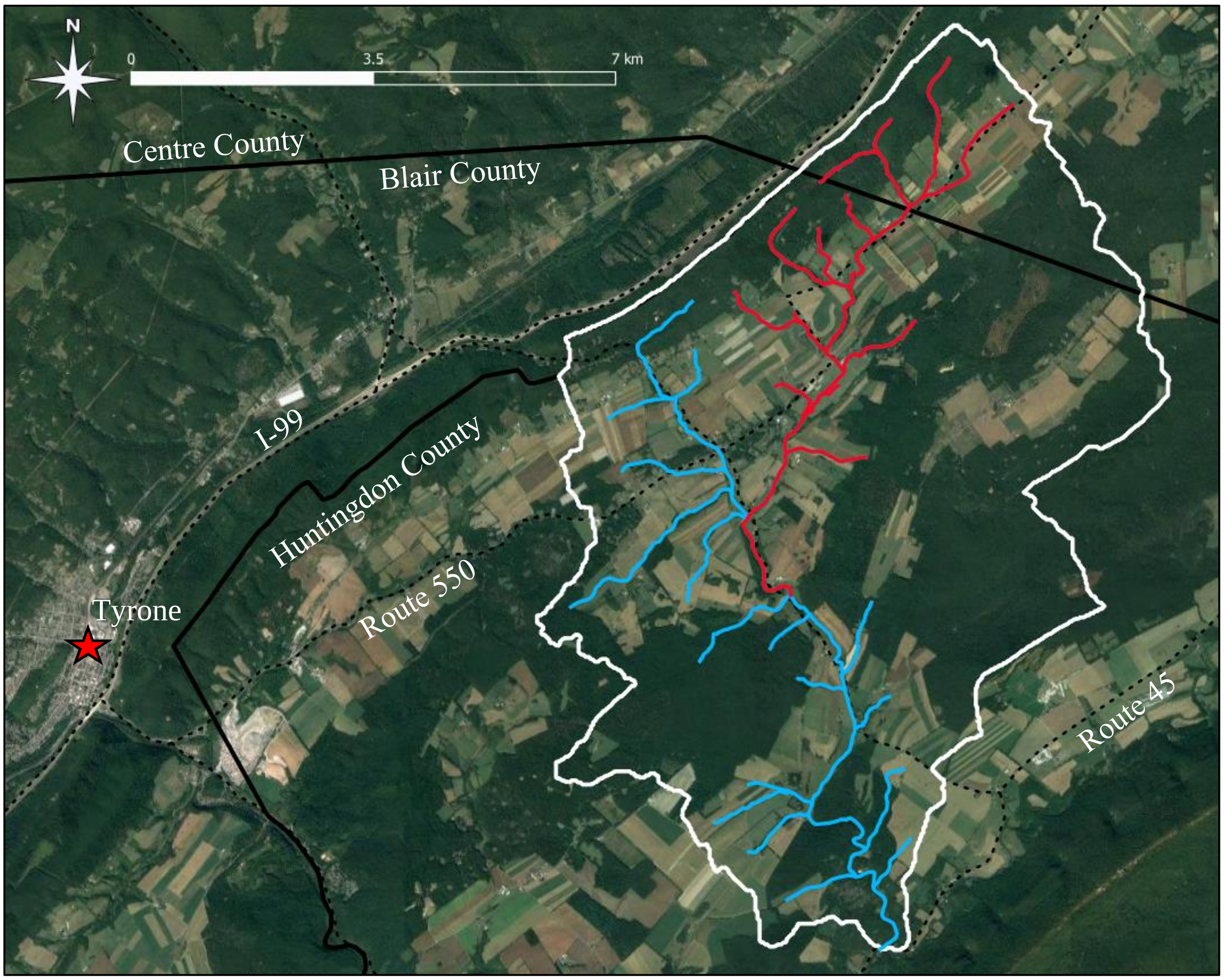
Water Quality Assessment Report

Warriors Mark Run

Huntingdon County, Pennsylvania



Logan Stenger, Watershed Specialist

Huntingdon County Conservation District

2020-2021

Introduction

Purpose

Since 2017, the Huntingdon County Conservation District (HCCD) has been actively involved in promoting and implementing conservation practices and restoration projects along Warriors Mark Run. In 2020, the HCCD also partnered with the Chesapeake Conservancy to begin implementing the Conservancy's Rapid Stream De-listing Strategy in Huntingdon County, Pennsylvania. This conservation strategy aims to focus water quality improvement projects where they can yield the greatest environmental benefits per the minimal cost of project implementation. Specifically, the Conservancy set the goal of working with its partners to de-list agriculturally impaired streams over the next 10-12 years. During the early planning stages of this partnership, the HCCD and the Conservancy identified Warriors Mark Run as a priority watershed in Huntingdon County for this conservation strategy. Therefore, in 2020 and 2021, HCCD staff completed detailed water quality assessments in this watershed. The following report summarizes the methods, results, and conclusions from these two assessments.

Photos 1-2. Before and after photos from a HCCD restoration project along Warriors Mark Run.

Photos 3-4. Before and after photos from a HCCD pasture restoration in the Warriors Mark Run watershed.

Watershed Description

Warriors Mark Run is a popular and locally significant waterway located in northwest Huntingdon County, Pennsylvania along the Huntingdon, Blair, and Centre County boundarties (Figure 1). In total, this watershed encompasses 26.8 square miles (17,152 acres) and is comprised of 55% forest, 40% agriculture (including cropland, pasture, and hay), and 5% developed space. In it's entirety, this basin contains approximately 17 miles of streams, including 8 miles of first-order streams, 3 miles of second-order streams, and 6 miles of third-order streams (Stroud Water Research Center 2017).

According to the Pennsyvania Department of Environmental Protection (PADEP), all 17 miles of Warriors Mark Run have a High Quality, Cold Water Fishery (HQ-CWF) designated use. A designated use is determined by Title 25 PA Code, Chapter 93 Water Quality Standards and are used to determine regulations and protection standards for a specific body of water. A HQ-CWF waterway is described as having "surface water quality that exceeds levels necessary to support the maintenance or propagation of coldwater species", including trout. Streams and rivers designated as HQ-CWF receive the second highest level of protections as they are often considered to be some of the healthiest and cleanest waters in Pennsylvania. Only an Exceptional-Value, Cold Water Fishery (EV-CWF) designated use receives higher levels of protection restrictions (Title 25 PA Code Chapter 93).

