2018

Water Quality Study

Monroe County, Pennsylvania

ABSTRACT

The Monroe County Planning Commission along with the Monroe County Conservation District studied 35 stream sites throughout Monroe County in the spring of 2018. The sites were studied based on four parameters including field surface water measurements, laboratory chemistry analysis, macro-invertebrate identification, and habitat assessment.

Monroe County Planning Commission
and Monroe County Conservation District
1 Quaker Plaza, Room #106
Stroudsburg, Pa. 18360-2169
(570) 517-3100
Fax (570) 517-3858
www.monroecountypa.gov

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PREPARED BY MONROE COUNTY

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PROJECT PARTICIPANTS

Lead Agencies:

Monroe County Planning Commission (MCPC)
Program Director: Christine Meinhart-Fritz
Program Coordinator: Evan Makuvek
Vector Control Program Coordinator: Lee Schuler

Monroe County Conservation District (MCCD)
District Manager: Adam Schellhammer
Resource Conservationist: Steven Baade
Watershed Specialist: Andrea Polkowski
Head Resource Conservationist: Lori Kerrigan

Cooperating Agencies:

Pennsylvania Department of Environmental Protection (PA DEP)
United States Environmental Protection Agency (EPA)
Brodhead Watershed Association (BWA)

Entomology Consultants:

Donald Baylor & Ken Ersbak
Aquatic Resource Consulting (ARC)
Route 715, Saylorsburg, PA 18353

Professional Laboratory Consultant:

Microbac Laboratories
1620 North Main Avenue
Scranton, PA 18508

Materials & Methods

1. Field Chemistry Sampling *(Appendix A)*

The following parameters were measured and stored using A hand-held YSI Professional Digital Sampling System (ProDSS) Multiparameter water quality meter
and recorded on standard data forms:

-pH
-Temperature
-D.O. Concentration
-D.O. %
-Conductivity

2. Lab Chemistry Sampling *(Appendix A)*

The following table shows water chemistry parameters that were tested by Microbac Laboratories for analysis of the stream samples.

Test	Units	Method	PQL
Total Organic Carbon (TOC)	mg/L	SM5310 C-2000	0.500
Aluminum, Total	mg/L	E200.7	0.200
Calcium, Total	mg/L	E200.7	0.500
Iron, Total	mg/L	E200.7	0.100
Magnesium, Total	mg/L	E200.7	0.500
Hardness	mg/L	SM2340-B-1997	5.00
Chloride	mg/L	EPA 300.0, Rv 2.1	0.250
pH	pH Units	SM4500 H+ B-2000	0.100
Nitrogen, Total as N (Calc)	mg/L	Calculation	0.500
Ammonia as N	mg/L	EPA 350.1, Rv 2	0.0500
Total Kjeldahl Nitrogen (TKN)	mg/L	EPA 351.2, Rv 2	0.500
Nitrate-Nitrate as N	mg/L	EPA 353.2, Rv 2.0	0.0200
Alkalinity to pH 4.5	mg $CaCO_3$/L	SM2320 B-1997	20.0
Total Dissolved Solids (TDS)	mg/L	SM2540 C-1997	20.0
Phosphorus - Total as P	mg/L	SM4500 P E-1999	0.0500
Biochemical Oxygen Demand	mg/L	SM5210 B-2001	3.00

Materials & Methods

3. Macroinvertibrate Sampling *(Appendix B)*

At each site, macroinvertebrates were collected using A 12" 500 micron D-frame net that was held on the stream bottom. The collector thoroughly disturbed the stream bottom to dislodge any macroinvertebrates from the substrate. This process was repeated 6 times for Riffle/Run streams and 10 times for Multihabitat streams.

Riffle/Run 6 Samples (at least one of each)

-Fast & Shallow
-Fast & Deep
-Slow & Shallow
-Slow & Deep

Multihabitat 10 Samples (based on abundance)

-Cobble/Gravel
-Snag
-CPOM (Course Particulate Organic Matter)
-Submerged Aquatic Vegetation
-Sand/Fine Sediment

4. Habitat Analysis *(Appendix C)*

The following tables show habitat assessment parameters for Riffle/Run and Low Gradient Streams. Each parameter is rated on a score from 1 to 20; 20 being the highest, and 1 being the lowest

Riffle Run Streams

1	Instream Fish Cover
2	Epifaunal Substrate
3	Embeddedness
4	Velocity/Depth Regimes
5	Channel Alteration
6	Sediment Deposition
7	Frequency of Riffles
8	Channel Flow Statues
9	Condition of Banks
10	Bank Vegetative Protection
11	Grazing or Other Disruptive Pressures
12	Riparian Vegetative Zone Width

Multihabitat/Low Gradient Streams

1	Epifaunal Substrate/ Available Cover
2	Pool Substrate Characterization
3	Pool Variability
4	Sediment Deposition
5	Channel Flow Status
6	Channel Alteration
7	Bank Stability (score each bank)
8	Vegetative Protection (score each bank)
9	Riparian Vegetative Zone Width (score each bank)

Appendix A

SURFACE WATER PARAMETERS

The chemical characterization of waterways is important for the general description of water quality conditions. The following parameters were measured in the field, water samples were also analyzed by Microbac Laboratories.

Field Measurements

pH

The pH of a solution refers to its hydrogen ion concentration. Measurement of pH is one of the most important and frequently used tests in water chemistry. The pH value of most natural waters falls within the range of 4 to 9. The pH scale ranges from 0 (acid) to 14 (base). Most waters are slightly basic because of the presence of carbonates and bicarbonates (i.e., salts within the geology). Most fish can tolerate pH values from 5.0 to 9.0. However, optimum fishing habitats fall within the range of 6.5 to 8.2.

Temperature

Temperature is essential in determining if acceptable standards exist for individual stream classification. Elevated temperatures from heated water discharges may have a significant ecological effect. Temperature has an inverse relationship with the solubility of dissolved oxygen.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a measure of oxygen that is dissolved in water. Different levels of DO are necessary to support various types of aquatic life. These levels in natural and waste waters are dependent on the physical, chemical, and biochemical activities prevailing in the water body. The minimum D.O. levels are: HQ-CWF 7.0 mg/L CWF 5.0. mg/L TSF (February 15th – July 31st) 6.0 mg/L; Remainder of year 5.0 mg/L.

Specific Conductance

Conductivity is a numerical expression of the ability of water to carry an electrical current. It is an indication of the dissolved inorganic solids in the water. The higher the specific conductance, the more impurities are in the water. Freshly distilled water has a conductivity of 0.5 to 2.0 microsiemens(µS)/cm. The conductivity of the drinking water in the U.S. generally ranges from 50 to 500 µS/cm. It is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron.

Water Chemistry Laboratory Analysis

Total Organic Carbon (TOC)

Total organic carbon (TOC) is a measurement of the amount of carbon containing compounds in a sample that can be quantified. This measurement is significant because the amount identified in a stream can be an indicator of the organic character of a stream. The larger the carbon or organic content, the more oxygen is consumed, thus a high content equates to an increase of microorganisms that could contribute to the depletion of oxygen levels. Samples are preserved in the field by the addition of 1 ml of sulfuric acid (H2SO4). There is no numeric standard for TOC.

Aluminum

Aluminum is found naturally in the environment and is found in water in a dissolved form. Its concentration is influenced by multiple factors including pH, surface water flow over soil and bedrock, and groundwater flow through soil horizons and underlying geologic material. The Aluminum concentrations of water in healthy streams and rivers usually range from 0.001 to 0.05 mg/L.

Calcium

Calcium occurs most commonly in sedimentary rocks in the minerals calcite, dolomite and gypsum. Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer because of its buffering qualities. Rivers generally contain 1-2 mg/L calcium. In limestone areas, rivers may contain calcium concentrations as high as 100 mg/L. There is no numeric standard for calcium.

Iron

Surface water and groundwater naturally contain iron along with other metals. Rainwater infiltrates soil horizons and iron bearing rocks, and dissolves the iron into the water solution. There are two kinds of iron that occur in water. The first is called ferrous, which is soluble in the water and results in clear, colorless water. The other state is called ferric, which results in a reddish-brown color because the iron is not completely dissolved in the water. Iron can also be combined with naturally-occurring acids (tannins) which will stain the water a tea color.

Magnesium

This element is essential to chlorophyll and red blood cells. Magnesium commonly occurs in the minerals of magnesite ($MgCO_3$) and dolomite. It contributes to water hardness and is used in alloys, fertilizers, pharmaceuticals, and foods.

TOTAL HARDNESS

Hardness is defined as the total amount of calcium and magnesium salts that are present in the water. Hard water aids buffering capacity. Water can be defined by its total hardness as follows:

Soft Water	0 - 60 mg/L
Moderately Hard Water	60 - 120 mg/L
Hard Water	120 - 180 mg/L
Very Hard Water	180 mg/L and up

CHLORIDES

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Common chlorides are sodium chloride, calcium chloride and magnesium chloride. Most productive fish habitats have a chloride concentration of less than 170 mg/L. The recommended maximum chloride levels are 250 mg/L for water supply.

NITROGEN

Ammonia, nitrite, and nitrate are all forms of Nitrogen. Nitrogen is considered a limiting nutrient for primary production in aquatic ecosystems along with Phosphorus, and excess nitrogen can result in eutrophication. Nitrogen is most commonly found as nitrate, nitrite, and ammonia in aquatic ecosystems.

AMMONIA (NH3)

Ammonia is naturally present in surface water, ground water, and in wastewater. Pure ammonia is strong smelling and colorless. In nature, ammonia is formed by the action of bacteria on proteins and urea. Ammonia concentrations of 0.06 mg/L can cause gill damage in fish; 0.1 mg/L may indicate domestic or agricultural wastes and levels 0.2 mg/L and above are lethal to trout.

NITRITE (NO2)

Nitrite is the intermediate stage between nitrate and ammonia. It is relatively short-lived because it is quickly converted to nitrates by bacteria. Nitrite concentrations in drinking water seldom exceed 0.1 mg/L. There is no numeric standard for nitrite.

NITRATE (NO3)

Nitrate is found only in small amounts in domestic wastewater and is a major ingredient in farm fertilizer. During precipitation events, varying amounts of this chemical wash into nearby waterways. Nitrates stimulate the growth of phytoplankton and algae. When these photosynthetic organisms die, bacteria consume the dead organic material. This process also requires oxygen which depletes dissolved oxygen levels in the water and the fish may not be able to respire. Because Nitrate can be the limiting nutrient for plant growth in many ecosystems, the discharge from a septic tank into the aquatic environment can trigger prolific plant growth including algal blooms. There is no numeric standard for nitrate.

TOTAL KJELDAHL NITROGEN (TKN)

T.K.N. is the sum of organic nitrogen and ammonia nitrogen. Samples are preserved in the field by the addition of 1 ml of Sulfuric Acid (H_2SO_4). There is no numeric standard for TKN.

TOTAL ALKALINITY

Alkalinity measures the water's ability to buffer acid or acid neutralizing capacity. It indicates the water's ability to protect fish and other aquatic life against sudden changes in pH. The best fishing waters are those with alkalinity of 100 - 120 mg/L. The minimum level of total alkalinity for aquatic life buffering capacity is 20 mg/L, except where natural conditions are less. Stream alkalinity can be influenced by geologic material, soil horizons, salts, plant activities and certain industrial wastewater discharges. Water flowing through Carbonate rich limestone generally has high alkalinity – hence good buffering capacity. Conversely, areas rich in granites and some conglomerates and sandstones may have low alkalinity and therefore poor buffering capacity.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (T.D.S.), also termed total filterable residue, refers to the portion of residue that passes through a filter of a particular size. The DEP, as well as the EPA, have established secondary maximum contaminant levels of 500 mg/L of TDS for the Commonwealth's drinking water and waterways. The maximum recommended value for T.D.S. is 750 mg/L.

TOTAL PHOSPHORUS

Total Phosphorus is a measure of all the forms of phosphorus (dissolved or particulate) that are found in a sample. It occurs in natural waters and wastewaters almost solely in the form of phosphates. Phosphates enter waterways from animal wastes, phosphate rich rocks, fertilizers, and from the detritus of aquatic organisms. Phosphorus is essential to the growth of organisms and can be the limiting nutrient to plant growth. If high concentrations are present in streams the algae can grow more rapidly. This increase in algae is eventually consumed by bacteria which require oxygen. This process reduces dissolved oxygen in the water which can impact fish populations. Phosphate levels below 0.03 mg/L are generally considered to be unpolluted. The recommended maximum level is 0.01 mg/L for rivers and streams.

BIOLOGICAL OXYGEN DEMAND (BOD)

BOD is a measure of the dissolved oxygen required for the complete breakdown of organic matter, by aerobic bacteria over a five-day period. It is a key criterion used where organic loading must be restricted to maintain desired levels of dissolved oxygen in water. Sources of BOD, in addition to direct loading from STPs, include decaying algae, macrophytes and other biota. In streams that are polluted with sewage or high levels of other nutrients, the oxygen use or demand by microorganisms will be high, leaving little oxygen for other aquatic organisms. Most pristine rivers will have a 5-day carbonaceous BOD below 1 mg/L.

