biological conditions within the watershed will be essential for measuring the progress of the overall health of the watershed and to monitor the effects of the proposed implementation plan. The stream monitoring program outlined in the Watershed Analysis section provides a replicable design for future monitoring. A baseline in water quality parameters will be established within the first three years after WIP approval (Table 10). Stream monitoring sites are shown in Figure 11. Fishery and benthic macroinvertebrate surveys should be completed annually. Funding for monitoring will be pursued and water quality sampling will occur at a minimum of one high and one low flow event annually, however more frequent sampling would provide better detail regarding changes in water chemistry under different hydrological regimes and will occur if funding allows. Routine monitoring throughout the watershed would provide an indication of when/if the impaired sections should be reevaluated for potential delisting. As future funding in the watershed is obtained for project implementation, the project will also include a strong monitoring component to adequately track progress and allow for an adaptive management strategy to be employed.

Additional monitoring could also be considered throughout the implementation phases of this plan depending on available funding. Specifically, turbidity or other methods more directly related sediment could be employed. As public interest grows in relation to this project through the outreach and education component, it would be valuable to establish a volunteer-based citizen science monitoring program. Citizen science is a valuable tool to further community engagement in the watershed while collecting critical scientific data. Another consideration is pursuing a USGS gauging station within the Fishing Creek watershed. The watershed at the time of writing this plan does not currently have a gauging station and continuous water level and flow monitoring (as well as additional parameters, if available) would be advantageous for future monitoring efforts to track success. Finally, given the karst geology of the watershed, an emphasis should be placed on a better understanding of the groundwater movement through the watershed. A detailed inventory of sinkholes throughout the watershed may enhance this understanding as well as aid in the identification of priority sinkhole locations that warrant additional protection.

### *Milestone Tracking*

**Table 10.** Percent reduction in selected water quality metrics for interim and milestone goals over the course of 20 years.

| Metric | % Reduction | | | | |
|---|---|---|---|---|---|
| | **3 Years** | **5 Years** | **10 Years** | **15 Years** | **20 Years** |
| Embeddedness | Establish Baseline | 1% | 5% | 7% | 10% |
| Total Dissolved Solids (TDS) | Establish Baseline | 1% | 5% | 7% | 10% |
| Turbidity | Establish Baseline | 1% | 5% | 7% | 10% |

- Reductions in TDS would be measured during moderate and high flow events.
- Reductions in turbidity would be based on secchi disc measures during moderate and high flow events.
- A baseline for each of the metrics above will be established within the first three years after WIP approval.

## Adaptive Management

The implementation plan outlined in this document provides a general guideline for directing resources into priority areas that will maximize success for overall watershed health. However, flexibility and adaptability are necessary for any restoration plan as new opportunities may arise throughout the implementation phase of the plan. Given that the Bull Run – Fishing Creek watershed is largely privately owned, landowner willingness and personal interests will be critical for the success of the implementation plan. The outreach and education component of the plan seeks to encourage landowner participation and foster good relationships with those in the community. Some restoration projects may be directed towards the most willing landowners at the onset of the implementation phase in order to build relationships and demonstration sites to engage and encourage participation from other landowners for future projects.

The monitoring of the watershed, through physical, water quality, and biological surveys will be used to ensure that adjustments to the implementation plan can be made based on scientific data. The plan should be re-evaluated every five years as monitoring data is collected to ensure that the watershed continues on a trajectory towards improvement. Deviations from that trajectory should lead to adjustments to the implementation strategy. The plan will also be evaluated and potentially updated after 10 years

# Conclusions

The proposed restoration plan for the Bull Run – Fishing Creek watershed achieves and surpasses the targeted sediment load reduction based on the Town Creek reference watershed. It accomplishes this by setting feasible goals without becoming overbearing to the private farmers that make up this community. The restoration actions outlined in this plan will seek to decrease sediment loads (and secondarily nitrogen and phosphorus loads), restore aquatic and riparian habitat in degraded portions of the watershed, and foster greater community awareness and advocacy for the overall health of the watershed.

The implementation plan was developed through an analytical approach that allowed for the prioritization of restoration projects to areas of the watershed where they would have the most impact toward sediment reduction. The implementation plan provides an outline of these restoration projects as well as providing guidance on community outreach and education. The plan also provides guidance on continued monitoring throughout the watershed, allowing for an adaptive management strategy to be employed during the implementation phases of the plan. The phased implementation of the plan will allow for the achievement of success in a cost effective, efficient, and timely manner.

Overall, the successful implementation of this plan will rely on strong partnerships, stakeholder engagement, and landowner participation. If fully implemented, the plan should result in a healthier watershed for those that live and work in the watershed as well as the visitors that frequent this region for recreation, ensuring that the watershed is a resource that can be utilized by generations to come.