In addition, PADEP also assigns an "attaining" (healthy) listing to bodies of water if their respective designated use water quality standards are observed. If a waterway fails to meet one or more of these standards, the water may be listed as an "impaired" (unhealthy) waterway (Clean Water Act Section 303d). In 2002, PADEP staff assessed this watershed for Aquatic Life and determined that approximately 8 miles of stream qualified for 303(d) impaired stream listing due to sediment and nutrient pollution likely resulting from livestock grazing in riparian or shoreline areas (PADEP 2020).

Only 30% of Pennsylvania streams are considered HQ-CWF. Of that, fewer than 2% are designated as highly productive waters that contain natural reproducing trout populations. According to the Pennsylvania Fish and Boat Commission (PFBC), the Warriors Mark Run watershed contains approximately 14 stream miles that support naturally reproducing trout populations (Figure 2). In addition, 6 miles of these natural reproduction trout waters have also been designated as Class A wild brown trout (*S. trutta*) streams. Class A trout streams are "streams that support a population of naturally produced trout of sufficient size and abundance to support a long-term and rewarding sport fishery" (PA Fish and Boat Commission 2021). The presence of wild, naturally reproducing trout populations is often associated with clear, silt-free streams with cold, highly oxygenated waters (Stauffer et al. 2016), reinforcing the need to conserve and protect and improve this important coldwater ecosystem.

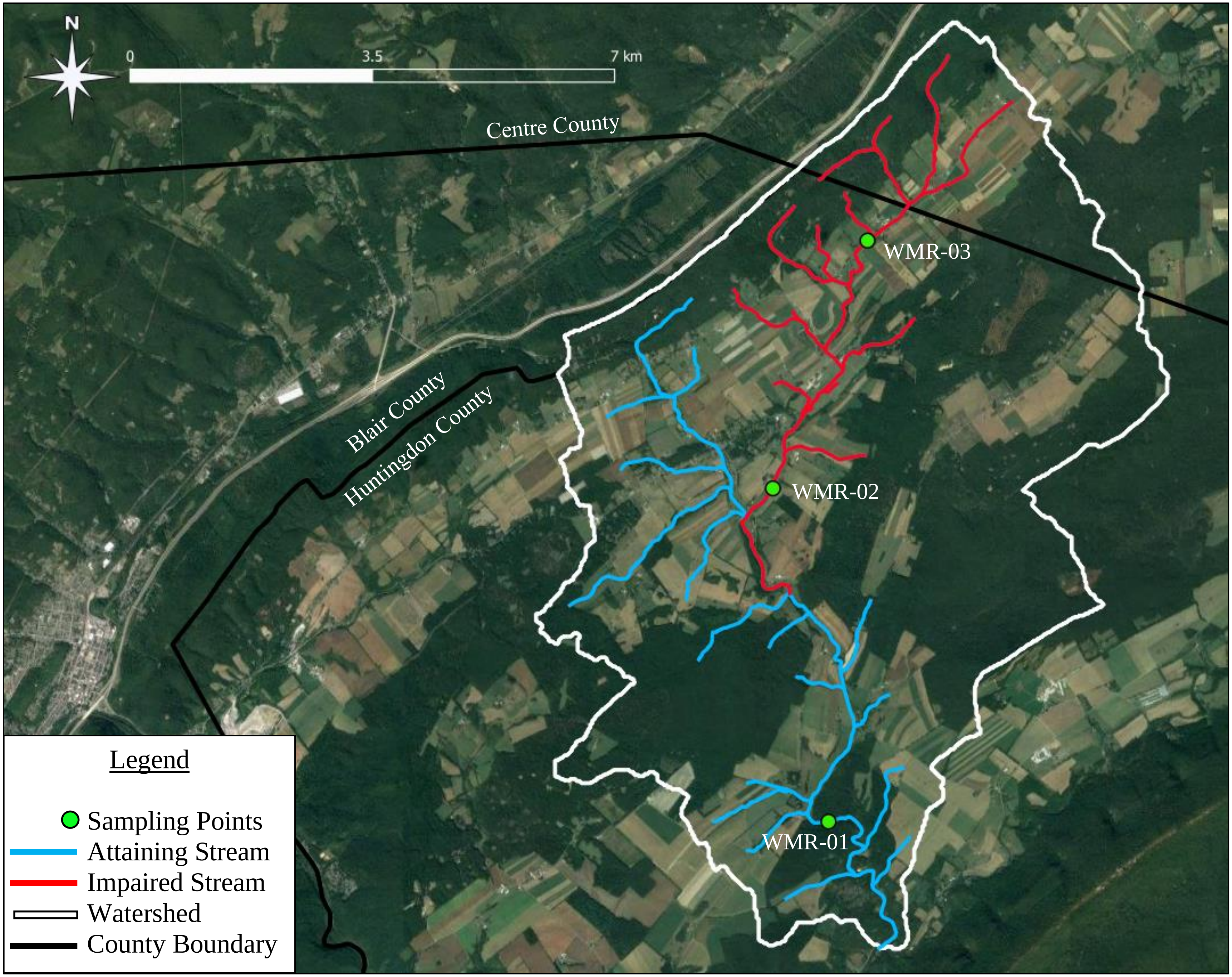


Figure 1. Map of 2020 and 2021 sample sites in the Warriors Mark Run watershed.