Appendix B

Benthic Macroinvertebrates

What is a Macroinvertebrate?

A macroinvertebrate is an organism that is large enough to see with the naked eye (macro) and lacks a vertebral column (invertebrate). The organisms that are collected for this study are called benthic macroinvertebrates. Benthic refers to the bottom layer of an aquatic ecosystem including underneath stream sediment. These organisms include mayflies, caddisflies, stoneflies, snails, clams, crayfish, freshwater shrimp, beetle larvae, midges, leeches, dragonflies, and more.

Why collect Macroinvertebrates?

- They are relatively easy to collect.
- They play a key role in the ecosystem's food web.
- They are used as bio indicators for environmental stress and can show varying responses to water chemistry and physical habitat.
- Due to their relative immobility (unlike fish) they cannot move upstream or downstream to avoid poor water conditions.
- They are extremely diverse. Different macroinvertebrates will live in different water bodies due to water conditions, available food, and absence or abundance of sediment, nutrients, and detritus (dead organic matter).

Macroinvertebrate Analysis

The protocols used in the development for the riffle/run Index of Biotic Integrity (IBI) were conducted from small first through third order riffle/run type streams, which totaled a drainage area of less than 50 square miles. The second protocol type is the multi-habitat assessment for low-gradient streams, which involved sampling a variety of habitat types. The difference between the two assessment protocols involved sampling different micro-habitats for macroinvertebrate collections and different habitat evaluation categories. These bio assessments were employed to cumulatively evaluate the ecological conditions of streams that are present within Monroe County.

Metric Calculations

The following are the riffle/run metrics used for the benthic macroinvertebrate analysis. Metrics are the various counts, indexes, and ratios computed from the results of the subsamples.

Different metrics convey different types of information about the macroinvertebrate community. For example, taxa richness is an index of diversity and the Hilsenhoff Biotic Index measures an organism's pollution tolerance. By using a set of metrics that measures multiple aspects of the macroinvertebrate community, a complete picture of a community can be attained. This enables the reader to understand the importance of measuring the relative stability of the aquatic community.

Source of Photos: http://kentschools.net thebeachschool.eq.edu.au www.fly-fishing-discounters.com

The following is a list of metric calculations utilized during the 2018 study:

Freestone Riffle/Run (6 D Frame):

Modified Beck's Index, version 3 (MBI)
MBI metric is projected to decline in assessment score when anthropogenic stress to a stream ecosystem increases, therefore representing the loss of pollution-sensitive taxa. It should be noted that this index metric for this project, while similar in name and concept, differs slightly from the Beck's Index used in DEP's multihabitat protocol for assessing biological condition of low gradient pool-glide type streams.

EPT Taxa Richness
EPT taxa richness metric is a count of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) in a sub-sample that represents community structure. These orders are commonly referred to as mayflies, stoneflies, and caddisflies, respectively. 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.

Total Taxa Richness
Total taxa richness is a community structure metric, which is a count of taxa in the sub sample. Generally, this metric is expected to decrease with increasing anthropogenic stress to the ecosystem, reflecting loss of taxa and increasing dominance of a few pollution tolerant taxa.

Shannon Diversity Index (SDI)
SDI is a taxonomic composition metric that measures taxonomic richness and evenness of individuals across taxa of a sub-sample. This metric is expected to decrease in values with increasing anthropogenic stress to a stream ecosystem.

Hilsenhoff Biotic Index (HBI)
HBI is a taxonomic composition metric and is calculated as an average pollution tolerance value weighted by the number of individuals of each taxa in the sub-sample. The Hilsenhoff Biotic Index generally increases with increasing ecosystem stress.

Percent Sensitive Individuals
Percent Sensitive Individuals is a taxonomic composition metric which is the percentage of individuals with pollution tolerance values of three or less in a sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

Index Calculation-Riffle/Run:

Through the combination of the various metrics noted , standardization is needed. Table 1 depicts the standardization table with the associated standardized and adjusted metric scores with the total producing the IBI score. This index is a way to integrate all of the data that is collected. The sum of these specific metric equations constructs an IBI, which then can be related to reflect the ecology and impacts to the aquatic community being studied. There are six metrics involved, the Hilsenhoff Biotic Index (HBI) is the only one predicted to increase in value if the community is stressed. The other five IBI metrics are predicted to decrease in value if the community is exposed to increased stress. The index calculation and standardization are included in Table 1.

Table 1. Metric Standardization Equations and Index calculations for sub-sampled sites.

Metric	**Standardized Equation**	**Observed Metric Value**	**Standardized Metric Score**	**Adjusted Standardized Metric Score** Maximum = 1.000
Modified Beck's Index	Observed value / 33			
EPT Taxa Richness	Observed value / 19			
Total Taxa Richness	Observed value / 38			
Shannon Diversity Index	Observed value / 2.86			
Hilsenhoff Biotic Index	(10 - Observed value) / (10 – 1.89)			
Percent Intolerant Individuals	Observed value / 84.5			
Average of adjusted standardized core metric scores * 100 = **IBI Score**				

Aquatic Life Use Attainment Benchmarks

Figure 1 depicts the Aquatic Life Use (ALU) IBI scoring benchmarks utilized by DEP for assessment purposes. DEP implements a multi-tiered benchmark decision process for small wadable freestone riffle/run streams in Pennsylvania that incorporates sampling season as a factor for determining ALU attainment and impairment; this process is outlined in the diagram below (PADEP). Title 25, Chapter 93 of the Pennsylvania Code provides further information on these uses.

Figure 1. Aquatic Life Use (ALU) IBI scoring benchmarks for Instream Comprehensive Evaluation (ICE) assessment purposes.

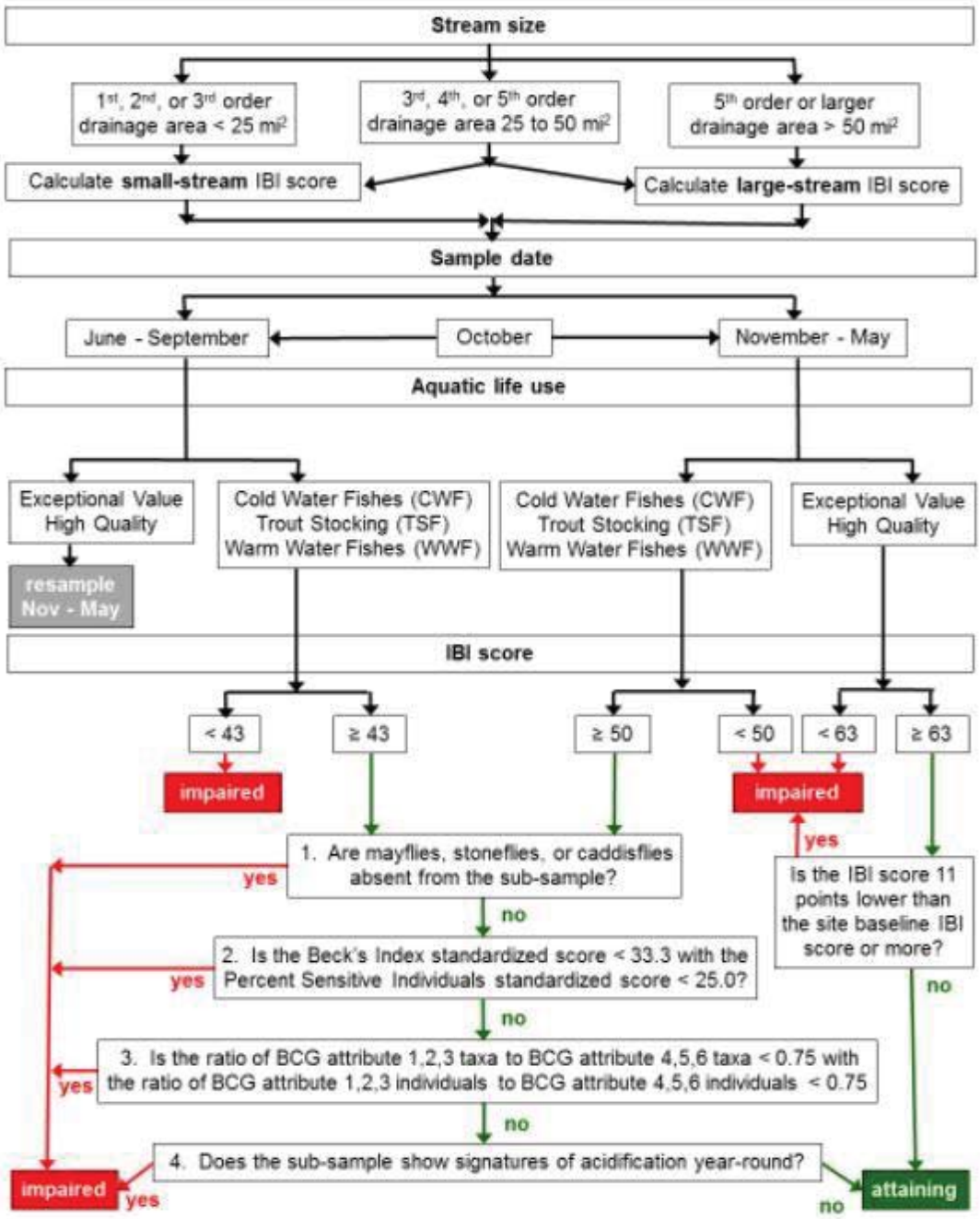


Figure 1 depicts the adjusted and standardized Aquatic Life Use (ALU) IBI scoring benchmarks for Instream Comprehensive Evaluation (ICE) assessment purposes. For samples collected from smaller streams between October and May, an IBI score > 63 results in ALU attainment and an IBI score < 50 results in ALU impairment. An IBI score between 50 and 63 requires further evaluation to determine ALU impairment. Three guidelines may be used:

(**1**)If the Beck's Index score is < 20 and the % Sensitive Individuals in the sub-sample is < 20%, the ALU should be impaired without compelling reason otherwise;

(**2**) If the sample is dominated by tolerant taxa or individuals, the ALU should be impaired without compelling reason otherwise; or

(**3**) If mayflies, stoneflies or caddisflies are absent from the sub-sample the ALU should be impaired. For samples collected between June and September from smaller streams, an IBI score > 50 results in ALU attainment and an IBI score < 40 results in ALU impairment; an IBI score between 40 and 50 requires further evaluation to determine ALU impairment, guided by the same three guidelines outlined above for October to May samples scoring between 50-63.

Multihabitat - Low Gradient (10 D Frame):

EPT Taxa Richness - Refer to riffle/run definition.
Total Taxa Richness - Refer to riffle/run definition.

Modified Beck's Index (version 4) - This is a pollution weighted taxa richness measure that is based on the Hilsenhoff Biotic Index Score. It is a modified Beck's Index giving organisms with a Hilsenhoff score of 0 or 1 two points and Hilsenhoff scores of 2, 3, or 4 are given 1 point. This metric differs slightly from the Beck's Index used in DEP's riffle/run protocol for assessing the biological condition of freestone type streams.

Shannon Diversity Index - Refer to riffle/run definition.
#Caddisfly Taxa - Total number of Caddisflies (Trichoptera) in the sub-sample
#Mayfly Taxa - Total number of Mayflies (Ephemeroptera) in the sub-sample

Index Calculation, multihabitat:

Through the combination of the various metrics noted above, normalization is needed. This index is a way to integrate data that is collected from the described data. Table 2 depicts the standardization table with the associated normalized and adjusted metric scores with the total generating an IBI score. The sum of these specific metric equations builds an IBI, which then can be related to reflect the ecology & impacts to the aquatic community being studied. Of the six metrics utilized, all are predicted to decrease in value if the community is stressed. The normalized scores above 100 are adjusted to a score of 100

Table 2. Normalization of Metric and Total Biological Score Calculation.

Metric	Standardized Equation	Observed Value	Normalized Metric Score	Adjusted Metric Score Maximum = 100
EPT	(Observed value / 17) x 100			
Taxa Richness	(Observed value / 31) x 100			
Beck4	(Observed value / 22) x 100			
Shannon Diversity	(Observed value / 2.43) x 100			
% Caddisfly Taxa	(Observed value / 11) x 100			
% Mayfly Taxa	(Observed value / 6) x 100			
Total Biological Score				

Aquatic Life Use Attainment Benchmarks

The following depicts the aquatic life use (ALU) IBI scoring benchmarks utilized by DEP for assessment purposes. This multimetric approach simplifies management decisions, being presented as a single index score (PADEP 2007). If the total benchmark score of 55 is not reached, then the stream reach is not attaining the threshold for aquatic life. Title 25, Chapter 93 of the Pennsylvania Code provides further information on these uses.