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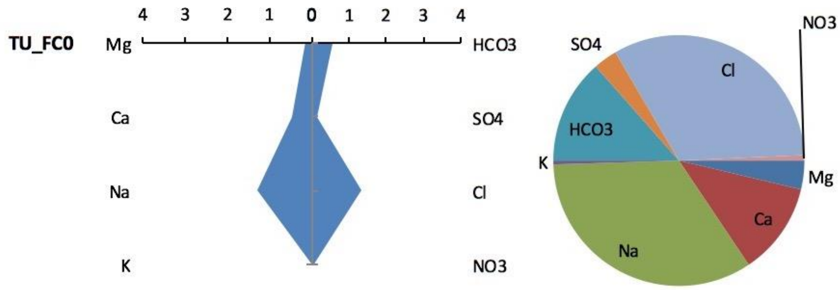
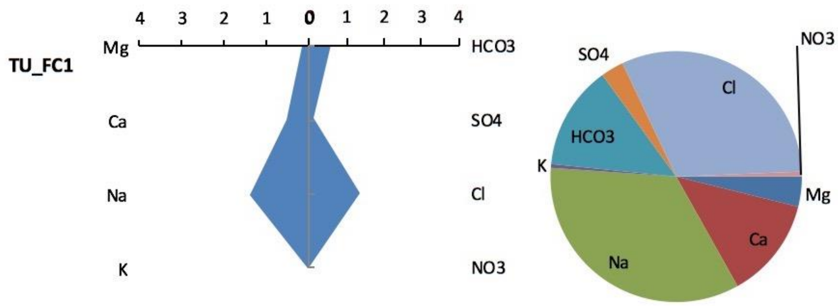
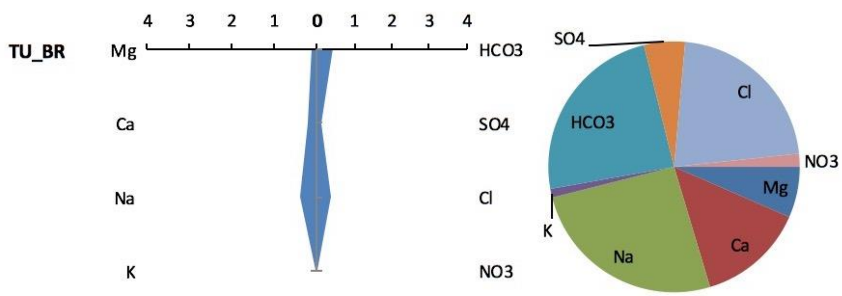
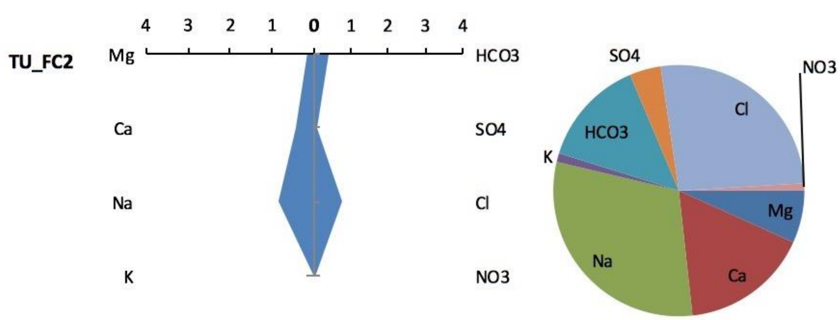
**APPENDIX 1.** Stiff Plots for all sites that had ions evaluated. Receding flow and peak flow are noted next to the plots.