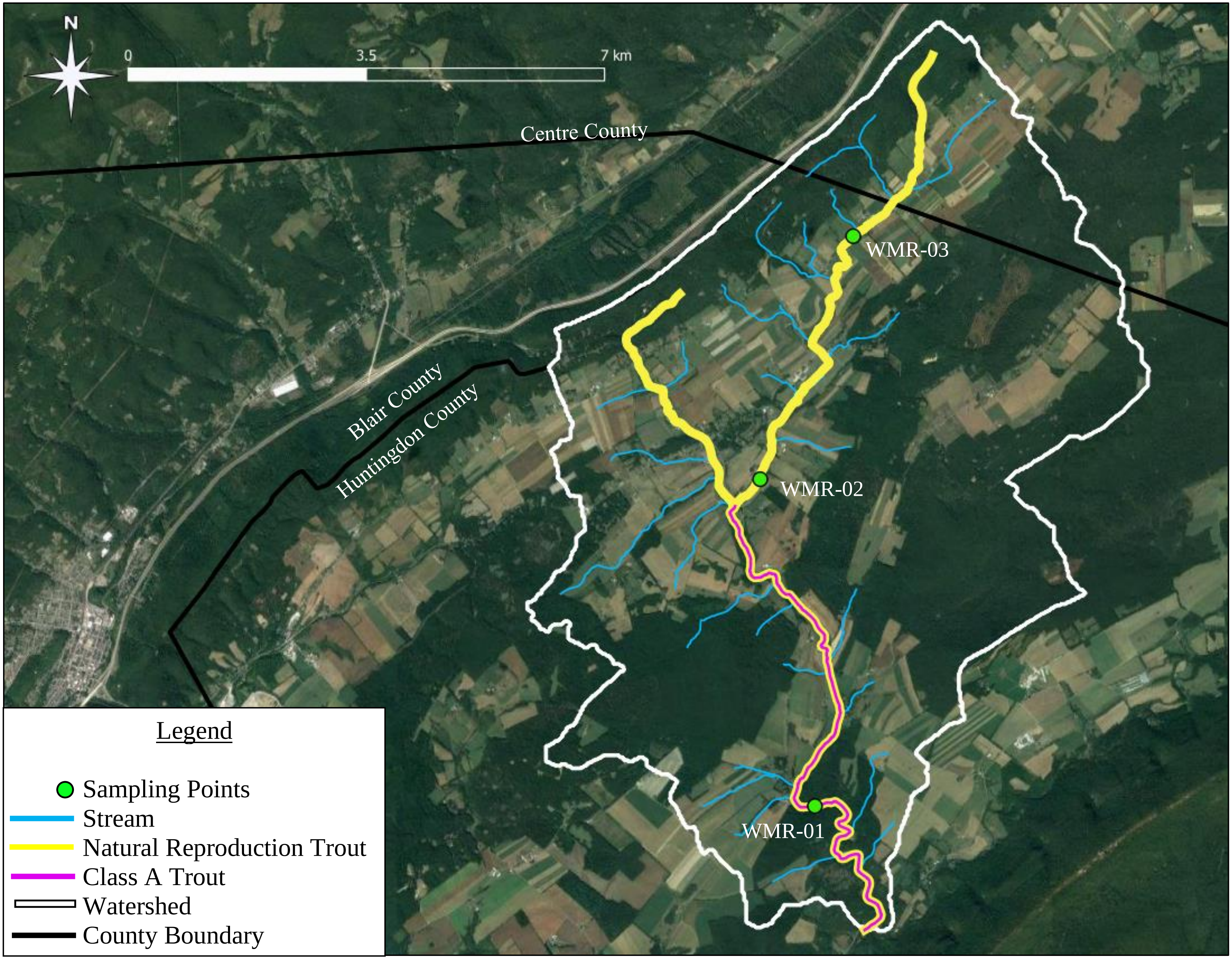


Figure 2. Map of the Warriors Mark Run watershed Natural Reproduction Trout and Class A Trout waters

Methods

Study Sites

To accurately provide a snapshot analysis of the entire watershed's current health, a total of three sites were selected throughout the Warriors Mark Run watershed (Figure 1). Specifically, one site was sampled along a downstream "attaining" section of stream, while the other two were collected on the upstream and downstream ends of the "impaired" section of stream. The downstream site located on the "attaining" section of stream had been previously assessed by PADEP in 2005. Water chemistry, physical habitat, and benthic macroinvertebrates were all measured at each study site. An upstream and downstream facing photo at each study site is available in Appendix I.

Table 1. Summary of 2021 sample sites.

Stream Name	DEP Code	2020 HCCD Code	2021 HCCD Code	Site ID	Latitude	Longitude
Warriors Mark Run	20120412-0945-jeremmille	20200318-1045-LRS	20210422-1100-LRS	WMR-01	40.654643	-78.111271
Warriors Mark Run	-	20200318-1220-LRS	20210422-1230-LRS	WMR-02	40.697891	-78.120417
Warriors Mark Run	-	20200318-1410-LRS	20210422-1330-LRS	WMR-03	40.729929	-78.104203

Water Chemistry

Comprehensive water chemistry measurements were taken with a Yellow Springs Instrument (YSI) Professional Series Pro2030 meter for temperature (C°), dissolved oxygen (mg/L), and specific conductance (uS/cm), and a YSI Ecosense pH100 meter for pH (standard units). Meter calibration and data collection was completed in accordance with PADEP protocols described in Shull and Lookenbill (2018).

While this method of measuring chemical parameters at a single point in time, known as "in-situ" collection, provides valuable insight towards water quality, our interpretation of these results is limited. Chemical parameters, especially temperature and dissolved oxygen, can be highly variable and influenced by factors such as time of collection, season, flow, and more.

Therefore, our results provide a short-term "snapshot" of the watershed's chemical parameters rather than a long-term analysis. To draw more detailed conclusions from water chemistry, continuous water chemistry data would need be collected either through regular monitoring activities or the installation of permanent data loggers.

Physical Habitat

A physical habitat assessment was completed at each sample site in accordance with PADEP protocols for high gradient, riffle-run, wadable streams (Shull and Lookenbill 2018). This process involves ranking 12 parameters over a 100-meter reach that represent potential limitations to the quality and quantity of instream habitat. The observer classifies each parameter as optimal, suboptimal, marginal, and poor by assigning each parameter a value ranging from 1-20. Parameters evaluated include instream cover, epifaunal substrate, embeddedness, velocity/depth regimes, channel alterations, sediment deposition, frequency of riffles, channel flow status, condition of banks, bank vegetative protection, grazing or other disruptive pressure, and riparian vegetative zone width (Appendix II). After all parameters are evaluated, the scores are combined to calculate a Total Habitat Score and rated as follows: optimal (240-181); suboptimal (180-121); marginal (120-61); and poor (60-0).

