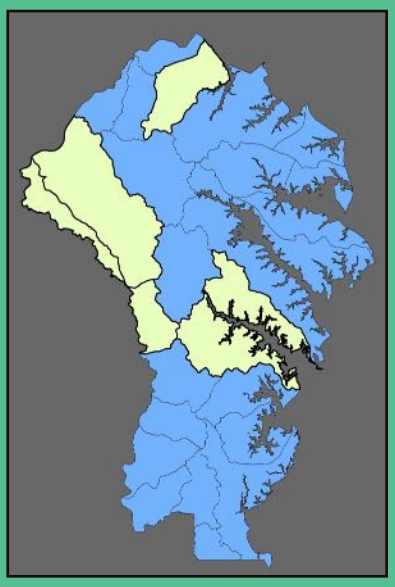

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2019

Anne Arundel County, Maryland
Department of Public Works
Watershed, Ecosystem, and Restoration Services

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2019
Round Three—Year Three

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Ecological Assessment Program

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Abstract

The Anne Arundel County Department of Public Works' Watershed Protection and Restoration Program assesses water resource quality using a comprehensive countywide Biological Monitoring and Assessment Program. The primary goals of the Program are to document and track the ecological health of County streams and watersheds, identify the primary stressors on ecological health, and support natural resource management decision-making as it relates to the intended uses of County waterbodies and State regulations. One intended use of all water bodies is the support of aquatic life. A stream's ability to support aquatic life is assessed for the entire County through probabilistic (random) site selection, surveying of biological communities, and observations of the physical habitat and water quality.

The County's assessment Program was continued in 2019 with sampling in five primary sampling units; Sawmill Creek, Lower North River, Upper Patuxent, Little Patuxent, and Middle Patuxent. Sampling consisted of a 50/50 split between newly selected random sites, and repeat sites from Round One and Round Two. The indicators used to assess the aquatic life and habitat in Anne Arundel County streams include the Maryland Biological Stream Survey (MBSS) Benthic Index of Biological Integrity (BIBI), Fish Index of Biotic Integrity (FIBI), the USEPA Rapid Bioassessment Protocol (RBP) physical habitat assessment, the MBSS Physical Habitat Index (PHI), five physio-chemical water quality measures (temperature, dissolved oxygen, specific conductance, pH, and turbidity), seventeen water quality parameters measured from grab sample, as well as a detailed geomorphic assessment and classification using methods developed by Rosgen (1996).

Each of the biological and physical habitat indicators was compared to established thresholds to determine narrative condition ratings. All five sampling units had mean BIBI values that resulted in 'Poor' biological condition ratings. Four of the five sampling units had mean FIBI values that resulted in 'Poor' biological condition ratings, and one sampling unit had a mean FIBI value that resulted in 'Fair' rating. Three of the five sampling units had mean physical habitat conditions rated as 'Partially Supporting' by the RBP method from spring sampling, while the remaining two a mean rating of 'Supporting'. Using the PHI from summer sampling, four sampling units had 'Partially Degraded' mean physical habitat conditions, and the remaining sampling unit had a mean habitat condition of 'Degraded'.

There was high variability in stream types throughout the sampling units in 2019. The largest portion of the sites were E and G type channels at 22.5% and 20%, respectively. Approximately 17.5% of the sites were classified as F type channels. Water quality measurements exceeded COMAR standards for acute turbidity exposure (i.e., <150 NTU) at one site in the spring in the Little Patuxent River sampling unit and at one site in the summer in the Upper Patuxent River sampling unit. Low pH values, which were below the acceptable range of values set forth by COMAR (i.e., 6.5-8.5 SU), were recorded at 14 sites spanning three of the five sampling units in the spring and at 20 sites spanning all sampling units in the summer. For dissolved oxygen, 12 of 40 sites in the summer had measured DO concentrations below the 5.0 mg/L standard. Fifteen of 40 sites in the spring and 15 sites in the summer had specific conductance values that exceeded 247 µS/cm threshold of BIBI impairment developed from MBSS data. All streams were within their designated criteria (Use I) for temperature in 2019 (i.e., <32 °C).

On average, BIBI scores improved in Sawmill Creek from Round 1 to Round 3, and remained the same in all other sampling units from Round Two to Round Three. Physical habitat comparisons between Round One and Three showed a significant decrease in the both the mean RBP score and PHI score in the Middle Patuxent and a significant increase in the PHI score in Sawmill Creek. Upper Patuxent showed a significant decrease in PHI scores between sampling Rounds Two and Three. No significant differences in for RBP scores were observed between sampling Round Two and Round Three.

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1 Introduction

Anne Arundel County, Maryland is bordered on the north by the Patapsco River, to the west by the Patuxent River, and to the east by the Chesapeake Bay. Anne Arundel County has approximately 1,500 miles of streams and rivers within its borders, all of which drain either directly or indirectly into the Chesapeake Bay. With a drainage area of 64,000 square miles, the Chesapeake Bay is the largest estuary in the United States (USEPA, 2004). The Chesapeake Bay provides habitat for many animal and plant species and is an important economic and recreational resource for more than 15 million people who live in the drainage basin. Increasing human population and development in the basin are intensifying point and nonpoint sources of pollutants and multiple other stressors that affect environmental conditions.

In order to protect these important resources and inform management decisions – not only for the streams and rivers of the County but ultimately for the Chesapeake Bay – basic information regarding overall conditions must be understood. To more fully assess the condition of its watershed and stream resources, a Countywide Biological Monitoring and Assessment Program (Program) was initiated in the spring of 2004 by the Anne Arundel County Office of Environmental and Cultural Resources (now the Watershed Protection and Restoration Program of the Department of Public Works). The sampling program involves monitoring the biological health and physical condition of the County's water resources to assess the status and trends at the stream level, the watershed level, and ultimately at the County level.

The County initiated the Program, in part, to establish a baseline ecological stream condition for all of the County's watersheds and to track changes in condition over time. The Program is designed on a five-year rotating basis such that each of the County's 24 watersheds or primary sampling units (PSU) will be sampled once every five years. In general, four to five PSUs are sampled each year. During Rounds 1 and 2, 10 sites were sampled in each PSU. However, beginning in Round Three the sampling approach was revised to allow for sampling eight sites per PSU. Table 1 illustrates the progress made to date within the Program. The first sampling rotation, Round One, was completed from 2004-2008, while Round Two was completed from 2009-2013. Sampling efforts in 2019 mark the third year of Round Three sampling with 40 randomly selected sites sampled throughout five sampling units (i.e., 8 per PSU).