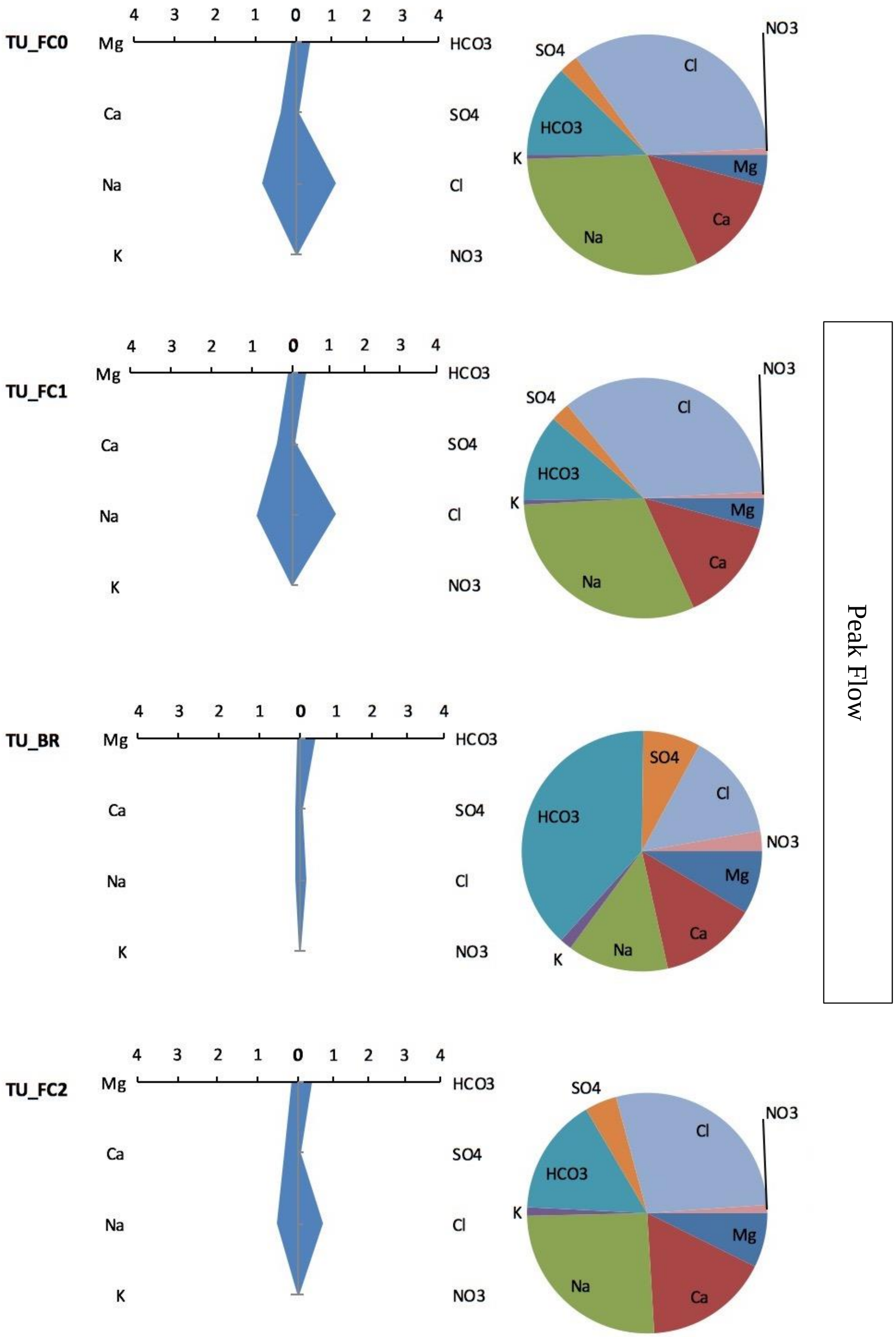


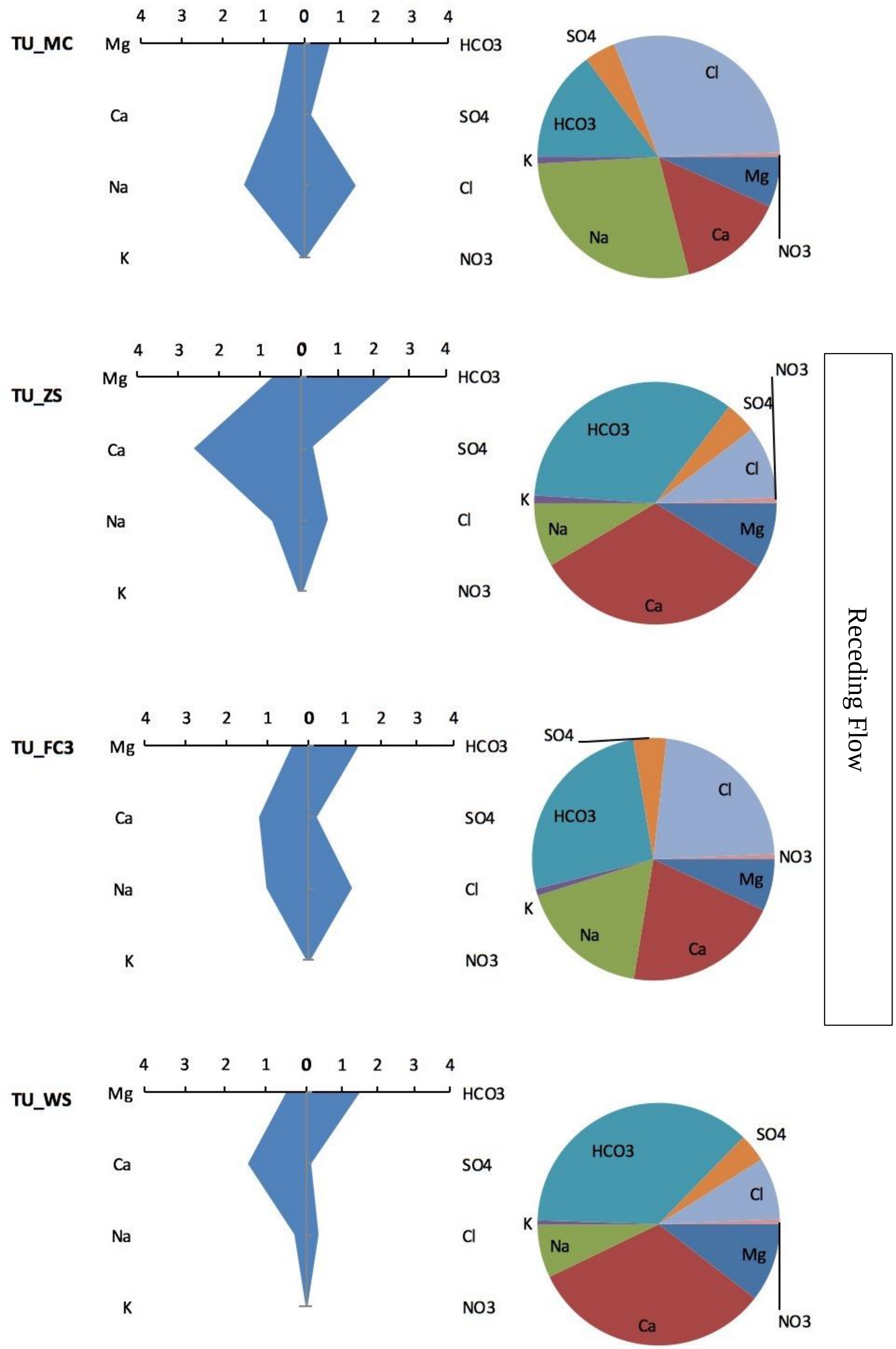



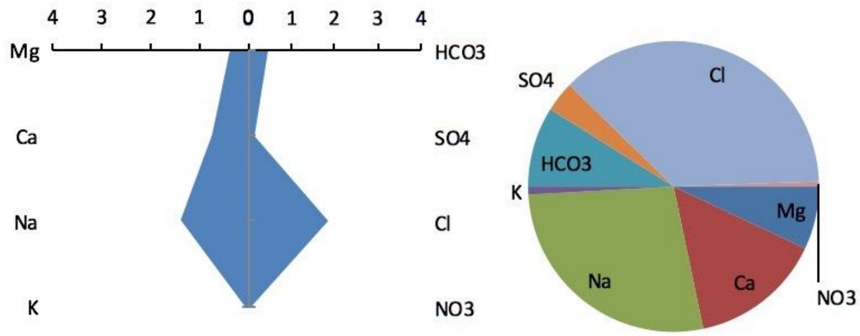




Receding Flow

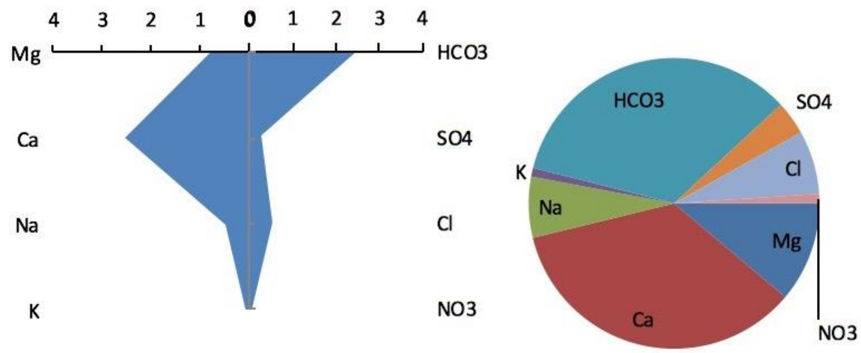

TU_FC0
TU_FC1
TU_BR
TU_FC2
4 3 2 1 0 1 2 3 4
Mg
Ca
Na
K
HCO3
SO4
Cl
NO3
Peak Flow


TU_MC
TU_ZS
TU_FC3
TU_WS
4 3 2 1 0 1 2 3 4
Mg
Ca
Na
K
HCO3
SO4
Cl
NO3
Receding Flow