To further assess the quality of a stream's physical habitat, scores are compared to multiple PADEP impairment thresholds (Shull and Pulket 2018). The first impairment threshold for high gradient, riffle-run, wadable streams includes a Total Habitat Score ≤ 140. In addition, certain habitat parameters are exceptionally strong indicators of habitat degradation. Therefore, two additional impairment thresholds for 1) Embeddedness + Sediment Deposition and 2) Condition of Banks + Bank Vegetative Protection were calculated and compared across all sample sites. The impairment threshold for either parameter combination is a total score of ≤ 24.

Benthic Macroinvertebrate Sample Collection

Benthic macroinvertebrates are small, aquatic organisms such as aquatic insects (mayflies, stoneflies, "hellgrammites", etc.), crayfish, snails, mussels, and more that inhabit the stream bottom. Different species of benthic macroinvertebrates are sensitive to different levels of pollution, making them excellent bioindicators of stream health. By examining a stream's benthic macroinvertebrate community to determine the abundance of "pollution-intolerant" (healthy) and "pollution-tolerant" (unhealthy) species, biologists can accurately assess water quality.


Photo 5. HCCD Watershed Specialist collecting a benthic macroinvertebrate sample.

Benthic macroinvertebrate samples were collected at each sample site following PADEP methodology for wadeable, freestone, riffle-run streams (Shull and Lookenbill 2018). Collection begins by delineating a 100-meter reach along the stream of interest. A six-kick composite sample is collected from the reach using a 12-inch wide x 10-inch high D-frame net with 500 micron mesh. For each kick, the collector places the net against the stream bottom and disturbs a one square meter area immediately upstream of the net for approximately one minute. The collector attempts to distribute the kicks among a variety of riffle habitats (e.g., slow-flowing, shallow riffles and fast-flowing, deeper riffles). Kicks were also conducted throughout the width of the stream to include the left, middle, and right areas. This is done to ensure the composited sample provides an accurate representation of the macroinvertebrate community throughout the stream The composited sample is placed into a jar and preserved with 95% ethanol. Jars are labelled inside and outside with the date, time, collector, and location. Upon completion of the six collection kicks, the net is thoroughly examined for any attached organisms, which are added back into the sample jar. The net is then rinsed to prevent contamination at succeeding sample sites.

Benthic Macroinvertebrate Subsampling

In the laboratory, benthic macroinvertebrate samples were sorted and processed following PADEP methodology for macroinvertebrate samples collected from freestone streams (Shull and

Lookenbill 2018). Prior to subsampling, the composited sample is removed from the collection container and placed in a 500-micron sieve. The sample is gently rinsed under running water to remove ethanol and minimize damage to the macroinvertebrates. The sample is then placed in an 18-inch x 12-inch x 3½-inch pan, marked off into (28) 2-inch x 2-inch grids. Water is added to the pan before sample placement to ensure the macroinvertebrates are evenly distributed throughout the pan, and to prevent the contents of the sample from drying out during the subsampling process. Once the contents of the sample are placed in the pan, four 2-inch x 2-inch grids are randomly selected.

The materials and organisms from the selected grids are removed from within four-square inch circular “cookie cutters” placed in the randomly selected grids and removed using spoons, turkey basters, tweezers, and other implements as needed. The extracted contents are then placed into a second pan with water. Identifiable organisms are then picked and counted from the second pan. If less than 180 identifiable organisms are picked from the second pan, an additional grid is randomly selected and extracted from the first pan. The materials and organisms from this additional grid are moved to the second pan, and the organisms are picked. This process goes on until a subsample target number of 200 ± 20 organisms is reached.

If more than 220 identifiable organisms are picked from the initial four grids, then those organisms are all placed and evenly distributed into another pan with the same dimensions and gridding as the first pan. A grid is then randomly selected, and the organisms are picked from the selected grid. This process continues until the subsample target number of 200 ± 20 organisms is reached.

Each grid selected during the subsampling process is picked in its entirety. The total number of grids selected from each pan and the count of organisms picked from each grid is recorded. Once the subsampling is complete and the target number of organisms is achieved, all organisms are placed in a clean, 125mL container with 70% - 80% ethanol. The container is labelled both inside and outside with date, time, collector, and location. The container is then stored for later identification.

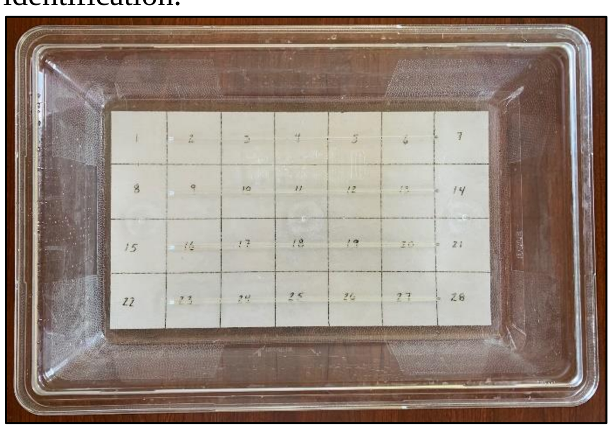


Photo 6. Example of gridded subsampling pan.

Photo 7. Subsampling pan with sample contents and one “cookie cutter” grid selected.

Photos 8-10. Contents of the subsampling grid are removed using spoons, turkey basters, etc.

Benthic Macroinvertebrate Identification

The HCCD Watershed Specialist served as the macroinvertebrate taxonomist for this study and is certified by the Society for Freshwater Science (SFS) for those tests that covered the identifications performed (Ephemeroptera, Plecoptera, & Trichoptera East and General Arthropods East). To begin identification, organisms are removed from the subsample vial and placed under a microscope for identification and enumeration. All macroinvertebrates are identified to the genus level, except for those taxonomic groups listed in Table 2. Once identification is complete, all organisms are returned to the labelled vial with 70% - 80% ethanol.

Table 2. Taxonomic groups that are identified to a higher taxonomic level than genus (Shull and Lookenbill 2018).