Prior to the start of Round Three, the County commissioned a review of the Program which was completed in 2016 (Southland et al, 2016). Based on this review the County added several new sampling components to the Program. These new components of the Program were collected for the first time in 2017 and will continue through the completion of Round Three. A water quality grab sample is now collected at each of the sites and is analyzed for nutrients, sediment, metals, and other parameters. A complete discussion of the water quality grab sample methods is available in section 2.2.4. To complement the benthic macroinvertebrate community data and Benthic Index of Biotic Integrity (BIBI) collected by the Program, a fish community assessment was added to each site to allow for the calculation of the Fish Index of Biotic Integrity (FIBI). The fish sampling follows closely the two-pass electrofishing method developed by the MBSS and is explained in detail in section 2.2.3. Each site is now visited two times, once in the spring and once in the summer. The addition of the second visit during the summer allows for collection of an additional set of habitat data. The Rapid Bioassessment Protocol (RBP) and MBSS Physical Habitat Index (PHI) habitat assessments are now collected a second time during the summer visit. Both the RBP and PHI habitat assessments are described in detail in section 2.2.1. For the purpose of this annual monitoring summary report, the BIBI data are compared with the spring-collected RBP habitat assessment and the FIBI data are compared with the summer-collected PHI habitat assessment.

Table 1 - Summary of Bioassessment Progress

Year	Number of Sites	Primary Sampling Unit (code and name)		
Round 1				
2004	50	03-Lower Patapsco 09-Severn Run	10-Severn River 18-Middle Patuxent	21-Ferry Branch
2005	50	11-Upper North River 12-Lower North River	15-Herring Bay 19-Stocketts Run	22-Lyons Creek
2006	40	05-Marley Creek 06-Bodkin Creek	07-Upper Magothy 24-Hall Creek	
2007	50	01-Piney Run 02-Stony Run	08-Lower Magothy 16-Upper Patuxent	17-Little Patuxent
2008	50	04-Sawmill Creek 13-Rhode River	14-West River 20-Rock Branch	23-Cabin Branch
Round 2				
2009	50	05-Marley Creek 12-Lower North River	14-West River 17-Little Patuxent	20-Rock Branch
2010	50	02-Stony Run 04-Sawmill Creek	15-Herring Bay 18-Middle Patuxent	21-Ferry Branch
2011	50	06-Bodkin Creek 07-Upper Magothy	09-Severn Run 11-Upper North River	16-Upper Patuxent
2012	40	01-Piney Run 03-Lower Patapsco	13-Rhode River 24-Hall Creek	
2013	50	08-Lower Magothy 10-Severn River	19-Stocketts Run 22-Lyons Creek	23-Cabin Branch
Round 3				
2017	40	06-Bodkin Creek 09-Severn Run	10-Severn River 11-Upper North River	13-Rhode River
2018	40	01-Piney Run 03-Lower Patapsco River	05-Marley Creek 08-Lower Magothy River	19-Stocketts Run
2019	40	04-Sawmill Creek 17-Little Patuxent	12-Lower North River 18-Middle Patuxent	16-Upper Patuxent

1.1 Purpose of Biological and Physical Habitat Assessment

The use of benthic macroinvertebrates as the basis of biological assessments offers many considerable advantages over other biological assemblages (e.g., fish, periphyton, herpetofauna). For instance, benthic macroinvertebrates are relatively sedentary and easy to sample in large numbers, they respond to cumulative effects of physical habitat alteration, point source pollution, and nonpoint source contaminants, and different aspects of the benthic assemblage change in response to degraded conditions (Barbour et al. 1999).

As detailed in the Round 3 Program design update (Southerland et al., 2016), since fish communities respond to different environmental stressors compared to benthic macroinvertebrates, the addition of fish as a biological parameter provides a more complete picture of stream health. Fish sampling provides data on stream habitat connectivity and barriers, invasive species, recreational fisheries, and migratory species.

Physical habitat is also visually assessed at each sampling location to reflect current conditions of physical complexity of the stream channel, the capacity of the stream to support a healthy biota, and the potential of the channel to maintain normal rates of erosion and other hydrogeomorphic functions. Physical habitat of the stream channel can be affected by farming operations, increased housing density, and other urban-

suburban developments; all of which may cause sedimentation, degradation of riparian vegetation, and bank instability, leading to reduced overall habitat quality (Richards et al. 1996).

Geomorphic assessments are performed to obtain quantitative information regarding the stream's morphology. The morphological characteristics of a stream channel can provide insight into the impacts of past and present land use on stream stability and/or erosion potential, which can influence the resident biota.

Physicochemical parameters are measured *In situ* and while water quality grab samples are collected for laboratory analysis at every site to supplement biological and physical data. Physicochemical parameter data provide some basic water quality condition information and ensure that extreme water quality conditions are not present during biological sample collection. Water chemistry grab sample data provides a general indication of the chemical constituents of a waterbody and may indicate the presence of water quality stressors.

The combined use of biological, physical, and chemical data is beneficial for detecting impairment and providing insight into the potential types of stressors and stressor sources. This allows prioritization of more detailed, diagnostic investigations based on the severity of observed biological responses.

2 Methods

2.1 Network Design

2.1.1 Summary of Sampling Design

The sampling design uses a stratified random sampling approach, stratified by stream order. Details of the overall sampling program design, including the approach for the selection of sampling locations, can be found in Design of the Biological Monitoring and Assessment Program for Anne Arundel County, Maryland (Southerland et al, 2016; Hill and Stribling, 2004). Stream assessment protocols including documented standard operating procedures (SOPs) for data collection, sample processing, taxonomic identification, and data management, the technical rationale behind the procedures, and the series of activities and reporting procedures that are used to document and communicate data quality are included in Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (QAPP) (Anne Arundel County, 2017). Documentation of data quality and method performance characteristics, including measurement and data quality objectives (MQOs and DQOs), are presented in Hill and Pieper (2011a).

2.1.2 Site Selection

The County was separated into 24 primary sampling units (PSUs) in which sites are randomly selected for sampling based on stream order stratification. In this approach, the number of sampling sites within each of the first through third order channel types, as defined by Strahler (1957), was proportional to the percentage of the total PSU stream length that each type comprised. The National Hydrologic Dataset (NHD) 1:100,000-scale stream layer was used in the selection. Four to five PSUs are sampled each year, so that all sampling units are assessed over a five-year period.