The following summaries are presented in the sequence they were sampled. They depict the macroinvertebrate community per site, specifically genus level taxonomy, water pollution tolerances values (0 intolerant to 10 tolerant), trophic codes and the statistics that comprise the total standardized biological score. The trophic code is a general classification system, which is based on what type of feeding mechanism the macroinvertebrate utilized or how the food is acquired. These categories are presented to facilitate the descriptions on the following pages:

SC - **Scrapers**: graze or scrape materials from mineral and organic substrates

SH - Shredders: chew on plant and some animal material, breaking it down into smaller particles feeding directly on living vascular hydrophytes, or gouge decomposing wood submerged in streams

CG - Collector/Gatherers: feed primarily on fine pieces of decomposing particulate organic matter (< 1 mm diameter) deposited in streams;

FC - Filterer/Collector: remove particulate matter from suspension

PR - Predators: Organisms that feed on animal tissue by either engulfing or piercing and sucking body contents of prey (Merritt & Cummins 1984).

Monroe County executed two progressive stream evaluation surveys, the riffle-run and the multihabitat protocols, which were conducted within a 100 meter stream reach. These biological screening protocols were modified from the United States Environmental Protection Agency (EPA) rapid bioassessment protocols (RBPs), for assessing stream macroinvertebrate communities (PADEP 2009). These biological screening protocols are specifically designed per stream type, to provide intensive field surveys and water quality assessment approaches.
The riffle-run Index of Biological Integrity (IBI) applies to benthic macroinvertebrate samples collected using a handheld 500-micron mesh D-frame net, which employed the semi-quantitative (PADEP-RBP) method, applied for each Instream Comprehensive Evaluation (ICE). Staff conducted six swipes from shallow, fast and slow riffle areas within a 100-meter stream reach. Each swipe disturbed approximately one square meter, immediately upstream of the net for approximately one minute, to an approximate depth of 10 cm, as substrate permits (PADEP 2009). The second sampling protocol was the multihabitat approach for low gradient streams, which required 10 jabs utilizing a 500-micron mesh D-frame net distributed between five possible habitat types: Cobble/Gravel Substrate; Snag; Coarse Particulate Organic Matter (CPOM); Submerged Aquatic Vegetation (SAV); and Sand/Fine Sediment) (PADEP 2007).

For the riffle-run dominated streams, each sample is composited into one container preserved with 95% ethanol in the field and transported to the contracted entomologist for enumeration and identification and placed into a pan marked with 28 four square inch grids. Debris from four grids is randomly selected and extracted using a four-square inch circular "cookie cutter," then placed into another identical empty pan. From this second pan, organisms are randomly selected from the grids until a 200-organism sub-sample (+/- 40 organisms) is obtained. Organisms in the sub-sample are identified according to taxonomic groupings and enumerated. Midges are identified to the family level of Chironomidae. Roundworms and proboscis worms are identified to the phylum level. Flatworms and segmented worms, aquatic earthworms, and tubificids are identified to class. Water mites are identified as Hydracarina, and all other macroinvertebrates are identified to genus level (PADEP 2009).
For low gradient dominated streams, each sample is composited into one container preserved with 95% ethanol in the field and transported to the contracted entomologist for enumeration and identification and placed into a pan marked with 28 2” x 2” grids. Debris from four grids is randomly selected and extracted until a 200-organism sub-sample (+/- 20 %) is obtained. Organisms in the sub-sample are identified according to taxonomic groupings. Midges are identified to the family level of Chironomidae. Roundworms and proboscis worms are identified to the phylum level. Flatworms are identified to Phylum Turbellaria. Segmented worms, aquatic earthworms and tubificids are identified to Class Oligochaeta. Water mites are identified as Hydracarina, weevils to family, sand flies to family Ceratopogonidae, Decapoda, Gastropoda, and Pelecypoda to family. All other macroinvertebrates are identified to genus level (PADEP

2007). The specifics of the macroinvertebrate analyses are discussed in Appendix B of this report.

Precision Quantification

To quantify precision methods, two of the biological samples were replicated and collected by the same investigator to minimize variability, and complies with the PADEP's quality assurance manual to verify identification work performed on macroinvertebrates. The Field data sheets are available for review at the MCPC office.

Quality Assurance

Accuracy was determined through the use of routine laboratory protocols that required random spiking of samples as per *consistency with the Quality Assurance Manual for* PADEP. Data quality requirements were maintained in the field throughout the collections. Calibration of field equipment was performed daily.

During the field sampling, water samples were collected at mid-depth and mid-channel. These water samples were stored in coolers with ice packs in order for stabilization and then transported to Microbac Laboratories, which is EPA certified for analysis. The specifics of the chemical parameters are discussed in Appendix A of this report.

Table 3. Macroinvertebrate Data

2018 MONROE COUNTY MACROINVERTEBRATE DATA

TAXON	Pollution Tolerance	NUMBER COLLECTED AT SAMPLING STATION												
ORDER *GENERA/SPECIES*		01	02	03	04	05	06	07	08	09	10	11	12	13
AMPHIPODA (shrimp)														
Gammarus spp.	4								24					
BIVALVIA (clams)														
Pisidium spp.	8													
COLEOPTERA (beetles)														
Berosus spp.	5													
Stenelmis spp.	5					4		1	2					
Promoresia spp.	2	1		2	1		1			3				
Dubiraphia spp.	6			4										
Optioservus spp.	4	3	33	11	2			4		6			7	
Ectopria spp.	5			1										
Psephenus herricki	4		11	1	22	3	11	6	12		2	2		
Microcylloepus spp.	2		1	3	1	4	3		3		2			
Hydrochus spp.	5													
Leutrochus spp.	6			7										
Oulimnius spp.														
DIPTERA (true flies)														
Chironomidae	6	116	26	17	15	9	11	30	37	24	48	78	13	
Blepharicera spp.	0					4		1				1		
Tipula spp.	4	1		3	1					1		2		
Hexatoma spp.	2		1	1	5		1			6		3		
Pericoma spp.	4													
Hemerodromia spp.	6	2	4		5		4	6						
Tabanus spp.	5											2		
Atherix spp.	2		5											
Antocha spp.	3	7	1							2	1	2	1	
Simulium spp.	6	5	7	49	2				1	1		8	27	
Dicranota spp.	3								2	1	1			
Empididae spp.	6													
Prosimulium	2		6		3	19			3	11				
EPHEMEROPTERA (mayflies)														
Epeorus spp.	0		11		15	3	1	4	2	27	6	13		
Mccaffertium spp.	3	7	2	9	4	1	2	4	7	9	6		2	
Stenacron spp.	4							1	1					
Ephemerella spp.	1	45	13	41	30	11	5	13	2	20	60	12	79	
Eurylophella spp.	4		7								6	4	3	
Drunella spp.	1	1	5		1	30	47	28	2		4	3		
Danella spp.	2													
Attenuatella spp	2													
Seratella spp.	2			1							1			
Leucrocuta spp.	1													
Paraleptophlebia spp.	1			9	8		1			4	23			
Leptophlebia spp.	4													
Heterocloen spp.	2													
Cinygmula spp.	1									15				
Nixe spp.	2													
Rithrogena spp.	0									4				
Heptageniidae	3													
Isonychia spp.	3	5	6		1	4	2	4	4		2		2	
Ameletus spp.	0											1		
Baetidae	6											5		
Baetis spp.	6	10	5	2	14	3	7	5		46			5	
Acerpenna spp.	6												1	
Plauditus spp.	4													
Acentrella spp.	4													
GASTROPODA (snails)														
Physinae	8													
HEMIPTERA (true bugs)														
Microvelia spp.	9		1											
HIRUDINEA (leeches)	8													
Myzobdella spp.														
ISOPODA (sowbugs)														
Caecidotea spp.	6			1		1	2				1			
LEPIDOPTERA (moths)														
Petrophila spp.	5										1			
MEGALOPTERA (hellgramites)														
Sialis spp.	6													
Corydalus spp.	4						1		2					
Nigronia spp.	2		1	3	5	1	3	1				1		
NEMERTEA	6													
NEMATOPHORA (horsehair worm)	9													

Table 4. Macroinvertebrate Data

TAXON (continued)	Pollution Tolerance	NUMBER COLLECTED AT SAMPLING STATION (continued)												
ORDER *GENERA/SPECIES*		01	02	03	04	05	06	07	08	09	10	11	12	13
ODONATA (dragon flies)														
Libellula spp.	8													
Calopteryx spp.	6												1	
Boyeria spp.	2													
Ophiogomphus spp.	1										1			
Lanthus spp.	5							1						
Gomphidae	4						1							
Stylogomphus spp.	4			6				1						
calopteryx spp.														
Cordulegaster spp.	3			1										
Tachopteryx spp.	5												1	
OLIGOCHAETA (worms)	10	1												
PLECOPTERA (stoneflies)														
Leuctra spp.	0									8				
Taeniopteryx spp.	2													
Amphinemura spp.	3	1											1	
Pteronarcys spp.	0									4		2		
Acroneuria spp.	0		5	2	5	3	4	3	1	2	1	4		
Paragnetina spp.	1										1			
Agnetina spp.	1				18	1			1	1				
Perlesta spp.	4													
Suwallia/Sweltsa spp.	0	2								2		25	1	
Shipsa spp.	2													
Tallaperla spp.	0													
Diploperla spp.	2													
Clioperla spp.	2													
Diura spp.	2													
Cultus spp.	2										4			
Isoperla spp.	2				4	2	2	2			2			
TURBELLARIA (flatworms)														
Macrostemum spp.	8													
TRICHOPTERA (caddisflies)														
Chimarra spp.	4	1	6			3	1	3						
Brachycentrus spp.	1				4									
Dolophilodes spp.	0							1						
Neophylax spp.	3				7		5	4			2	3	2	
Hydropsyche spp.	5			4					3					
Ceratopsyche spp.	5	21	20	5	6	22	19	22	4	2	2	2	4	
Cheumatopsyche spp.	6	8	20	9	2	44	40	31	13		10	4	3	
Diplectrona spp.	0			5						5		1		
Rhyacophila spp.	1	1	7	2	16	15	21	27	1	10	2	6		
Lepidostoma spp.	1				1		1		2		1		1	
Psilotreta spp.	0				2	1								
Glossossoma spp.	0													
Agapetus spp.	0													
Protoptila spp.	1													
Psychomyia spp.	2	1												
Lype spp.	2													
Micrasema spp.	2													
Ceraclea spp.	3											2		
Helicopsuche spp.	3				1									
Leucotrichia spp.	6													
Oxyethira spp.	3													
Hydatophylax spp.	2			1										
Polycentropus spp.	6			1										
Nectopsyche spp.	3													
Pycnopsyche spp.	4				3			1		1			1	
TOTAL		239	204	201	204	188	196	204	129	215	190	186	155	
METRICS														
Total Taxa Richness		20	24	28	30	22	25	25	22	25	25	24	19	
Shannon Diversity Index		1.81	2.78	2.60	2.93	2.47	2.45	2.59	2.40	2.66	2.20	2.41	2.57	
EPT Taxa Richness		9	9	9	16	11	12	13	10	14	15	12	9	
Hilsenhoff Biotic Index		4.57	3.87	3.87	2.57	3.30	3.39	3.58	4.39	2.76	2.88	3.61	3.05	
Percent Intolerant Individuals		29.7	31.4	39.8	64.7	52.7	50.5	45.1	23.3	62.3	63.2	42.5	57.4	
Modified Beck's Index		11	17	19	29	24	21	20	18	34	24	29	7	
IBI SMALL STREAM		**50.4**	**62.5**	**66.0**						**82.5**		**70.9**	**61.1**	
IBI LARGE STREAM					**99.0**	**84.6**	**84.6**	**83.9**	**69.1**		**91.0**			