Taxonomic Group	Identification Level
Midges	Family
Snails	Family
Mussels & Clams	Family
Aquatic Earthworms & Tubificid Worms	Class (Oligochaeta)
Leeches	Class (Hirudinea)
Flatworms	Phylum (Turbellaria)
Proboscis Worms	Phylum (Nemertea)
Roundworms	Phylum (Nematoda)
Moss Animalcules	Phylum (Bryozoa)
Water Mites	Hydracarina (artificial grouping of several water mite superfamilies)

Index of Biological Integrity Metric Calculation

The index of biological integrity (IBI) is a method used to quantify stream health through benthic macroinvertebrates. By examining the diversity and abundance of the different benthic macroinvertebrates present in a stream community, we can calculate multiple metrics that exhibit a strong ability to discern between streams considered relatively pristine and heavily degraded (Shull and Pulket 2018). The following six metric calculations were included in the IBI analysis for each sampling site: Total Taxa Richness, Ephemeroptera + Trichoptera + Plecoptera (EPT) Richness (Pollution Tolerance Values 0-4 only), Becks Index (version 3), Shannon Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals (Pollution Tolerance Values 0-3 only). To compare biological conditions between each sample site, each metric is standardized to a value of 0-100. Higher scores are associated with unimpacted, "natural" environments, while lower scores are associated with anthropogenically degraded environments. The six standardized metrics are then averaged to produce a final total IBI score. A description of each metric and standardization process is given in detail by Shull and Pulket (2018).

Results and Discussion

Water Chemistry

In total, four water chemistry parameters were measured at each sample site, including temperature, dissolved oxygen (DO), pH, and specific conductance (SPC) (Table 3).

Table 3. Summary of 2020 and 2021 water chemistry measurements.

	WMR-01		WMR-02		WMR-03	
Water Chemistry Parameters	3/18/2020	4/22/2021	3/18/2020	4/22/2021	3/18/2020	4/22/2021
Temperature (C°)	7	7.3	7.3	6.6	10.8	9.1
Dissolved Oxygen (mg/L)	12.45	13.33	13.47	16.08	13.8	12.25
pH	8.57	8.63	9.05	8.85	8.68	8.18
Specific Conductivity (uS/cm)	332.6	317.8	352.2	311.2	299.4	281.7

In 2020, all three sites recorded temperatures above the 5.6 C° temperature standard for coldwater streams measured between March 1-31. However, in 2021, all three sites recorded temperatures below the 11.1 C° temperature standard for coldwater streams taken between April 16-30 for coldwater streams. In 2020 and 2021, pH levels measured along the upper limit of Chapter 93's criteria of 6.0 to 9.0.

Chapter 93 does not list criteria for in-situ dissolved oxygen measurements but instead requires a 7-day continuous average. The criteria for the continuous DO measurements in coldwater streams is as follows: 1) for flowing waters, 7-day average of 6.0 mg/L, 2) for natural reproduction trout waters, 7-day average of 9.0 mg/L with a minimum of 8.0 mg/L. All recorded DO levels in 2020 and 2021 exceeds these minimum standards.

In addition, Chapter 93 does not list specific water quality criteria for specific conductivity. Since specific conductivity is a measure of dissolved ions such as metals, salts, and other conductive materials, it can be greatly influenced by elevation and geology, and therefore difficult to set "normal" thresholds. Typically, headwater streams tend to have lower conductivity values that gradually increase as surface water flows downstream and begins accumulating more conductive materials from the surrounding landscape. In addition, streams receiving water that flows through limestone geology tend to have higher concentrations of dissolved calcium carbonate ($CaCO3$), and thus have naturally higher conductivity values than normal freestone streams. However, conductivity can also be greatly impacted by human activity, and streams receiving abandoned mine, urban stormwater, or agricultural runoff tend to have unnaturally high conductivity measurements due to increased levels of dissolved heavy metals, road salt, nitrates, phosphates, and more.

Given their position in the watershed, all three sites appear to have unusually high specific conductivity readings. These values are concerning and may be indicative that Warriors Mark Run is being actively impacted by some level of human disturbance. While no abandoned mines are in this area, the surrounding landscape was observed to be in active agriculture and some development. Therefore, is likely that the surrounding agricultural activities are having an impact on the water chemistry in Warriors Mark Run.

Physical Habitat

Twelve habitat parameters were assessed and combined to determine a total habitat score for each sample site (Table 4). In 2020, one site scored in the optimal range (240-181) and two sites scored in the suboptimal range (180-121). In 2021, all three sites scored in the suboptimal range (180-121). Only one site (WMR-02) from 2020 scored below PADEP's habitat impairment threshold of 140.

Table 4. Comparison of 2020 and 2021 physical habitat assessment results.

	WMR-01		WMR-02		WMR-03	
Habitat Parameter	3/18/2020	4/22/2021	3/18/2020	4/22/2021	3/18/2020	4/22/2021
Instream Cover	17	10	10	9	7	5
Epifaunal Substrate	15	15	11	18	11	18
Embeddedness	15	10	9	8	10	15
Velocity/Depth Regimes	18	13	13	14	16	9
Channel Alteration	17	14	16	13	16	15
Sediment Deposition	12	10	8	10	11	15
Riffle Frequency	18	17	13	18	18	18
Channel Flow Status	16	15	16	16	16	16
Condition of Banks	14	13	8	15	9	7
Bank Vegetative Protection	15	12	3	7	7	7
Grazing or Other Disruptive Pressure	18	17	8	11	12	13
Riparian Vegetative Zone	16	12	8	14	8	11
Total Habitat Score	**191**	**158**	**123**	**153**	**141**	**149**

Further analyses show that two sites received scores below the impairment threshold (≤ 24) for Embeddedness + Sediment Deposition in 2020 and 2021. In addition, two sites also received scores below the impairment threshold (≤ 24) for Condition of Banks + Bank Vegetative Protection in 2020 and 2021 (Table 5). The variation in habitat scores between 2020 and 2021 is contributed towards additional assessment trainings HCCD conducted with DEP between the two assessment periods.

Table 5. Comparison of 2020 and 2021 physical habitat impairment results.

	WMR-01		WMR-02		WMR-03	
Habitat Parameter	3/18/2020	4/22/2021	3/18/2020	4/22/2021	3/18/2020	4/22/2021
Embeddedness + Sediment Deposition	27	20	17	18	21	30
Condition of Banks + Bank Vegetative Protection	29	25	11	22	16	14

Benthic Macroinvertebrate Analysis

To develop an inventory of the benthic macroinvertebrates identified and recorded in the Warriors Mark Run watershed, the 2020 and 2021 taxonomic data was combined with PADEP's 2005 taxonomic data in Appendix III. In total, 42 distinct taxa were identified between 2005 and 2021. The presence or absence of certain taxa between 2005 and 2021 could be attributed to recent taxonomic changes published in Merritt et al. 2019. Benthic macroinvertebrate samples from 2020 have underwent quality assurance audits by PADEP (Appendix III), while the 2021 samples have yet to be submitted.