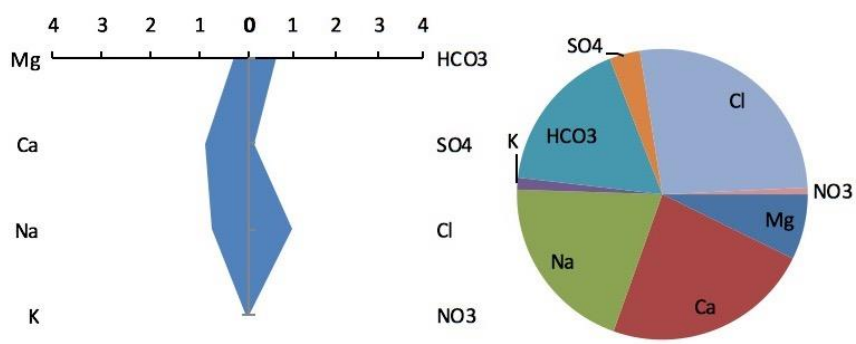
TU_MC



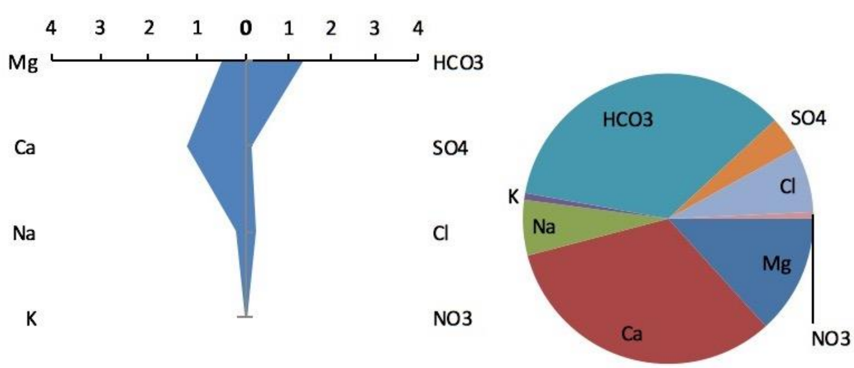

TU_ZS



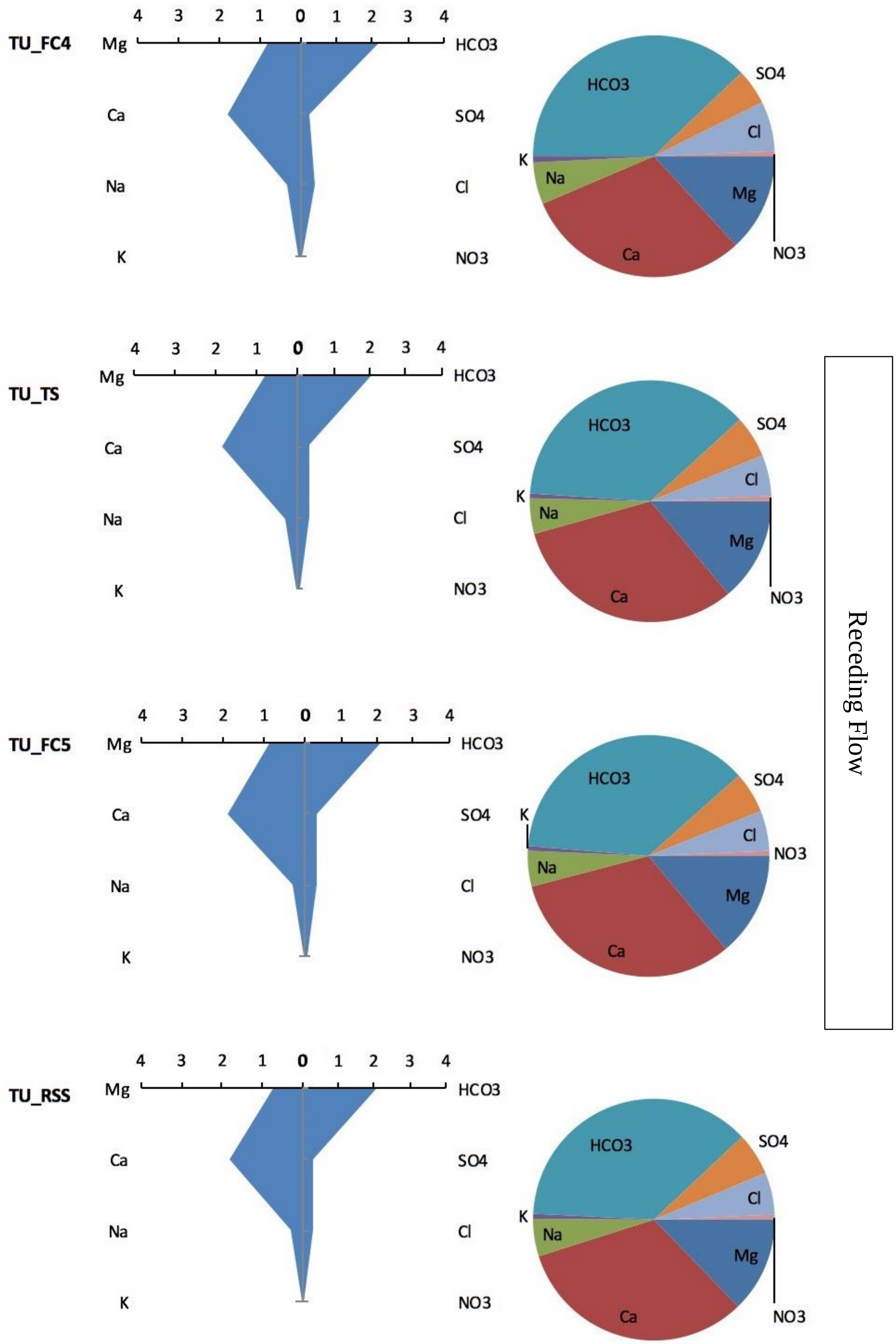

TU_FC3



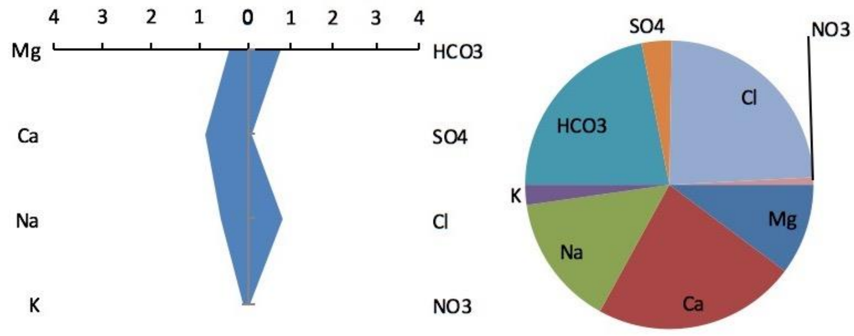

TU_WS



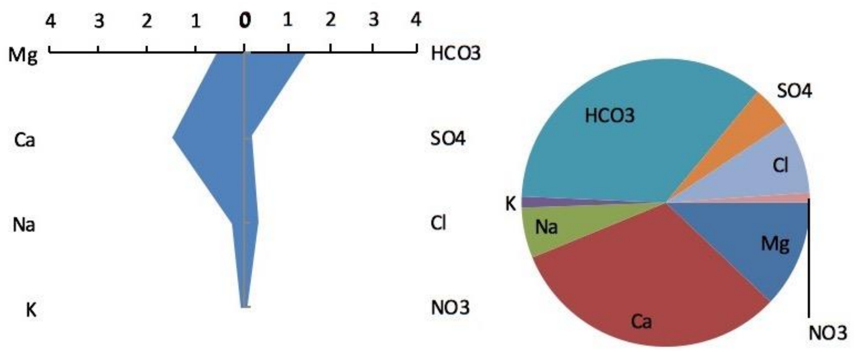

Peak Flow


TU_FC4
TU_TS
TU_FC5
TU_RSS
Mg
Ca
Na
K
HCO3
SO4
Cl
NO3
4 3 2 1 0 1 2 3 4
Receding Flow