For 2019, sites were randomly selected from each of the following PSUs (with PSU code); Sawmill Creek (04), Lower North River (12), Upper Patuxent (16), Little Patuxent (17), and Middle Patuxent (18). Figure 1 shows the geographic distribution of PSUs assessed during this sampling period. Sampling was

conducted at eight sites in each of the five PSUs during 2019. A single site within each PSU was selected to conduct duplicate sampling for quality assurance/quality control (QA/QC) purposes. Duplicate sampling reaches, or QC sites, were located immediately upstream of their paired sampling sites, and were first selected in the office and then reviewed in the field to ensure that they had similar habitat characteristics and were not impacted by road crossings, confluences, or other unique stressors not present at the original sampling reach. Habitat assessments, biological sampling, and water quality measurements were repeated at the duplicate sites.

Sites were located in the field using a Trimble R1 GNSS GPS unit coupled with a Microsoft Surface tablet running ESRI's ArcPad mapping software and loaded with recent (2016), high-resolution aerial orthophotography layers and the same NHD stream layer that was used in the site selection process to ensure that the appropriate stream reach was sampled and surveyed. Since the targeted stream layer is based on coarse 1:100,000-scale mapping, pre-selected site coordinates are often several meters away from the actual stream channels. Consequently, the position of the reach mid-point was collected with a Trimble® GPS unit capable of sub-meter accuracy to ensure accurate final positioning of sampling locations. GPS data were recorded in the Maryland State Plane, NAD 1983 Feet coordinate system. The procedures performed at each site are described in detail in Section 2.2.

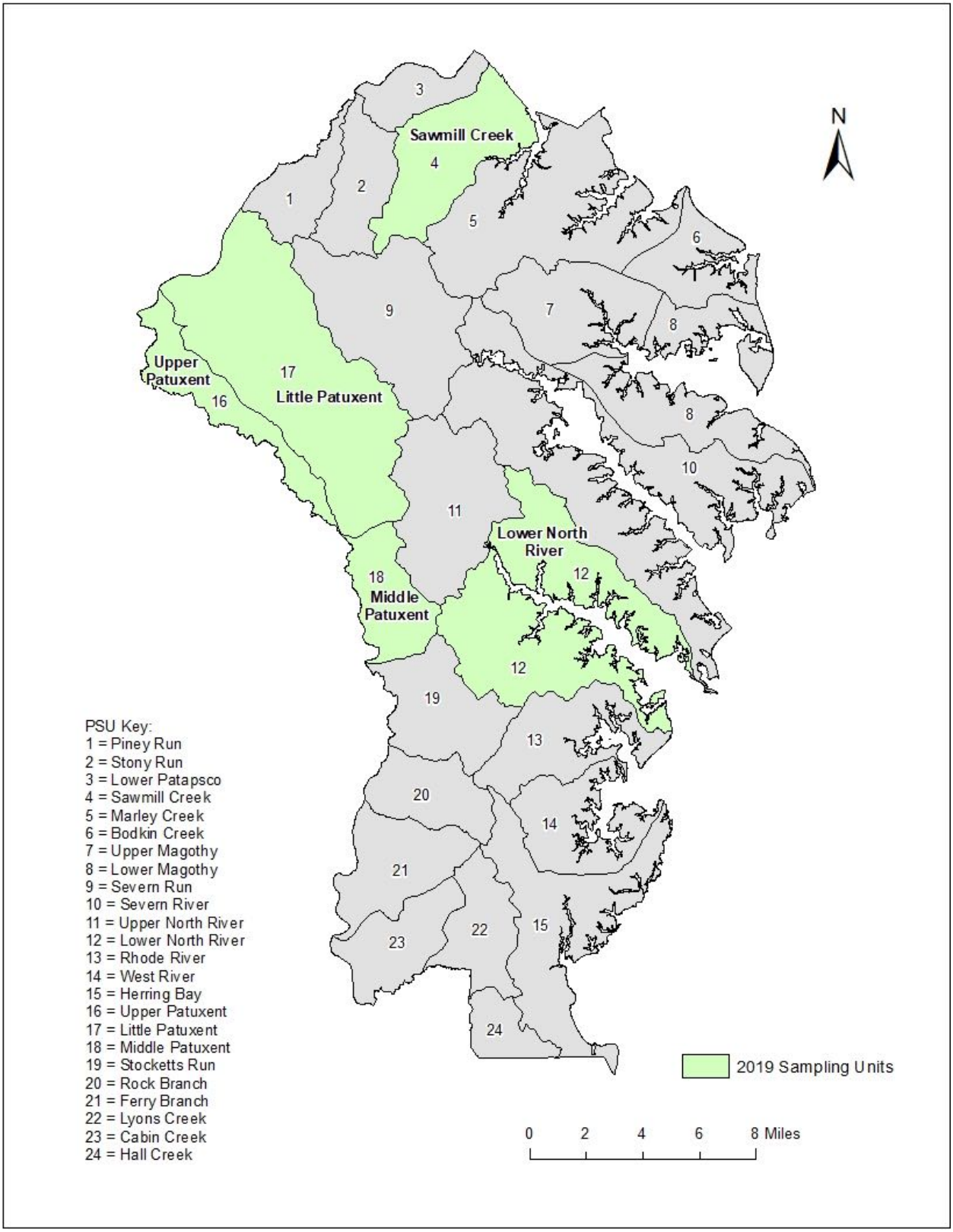

Figure 1 - 2019 Sampling Units

2.2 Field and Laboratory Procedures

2.2.1 Stream Physical Habitat Assessment

Each biological monitoring site was characterized based on visual observation of physical characteristics and various habitat parameters. Both the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2003) were used to visually assess the physical habitat at each site. Both physical habitat assessment methods were completed during the Spring and Summer assessments. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photo-documentation of the assessment reach was performed. Photographs were taken from three locations within the sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction to document general reach conditions. Four additional photographs were taken at the cross-section location facing in the upstream, downstream, left bank, and right bank directions, documenting the channel conditions at the cross-section for a total of ten photographs per site. Additional photographs were occasionally taken to document important or unusual site features.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of 'Optimal', 'Suboptimal', 'Marginal', or 'Poor'. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for low gradient streams are listed in Table 2.

Table 2 - RBP Low Gradient Habitat Parameters

Parameters Assessed	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetation zone width

Source: Barbour et al. 1999

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont, and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for the Coastal Plain streams (Table 3). Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count).