A summary of index of biological integrity (IBI) metrics for each study site is provided in Table 6. In Pennsylvania, PADEP utilizes IBI assessments to determine whether a stream is “attaining” (meets water quality standards) or “impaired” (fails to meet water quality standards). For HQ-CWF streams, the PADEP impairment threshold is an IBI score less than 63 for samples collected between November-May (Shull and Pulket 2018).

Overall, the two upstream sites (WMR-02 and WMR-03) scored below the PADEP impairment threshold in both 2020 and 2021. However, the downstream site (WMR-01) continues to show signs of improvement. In 2005, WMR-01 produced an IBI score equivalent to 35.7, well below the impairment threshold of 63. In 2020, 15 years later, the IBI increased to 58.5. In 2021, the IBI score continued to improve slightly as the 2021 score was equivalent to 63.1, just above the impairment threshold. This improvement is exciting to see as it provides evidence that the HCCD’s and other partners conservation activities in the watershed over the last decade is contributing to improved water quality.

Table 6. Comparison of 2005, 2020, and 2021 index of biological integrity metrics.

	WMR-01			**WMR-02**		**WMR-03**	
Metric Scores	4/29/2005	3/18/2020	4/22/2021	3/18/2020	4/22/2021	3/18/2020	4/22/2021
Total Taxa Richness	13	26	27	18	13	17	19
EPT Richness	3	11	12	4	1	6	6
Beck's Index	5	14	18	5	3	8	5
Hilsenhoff Biotic Index	5.04	4.44	4.37	5.22	5.45	4.13	4.13
Shannon Diversity	1.77	2.40	2.48	1.77	1.51	2.19	2.06
% Sensitive Individuals	19.2	21.1	25.8	7.8	1.4	18.7	14.3
Total IBI Score	**35.7**	**58.5**	**63.1**	**36.6**	**27.2**	**45.9**	**43.9**

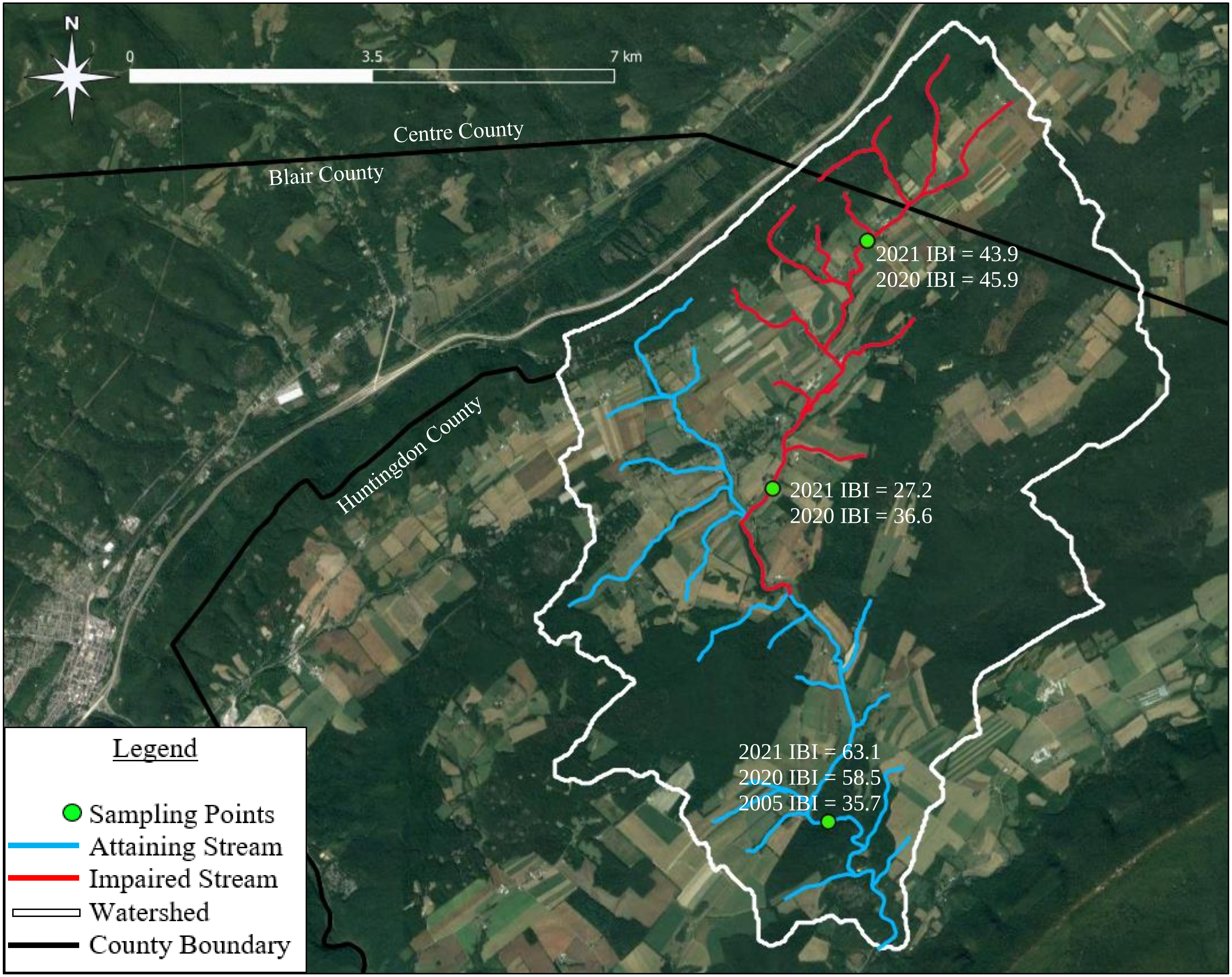


Figure 3. Map of sample sites with corresponding IBI metric scores.

Conclusions

In 2020 and 2021, three sites along Warriors Mark Run (WMR) in northwest Huntingdon County, Pennsylvania, were sampled by the HCCD for water chemistry, physical habitat, and benthic macroinvertebrates.