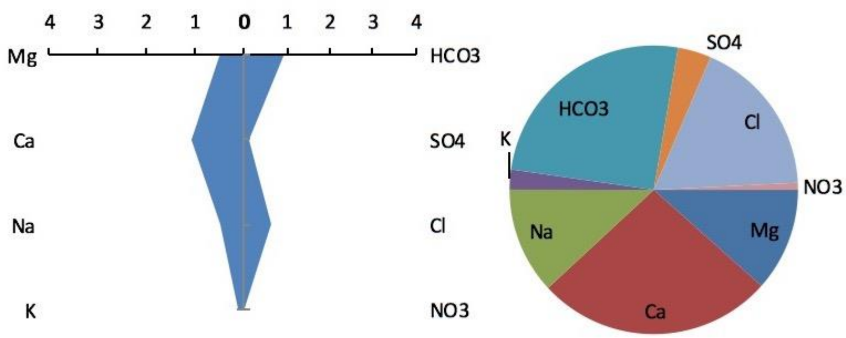
TU_FC4



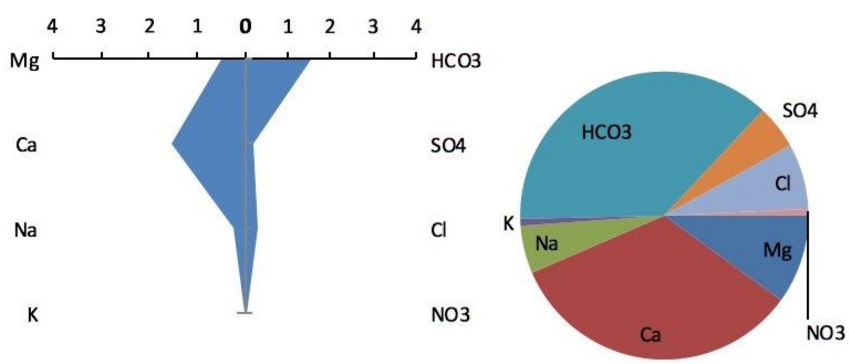

TU_TS



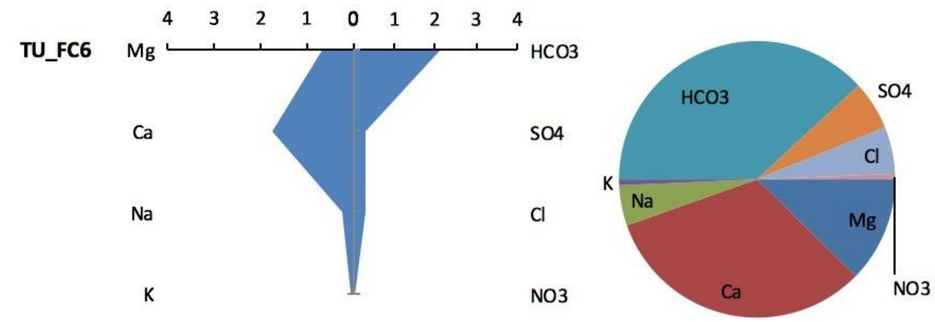

TU_FC5



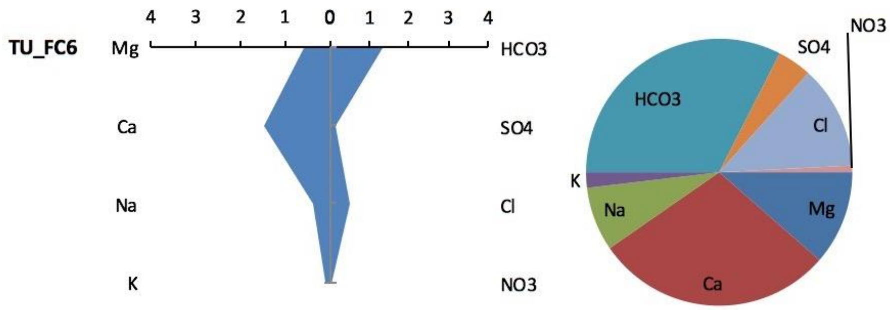

TU_RSS




Peak Flow




Receding Flow




Peak Flow

## APPENDIX 2. Description of Instream Comprehensive Evaluation biological metrics that were used in this project.

*Total Abundance (Freestone and Limestone)*

The total abundance is the total number of organisms collected in a sample or sub-sample.

*Total Taxa Richness (Freestone and Limestone)*

This is a count of the total number of taxa in a sample or sub-sample. This metric is expected to decrease with increasing anthropogenic stress to a stream ecosystem, reflecting loss of taxa and increasing dominance of a few pollution-tolerant taxa.

*EPT Taxa Richness (Freestone and Limestone)*

This is a count of the total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa in a sample or sub-sample. Common names for these orders are mayflies, stoneflies, and caddisflies, respectively. The aquatic life stages of these three insect orders are generally considered sensitive to pollution (Lenat and Penrose 1996). This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders.

*Shannon Diversity Index (Freestone and Limestone)*

The Shannon Diversity Index is a community composition metric that takes into account both taxonomic richness and evenness of individuals across taxa of a sample or sub-sample. In general, this metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and increasing dominance of a few pollution-tolerant taxa.

*Hilsenhoff Biotic Index (Freestone and Limestone)*

This community composition and tolerance metric is calculated as an average of the number of individuals in a sample or sub-sample, weighted by pollution tolerance values. The Hilsenhoff Biotic Index was developed by William Hilsenhoff (Hilsenhoff 1977, Hilsenhoff 1987; Klemm et al. 1990) and generally increases with increasing ecosystem stress, reflecting dominance of pollution-tolerant organisms. Pollution tolerance values used to calculate this metric are largely based on organic nutrient pollution. Therefore, care should be given when interpreting this metric for stream ecosystems that are largely impacted by acidic pollution from abandoned mine drainage or acid deposition.

*Beck's Biotic Index (Freestone and Limestone)*

This metric combines taxonomic richness and pollution tolerance. It is a weighted count of taxa with PTVs of 0, 1, or 2. It is based on the work of William H. Beck in 1955 (Beck 1955). The metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive taxa.

*Ratio of Biological Condition Gradient (BCG) Attribute (Freestone and Limestone)*

This screening question evaluates the balance of pollution tolerant organisms with more sensitive organisms in terms of taxonomic richness and organismal abundance. By using the BCG attributes to measure pollution tolerance, this screening question serves as a check against the IBI metrics which account for pollution sensitivity based only on PTVs. *This question must be applied to small-stream samples collected between November and May, but does not have to be applied to samples from larger streams and samples collected between June and September*.