Table 5. Macroinvertebrate Data

TAXON	Pollution Tolerance	NUMBER COLLECTED AT SAMPLING STATION												
ORDER		14	15	16	17	18	19	20	21	22	23	24	25	26
GENERA/SPECIES														
AMPHIPODA (shrimp)														
Gammarus spp.	4							5		4	12			
BIVALVIA (clams)														
Pisidium spp.	8													
COLEOPTERA (beetles)														
Berosus spp.	5													
Lutrochus spp.	6													
Microcylloepus spp.	2					2		1						
Stenelmis spp.	5										2			
Dubiraphia spp.	6													
Promoresia spp.	2						6		2					
Stenelmis spp.	5									1				
Ectopria spp.	5						2							
Optioservus spp.	4		3	7				1	1		6		2	
Agabus spp.	5													
Micronychus spp.	2													
Psephenus herricki	4						1	2	2	7	2			
DIPTERA (true flies)														
Chironomidae	6		26	8		78	18	23	3	9	36	38	16	17
Bezzia spp.	6		1											
Hemerodromia spp.	6		4					2	1	1	3			2
Blepharicera spp.	0		1											
Limnophora spp.	6													
Muscidae	6													
Tipula spp.	4		1			1	1					1		
Hexatoma spp.	2		7	3					2	1			5	
Atherix spp.	2								1					
Antocha spp.	3		19	5				4	1	2			1	1
Tabanus spp.	5					1								
Empedidae spp.	6													
Dicranota spp.	3													
Prosimulium spp.	0		5			12	2					1		1
Pedecia spp.	6													
Ptychoptera spp.	8					1								
Simulium spp.	6		6	18		50	6	1	3		5	18	27	
EPHEMEROPTERA (mayflies)														
Epeorus spp.	0		38	29		1	5		8		1	11	16	13
Mccaffertium spp.	3						5	2	19	11	3	1	3	3
Stenacron spp.	4													
Ephemerella spp.	1		14	22		29	45	120	25	53	32	35	35	5
Eurylophella spp.	4					10		1	1					1
Serratella spp.	2							1		2	4			
Leucrocuta spp.	1													
Dannella spp.	2													
Drunella spp.	1		3					2	10		10			52
Heterocloen spp.	2													
Paraleptophlebia spp.	1		1	10		2	5		4			1	1	2
Isonychia spp.	3						4	5	8	7	1	2		4
Ameletus spp.	0						1							
Caenis spp.	7													
Baetis spp.	6		13	8			22	2	8	1	5	40	21	13
Acerpenna spp.	6													
Acentrella spp.	4								1					
Ephemera spp.	2													
Plauditus spp.	4													
Diphetor spp.	6													
Cinygmula spp.	1													
GASTROPODA (snails)														
Gyraulus spp.	6													
Valvata spp.	2													
HEMIPTERA (true bugs)														
HIRUDINEA (leeches)														
ISOPODA (Sowbugs)														
Caecidotea spp.	6												2	
MEGALOPTERA (hellgramites)														
Sialis spp.	6													
Nigronia spp.	2						1	2	7			4	2	
Corydalus spp.	4													

Table 6. Macroinvertebrate Data

TAXON (continued)	Pollution Tolerance	14	15	16	17	18	19	20	21	22	23	24	25	26
ORDER														
GENERA/SPECIES														
ODONATA (dragon/damsel flies)	4													
Gomphidae	5													
Lanthus spp.	4		1	4		2								
Stylogomphus spp.	10													
Bayeria spp.	2													
Ophiogomphus spp.	1						1						1	1
Cordulegaster spp.	3							1				1		
OLIGOCHAETA (worms)	10											1		
PLECOPTERA (stoneflies)														
Paraleuctra spp.	0													
Leuctra spp.	0		2	1					2			1	1	
Amphinemura spp.	3													
Pteronarcys spp.	0		3			1	3		1	1				
Acroneuria spp.	0					1	8		2		5	9	3	9
Paragnetina spp.	1						1		5		2			1
Agnetina spp.	2		1									1	1	
Suwallia/Sweltsa spp.	0		9	22					2			1	9	
Perlesta spp.	4													
Tallaperla spp.	0			11		1	2						10	
Diploperla spp.	2								1					
Cultus spp.	2													
Isoperla spp.	2		1	4		3	1		4				4	3
Isogenoides spp.	0													
Diura spp.	2		1											
Clioperla spp.	2													
Remenus spp.	2		1											
TURBELLARIA (flatworms)														
TRICHOPTERA (caddisflies)														
Chimarra spp.	4							2	1	2		1		15
Wormaldia spp.	0					1								
Dolophilodes spp.	0			1			1		1			4		
Hydropsyche spp.	5							3			2			
Cheumatopsyche spp.	6		12				6	16	23	81	56	8		31
Ceratopsyche spp.	5						9	4	8	3	6	17	4	5
Diplectrona spp.	0			17		4	17		1			7	7	
Rhyacophila spp.	1		8	13		2	5		23	2	1	8	9	16
Glossosoma spp.	0													
Neureclipsis spp.	7													
Psychomyia spp.	2													
Nyctiophylax spp.	6													
Parapsyche spp.	0			2										
Lepidostoma spp.	1		2				3	5		1	1	1	2	
Leucotrichia spp.	6													
Micrasema spp.	2						1							
Neophylax spp.	3		1						13					
Brachycentrus spp.	1		2											
Agapetus spp.	0													
Psychomyia spp.	2													
Nectopsyche spp.	3													
Mystacides spp.	4													
Polycentropus spp.	6							1	1					
Pycnopsyche spp.	4		3			1	1						1	
Psilotreta spp.	0													1
TOTAL			189	190		203	183	206	195	189	195	212	183	196
METRICS			**189**	**375**		**203**	**183**	**206**	**195**	**189**	**195**	**212**	**183**	**196**
Total Taxa Richness			29	18		20	29	23	34	18	21	24	24	21
Shannon Diversity Index			2.75	2.57		1.89	2.71	1.72	2.96	1.78	2.29	2.45	2.62	2.41
EPT Taxa Richness			16	11		12	15	8	20	8	10	14	14	13
Hilsenhoff Biotic Index			2.78	1.69		4.45	2.67	2.52	2.68	3.95	4.24	3.75	2.80	2.46
Percent Intolerant Individuals			63.0	73.7		29.1	63.9	68.9	73.3	42.3	28.7	41.5	60.1	57.1
Modified Beck's Index			31	29		27	38	9	37	11	17	29	32	23
IBI SMALL STREAM			**85.6**	**77.6**		**60.4**	**80.5**		**95.7**	**52.1**		**72.4**	**80.4**	
IBI LARGE STREAM								**70.9**			**68.9**			**86.5**

Table 7. Macroinvertebrate Data

TAXON	Pollution Tolerance	NUMBER COLLECTED AT SAMPLING STATION										
ORDER *GENERA/SPECIES*		27	28	29	30	31	32	33	34	35	36	Red Run
AMPHIPODA (shrimp)												
Gammarus spp.	4			1			1					9
BIVALVIA (clams)												
COLEOPTERA (beetles)												
Lutrochus spp.	6											
Microcylloepus spp.	2					1	89		3	15	7	
Macronychus spp.	2											
Stenelmis spp.	5			1								
Promoresia spp.	2				3				11	1	8	7
Stenelmis spp.	5											
Optioservus spp.	4	1			11	3	4					1
Ancyronyxs pp.	2		1									
Psephenus herricki	4		3	5					1			
Ectopria spp.	5				2							
DIPTERA (true flies)												
Chironomidae	6	14	22	64	16	18	32	40	23	27	18	39
Blepharicera spp.	0	3	1									
Hemerodromia spp.	6	3	10	9	1		1	4	5	2		4
Empididae	6											
Muscidae	6											
Tipula spp.	4	2					1			2		
Hexatoma spp.	2	5	1		2					1		1
Atherix spp.	2										1	
Antocha spp.	3	1		4	4	1			1	2	1	1
Proimulium spp.	0	1	6		2							
Simulium spp.	6	2	11	6	3	4	35		2	3	2	30
Dicranota spp.	3				1						1	
Probezzia spp.	6											
Bezzia spp.	6	2										
Tabanus spp.	5											2
EPHEMEROPTERA (mayflies)												
Epeorus spp.	0	35	21	4	4	4				1		
Mccaffertium spp.	3	1	10	7	3	1	2	5	1	3	17	
Stenacron spp.	4										1	
Cinygmula spp.	1	5										
Ephemerella spp.	1	45	13	22	31	61		9	12	9	4	54
Eurylophella spp.	4				32		1	5			3	15
Caenis spp.	7											
Drunella spp.			5					2		6		
Serratella spp.	2	1							1	1		1
Drunella spp.	1			24								
Paraleptophlebia spp.	1	2	1		6			1	1	8		
Leptophlebia spp.	4											
Habrophlebiodes spp.	6											
Isonychia spp.	3			3		6			23	11		6
Ameletus spp.	0											
Baetis spp.	6	47	52	14	9	27		74				
Diphetor spp.	6		1					6				
Acerpenna spp.	6						1					
Acentrella spp.	4											
GASTROPODA (snails)												
HEMIPTERA (true bugs)												
Microvelia spp.	9											
HIRUDINEA (leeches)												
ISOPODA (sowbugs)												
MEGALOPTERA (hellgramites)												
Sialis spp.	6								1			
Nigronia spp.	2							1		4	1	4
Corydalus spp.	4											

Table 8. Macroinvertebrate Data

TAXON (continued)	Pollution Tolerance											
ORDER *GENERA/SPECIES*		27	28	29	30	31	32	33	34	35	36		
ODONATA (dragon/damsel flies)													
Boyeria spp.	2								1	1			2
Cordulegaster spp.	3												
Gomphidae	4				3				3				6
Ophiogomphus spp.	1				2				3	1			6
Gomphus spp.	5												
Hagenius spp.	3												
Lanthus spp.	5											4	4
Argia spp.	6										1		1
Progomphus spp.	5									1			1
Stylogomphus spp.	4										1		1
OLIGOCHAETA (worms)	10												
PLECOPTERA (stoneflies)													
Leuctra spp.	0	1									1		2
Amphinemura spp.	3												
Pteronarcys spp.	0				2						1		3
Perlidae	3												
Acroneuria spp.	0	2		4	2	1		1	10	7	2	10	39
Paragnetina spp.	1		4	1		2			6		1		14
Agnetina spp.	1	7	1										8
Suwallia/Sweltsa spp.	0	11			3								14
Paranemoura spp.	2												
Tallaperla spp.	0				5								5
Diploperla spp.	2	5											5
Clioperla spp.	2												
Diura spp.	2												
Cultus spp.	2												
Taeniopteryx spp.	2												
Perlesta spp.	4												
Isoperla spp.	2	5	2		8			1		1	2		19
TURBELLARIA (flatworms)													
TRICHOPTERA (caddisflies)													
Chimarra spp.	4			1		8	30	3	14		1		57
Wormaldia spp.	0												
Dolophilodes spp.	0				2								2
Hydropsyche spp.	5					2	16	33				1	52
Cheumatopsyche spp.	6	2	3	18	8	8	17	5	19	75	8	7	170
Ceratopsyche spp.	5	3	14	12	8	37	7	7	34	18	7	2	149
Diplectrona spp.	0	2			10	1						1	14
Wormaldia spp.	0												
Rhyacophila spp.	1	3	18	3	19	26		2	6	1	1	3	82
Neureclipsis spp.	7												
Parapsyche spp.	0												
Agapetus spp.	0				3								3
Ceraclea spp.	3												
Lepidostoma spp.	1		6	1			1	1					9
Macrostemum spp.	3					1			2	3			6
Neophylax spp.	3			1					1				2
Psilotreta spp.	0										1	1	2
Apatania spp.	3			1									1
Micrasema spp.	2											3	3
Diphetor spp.	6												
Limnephilidae	4												
Phylocentropus spp.	5												
Polycentropus spp.	6												
Pycnopsyche spp.	4		1		3						1		5
Cyrnellus spp.	8									7			7
TOTAL		211	207	206	208	212	238	200	184	211	92	206	206
METRICS													
Total Taxa Richness		27	23	22	30	19	15	18	24	26	25	23	
Shannon Diversity Index		2.47	2.55	2.37	2.94	2.19	1.90	1.99	2.62	2.39	2.63	2.34	
EPT Taxa Richness		13	11	12	15	10	4	10	11	11	13	9	
Hilsenhoff Biotic Index		2.60	3.76	3.87	2.79	3.30	4.05	5.20	3.73	4.41	3.67	3.57	
Percent Intolerant Individuals		58.8	43.5	32.5	53.9	49.5	38.7	11.5	44.6	36.0	53.3	45.1	
Modified Beck's Index		33	34	16	36	16	3	15	17	22	23	18	
IBI SMALL STREAM		**80.7**	**72.4**		**86.2**		**43.3**	**48.2**	**66.2**		**73.0**	**63.2**	
IBI LARGE STREAM				**73.1**		**74.0**				**74.6**		**75.7**	

Appendix C

Habitat Assessment

Both the quality and quantity of available habitat affects the macroinvertebrate community. A healthy biological community not only requires good water quality, but also a supportive habitat. There are two types of rating systems for 2018. One is for a Riffle/Run prevalent stream, like most of the streams in Monroe County, which incorporates three categories for a total of 12 parameters. Habitat assessment data can be interpreted by summing the twelve habitat parameter scores for an overall assessment value; 161-200: optimal, 101-160: suboptimal, 51-100: marginal, <51: poor.
The second is the multi-habitat, low-gradient stream for the low gradient streams that utilizes 9 parameters. Total habitat site scores can range from 0-180, with 180 being a perfect score. These assessment values are used when assessing a site's attainable biological condition based on a local reference station. Below is an explanation of the habitat parameters:

Habitat Parameter Descriptions *Riffle/Run Streams*

1. **Instream Cover:**
   This is a measure of quantity and variety of natural structures in the stream that will provide a habitat for fish (e.g., fallen trees, branches, logs, undercut banks, and large rocks)

2. **Substrate for Benthic Macroinvertebrates:**
   This measures the amount of hard substrate available for insects and snail habitat. Many insect larvae attach themselves to submerged substrate. Areas with rocky bottoms are critical for maintaining a healthy variety of insects.