Table 3 - PHI Habitat Parameters

Parameters Assessed	
Remoteness	Instream habitat
Shading	Woody debris and rootwads
Epifaunal substrate	Bank stability

Source: Paul et al. 2003

2.2.2 Benthic Macroinvertebrate Sampling and Processing

Benthic macroinvertebrate samples were collected during the Spring Index Period (March 1 through April 30) following the sampling protocols in the QAPP, which closely mirrors MBSS procedures (Stranko et al. 2017). The approach was used to sample a range of the most productive habitat types within the reach. In this multi-habitat sampling approach, a total of twenty jabs sampling approximately 1 square foot of habitat per jab are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their dominance within the segment using a D-frame net. The most productive stream habitats are riffles followed by, rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Less preferred habitats include gravel, broken peat, and clay lumps located within moving water and detrital or sand areas in runs.

All sorting and identification of the subsampled specimens was conducted by EcoAnalysts, Inc., which currently holds certification for laboratory sorting by the MBSS and employs taxonomists who hold taxonomic identification certification from the Society for Freshwater Science. Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and based on the methods described in Boward and Friedman (2011). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample is spread evenly across a gridded tray (100 total grids) and each grid is picked clean of organisms until a count of 100 to 120 is reached. If there were any samples containing greater than 120 organisms after taxonomic identification and enumeration, a post-processing subsampling procedure was conducted using an Excel spreadsheet application (Tetra Tech, 2006). This post-processing application is designed to randomly subsample all identified organisms within a given sample to a desired target number. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20%) but keeps the total number of individuals below the 120 maximum set in the County QAPP.

Taxa were primarily identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematoda was left at phylum. Individuals of early instars or those that may be damaged were identified to the lowest possible level. Most taxa were identified using a stereoscope. Temporary slide mounts were used to identify Oligochaeta to family with a compound scope. Chironomidae identification was conducted using temporary slide wet mounts. Permanent slide mounts were used for Chironomidae for specimens in samples selected for secondary lab re-identification for quality control checks. Results were logged on a bench sheet and entered into a spreadsheet for data analysis.

During the Spring Index Period, the crew searched for vernal pools in the 50-meter wide buffer zone (each side) perpendicular to the 75-meter study reach. Vernal pools are defined by MBSS as “small, temporary bodies of water that provide vitally important habitat for many amphibians and aquatic invertebrates”, typically being less than one acre (as small as one square meter) and not directly connected to a flowing stream. If encountered, information on the location and size of vernal pools as well as fish or amphibian species found in or immediately adjacent to the pool were recorded for each site.

2.2.3 Fish Sampling

The fish community was sampled at each of the 40 sites during the Summer Index Period, June 1 through September 30, according to methods described in Maryland Biological Stream Survey: Round Four Field Sampling Manual (Stranko et al. 2017). In general, the approach uses two-pass electrofishing of the entire 75-meter study reach. Block nets were placed at the upstream and downstream ends of the reach, as well as at tributaries or outfall channels, to obstruct fish movement into or out of the study reach. Two passes were completed along the reach to ensure the segment was adequately sampled. The time in seconds for each pass was recorded and the level of effort for each pass was similar. Captured fish were identified to species and enumerated following MBSS protocols (Stranko et al. 2017) by crew members holding MBSS certification in fish taxonomy. A total fish biomass for each electrofishing pass was measured. Unusual anomalies such as fin erosion, tumors, etc. were recorded. Photographic vouchers were taken in lieu of physical voucher specimens.

Herpetofauna (i.e., reptiles and amphibians) were surveyed at each site using methods following MBSS protocols (Stranko et al. 2017). A search of likely herpetofauna habitats was performed during both spring and summer visits at each site sampled. An intensive stream salamander survey was not performed. All collected individuals were identified to species level and released. Photographic vouchers were collected if a specimen could not be positively identified in the field. Herpetofauna data collection occurs primarily to assist MBSS with supplementing their inventory of biodiversity in Maryland's streams. Currently, MBSS has not developed any indexes of biotic integrity for herpetofauna, and therefore, they were not used to evaluate the biological integrity of sampling sites throughout this study. Rather, the data are provided to help document existing conditions.

Each site was surveyed for crayfish using MBSS protocols (Stranko et al. 2017). All crayfish observed while electrofishing were captured and retained until the end of each electrofishing pass. Captured crayfish were identified to species and counted before release back into the stream outside of the 75-meter sampling reach. Any crayfish encountered outside of the electrofishing effort were identified and noted on the datasheet as an incidental observation. Any crayfish burrows observed in and around the sampling site were excavated and an attempt made to capture the burrowing crayfish.

A survey of freshwater mussels was conducted at each site using MBSS protocols (Stranko et al. 2017). Any live individuals encountered were identified, photographed, and then returned back to the stream as closely as possible to where they were collected. Any dead shells encountered were retained as voucher specimens.

A survey of invasive plants was performed at each site during the Summer Index Period following MBSS protocols (Stranko et al. 2017). The common name and relative abundance of invasive plants (i.e., present or extensive) within view of the study reach and within the 5-meter riparian vegetative zone parallel the stream channel were recorded. Invasive plant data collection occurs to assist MBSS with supplementing their inventory of biodiversity. The data are provided to help document existing conditions at each site.

2.2.4 Water Quality Sampling

Water quality grab samples for laboratory analysis were collected at each site during the spring sampling visit following the sampling protocols in the QAPP, which closely mirrors MBSS procedures (Stranko et al. 2017). Samples were collected in triple-rinsed bottles from a suitable location along the thalweg with sufficient depth to submerge the bottle without disturbing the bottom sediments. Bottles were labeled

prior to sampling with sample ID, date, time, and parameters for analysis. Samples were preserved on ice immediately after collection and transported to the lab within 48 hours. In addition, a duplicate sample was collected from each PSU for quality assurance purposes. All grab samples were analyzed by UMCES – Appalachian Laboratory. The laboratory methods are consistent with Analytical Laboratory Standard Operating Procedures for the Maryland Biological Stream Survey (Kline and Morgan, 2006). A complete list of analytical parameters and methods, including method detection limits, is presented in Table 4 below.