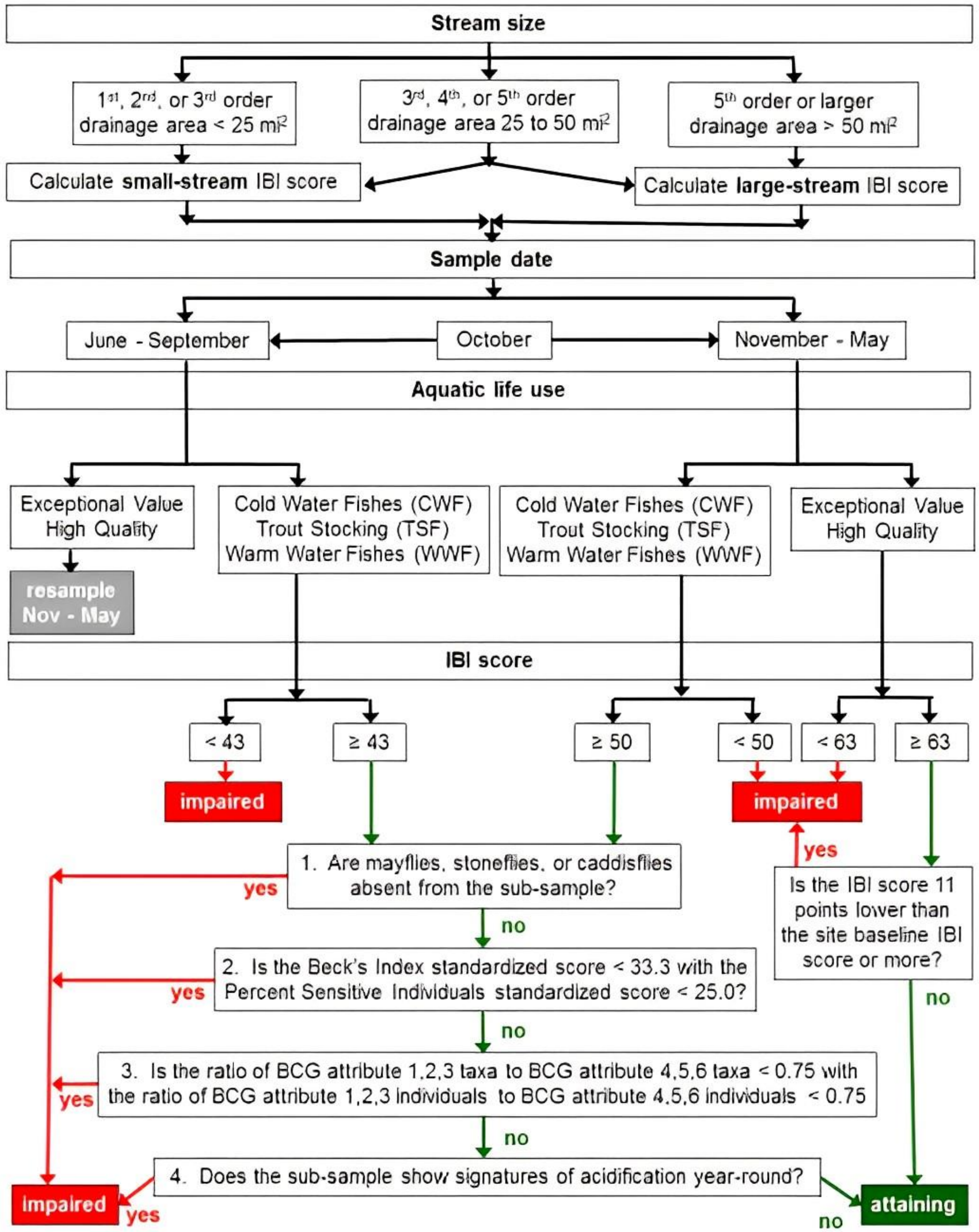
*Percent (%) Sensitive Individuals (Freestone only)*

This community composition and tolerance metric is the percentage of individuals with PTVs of 0 to 3 in a sample or sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive organisms

*Percent (%) Tolerant Individuals (Limestone only)*

This community composition and tolerance metric is the percentage of individuals with PTVs of 7 to 10 in a sample or sub-sample and is expected to increase in value with decreasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-tolerant organisms