3. **Embeddedness:**
   This refers to the degree to which rocks are covered or sunken into the silt, sand or mud. As substrates become embedded in the stream bottom, the amount of adequate surface space for insects to attach themselves decreases and the quantity and quality of the macroinvertebrate community is predicted to decrease.

4. **Velocity/Depth Regime:**
   There are four basic velocity/depth combinations:
   Shallow/fast, shallow/slow, deep/fast, and deep/slow

5. **Channel Alteration:**
   This parameter is a measure of changes to the shape of the stream channel. When

streams have been altered in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges), it can affect the macroinvertebrate community.

6. **Sediment Deposition:**
This parameter measures the sediment, which has accumulated on the stream bottom as a result of deposition. Deposition occurs as a result of large-scale movement of sediment caused by watershed erosion. This deposition may cause the formation of islands or point bars in the stream, which decreases the available habitat for macroinvertebrates.

7. **Frequency of Riffles:**
This parameter assumes that a stream with riffles or bends provides more diverse habitat than any straight or uniform depth stream. The ratio is calculated by dividing the average distance between riffles or bends by the average depth. The smaller ratio is an indicator of good habitat.

8. **Channel Flow Status:**
This is a measure of the degree to which the channel is filled with water. When the water reaches the base of both banks and a minimal amount of channel substrate is exposed, optimal conditions exist.

9. **Condition of Banks:**
This parameter addresses stream bank erosion (or potential for erosion). Steep banks are generally more susceptible to erosion and failure. Signs of erosion include crumbling banks, unvegetated banks, and exposed tree roots and soil.

10. **Bank Vegetative Protection:**
This measures the amount of stream bank covered by vegetation. Plant root systems on stream banks facilitate soil stability which reduces erosion. This parameter also provides information such as stream shading and nutrient uptake. Banks that support natural plant growth indicate a healthier habitat for macroinvertebrates and fish.

11. **Grazing Disruptive Pressure:**
This parameter measures the impact to the riparian zone due to livestock grazing or human activities such as urbanization, golf courses, and residential developments.

12. **Riparian Zone Width:**
This is a measure of the width of the natural vegetation from the edge of the stream bank. This zone serves as a buffer to pollutants entering the stream from surface runoff.

Habitat Parameter Descriptions Multihabitat Low-Gradient Streams

1. **Epifaunal Substrate for Macroinvertebrate:**
   The substrate in muddy bottom streams consists mostly of submerged logs, snags and aquatic vegetation.

2. **Pool Substrate Characterization:**
   This is an evaluation of the type and condition of bottom substrates found in pools. Firm sediment types such as gravel and sand as well as rooted aquatic plants support a wider variety of organisms. A pool substrate dominated by mud or bedrock will not support a diverse community.

3. **Pool Variability:**
   This parameter rates the overall mixture of pool types found in the streams. The four basic types of pools are: Large-shallow, small-deep, small-shallow, large-deep. General guidelines include: greater than one half the cross-section to separate large from small and one meter separating shallow and deep.

4. **Sediment Deposition:**
   This parameter measures the sediment, which has accumulated on the bottom as a result of deposition.

5. **Channel Flow Status:**
   This is a determination of the percent of the channel that is filled with water. The flow status changes as the channel enlarges or as flow is decreased as a result of dams or obstructions, diversions for irrigation, or drought. When water does not cover as much of the streambed the available habitat is decreased.

6. **Channel Alteration:**
   This parameter is a measure of changes to the shape of the stream channel. Streams that run through agricultural or urban areas may have been altered many times. When streams have been changed in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges) it can affect the macroinvertebrate community. Streams that have been altered have fewer natural habitats for fish, macroinvertebrates and plants.

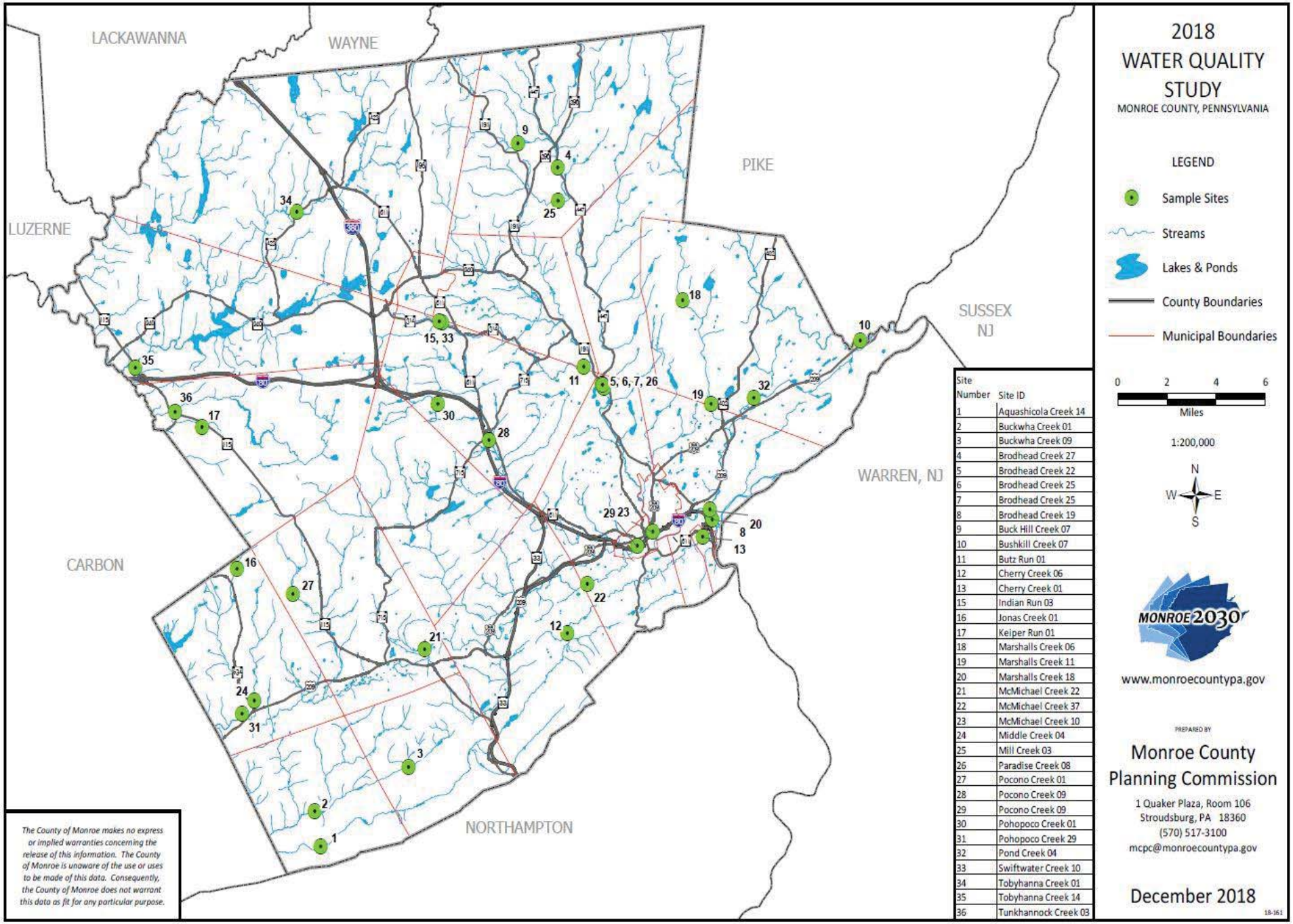
7. **Bank Stability:**
   This parameter addresses stream bank erosion or potential for erosion. Steep banks are generally more susceptible to erosion and failure. Signs of erosion include crumbling and unvegetated banks and exposed tree roots and soil.

8. **Vegetative Protection:**
   This measures the amount of stream bank, which is covered by vegetation. Plant root systems on stream banks facilitate soil stability, which reduces the stream bank erosion. Banks that support full natural plant growth indicate a healthier habitat for macroinvertebrates and fish.

9. **Riparian Vegetative Zone Width:**
   Refer to riffle/run definition.

Site Map

Figure 2. Map of Sampling Sites



Site Number	Site ID
1	Aquashicola Creek 14
2	Buckwha Creek 01
3	Buckwha Creek 09
4	Brodhead Creek 27
5	Brodhead Creek 22
6	Brodhead Creek 25
7	Brodhead Creek 25
8	Brodhead Creek 19
9	Buck Hill Creek 07
10	Bushkill Creek 07
11	Butz Run 01
12	Cherry Creek 06
13	Cherry Creek 01
15	Indian Run 03
16	Jonas Creek 01
17	Keiper Run 01
18	Marshalls Creek 06
19	Marshalls Creek 11
20	Marshalls Creek 18
21	McMichael Creek 22
22	McMichael Creek 37
23	McMichael Creek 10
24	Middle Creek 04
25	Mill Creek 03
26	Paradise Creek 08
27	Pocono Creek 01
28	Pocono Creek 09
29	Pocono Creek 09
30	Pohopoco Creek 01
31	Pohopoco Creek 29
32	Pond Creek 04
33	Swiftwater Creek 10
34	Tobyhanna Creek 01
35	Tobyhanna Creek 14
36	Tunkhannock Creek 03

Site Chart

Table 9. Sampling Site Chart

#	Site ID	Stream Name	Location
1	AQUACR14	Aquashicola Creek	Upstream of Lower Smith Gap Rd. near Quinton Drive
2	BUCKCR01	Buckwah Creek	Immediately downstream of Chestnut Ridge Road
3	BUCKCR09	Buckwah Creek	Roger and Sandra Green Farm on Kunkletown Rd. Just Upstream of small bridge
4	BRODCR27	Brodhead Creek	Pasold Farms Nature Preserve at the downstream section of the property
5	BRODCR22	Brodhead Creek	Upstream of Paradise Confluence
6	BRODCR25	Brodhead Creek	Immediatley downstream of Paradise confluence (Forevergreen Preserve)
7	BRODCR25	Brodhead Creek	Immediatley downstream of Paradise confluence (Forevergreen Preserve)
8	BRODCR19	Brodhead Creek	Immediatley uptream from River Road bridge
9	BUHICR07	Buck Hill Creek	Just upstream of golfcourse fairway at Clubhouse, above Falls
10	BUSHCR07	Bushkill Creek	Downstream from STP at DWGNRA boundary
11	BUTZRN01	Butz Run	Approximately 50 yards upstream of confluence with Paradise Creek.
12	CHERCR06	Cherry Creek	Immediatley Upstream of Kemmertown Bridge
13	CHERCR01	Cherry Creek	Approximately 100 yards upstream of Route 611 in Delaware Water Gap Borough
15	INDIRN03	Indian Run	Immedialtely upstream of the confluence with Swiftwater Creek
16	JONACR01	Jonas Creek	PHLT Jonas Mountain Nature Preserve
17	KEIPRN01	Keiper Run	Upstream of culvert pipes on Schochs Rd. in SGL
18	MARSCR06	Marshalls Creek	Upstream of Wood Dale Rd in Delaware State Forest
19	MARSCR11	Marshalls Creek	Approximately 100 yards upstream of Newton Run and White Heron Lake
20	MARSCR18	Marshalls Creek	Immediatley Upstream from Post Office Road
21	MCMICR22	McMichael Creek	Upstream of McIlhaney Rd.
22	MCMICR37	McMichael Creek	Hickory Valley Park
23	MCMICR10	McMichael Creek	Upstream of confluence with Brodhead
24	MIDDCR04	Middle Creek	Polk Township Open Space Property at the pavilion
25	MILLCR03	Mill Creek Creek	Mill Creek Road on Natural Lands Trust property
26	PARACR08	Paradise Creek	Upstream of Brodhead confluence
27	POCOCR01	Pocono Creek	Approximately 250 yards downstream of Wilke Road, east of Wilkie Road.
28	POCOCR09	Pocono Creek	Upstream of Old Mill Rd. on Pocono Heritage Land Trust property
29	POCOCR14	Pocono Creek	Upstream of confuence with McMichael Creek
30	POHOCR01	Pohopoco Creek	Southern end of Shiffer Property off Merwinsburg Road (near Burger Hollow Road
31	POHOCR29	Pohopoco Creek	Near Whitey B. Drive on Polk Township Property
32	PONDCR04	Pond Creek	Immediatley downstream of Primrose Lane
33	SWIFCR10	Swiftwater Creek	Immediately Downstream of Route 314 Bridge
34	TOBYCR01	Tobyhanna Creek	Upstream of Route 423 bridge in SGL. 127
35	TOBYCR14	Tobyhanna Creek	Upstream of Route 115 bridge in Blakeslee
36	TUNKCR03	Tunkhannock Creek	Immediatley upstream of Route 115

Site Chart

AQUACR14

Location	Upstream of Lower Smith Gap Rd. near Quinton Drive		
Site #	2018-1	Date	4/20/2018
Stream Name	Aquashicola Creek	Time	10:30 AM
Township	Eldred	Latitude	40.828778
Habitat Asmt.	186	Longitude	-75.447944