Table 4 - Water Quality Parameters

Parameter	Method Detection Limit*	Method Number
Turbidity	0.1 NTU	APHA 2130B
Total Nitrogen	0.022	APHA 4500-N C
Total Phosphorus	0.004	APHA 4500-P H
Ammonia-N	0.003	USGS (1993) NWQL I-2525
TKN (calculated)	0.022	NA
Nitrate-Nitrogen	0.050	APHA 4500-NO3 E
Nitrite-Nitrogen	0.002	APHA 4500-NO2 B
Dissolved Organic Carbon	0.067	APHA 5310 C
Orthophosphate	0.003	APHA 4500-P G
Total Organic Carbon	0.067	APHA 5310 C
Total Copper	0.008 µg/L	APHA 3125
Total Lead	0.006 µg/L	APHA 3125
Total Zinc	0.078 µg/L	APHA 3125
Chloride	0.003	APHA 4110B
Total Hardness	0.78	APHA 2340B

*All values in mg/L, except as noted.

To supplement the water quality grab sampling, *in situ* physicochemical water quality measurements (i.e., temperature, pH, specific conductivity, dissolved oxygen, and turbidity) were taken at each site during both the spring and summer sampling visits. All measurements were collected from the upstream end of the site, prior to any other sampling activities to ensure that measurements were not influenced by sampling activities within the stream and were measured with either a YSI ProDSS or a YSI Professional Plus series multiparameter meter. At some sites, however, turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters were regularly inspected, maintained, and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

2.2.5 Geomorphic Assessment

Geomorphic assessments, which included a cross-section survey, a simplified longitudinal profile survey for measurement of channel slope, and a modified Wolman pebble count, were conducted within each 75-meter sampling reach. Data were directly entered into the Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006) in the field using a computer loaded with Microsoft Excel software. Data collected from the assessments were primarily used to determine the morphological stream type of each sampling reach according to the Rosgen Stream Classification (Rosgen, 1994, 1996). Assessment methods followed the standard operating procedures (SOPs) described in the QAPP, and are described briefly below.

Permanent cross-sections were established on a representative cross-over reach, typically in a riffle feature, and monumented with iron reinforcement bars topped with yellow plastic survey marker caps. The location of each monument was recorded using a Trimble Pathfinder ProXT GPS unit capable of sub-meter accuracy. Cross-sections were surveyed using a laser level, calibrated stadia rod, and measuring tape. The surveys captured features of the floodplain, monuments, and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point and instream depositional features
- Thalweg
- Floodprone elevation

Bankfull elevation was determined in the field using appropriate bankfull indicators as described in Rosgen (1996) and with the assistance of the Maryland Coastal Plain (MCP) regional relationships of bankfull channel geometry (McCandless, 2003). Using the drainage areas delineated to each monitoring location, as described in section 2.3.6 *Land Use Analysis and Impervious Surface*, the approximate bankfull cross-sectional areas were derived from the MCP curve, and field crews verified bankfull elevations while in the field.

Sinuosity was determined based on the length of the survey reach following the thalweg thread (i.e., 75-meters) and the straight-line distance between the upstream and downstream extent of the channel. If the stream was not incised, the floodprone width was measured at the cross-section using an elevation of two times the bankfull depth.

Survey points were taken near the upstream, midpoint, and downstream end of the sampling reach to obtain the water surface slope and elevation of the bankfull discharge. Survey points for slope calculations were typically taken at top of riffle features, although this was not always possible due to available instream features. In the absence of riffle features, the best available feature (e.g., run, glide) was used ensuring that the same bed feature was used in the upstream and downstream extents of the reach.

Bed materials were characterized in each reach using a proportional pebble count procedure adapted from Harrelson et al. (1994), which stratifies the reach by the proportion of pool, riffle, run, and glide features within the entire reach. The pebble count technique, modified from Wolman (1954), was conducted at each site to determine the composition of channel materials and the median particle size (i.e., D_{50}) within each survey reach. The pebble count was conducted at 10 transects positioned throughout the entire reach based on the proportion of bed features, and 10 particles (spaced as evenly as possible) were measured across the bankfull channel of each transect, resulting in a total of 100 particles. Particles were chosen without visual bias by reaching forth with an extended finger into the stream bed while looking away and choosing the first particle that comes in contact with the sampler's finger. All particles are then measured to the nearest millimeter across the intermediate axis using a ruler. For channels comprised entirely of fine sediments (e.g., sand, silt, or clay) with no distinct variation in material size, only two transects were performed and the results were extrapolated to the reach.

2.3 Data Analysis

2.3.1 Data Structure

Physical habitat, benthic macroinvertebrate, fish, water chemistry, geomorphic, land cover, land use, and impervious data were entered into an ESRI personal geodatabase. This relational database allows for the input and management of field collected data including physical habitat and water chemistry parameters, as well as taxonomic data, calculated metric and index scores, geomorphic and land use parameters, and other metadata. Furthermore, the data are geospatially linked to each site and drainage area for enhanced mapping and spatial analysis capabilities. Physical habitat index (RBP and PHI) scores, benthic macroinvertebrate index (BIBI) scores, and fish index (FIBI) scores were calculated using controlled and verified Microsoft Excel spreadsheets. Final index values and scores for each site were imported into the geodatabase.

2.3.2 Physical Habitat

The individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. The total score was then placed into one of four categories based on their percent comparability to reference conditions (Table 5). Since adequate reference condition scores do not currently exist for Anne Arundel County, the categories used in this report were adapted from Plafkin et al. (1989) and are based on western Coastal Plain reference conditions obtained from Prince George's County streams using a maximum score of 168 (Stribling et al., 1999).

Using the raw habitat values recorded in the field, a scaled PHI score (ranging from 0-100) for each parameter is calculated following the methods described in Paul et al. (2003). Several of the parameters (i.e., epifaunal substrate, instream habitat, and woody debris and rootwads) have been found to be drainage area dependent and are scaled according to the drainage area to each site. A detailed description of the procedure used to delineate site-specific drainage areas is included in section 2.3.7 *Land Use Analysis and Impervious Surface*. Calculated metric scores are then averaged to obtain the overall PHI index score, and a corresponding narrative rating of the physical habitat condition is applied (Table 6).

Table 5 - EPA RBP Scoring

Score	Narrative
151 +	Comparable
126-150	Supporting
101-125	Partially Supporting
0-100	Non Supporting

Source: Stribling et al. 1999

Table 6 - MBSS PHI Scoring

Score	Narrative
81-100	Minimally Degraded
66-80.9	Partially Degraded
51-65.9	Degraded
0-50.9	Severely Degraded

Source: Paul et al. 2003

2.3.3 Biological Index Rating

Benthic macroinvertebrate data were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures.