**APPENDIX 3.** Criteria for a site in order for it to be Attaining ALU



**APPENDIX 4.** Raw benthic macroinvertebrate data from the lab for all sites that were surveyed.

| Order | Family | PA Taxa Name | FC0 | FC1 | MC | FC3 | FC4 | FC5 | FC6 |
|---|---|---|---|---|---|---|---|---|---|
| | | Oligochaeta | | 1 | 5 | 7 | 1 | 2 | |
| Trombidiformes | | Hydracarina | 5 | 3 | 2 | 2 | | 9 | 2 |
| Coleoptera | Elmidae | Elmidae | | 24 | | | | | |
| | | Optioservus | 44 | 47 | 21 | 3 | 23 | 5 | 21 |
| | | Oulimnius | 11 | 35 | 37 | 2 | | | |
| | | Promoresia | 3 | 1 | 7 | | | | 1 |
| | Psephenidae | Ectopria | 1 | 1 | 1 | | | | |
| Diptera | Ceratopogonidae | Ceratopogonidae | 3 | | 1 | | 1 | 2 | 2 |
| | Chironomidae | Chironomidae | 31 | 15 | 26 | 16 | 26 | 12 | 51 |
| | | Trichoclinocera | 1 | | 7 | | | | |
| | Limoniidae | Antocha | | | | | | | 2 |
| | | Hexatoma | | 2 | | | | | |
| | | Limnophila | | | 1 | | | | |
| | | Pseudolimnophila | | | 3 | | 1 | | |
| | Muscidae | Muscidae | | | | 2 | | | |
| | Pedicidiidae | Dicranota | | 3 | 1 | | | | |
| | Psychodidae | | | | | | | | 2 |
| | Simuliidae | Prosimulium | 2 | 4 | 32 | 92 | 33 | 6 | 4 |
| | | Simulium | 1 | | | | 1 | | |
| | | Stegopterna | 2 | | 1 | | | | |
| Ephemeroptera | Baetidae | Baetis | | 3 | | | 2 | 2 | 14 |
| | | Diphetor | 1 | 1 | | | | | |
| | Ephemerellidae | Drunella | 1 | | | | 7 | | 1 |
| | | Ephemerella | 13 | 15 | 9 | 61 | 30 | 58 | 63 |
| | | Eurylophella | 1 | 2 | | | | 1 | |
| | | Teloganopsis | 64 | 17 | | | | | |
| | Heptageniidae | Cinygmula | 3 | 4 | 1 | 1 | | | |
| | | Epeorus | 5 | 2 | | | | | 5 |
| | | Leucrocuta | 1 | | | | | | |
| | | Maccaffertium | 1 | 1 | | | | | 2 |
| | Leptophlebiidae | Leptophlebiidae | | 8 | 1 | | 2 | | 11 |
| | | Paraleptophlebia | 11 | 5 | | | | | |
| Odonata | Gomphidae | Gomphidae | 1 | 2 | | | | | |
| Plecoptera | Capniidae | Paracapnia | 2 | | | | | | |
| | Chloroperlidae | Sweltsa | 1 | | | | | | |
| | Leuctridae | Leuctra | | 1 | | 2 | | | 1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nemouridae | Amphinemura | | 11 | 21 | 2 | | | |
| | | Prostoia | 1 | | 1 | | | | |
| | Perlidae | Acroneuria | | | 1 | | | | |
| | | Agnetina | | 2 | | | | | |
| | Perlodidae | Isoperla | 2 | 1 | 8 | 9 | | | 2 |
| Trichoptera | Brachycentridae | Micrasema | 7 | 6 | | | | 3 | |
| | Hydropsychidae | Cheumatopsyche | | | | | | 1 | 18 |
| | | Diplectrona | | 2 | | | | | |
| | | Hydropsyche | 1 | 8 | | | 1 | | 1 |
| | Hydroptilidae | Hydroptila | | | | | | 10 | |
| | Limnephilidae | Pycnopsyche | | | 1 | 1 | 1 | | |
| | Philopotamidae | Dolophilodes | | | | | 1 | | 3 |
| | Polycentropodidae | Polycentropus | | | | | | | 1 |
| | Rhyacophilidae | Rhyacophila | 2 | | | | | | |
| | Thremmatidae | Neophylax | 2 | 4 | 4 | 15 | 3 | 5 | 3 |
| Amphipoda | Gammaridae | Gammarus | | | | | 45 | 118 | 7 |
| Isopoda | Asellidae | Caecidotea | | | | 1 | 19 | | |
| Sphaeriida | Sphaeriidae | Sphaeriidae | 1 | 1 | | | 1 | | |
| Basommatophora | Physidae | Physella | | | | | 13 | | |
| | | Physidae | | | | 4 | | | |
| | Planorbidae | Gyraulus | | | | | 3 | | |
| | | Nematoda | | 1 | | 2 | | | |
| | | Turbellaria | | | | | | 3 | |
| **Total** | | | **225** | **233** | **192** | **222** | **214** | **237** | **217** |

**APPENDIX 5.** Alternate scenarios that were considered, the percent reduction is listed next to the total sediment reduction (lbs/yr).

| Scenario | BMP | Amount | Sediment Load Reduction (lbs/yr) | Total Capital Cost |
|---|---|---|---|---|
| **1** | Stream Restoration (ft) | 4,500 | 287,100 | 2,309,580 |
| | Ag E&S Plans (acres, 85%) | 6848.5 | 695,021 | 102,727 |
| | Cover Crops (acres) | 200 | 18,130 | 0 |
| | Conservation Tillage (acres) | 300 | 111,399 | 0 |
| | Riparian Buffers (acres) | 100 | 85,164 | 406,442 |
| | Sinkhole Riparian Buffers (acres) | 25 | 21,291 | 101,611 |
| | Grass filter strips (acres) | 50 | 155,538 | 44,958 |
| | Wetland Floodplain Restoration (acres) | 50 | 52,040 | 27,228 |
| | Dirt and Gravel Road Improvements (ft) | 8,000 | 23,680 | 119,840 |
| | ***Total*** | | ***1,449,363 (18.7%)*** | ***3,112,385*** |
| **2** | Stream Restoration (ft) | 6200 | 395,560 | 3,182,088 |
| | Ag E&S Plans (acres, 95%) | 7654.2 | 776,788 | 114,812 |
| | Cover Crops (acres) | 150 | 13,597 | 0 |
| | Conservation Tillage (acres) | 350 | 129,966 | 0 |
| | Riparian Buffers (acres) | 90 | 76,647 | 365,798 |
| | Sinkhole Riparian Buffers (acres) | 25 | 21,291 | 101,611 |
| | Grass filter strips (acres) | 40 | 124,431 | 35,966 |
| | Wetland Floodplain Restoration (acres) | 40 | 41,632 | 21,782 |
| | Dirt and Gravel Road Improvements (ft) | 4300 | 12,728 | 64,414 |
| | ***Total*** | | ***1,592,641 (20.6%)*** | ***3,886,471*** |
| **3** | Stream Restoration (ft) | 8600 | 548,680 | 4,413,864 |
| | Ag E&S Plans (acres, 100%) | 8057 | 817,672 | 120,855 |
| | Cover Crops (acres) | 250 | 22,662 | 0 |
| | Conservation Tillage (acres) | 400 | 148,533 | 0 |
| | Riparian Buffers (acres) | 80 | 68,131 | 325,154 |
| | Sinkhole Riparian Buffers (acres) | 25 | 21,291 | 101,611 |
| | Grass filter strips (acres) | 40 | 124,431 | 35,966 |
| | Wetland Floodplain Restoration (acres) | 40 | 41,632 | 21,782 |
| | Dirt and Gravel Road Improvements (ft) | 3837 | 11,358 | 57,478 |
| | ***Total*** | | ***1,804,389 (23.3%)*** | ***5,076,710*** |