Field Measurements	
Temp C	7.0
pH	7.75
Press inHg	29.69
DO Percent	104.2
DO mg/L	12.66
Cond (uS/cm)	136

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	1.81
EPT Taxa Richness	9
Hilsenhoff Biotic Index	4.57
Intolerant individuals (%)	29.7
Modified Becks Index	11
Index of Biotic Integrity	**50.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.43
Aluminum mg/L	<0.100
Calcium mg/L	14.30
Iron mg/L	0.0956
Magnesium mg/L	3.710
Hardness CaCO3	51.00
Chloride mg/L	10.80
pH	7.48
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.402
Alkalinity to pH 4.5 mg CaCO3/L	44.0
Total Dissolved Solids mg/L	94.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BUCKCR01

Location	Immediately downstream of Chestnut Ridge Road		
Site #	2018-2	Date	4/20/2018
Stream Name	Buckwah Creek	Time	10:30 AM
Township	Eldred	Latitude	40.847167
Habitat Asmt.	164	Longitude	-75.452056

Field Measurements	
Temp C	5.6
pH	7.44
Press inHg	29.69
DO Percent	101.80
DO mg/L	12.78
Cond (uS/cm)	107

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.78
EPT Taxa Richness	9
Hilsenhoff Biotic Index	3.87
Intolerant individuals (%)	31.4
Modified Becks Index	17
Index of Biotic Integrity	**62.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.24
Aluminum mg/L	<0.100
Calcium mg/L	7.41
Iron mg/L	0.0687
Magnesium mg/L	2.210
Hardness CaCO3	27.60
Chloride mg/L	14.10
pH	7
Nitrogen as N mg/L	1.67
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	1.67
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	70.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BUCKCR09

Location	Roger and Sandra Green Farm on Kunkletown Rd. Just Upstream of small bridge		
Site #	2018-3	Date	4/20/2018
Stream Name	Buckwah Creek	Time	11:45 AM
Township	Ross	Latitude	40.868944
Habitat Asmt.	165	Longitude	-75.378639

Field Measurements	
Temp C	6.3
pH	7.71
Press inHg	29.69
DO Percent	101.9
DO mg/L	12.56
Cond (uS/cm)	122

Macroinvertebrate Metrics	
Total Taxa	28
Shannon Diversity Index	2.60
EPT Taxa Richness	9
Hilsenhoff Biotic Index	3.87
Intolerant individuals (%)	39.8
Modified Becks Index	19
Index of Biotic Integrity	**66.0**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.11
Aluminum mg/L	<0.100
Calcium mg/L	10.30
Iron mg/L	0.141
Magnesium mg/L	1.700
Hardness CaCO3	32.80
Chloride mg/L	15.50
pH	7.02
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.677
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	0.677
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	5.0

BRODCR27

Location	Pasold Farms Nature Preserve at the downstream section of the property		
Site #	2018-4	Date	4/23/2018
Stream Name	Brodhead Creek	Time	08:30 AM
Township	Barrett	Latitude	41.180944
Habitat Asmt.	190	Longitude	-75.251028

Field Measurements	
Temp C	6.3
pH	6.87
Press inHg	30.03
DO Percent	99.6
DO mg/L	12.30
Cond (uS/cm)	64

Macroinvertebrate Metrics	
Total Taxa	30
Shannon Diversity Index	2.93
EPT Taxa Richness	16
Hilsenhoff Biotic Index	2.57
Intolerant individuals (%)	64.7
Modified Becks Index	29
Index of Biotic Integrity	**99.0**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.08
Aluminum mg/L	<1.00
Calcium mg/L	3.46
Iron mg/L	<0.0500
Magnesium mg/L	1.030
Hardness CaCO3	12.90
Chloride mg/L	10.60
pH	6.79
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.153
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	20.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BRODCR22

Location	Upstream of Paradise Confluence		
Site #	2018-5	Date	4/23/2018
Stream Name	Brodhead Creek	Time	10:20 AM
Township	Stroud	Latitude	41.065917
Habitat Asmt.	178	Longitude	-75.220639

Field Measurements	
Temp C	6.9
pH	7.00
Press inHg	30.03
DO Percent	102.2
DO mg/L	12.44
Cond (uS/cm)	102

Macroinvertebrate Metrics	
Total Taxa	22
Shannon Diversity Index	2.47
EPT Taxa Richness	11
Hilsenhoff Biotic Index	3.30
Intolerant individuals (%)	52.7
Modified Becks Index	24
Index of Biotic Integrity	**84.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.80
Aluminum mg/L	<1.00
Calcium mg/L	3.92
Iron mg/L	<0.0500
Magnesium mg/L	1.120
Hardness CaCO3	14.40
Chloride mg/L	11.70
pH	6.98
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.117
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	22.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	4.0

BRODCR25

Location	Immediatley downstream of Paradise confluence (Forevergreen Preserve)		
Site #	2018-6	Date	4/23/2018
Stream Name	Brodhead Creek	Time	10:30 AM
Township	Stroud	Latitude	41.064778
Habitat Asmt.	185	Longitude	-75.219861

Field Measurements	
Temp C	6.6
pH	6.96
Press inHg	30.03
DO Percent	101.5
DO mg/L	12.42
Cond (uS/cm)	90

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.45
EPT Taxa Richness	12
Hilsenhoff Biotic Index	3.39
Intolerant individuals (%)	50.5
Modified Becks Index	21
Index of Biotic Integrity	**84.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.82
Aluminum mg/L	<1.00
Calcium mg/L	4.16
Iron mg/L	<0.0500
Magnesium mg/L	1.230
Hardness CaCO3	15.5
Chloride mg/L	12.90
pH	6.96
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.132
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	28.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BRODCR25

Location	Immediatley downstream of Paradise confluence (Forevergreen Preserve)		
Site #	2018-7	Date	4/23/2018
Stream Name	Brodhead Creek	Time	10:30 AM
Township	Stroud	Latitude	41.064722
Habitat Asmt.	185	Longitude	-75.219861

Field Measurements	
Temp C	6.6
pH	6.97
Press inHg	30.03
DO Percent	101.4
DO mg/L	12.44
Cond (uS/cm)	74

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.59
EPT Taxa Richness	13
Hilsenhoff Biotic Index	3.58
Intolerant individuals (%)	45.1
Modified Becks Index	20
Index of Biotic Integrity	**83.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.75
Aluminum mg/L	<0.100
Calcium mg/L	4.03
Iron mg/L	<0.500
Magnesium mg/L	1.190
Hardness CaCO3	15.00
Chloride mg/L	13.10
pH	6.87
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.121
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	28.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BRODCR19

Location	Immediatley uptream from River Road bridge		
Site #	2018-8	Date	4/23/2018
Stream Name	Brodhead Creek	Time	1:00 PM
Township	Smithfield	Latitude	40.993861
Habitat Asmt.	154	Longitude	-75.138167

Field Measurements	
Temp C	9.2
pH	7.66
Press inHg	30.03
DO Percent	106.2
DO mg/L	12.22
Cond (uS/cm)	191

Macroinvertebrate Metrics	
Total Taxa	22
Shannon Diversity Index	2.40
EPT Taxa Richness	10
Hilsenhoff Biotic Index	4.39
Intolerant individuals (%)	23.3
Modified Becks Index	18
Index of Biotic Integrity	**69.1**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.77
Aluminum mg/L	<0.100
Calcium mg/L	4.03
Iron mg/L	<0.0500
Magnesium mg/L	2.130
Hardness CaCO3	35.80
Chloride mg/L	36.80
pH	7.35
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.375
Alkalinity to pH 4.5 mg CaCO3/L	22.0
Total Dissolved Solids mg/L	72.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BUHICR07

Location	Just upstream of golfcourse fairway at Clubhouse, above Falls		
Site #	2018-9	Date	4/18/2018
Stream Name	Buck Hill Creek	Time	09:30 AM
Township	Barrett	Latitude	41.194139
Habitat Asmt.	212	Longitude	-75.281444

Field Measurements	
Temp C	4.2
pH	6.88
Press inHg	29.33
DO Percent	95.9
DO mg/L	12.50
Cond (uS/cm)	35

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.66
EPT Taxa Richness	14
Hilsenhoff Biotic Index	2.76
Intolerant individuals (%)	62.3
Modified Becks Index	34
Index of Biotic Integrity	**82.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.39
Aluminum mg/L	0.163
Calcium mg/L	2.04
Iron mg/L	<0.0500
Magnesium mg/L	0.507
Hardness CaCO3	7.17
Chloride mg/L	5.08
pH	6.78
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.0982
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	18.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BUSHCR07

Location	Downstream from STP at DWGNRA boundary		
Site #	2018-10	Date	4/19/2018
Stream Name	Bushkill Creek	Time	10:30 AM
Township	Middle Smithfield	Latitude	41.084861
Habitat Asmt.	188	Longitude	-75.019417

Field Measurements	
Temp C	6.2
pH	7.96
Press inHg	29.25
DO Percent	99.2
DO mg/L	12.50
Cond (uS/cm)	66

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.20
EPT Taxa Richness	15
Hilsenhoff Biotic Index	2.88
Intolerant individuals (%)	63.2
Modified Becks Index	24
Index of Biotic Integrity	**91.0**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.61
Aluminum mg/L	0.101
Calcium mg/L	15.60
Iron mg/L	0.0662
Magnesium mg/L	2.850
Hardness CaCO3	50.60
Chloride mg/L	53.7
pH	7.6
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.614
Alkalinity to pH 4.5 mg CaCO3/L	50.0
Total Dissolved Solids mg/L	182.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

BUTZRN01

Location	Approximately 50 yards upstream of confluence with Paradise Creek.		
Site #	2018-11	Date	4/18/2018
Stream Name	Butz Run	Time	11:00 AM
Township	Paradise	Latitude	41.076083
Habitat Asmt.	202	Longitude	-75.234944

Field Measurements	
Temp C	5.3
pH	7.50
Press inHg	29.33
DO Percent	96.9
DO mg/L	12.27
Cond (uS/cm)	114

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.41
EPT Taxa Richness	12
Hilsenhoff Biotic Index	3.61
Intolerant individuals (%)	42.5
Modified Becks Index	29
Index of Biotic Integrity	**70.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.97
Aluminum mg/L	<0.100
Calcium mg/L	7.69
Iron mg/L	0.0733
Magnesium mg/L	1.410
Hardness CaCO3	25.00
Chloride mg/L	18.80
pH	7.13
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.349
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	84.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

CHERCR01

Location	Immediatley Upstream of Kemmertown Bridge		
Site #	2018-12	Date	4/26/2018
Stream Name	Cherry Creek	Time	11:40 AM
Township	Deleware Water Gap	Latitude	40.984778
Habitat Asmt.	171	Longitude	-75.145889

Field Measurements	
Temp C	12.0
pH	8.05
Press inHg	29.92
DO Percent	106.7
DO mg/L	11.50
Cond (uS/cm)	191

Macroinvertebrate Metrics	
Total Taxa	19
Shannon Diversity Index	2.57
EPT Taxa Richness	9
Hilsenhoff Biotic Index	3.05
Intolerant individuals (%)	57.4
Modified Becks Index	7
Index of Biotic Integrity	**61.1**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.11
Aluminum mg/L	0.12
Calcium mg/L	17.70
Iron mg/L	0.111
Magnesium mg/L	3.760
Hardness CaCO3	59.60
Chloride mg/L	7.29
pH	7.6
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.192
Alkalinity to pH 4.5 mg CaCO3/L	46.0
Total Dissolved Solids mg/L	79.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

CHERCR06

Location	Approximately 100 yards upstream of Route 611 in Delaware Water Gap Borough.		
Site #	2018-13	Date	4/26/2018
Stream Name	Cherry Creek	Time	10:40 AM
Township	Hamilton	Latitude	40.936583
Habitat Asmt.	193	Longitude	-75.252806

Field Measurements	
Temp C	12.0
pH	8.11
Press inHg	29.92
DO Percent	107.3
DO mg/L	11.76
Cond (uS/cm)	150

Macroinvertebrate Metrics	
Total Taxa	
Shannon Diversity Index	
EPT Taxa Richness	
Hilsenhoff Biotic Index	
Intolerant individuals (%)	
Modified Becks Index	
Index of Biotic Integrity	

*High organic content in two samples allowed for decomposition and forced omission of those sample results.