Raw values from each metric are given a score of one (1), three (3) or five (5) based on ranges of values developed for each metric, as shown in Table 7. The scored metrics are combined and averaged into a scaled BIBI score ranging from 1.00 to 5.00, and a corresponding narrative biological condition rating is assigned (Table 8). Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions, which include the Coastal Plain, Piedmont, and Combined Highlands regions. Anne Arundel County is located entirely within the Coastal Plain region; therefore, the metrics selected and calibrated specifically for Maryland Coastal Plain streams were used for the BIBI scoring and include:

1) *Total Number of Taxa* – Equals the richness of the community in terms of the total number of genera at the genus level or higher. A large variety of genera typically indicate better overall water quality, habitat diversity and/or suitability, and community health.

2) *Number of EPT Taxa* – Equals the number of genera that classify as Ephemeroptera (mayflies), Plecoptera (stoneflies), and/or Trichoptera (caddisflies) in the sample. EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

3) *Number of Ephemeroptera Taxa* – Equals the total number of Ephemeroptera Taxa in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

4) *Percent Intolerant Urban* – Percentage of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3. As impairment increases, the percent of intolerant taxa decreases.

5) *Percent Ephemeroptera* – Equals the percent of Ephemeroptera individuals in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

6) *Number Scraper Taxa* – Equals the number of scraper taxa in the sample. Individuals in these taxa scrape food from the substrate. As the levels of stressors or pollution rise, there is an expected decrease in the numbers of scraper taxa.

7) *Percent Climbers* – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers typically represent a decrease in stressors and overall better water quality.

Information on functional feeding group, habit, and tolerance values for each organism were derived primarily from Southerland et al. (2005), which is based heavily on information compiled from Merritt and Cummins (1996) and Bressler et al. (2004).

Table 7 - MBSS Coastal Plain BIBI Metric Scoring

Metric	Score		
	5	3	1
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2	1-1	<1
Percent Intolerant Urban	≥28	10-27	<10
Percent Ephemeroptera	≥11.0	0.8-10.9	<0.8
Number of Scraper Taxa	≥2	1-1	<1
Percent Climbers	≥8.0	0.9-7.9	<0.9

Source: Southerland et al. 2005

Table 8 - MBSS Biological Condition Rating

BIBI Score	Narrative Rating	Characteristics
4.00 – 5.00	Good	Comparable to reference streams considered to be minimally impacted.
3.00 – 3.99	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble minimally impacted streams.
2.00 – 2.99	Poor	Significant deviation from reference conditions, indicating some degradation.
1.00 – 1.99	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling minimally impacted streams indicating severe degradation.

2.3.4 Fish Index Analysis

Fish data for all sites were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005). The IBI approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. Raw values from each metric were assigned a score of one (1), three (3) or five (5) based on ranges of values developed for each metric. The results were combined into a scaled FIBI score, ranging from 1.00 to 5.00, and a corresponding narrative rating of 'Good', 'Fair', 'Poor' or 'Very Poor' was applied, again in accordance with standard practice.

Four sets of FIBI metric calculations have been developed for Maryland streams. Like the BIBI, these metrics were developed for Maryland's streams based on physiographic region and include the Coastal Plain, Eastern Piedmont, and warmwater and coldwater Highlands. As all sites were located in the Coastal Plain region the following metrics listed in Table 9 were used for the FIBI scoring and analysis and then given the condition ratings as shown in Table 10. The individual FIBI metrics are defined below:

1) Abundance per Square Meter-- The total number of fish found per square meter of assessed reach. Overall fish numbers tend to decrease as impairment increases.

2) Number of Benthic Species--The number of fish species found that inhabit stream bottom substrates. These species tend to decrease as levels of impairment increase.

3) Percent Tolerant--The percentage of individuals collected at a site considered tolerant to disturbance. This percentage increases as disturbance increases.

4) Percent Generalists, Omnivores, Invertivores--Fishes found in these trophic guilds are less sensitive to watershed disturbance, so a higher percentage of these fish in a sample indicate a more disturbed site.

5) Percent Round Bodied Suckers--These types of suckers tend to live in less disturbed streams, so a lower observed percentage is indicative of higher levels of watershed development.

6) Percent Abundance of Dominant Taxon—The more one species dominates a sample, the less diverse the overall fish community. Less diversity is generally considered a sign of impairment, so a higher score for this metric indicates higher levels of watershed impairment or disturbance.

Table 9 – Fish Metric Scoring for the Coastal Plain FIBI

Metric	Score		
	5	3	1
Abundance per Square Meter	≥ 0.72	0.45 – 0.71	< 0.45
Number of Benthic species *	≥ 0.22	0.01 – 0.21	0
% Tolerant	≤ 68	69 – 97	> 97
% Generalist, Omnivores, Invertivores	≤ 92	93 – 99	100
% Round Bodied Suckers	≥ 2	1	0
% Abundance of Dominant Taxon	≤ 40	41 - 69	> 69

*Adjusted for catchment size

Table 10 – MBSS FIBI Condition Ratings

IBI Score	Narrative Rating
4.00 – 5.00	Good
3.00 – 3.99	Fair
2.00 – 2.99	Poor
1.00 – 1.99	Very Poor

2.3.5 Water Quality

The water quality grab sample parameters were compared against published acute and chronic water quality criteria for aquatic life and criteria for toxic substances in surface waters (Table 11) for each corresponding parameter. MBSS has established water quality ranges for nutrients from the distribution of concentrations from the MBSS dataset and published in Southerland et al. (2005), which are listed in Table 12. However, comparisons of nitrite levels with categories used by MBSS were limited due to analytical detection limits. The Maryland Department of the Environment (MDE) has established water quality criteria for several of the water chemistry parameters measured in this study for each designated Stream Use Classification. All sites sampled during 2019 were located on streams listed as Use Class I in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to the creteria for the appropriate designated use listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 13). Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, and agricultural, and industrial water supply. Currently, there is no State of Maryland criterion for specific conductance.

However, Morgan et al. (2007) identified a critical threshold of impairment of BIBI scores for Maryland streams at 247 µS/cm. Furthermore, Morgan et al. (2012) identified a critical threshold of 469 µS/cm for fish within the Coastal Plain physiographic region. These values are used by the Program as informal criteria for this parameter.