There was a noticeable lack in abundance of “pollution-intolerant” or “sensitive” taxa, such as mayflies, stoneflies, and caddisflies, and a noticeable abundance of “pollution-tolerant” taxa, such as midges and beetles, across all three study site macroinvertebrate samples in 2005, 2020, and 2021. IBI metrics appear to be remain below PADEP’s impairment threshold along the two upper sites (WMR-02 and WMR-03). However, the lower study site (WMR-01) continues to show signs of improvement in water quality with the most recent IBI scoring slightly above the impairment threshold. Future monitoring activities will be completed to continue to track any improvements in watr quality conditions.

The results of this study support the evidence that in order to de-list this stream as a 303(d) impaired waterbody there needs to be an emphasis on better conservation practices in this watershed. To achieve the goal of de-listing, the HCCD and Chesapeake Conservancy intend to work with local landowners and partner organizations to design, fund, and implement Best Management Practices (BMPs). BMPs include many different methods landowners can use to manage their land while reducing pollution and conserving natural resources. Specifically, the HCCD and Chesapeake Conservancy will aim to implement BMPs associated with improving water quality. Some popular examples of stream BMPs include cover cropping, installing fence to exclude livestock from a stream, constructing in-stream erosion control and fish habitat structures, and planting riparian forest buffers. Both the HCCD and the Conservancy have implemented such strategies in several watersheds throughout Huntingdon County which has improved water quality in those areas. Typically, these projects incorporate multiple BMPs to ensure the stream receives the best environmental improvements possible. It is expected that the implementation of such projects would likely bring the IBI scores closer to an attaining value of ≥63 and this partnership’s overarching goal of de-listing this stream as an impaired waterbody.

References

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Appendix I – Sample Site Photos

Warriors Mark Run: **Site WMR-01**

Warriors Mark Run: **Site WMR-02**

Appendix I cont.

Warriors Mark Run: **Site WMR-03**

Appendix II: Habitat evaluation form (Shull and Lookenbill 2018)

Physical Habitat Evaluation Form for Riffle/Run Prevalence

Waterbody Name: | GIS Key (YYYYMMDD-hhmm-User):

Location:

Investigators: | Completed By:

Parameter	Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	Greater than 50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat.	30-50% mix of boulder, cobble, or other stable habitat; adequate habitat.	10-30% mix of boulder, cobble, or other stable habitat; habitat availability less than desirable.	Less than 10% mix of boulder, cobble, or other stable habitat; lack of habitat is obvious.
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present.	Riffles or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking.
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Velocity/Depth Regimes	All four velocity/depth regimes present (slow-deep, slow shallow, fast-deep, fast shallow)	Only 3 of the 4 regimes present if fast-shallow is missing, score lower than if missing other regimes.)	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score lower than if missing other regimes).	Dominated by 1 velocity/depth regime (usually slow-deep).
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Alteration	No channelization or dredging present.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr.) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement over 80% of the stream reach channelized and disrupted.
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar information, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstruction, construction and bends, moderate depositions of pools prevalent.	Heavy deposits of fine material increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
_______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Appendix II cont.

Parameter	Optimal	Suboptimal	Marginal	Poor
7. Riffle Frequency	Occurrence of riffles relatively frequent;; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is >25.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
9. Condition of Banks	Banks stable; no evidence of erosion or bank failure.	Moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes, 60-100% of bank has erosional scars.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
10. Bank Vegetative Protection	More than 90% of the stream bank surfaces covered by vegetation.	70-90% of the stream bank surfaces covered by vegetation.	50-70% of the stream bank surfaces covered by vegetation.	Less than 50% of the stream bank surfaces covered by vegetation.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
11. Grazing or Other Disruptive Pressure	Vegetative disruption through grazing or mowing is minimal or not evident; almost all plants allowed to grow naturally.	Disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	Disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Disruption of stream bank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
12. Riparian Vegetative Zone	Width or riparian zone >18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

TOTAL ______

Appendix III: Benthic Macroinvertebrate Inventory

Warriors Mark Run - Benthic Macroinvertebrate Inventory										
Taxa				**WMR-01**			**WMR-02**		**WMR-03**	
Order	**Family**	**Genus**	**PTV**	4/29/2005	3/18/2020	4/22/2021	3/18/2020	4/22/2021	3/18/2020	4/22/2021
Ephemeroptera (Mayflies)	Baetidae	Baetis	6	97	25	37	4	3	22	3
	Ephemerellidae	Drunella	1	2	0	1	0	0	0	0
		Ephemerella	1	14	17	40	1	2	32	14
		Serratella	2	0	3	3	0	0	0	0
	Ephemeridae	Ephemera	2	0	1	1	0	0	0	0
	Heptageniidae	Stenonema	3	0	2	5	0	0	1	0
		Stenacron	4	0	1	0	0	0	0	0
	Isonychiidae	Isonychia	3	0	1	0	0	0	0	0
	Leptoplebiidae	Paraleptophlebia	1	0	0	1	0	0	0	2
Plecoptera (Stoneflies)	Leuctridae	Leuctra	0	0	0	0	0	0	1	0
	Nemouridae	Amphinemura	3	0	0	2	0	0	0	1
	Perlidae	Acroneuria	0	0	1	1	0	0	0	0
	Perlodidae	Isoperla	2	0	2	1	0	0	1	5
Tricoptera (Caddisflies)	Glossosomatidae	Agapetus	0	0	0	1	0	0	0	0
	Goeridae	Goera	0	0	1	0	0	0	0	0
	Helicopsychidae	Helicopsyche	3	0	0	1	2	0	0	0
	Hydropsychidae	Hydropsyche	5	13	4	18	5	9	28	15
		Cheumatopsyche	6	1	8	10	7	9	12	8
	Philopotamidae	Chimarra	4	0	3	0	0	0	13	4
	Rhyacophilidae	Rhyacophila	1	0	0	1	2	0	0	0
	Thremmatidae	Neophylax	3	7	3	0	4	0	1	8
Diptera (Flies)	Athericidae	Atherix	2	2	3	0	0	0	1	0
	Ceratopogonidae	Bezzia	6	0	0	1	0	0	1	1
	Chironomidae		6	20	43	32	96	105	17	21
	Empididae	Chelifera	6	0	0	1	0	1	0	0
		Hemerodromia	6	9	0	0	1	0	0	1
	Limoniidae	Antocha	3	12	4	1	1	0	0	1
	Simuliidae	Prosimulium	2	0	2	0	6	1	2	0
		Simulium	6	1	4	8	5	2	0	1
	Tipulidae	Tipula	4	0	0	1	0	0	0	0
Coleoptera (Beetles)	Elmidae	Dubiraphia	6	0	0	0	1	2	0	0
		Optioservus	4	13	62	26	29	16	30	68
		Promoresia	2	0	6	2	0	0	0	0
		Stenelmis	5	2	14	15	36	52	1	4
	Psephenidae	Psephenus	4	0	1	0	2	4	0	0
Amphipoda (Scuds)	Gammaridae	Gammarus	4	0	0	2	0	0	45	58
Decapoda (Crayfish)	Cambaridae	Cambarus	6	0	0	0	0	0	0	1
Bivalvia (Clams/Mussels)	Corbiculidae		4	0	2	0	0	0	0	0
Gastropoda (Snails)	Viviparidae		7	0	3	2	0	0	0	0
Annelida (Worms)	Hirudinea		8	0	0	0	1	1	0	0
	Oligochaeta		10	0	2	3	0	0	0	1
	Turbellaria		9	0	0	0	1	0	1	0