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.26
Aluminum mg/L	0.113
Calcium mg/L	21.40
Iron mg/L	0.192
Magnesium mg/L	4.470
Hardness CaCO3	71.70
Chloride mg/L	12.80
pH	7.3
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.171
Alkalinity to pH 4.5 mg CaCO3/L	60.0
Total Dissolved Solids mg/L	102.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

INDIRN03

Location	Immedialtely upstream of the confluence with Swiftwater Creek		
Site #	2018-15	Date	4/17/2018
Stream Name	Indian Run	Time	12:28 PM
Township	Pocono	Latitude	41.102083
Habitat Asmt.	184	Longitude	-75.346194

Field Measurements	
Temp C	6.2
pH	7.38
Press inHg	28.21
DO Percent	9.71
DO mg/L	12.00
Cond (uS/cm)	222

Macroinvertebrate Metrics	
Total Taxa	29
Shannon Diversity Index	2.75
EPT Taxa Richness	16
Hilsenhoff Biotic Index	2.78
Intolerant individuals (%)	63.0
Modified Becks Index	31
Index of Biotic Integrity	**85.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.33
Aluminum mg/L	<0.100
Calcium mg/L	9.20
Iron mg/L	<0.0500
Magnesium mg/L	2.220
Hardness CaCO3	32.10
Chloride mg/L	49.20
pH	6.6
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.49
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	106.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

JONACR01

Location	PHLT Jonas Mountain Nature Preserve		
Site #	2018-16	Date	4/17/2018
Stream Name	Jonas Creek	Time	9:45 AM
Township	Polk	Latitude	40.975833
Habitat Asmt.	220	Longitude	-75.507778

Field Measurements	
Temp C	6.8
pH	6.5
Press inHg	29.21
DO Percent	97.4
DO mg/L	11.89
Cond (uS/cm)	96

Macroinvertebrate Metrics	
Total Taxa	18
Shannon Diversity Index	2.57
EPT Taxa Richness	11
Hilsenhoff Biotic Index	1.69
Intolerant individuals (%)	73.7
Modified Becks Index	29
Index of Biotic Integrity	**77.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	0.87
Aluminum mg/L	0.115
Calcium mg/L	3.69
Iron mg/L	<0.0500
Magnesium mg/L	1.520
Hardness CaCO3	15.50
Chloride mg/L	19.40
pH	6.77
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.642
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	73.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

KEIPRN01

Location	Upstream of culvert pipes on Schochs Rd. in SGL		
Site #	2018-17	Date	4/17/2018
Stream Name	Keiper Run	Time	10:39 AM
Township	Tunkhannock	Latitude	41.05041667
Habitat Asmt.	186	Longitude	-75.532417

Field Measurements	
Temp C	3.5
pH	6.91
Press inHg	29.21
DO Percent	91.3
DO mg/L	12.12
Cond (uS/cm)	177

Macroinvertebrate Metrics	
Total Taxa	0
Shannon Diversity Index	
EPT Taxa Richness	
Hilsenhoff Biotic Index	
Intolerant individuals (%)	
Modified Becks Index	
Index of Biotic Integrity	

*High organic content in two samples allowed for decomposition and forced omission of those sample results.

Lab Chemistry Analysis	
Total Organic Carbon mg/L	4.62
Aluminum mg/L	0.563
Calcium mg/L	4.34
Iron mg/L	0.414
Magnesium mg/L	0.705
Hardness CaCO3	13.70
Chloride mg/L	40.90
pH	6.38
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.0984
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	126.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MARSCR06

Location	Upstream of Wood Dale Rd in Delaware State Forest		
Site #	2018-18	Date	4/19/2018
Stream Name	Marshalls Creek	Time	8:30 AM
Township	Middle Smithfield	Latitude	41.108667
Habitat Asmt.	208	Longitude	-75.156722

Field Measurements	
Temp C	6.0
pH	7.21
Press inHg	29.33
DO Percent	87.9
DO mg/L	10.94
Cond (uS/cm)	58

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	1.89
EPT Taxa Richness	12
Hilsenhoff Biotic Index	4.45
Intolerant individuals (%)	29.1
Modified Becks Index	27
Index of Biotic Integrity	**60.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.06
Aluminum mg/L	<0.100
Calcium mg/L	4.01
Iron mg/L	<0.0500
Magnesium mg/L	0.831
Hardness CaCO3	13.40
Chloride mg/L	7.02
pH	6.95
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	<0.0500
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	54.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MARSCR11

Location	Approximately 100 yards upstream of Newton Run and White Heron Lake		
Site #	2018-19	Date	4/19/2018
Stream Name	Marshalls Creek	Time	10:30 AM
Township	Middle Smithfield	Latitude	41.054250
Habitat Asmt.	195	Longitude	-75.136694

Field Measurements	
Temp C	6.2
pH	7.11
Press inHg	29.33
DO Percent	98.1
DO mg/L	12.15
Cond (uS/cm)	90

Macroinvertebrate Metrics	
Total Taxa	29
Shannon Diversity Index	2.71
EPT Taxa Richness	15
Hilsenhoff Biotic Index	2.67
Intolerant individuals (%)	63.9
Modified Becks Index	38
Index of Biotic Integrity	**80.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.30
Aluminum mg/L	<0.100
Calcium mg/L	6.52
Iron mg/L	<0.0500
Magnesium mg/L	1.400
Hardness CaCO3	22.00
Chloride mg/L	12.60
pH	6.84
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.197
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	57.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MARSCR18

Location	Immediatley Upstream from Post Office Road		
Site #	2018-20	Date	4/19/2018
Stream Name	Marshalls Creek	Time	10:00 AM
Township	Smithfield	Latitude	40.998722
Habitat Asmt.	174	Longitude	-75.139750

Field Measurements	
Temp C	7.1
pH	7.59
Press inHg	29.33
DO Percent	99.4
DO mg/L	12.04
Cond (uS/cm)	185

Macroinvertebrate Metrics	
Total Taxa	23
Shannon Diversity Index	1.72
EPT Taxa Richness	8
Hilsenhoff Biotic Index	2.52
Intolerant individuals (%)	68.9
Modified Becks Index	9
Index of Biotic Integrity	**70.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.68
Aluminum mg/L	<0.100
Calcium mg/L	16.50
Iron mg/L	0.0808
Magnesium mg/L	2.170
Hardness CaCO3	50.2
Chloride mg/L	25.80
pH	7.06
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.221
Alkalinity to pH 4.5 mg CaCO3/L	32.0
Total Dissolved Solids mg/L	116
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MCMICR22

Location	Upstream of McIlhaney Rd.		
Site #	2018-21	Date	4/24/2018
Stream Name	McMichael Creek	Time	12:00 PM
Township	Chestnuthill	Latitude	40.930667
Habitat Asmt.	207	Longitude	-75.36383333

Field Measurements	
Temp C	10.7
pH	7.16
Press inHg	29.92
DO Percent	104.8
DO mg/L	11.63
Cond (uS/cm)	76

Macroinvertebrate Metrics	
Total Taxa	34
Shannon Diversity Index	2.96
EPT Taxa Richness	20
Hilsenhoff Biotic Index	2.68
Intolerant individuals (%)	73.3
Modified Becks Index	37
Index of Biotic Integrity	**95.7**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	0.95
Aluminum mg/L	<0.100
Calcium mg/L	4.27
Iron mg/L	0.0561
Magnesium mg/L	1.710
Hardness CaCO3	17.70
Chloride mg/L	13.1
pH	6.97
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.415
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	69.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MCMICR37

Location	Hickory Valley Park		
Site #	2018-22	Date	4/24/2018
Stream Name	McMichael Creek	Time	12:56 PM
Township	Stroud	Latitude	40.962111
Habitat Asmt.	160	Longitude	-75.236500

Field Measurements	
Temp C	11.4
pH	7.89
Press inHg	29.92
DO Percent	115.3
DO mg/L	12.59
Cond (uS/cm)	149

Macroinvertebrate Metrics	
Total Taxa	18
Shannon Diversity Index	1.78
EPT Taxa Richness	8
Hilsenhoff Biotic Index	3.95
Intolerant individuals (%)	42.3
Modified Becks Index	11
Index of Biotic Integrity	**52.10**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.48
Aluminum mg/L	<0.100
Calcium mg/L	11
Iron mg/L	0.0573
Magnesium mg/L	2.270
Hardness CaCO3	36.80
Chloride mg/L	23.80
pH	7.63
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.45
Alkalinity to pH 4.5 mg CaCO3/L	28.0
Total Dissolved Solids mg/L	110.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MCMICR10

Location	Upstream of confluence with Brodhead		
Site #	2018-23	Date	4/24/2018
Stream Name	McMichael Creek	Time	01:45 PM
Township	East Stroudsburg Borough	Latitude	40.988194
Habitat Asmt.	144	Longitude	-75.184778

Field Measurements	
Temp C	12.2
pH	7.84
Press inHg	29.92
DO Percent	105.5
DO mg/L	11.32
Cond (uS/cm)	266

Macroinvertebrate Metrics	
Total Taxa	21
Shannon Diversity Index	2.29
EPT Taxa Richness	10
Hilsenhoff Biotic Index	4.24
Intolerant individuals (%)	28.7
Modified Becks Index	17
Index of Biotic Integrity	**68.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	
Aluminum mg/L	
Calcium mg/L	
Iron mg/L	
Magnesium mg/L	
Hardness CaCO3	
Chloride mg/L	
pH	
Nitrogen as N mg/L	
Ammonia as N mg/L	
Total Kjeldahl N mg/L	
Nitrate as N mg/L	
Alkalinity to pH 4.5 mg CaCO3/L	
Total Dissolved Solids mg/L	
Phosphorus as P mg/L	
Biochemical Oxygen Demand mg/L	

*Labeling issues with three water samples caused those chemistry results to be omitted from the report.

MIDDCR04

Location	Polk Township Open Space Property at the pavilion		
Site #	2018-24	Date	4/17/2018
Stream Name	Middle Creek	Time	09:03 AM
Township	Polk	Latitude	40.906139
Habitat Asmt.	185	Longitude	-75.497056

Field Measurements	
Temp C	6.1
pH	7.28
Press inHg	29.21
DO Percent	97.9
DO mg/L	12.13
Cond (uS/cm)	86

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.45
EPT Taxa Richness	14
Hilsenhoff Biotic Index	3.75
Intolerant individuals (%)	41.5
Modified Becks Index	29
Index of Biotic Integrity	**72.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.46
Aluminum mg/L	0.201
Calcium mg/L	5.30
Iron mg/L	0.27
Magnesium mg/L	1.890
Hardness CaCO3	21.00
Chloride mg/L	13.00
pH	6.83
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.904
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	35.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

MILLCR03

Location	Mill Creek Road on Natural Lands Trust property		
Site #	2018-25	Date	4/18/2018
Stream Name	Mill Creek Creek	Time	10:09 AM
Township	Barrett	Latitude	41.163167
Habitat Asmt.	197	Longitude	-75.251556

Field Measurements	
Temp C	5.0
pH	7.9
Press inHg	29.33
DO Percent	96.4
DO mg/L	12.31
Cond (uS/cm)	73

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.62
EPT Taxa Richness	14
Hilsenhoff Biotic Index	2.80
Intolerant individuals (%)	60.1
Modified Becks Index	32
Index of Biotic Integrity	**80.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.08
Aluminum mg/L	<0.100
Calcium mg/L	3.83
Iron mg/L	0.139
Magnesium mg/L	0.963
Hardness CaCO3	13.50
Chloride mg/L	12.60
pH	7.04
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.164
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	167.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

PARACR08

Location	Upstream of Brodhead confluence		
Site #	2018-26	Date	4/23/2018
Stream Name	Paradise Creek	Time	10:45 AM
Township	Stroud	Latitude	41.066500
Habitat Asmt.	188	Longitude	-75.221333

Field Measurements	
Temp C	8.0
pH	7.44
Press inHg	30.03
DO Percent	103.8
DO mg/L	12.28
Cond (uS/cm)	204

Macroinvertebrate Metrics	
Total Taxa	21
Shannon Diversity Index	2.41
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.46
Intolerant individuals (%)	57.1
Modified Becks Index	23
Index of Biotic Integrity	**86.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.46
Aluminum mg/L	<0.100
Calcium mg/L	8.75
Iron mg/L	<0.0500
Magnesium mg/L	2.420
Hardness CaCO3	31.80
Chloride mg/L	45.00
pH	7.42
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.385
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	90.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

POCOCR01

Location	Approximately 250 yards downstream of Wilke Road, east of Wilkie Road.		
Site #	2018-27	Date	4/24/2018
Stream Name	Pocono Creek	Time	10:20 AM
Township	Pocono	Latitude	41.059028
Habitat Asmt.	197	Longitude	-75.349028

Field Measurements	
Temp C	7.8
pH	7.10
Press inHg	29.92
DO Percent	103.8
DO mg/L	11.77
Cond (uS/cm)	140

Macroinvertebrate Metrics	
Total Taxa	27
Shannon Diversity Index	2.47
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.60
Intolerant individuals (%)	58.8
Modified Becks Index	33
Index of Biotic Integrity	**80.7**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.65
Aluminum mg/L	<0.100
Calcium mg/L	4.27
Iron mg/L	0.0693
Magnesium mg/L	1.120
Hardness CaCO3	15.30
Chloride mg/L	32.10
pH	7.4
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.111
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	28.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