Table 11 - Water Quality Criteria

Parameter	Criteria	
	Acute	Chronic
Chloride (mg/L)**	860	230
Total Kjehldal Nitrogen (mg/L)	none	none
Dissolved Organic Carbon (mg/L)	none	none
Total Organic Carbon (mg/L)	none	none
Magnesium (mg/L)	none	none
Calcium (mg/L)	none	none
Hardness (mg equivalent $CaCO_3$/L)	none	none
Total Copper (µg/L)***	13	9
Total Zinc (µg/L)***	120	120
Total Lead (µg/L)***	65	2.5
Turbidity (NTU)***	150	50

** EPA National Recommended Water Quality Criteria for Aquatic Life

*** COMAR 26.08.02.03-2: Numerical Criteria for Toxic Substances in Surface Waters

Table 12 - MBSS Water Quality Ranges for Nutrients

Parameter*	Low	Moderate	High
Nitrate (NO3)	< 1.0	1.0 – 5.0	> 5.0
Nitrite (NO2)	< 0.0025	0.0025 – 0.01	> 0.01
Ammonia (NH3)	< 0.03	0.03 – 0.07	> 0.07
TN	< 1.5	1.5 – 7.0	>7.0
TP	< 0.025	0.025 – 0.070	> 0.070
Ortho-PO4	< 0.008	0.008 – 0.03	> 0.03

* All values in mg/L

Table 13 - Maryland COMAR Standards

Parameter	Standard
pH (SU)	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No State standard
Turbidity (NTU)	Maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
Temperature (°C)	Use I - Maximum of 32°C (90°F) or ambient temperature of the surface water, whichever is greater; Use III - Maximum of 20°C (68°F) or ambient temperature of the surface water, whichever is greater; Use IV - Maximum of 23.9°C (75°F) or ambient temperature of the surface water, whichever is greater

Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3 – Water Quality

2.3.6 Geomorphic Assessment

Geomorphic assessment data were managed using ODNR's Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006). This program was used to compile and plot field data and to analyze geometry, profile, and channel material characteristics of each assessment reach. In addition, the following values and/or ratios were calculated:

- Bankfull height, width, and area
- Mean bankfull depth
- Width/depth ratio
- Entrenchment ratio
- Floodprone width
- Sinuosity
- Water surface slope
- Median channel bed particle size - D_{50}

Data from the geomorphic assessments were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen, 1996). In this classification method, streams are categorized based on their measured values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials. General descriptions for each major stream type (i.e., A, G, F, B, E, C, D and DA) and delineative criteria for broad level (Level I) classification are provided in Table 14. Rosgen Level II characterization incorporates a numeric code (1 – 6) for dominant bed materials and a slope range modifier (i.e., a+, a, b, c, or c-) to provide a more detailed morphological description. For instance, a G type stream with gravel dominated bed and a water surface slope of less than 2% would be classified as a G4c stream.

Table 14 - Rosgen Channel Type Description and Delineative Criteria for Level I Classification.

Channel Type	General Description	Entr. Ratio	W/D Ratio	Sinu-osity	Slope	Landform/Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0-1.1	>10%	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0-1.2	4% - 10%	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.	1.4 - 2.2	>12	>1.2	2%-3.9%	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with scour pools.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	>2.2	>12	>1.2	<2%	Broad valleys w/ terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.	n/a	>40	n/a	<4%	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable stream banks.	>2.2	variable	variable	<0.5%	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastamosed geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.	>2.2	<12	>1.5	<2%	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.	<1.4	>12	>1.2	<2%	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable w/ high bank erosion rates. Riffle/pool morphology.
G	Entrenched 'gully' step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.	<1.4	<12	>1.2	2%-3.9%	Gullies, step/pool morphology w/ moderate slopes and low W/D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials. Unstable w/ grade control problems and high bank erosion rates.

Source: Rosgen, 1996

Since the primary goal of the geomorphic assessment component is to supplement biological assessments, the survey reach was constrained to within the randomly selected 75-meter sampling reach and a limited suite of geomorphic parameters was collected. Therefore, the data have certain limitations that should be noted:

- Stream classifications, slopes, and channel materials are only representative of the 75-meter reach in which they were evaluated. In some cases, these data are representative of shorter reaches, depending on site conditions. In other cases, a survey reach is located at a transition point between two different stream types and may contain more than one classification. Since only one cross-sectional survey is performed per reach, the remaining portion of the reach without the cross-sectional data is classified using best professional judgment. This classification is based primarily on the degree of incision and width/depth ratio in comparison to the surveyed cross-section.

- Typically, stream classification using the Rosgen methodology is best performed on riffle or step cross-sections. Some of the 75-meter survey reaches assessed in this study did not contain riffle or step features.

- Pebble count data were collected for stream classification purposes only and are not appropriate for use in hydraulic calculations of bankfull velocity and discharge. This is particularly the case for the many sand bed channels in the study area, where data on the dune height would be used instead of the 84th percentile particle size, or D_{84}, in hydraulic calculations. Dune height data were not collected for this study.

- No detailed analyses of stream stability were performed for this study. Statements referring to stream stability are based solely on observations and assumptions, which are founded on fundamental geomorphic principles. Conclusive evidence of the stability of the sampling units assessed could only be obtained after detailed watershed and stream stability assessments were performed.

2.3.7 Land Use Analysis and Impervious Surface

All geospatial analysis was performed using Countywide GIS coverages in ArcGIS 10.5.1. Land use analysis was completed with the use of the County's 2017 Land Cover GIS layer. Original land cover categories were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 15). The County's 2014 impervious layer was used to assess imperviousness to each site. Site specific land use and impervious surface analysis was completed using drainage areas delineated to each sampling point. The drainage area to each point was delineated using Anne Arundel County's raster grid digital elevation model (DEM) and flow accumulation grid using ESRI's ArcMap 10.5.1. Bioassessment sampling points were snapped to the closest point on the new stream grid generated from the DEM; then, batch sub-watersheds were generated using these three files. Subwatersheds were then summed where necessary to generate the appropriate drainage area to each bioassessment site. Dominant land use was determined as land use that comprises the largest percentage of the drainage area, relative to other land uses present.

Table 15 - Combined Land Use Classes

Land Use Class	Land Cover Type
Developed	Airport, Commercial, Industrial, Transportation, Utility, Residential (1/8-ac., ¼-ac., ½-ac., 1-ac., and 2-ac.)
Forested	Forested wetland, Residential woods, Woods
Agriculture	Pasture/hay, Row crops
Open Space	Open space, Open wetland, Water

3 Results and Discussion

This section first discusses the overall results across the 2019 sampling units, and is then followed by a more detailed discussion on results specific to each sampling unit. Appendix A includes a summary of the geomorphic assessment results. Appendix B includes a thorough discussion on the data QA/QC results. A listing of all taxa identified and their characteristics (i.e., functional feeding group, habit, tolerance value) is included as Appendix C, summaries for each site are in Appendix D, and water quality data are presented in Appendix E.