*PTV = Pollution Tolerance Value. This value is assigned to individual organisms based on their tolerance to pollution levels. Scores range from 0-10 with lower scores associated with “pollution-intolerant” taxa, while higher scores are associated with “pollution-tolerant” taxa.

Appendix IV: PADEP Macroinvertebrate Quality Assurance Documentation

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

MEMO

TO Logan Stenger
Watershed Specialist
Huntingdon County Conservation District

FROM Mark Brickner
Water Program Specialist
Water Quality Division - Monitoring

DATE August 20, 2021

RE Taxonomic Identification Quality Assurance

MESSAGE:

INTRODUCTION

A request for a benthic macroinvertebrate identification quality assurance audit for samples identified by Logan Stenger was received. DEP staff received the samples from Huntingdon County Conservation District and reidentified 4 of the samples received.

METHODS

Benthic Macroinvertebrate Identification Quality Assurance

DEP monitoring protocols require at least 10% of all samples identify by a biologist be quality assured by a certified taxonomist. (Shull 2017). To accomplish the 10% quality assurance of all samples identified, taxonomists will submit 10% of the samples they have identified for a calendar year. This is typically accomplished by flagging every tenth sample identified to be submitted for quality assurance. This subset of samples should represent an even distribution of all samples collected and/or identified for a calendar year. Samples from the previous calendar year should be delivered to the DEP regional or central office certified taxonomist responsible for performing quality assurance by the end of January each year. Collectors submitting samples for quality assurance or DEP certified taxonomists performing quality assurance evaluations may request additional samples to be evaluated above the standard 10% of samples collected in a given calendar year, additional samples from previous years, unique or special interest/project samples (e.g. permitting).

Samples submitted for taxonomic verification will undergo calculations to determine percent disagreements in taxonomy and enumeration between the biologist and quality assurer results. Errors documented by the taxonomic verification QA procedure were developed similarly to that described in Stribling et al. 2008. Of interest is Percent Taxonomic Disagreement (PTD) and Percent Enumeration Disagreement (PED). Percent taxonomic disagreement takes into account differences in specimen identifications between the biologist and the quality assurer. Individual taxon agreements are determined by comparing lists, and a percent difference is calculated according to Equation 1; calculated PTD error should be no greater than 10%. Percent enumeration disagreement is a calculation that determines the counting error. PED is calculated according to Equation 2 and should be no greater than 5%. If any calculated error, (PTD or PED) is greater than the 10% or 5% criteria, corrective action should be taken. Corrective action could include an opportunity for the biologist to re-look at the samples, a conversation between the biologist and quality assurer, or the recommendation to seek further training in the identification of problem taxa.

Equation 1 – Percent Taxonomic Disagreement (PTD), expressed as a percentage

$$\text{PTD} = \left(1 - \left[\frac{a}{\text{Nmax}}\right]\right) \text{x } 100$$

Where: a = total number of agreements (summed across all individuals and taxa); Nmax = total number of individuals identified (the greater of the two totals)

Equation 2 – Percent Enumeration Disagreement (PED), expressed as a percentage

$$\text{PED} = \left(\left[\frac{(\text{ni}-\text{nq})}{(\text{ni}+\text{nq})}\right]\right) \text{x } 100$$

Where: ni = number of individuals counted by the biologist; nq = number of individuals counted by the quality assurer

All taxonomic data was recorded on bench sheets and then entered into an access database that calculates the equations. Access data entries were double checked against bench sheets to ensure accurate database entries.

RESULTS

Of the five samples reidentified, all four passed and did not exceed the 10% for Percent Taxonomic Difference established as the passing threshold for quality assurance checks (Table 1). None of the five samples exceeded the 5% for Percent Enumeration Difference established as the passing threshold for quality assurance audits (Table 1).

Table 1. Quality assurance results

GISKEY	SumOfT1_Count	SumOfT2_Count	SumOfAgreements	Total Max	PTD	PED
20200406-1145-huntingdonccd	187	187	186	187	0.53	0
20200406-0845-huntingdonccd	193	191	191	193	1.03	0.52
20200422-1400-huntingdonccd	183	183	183	183	0	0
20200318-1045-huntingdonccd	218	218	218	218	0	0
20200310-1120-huntingdonccd	206	205	205	206	0.48	0.24

RECOMMENDATIONS

Based on the results of this quality assurance evaluation DEP offers the following recommendations:

1. Additional macroinvertebrate taxonomic training for is always encouraged.
2. Subsequent macroinvertebrate identification quality assurance should occur at a rate of at least 10% of all samples collected and identified.

LITERATUE CITED

Shull, D. R. 2017. Macroinvertebrate laboratory subsampling and identification protocol. Chapter 3, pages 31-41. *In* Shull, D. R., and M. J. Lookenbill (editors). Water quality monitoring protocols for streams and rivers. Pennsylvania Department of Environmental Protection. Harrisburg, Pennsylvania.