POCOCR09

Location	Upstream of Old Mill Rd. on Pocono Heritage Land Trust property		
Site #	2018-28	Date	4/24/2018
Stream Name	Pocono Creek	Time	11:07 AM
Township	Pocono	Latitude	41.039222
Habitat Asmt.	187	Longitude	-75.309778

Field Measurements	
Temp C	9.2
pH	7.47
Press inHg	29.92
DO Percent	104.1
DO mg/L	11.98
Cond (uS/cm)	221

Macroinvertebrate Metrics	
Total Taxa	23
Shannon Diversity Index	2.55
EPT Taxa Richness	11
Hilsenhoff Biotic Index	3.76
Intolerant individuals (%)	43.5
Modified Becks Index	34
Index of Biotic Integrity	**72.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.35
Aluminum mg/L	<0.100
Calcium mg/L	8.54
Iron mg/L	<0.0500
Magnesium mg/L	2.330
Hardness CaCO3	30.90
Chloride mg/L	52.40
pH	6.98
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.276
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	89
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

POCOCR14

Location	Upstream of confuence with McMichael Creek		
Site #	2018-29	Date	4/24/2018
Stream Name	Pocono Creek	Time	01:16 PM
Township	Stroudsburg	Latitude	40.981194
Habitat Asmt.	166	Longitude	-75.196917

Field Measurements	
Temp C	12.4
pH	8.09
Press inHg	29.92
DO Percent	111.3
DO mg/L	11.9
Cond (uS/cm)	279

Macroinvertebrate Metrics	
Total Taxa	22
Shannon Diversity Index	2.37
EPT Taxa Richness	12
Hilsenhoff Biotic Index	3.87
Intolerant individuals (%)	32.5
Modified Becks Index	16
Index of Biotic Integrity	**73.1**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.06
Aluminum mg/L	<0.100
Calcium mg/L	13.50
Iron mg/L	<0.0500
Magnesium mg/L	3.010
Hardness CaCO3	46.20
Chloride mg/L	61.50
pH	7.6
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.324
Alkalinity to pH 4.5 mg CaCO3/L	28.0
Total Dissolved Solids mg/L	161.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

POHOCR01

Location	Southern end of Shiffer Property off Merwinsburg Road (near Burger Hollow Road)		
Site #	2018-30	Date	4/20/2018
Stream Name	Pohopoco Creek	Time	08:30 AM
Township	Pocono	Latitude	41.058944
Habitat Asmt.	195	Longitude	-75.348944

Field Measurements	
Temp C	5.4
pH	8.1
Press inHg	29.72
DO Percent	98.2
DO mg/L	12.39
Cond (uS/cm)	136

Macroinvertebrate Metrics	
Total Taxa	30
Shannon Diversity Index	2.94
EPT Taxa Richness	15
Hilsenhoff Biotic Index	2.79
Intolerant individuals (%)	53.9
Modified Becks Index	36
Index of Biotic Integrity	**86.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	
Aluminum mg/L	
Calcium mg/L	
Iron mg/L	
Magnesium mg/L	
Hardness CaCO3	
Chloride mg/L	
pH	
Nitrogen as N mg/L	
Ammonia as N mg/L	
Total Kjeldahl N mg/L	
Nitrate as N mg/L	
Alkalinity to pH 4.5 mg CaCO3/L	
Total Dissolved Solids mg/L	
Phosphorus as P mg/L	
Biochemical Oxygen Demand mg/L	

*Labeling issues with three water samples caused those chemistry results to be omitted from the report.

POHOCR29

Location	Near Whitey B. Drive on Polk Township Property		
Site #	2018-31	Date	4/20/2018
Stream Name	Pohopoco Creek	Time	09:00 AM
Township	Polk	Latitude	40.899556
Habitat Asmt.	184	Longitude	-75.506500

Field Measurements	
Temp C	5.4
pH	7.43
Press inHg	29.72
DO Percent	98.4
DO mg/L	12.48
Cond (uS/cm)	118

Macroinvertebrate Metrics	
Total Taxa	19
Shannon Diversity Index	2.19
EPT Taxa Richness	10
Hilsenhoff Biotic Index	3.30
Intolerant individuals (%)	49.5
Modified Becks Index	16
Index of Biotic Integrity	**74.0**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	
Aluminum mg/L	
Calcium mg/L	
Iron mg/L	
Magnesium mg/L	
Hardness CaCO3	
Chloride mg/L	
pH	
Nitrogen as N mg/L	
Ammonia as N mg/L	
Total Kjeldahl N mg/L	
Nitrate as N mg/L	
Alkalinity to pH 4.5 mg CaCO3/L	
Total Dissolved Solids mg/L	
Phosphorus as P mg/L	
Biochemical Oxygen Demand mg/L	

*Labeling issues with three water samples caused those chemistry results to be omitted from the report.

PONDCR04

Location	Immediatley downstream of Primrose Lane		
Site #	2018-32	Date	4/18/2018
Stream Name	Pond Creek	Time	08:23 AM
Township	Middle Smithfield	Latitude	41.056389
Habitat Asmt.	151	Longitude	-75.103306

Field Measurements	
Temp C	5.7
pH	7.66
Press inHg	29.33
DO Percent	81.2
DO mg/L	10.14
Cond (uS/cm)	210

Macroinvertebrate Metrics	
Total Taxa	15
Shannon Diversity Index	1.90
EPT Taxa Richness	4
Hilsenhoff Biotic Index	4.05
Intolerant individuals (%)	38.7
Modified Becks Index	3
Index of Biotic Integrity	**43.3**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.34
Aluminum mg/L	<0.100
Calcium mg/L	14.60
Iron mg/L	0.159
Magnesium mg/L	2.53
Hardness CaCO3	46.80
Chloride mg/L	35.30
pH	7
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.141
Alkalinity to pH 4.5 mg CaCO3/L	24.0
Total Dissolved Solids mg/L	144.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

SWIFCR10

Location	Immediately Downstream of Route 314 Bridge		
Site #	2018-33	Date	4/26/2018
Stream Name	Swiftwater Creek	Time	08:30 AM
Township	Pocono	Latitude	41.102056
Habitat Asmt.	202	Longitude	-75.346194

Field Measurements	
Temp C	9.4
pH	7.28
Press inHg	29.33
DO Percent	98.6
DO mg/L	11.27
Cond (uS/cm)	46

Macroinvertebrate Metrics	
Total Taxa	18
Shannon Diversity Index	1.99
EPT Taxa Richness	10
Hilsenhoff Biotic Index	5.20
Intolerant individuals (%)	11.5
Modified Becks Index	15
Index of Biotic Integrity	**48.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.88
Aluminum mg/L	<0.100
Calcium mg/L	9.59
Iron mg/L	0.0639
Magnesium mg/L	2.550
Hardness CaCO3	34.40
Chloride mg/L	72.00
pH	7.25
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.4
Alkalinity to pH 4.5 mg CaCO3/L	20.0
Total Dissolved Solids mg/L	163
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

TOBYCR01

Location	Upstream of Route 423 bridge in SGL. 127		
Site #	2018-34	Date	4/24/2018
Stream Name	Tobyhanna Creek	Time	08:30 AM
Township	Coolbaugh	Latitude	41.161944
Habitat Asmt.	205	Longitude	-75.455083

Field Measurements	
Temp C	8.3
pH	6.84
Press inHg	29.92
DO Percent	95.2
DO mg/L	11.20
Cond (uS/cm)	133

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.62
EPT Taxa Richness	11
Hilsenhoff Biotic Index	3.73
Intolerant individuals (%)	44.6
Modified Becks Index	17
Index of Biotic Integrity	**66.20**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	5.13
Aluminum mg/L	0.139
Calcium mg/L	4.96
Iron mg/L	0.102
Magnesium mg/L	1.060
Hardness CaCO3	16.80
Chloride mg/L	28.60
pH	7.2
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.179
Alkalinity to pH 4.5 mg CaCO3/L	32.0
Total Dissolved Solids mg/L	67.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

TOBYCR14

Location	Upstream of Route 115 bridge in Blakeslee		
Site #	2018-35	Date	4/23/2018
Stream Name	Tobyhanna Creek	Time	09:00 AM
Township	Tobyhanna	Latitude	41.082778
Habitat Asmt.	194	Longitude	-75.583389

Field Measurements	
Temp C	8.2
pH	6.64
Press inHg	30.03
DO Percent	95.7
DO mg/L	11.26
Cond (uS/cm)	138

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.39
EPT Taxa Richness	11
Hilsenhoff Biotic Index	4.41
Intolerant individuals (%)	36.0
Modified Becks Index	22
Index of Biotic Integrity	**74.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	5.91
Aluminum mg/L	0.193
Calcium mg/L	4.64
Iron mg/L	0.143
Magnesium mg/L	1.010
Hardness CaCO3	15.7
Chloride mg/L	31.80
pH	6.87
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.178
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	76.0
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

TUNKCR03

Location	Immediatley upstream of Route 115		
Site #	2018-36	Date	4/17/2018
Stream Name	Tunkhannock Creek	Time	11:16 AM
Township	Tunkhannock	Latitude	41.058944
Habitat Asmt.	208	Longitude	-75.553000

Field Measurements	
Temp C	3.5
pH	4.85
Press inHg	29.21
DO Percent	91.4
DO mg/L	12.13
Cond (uS/cm)	48

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.63
EPT Taxa Richness	13
Hilsenhoff Biotic Index	3.67
Intolerant individuals (%)	53.3
Modified Becks Index	23
Index of Biotic Integrity	**73**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	10.40
Aluminum mg/L	0.257
Calcium mg/L	1.64
Iron mg/L	0.325
Magnesium mg/L	0.553
Hardness CaCO3	6.38
Chloride mg/L	9.13
pH	5.2
Nitrogen as N mg/L	<1.00
Ammonia as N mg/L	<0.500
Total Kjeldahl N mg/L	<1.00
Nitrate as N mg/L	0.101
Alkalinity to pH 4.5 mg CaCO3/L	<20.0
Total Dissolved Solids mg/L	27
Phosphorus as P mg/L	<0.0500
Biochemical Oxygen Demand mg/L	<3.00

Conclusions and Recommendations

Macroinvertebrates

The potentially impaired sites where IBI Scores did not reach the recommended Aquatic Life Use Attainment Benchmarks are indicated below in the order of IBI scoring. High organic content in two samples allowed for decomposition and forced omission of those sample results.

43.3: (32) Pond Creek (Impaired)
48.2: (33) Swiftwater Creek (Impaired)
50.0: (1) Aquashicola Creek (Possibly Impaired)
52.1: (22) McMichael Creek
60.2: (18) Marshall's Creek
61.1: (12) Cherry Creek
No macroinvertebrates to be collected: (17) Keiper Run (Possibly Impaired)

Table 10. Illustrating IBI score trends since 2015:

Site #	Site Code	IBI 2018	IBI 2017	IBI 2016	IBI 2015
2018-32	PONDCR04	43.3	43.8	46.3	N/A
2018-33	SWIFCR10	48.2	90.6	83.2	75.8
2018-01	AQUACR14	50	59.7	61.2	60.8
2018-22	MCMICR37	52.1	78.6	76.2	21
2018-18	MARSCR06	60.2	70.2	N/A	N/A
2018-12	CHERCR06	61.1	64.4	56.6	67.2
2018-02	BUCKCR01	62.5	73.5	N/A	N/A
2018-17	KEIPRN01	0	0	N/A	84.2

Chemistry Analysis

Low Alkalinity throughout Monroe County

Most of the sites showed low alkalinity scores. Low alkalinity is not harmful to a stream. However, low alkalinity decreases the water's ability to buffer acids and protect the aquatic life against sudden changes in pH. These values are normal when considering the geology of Monroe County. Most of the streams that were studied in this report flow within areas of silica rich sandstone and quartzite conglomerates, as well as red and grey sandstone and shales. These rocks generally have low carbonate values which would be responsible for low surface and ground water alkalinity values. Cherry Creek, the lower half of Marshalls Creek, and the mouth of Brodhead Creek flow through carbonate rich shales and siltstones which may be the reason for higher alkalinity values when compared to the rest of the county.

The lowest DO measurement at site number 32, Pond Creek is attributed to its naturally reduced flow and elevated water temperatures.

Labeling issues with three water samples caused those chemistry results to be omitted from the report.

Recommendations

After reviewing the data from the 2018 Water Quality Study, the lead and cooperating agencies recommend the following:

- We plan to ensure consistent trend data for the attaining and exceptional/high quality streams which dominate Monroe County.
- Further inspection of habitat and water chemistry concerning the absence of macroinvertebrates from Keiper Run in both 2017 and 2018. Additional sampling of Keiper Run is planned for 2019 along with the possibility of additional chemistry analysis.
- Investigation into the IBI decline in the Swiftwater and McMichael Creeks, including additional sampling sites.
- Further monitoring of Aquashicola, Marshall's, Cherry, and Pond creeks focusing on creating trend data and/or implementing corrective measures for all impaired or possibly impaired streams.

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