3.1 Comparisons among Sampling Units

Biological, physical, and water quality conditions, as well as geomorphic assessment results, are discussed for all of the sampling units assessed in 2019. Comparisons primarily focus on mean results for each sampling unit, which due to the random nature of the site selection process, are considered representative of the typical condition of streams contained within each PSU, even for stream reaches where no data were directly collected. Table 16 summarizes overall biological and habitat conditions for each sampling unit.

Table 16 - Summary of habitat, BIBI, and FIBI scores across sampling units (n=8 for each sampling unit unless noted)

Sampling Unit	Average PHI Summer Habitat Score ± SD / Condition Narrative	Average RBP Spring Habitat Score ± SD / Condition Narrative	Average BIBI Score ± SD / Condition Narrative	Average FIBI Score ± SD / Condition Narrative
Sawmill Creek	74.60 ± 7.76 Partially Degraded	126.1 ± 19.77 Supporting	2.93 ± 1.17 Poor	3.28 ± 1.02* Fair
Lower North River	69.19 ± 7.05 Partially Degraded	122.6 ± 17.48 Partially Supporting	2.39 ± 0.74 Poor	2.00 ± 0.89 Poor
Upper Patuxent	75.55 ± 6.69 Partially Degraded	128.6 ± 13.85 Supporting	2.07 ± 0.52 Poor	2.00 ± 0.85 Poor
Little Patuxent	64.31 ± 11.71 Degraded	115.5 ± 12.52 Partially Supporting	2.00 ± 0.48 Poor	2.83 ± 0.89 Poor
Middle Patuxent	68.13 ± 7.49 Partially Degraded	121.0 ± 10.65 Partially Supporting	2.68 ± 0.84 Poor	2.75 ± 0.83 Poor

*n=6 for FIBI

3.1.1 Biological and Habitat Assessment Summary

Overall, the majority of BIBI scores throughout the sampling units were split between a rating of 'Poor' (17 of 40; 42.5%) and 'Very Poor' (14 of 40; 35%), with a small percentage of sites rated as 'Fair' (7 of 40;

17.5%) and only two sites rated as 'Good' (5%; Figure 2). All five sampling units assessed in 2019 had mean BIBI values that equate to 'Poor' biological condition ratings (Table 16).

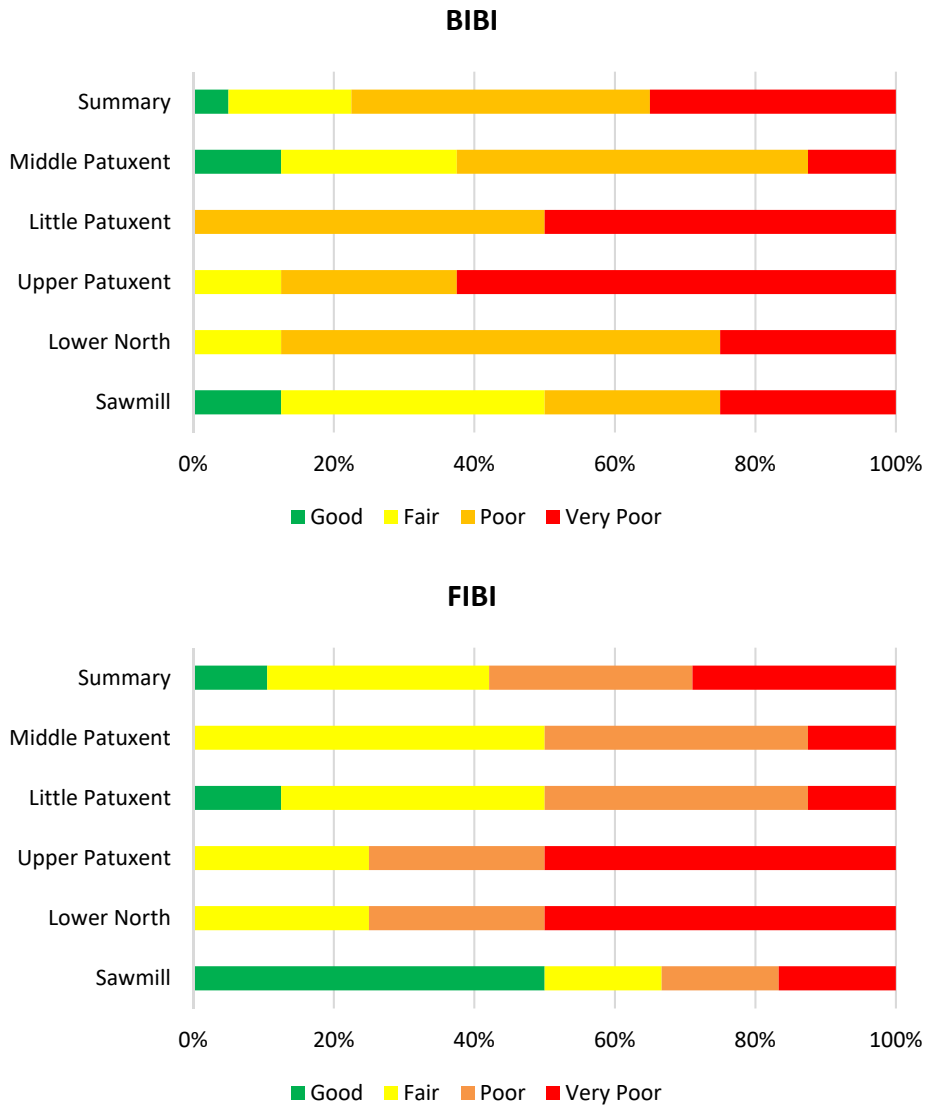

Figure 2 - Summary of biological conditions for sites assessed in 2019 (BIBI n=40, FIBI n=38)

The majority of FIBI sites sampled during 2019 were nearly evenly split between condition ratings of 'Fair' (12 of 38; 31.6%), 'Poor' (11 of 38; 28.9%) and 'Very Poor' (11 of 38; 28.9%). The remaining four (4) sites were rated 'Good' (10.5%; Figure 2). Four sampling units (Lower North River, Upper Patuxent River, Little Patuxent River, Middle Patuxent River) had mean FIBI scores equating to a 'Poor' biological condition rating and one had a mean FIBI rating of 'Fair' (Sawmill Creek; Table 16). Upper Patuxent River and Lower North River were the sampling units with the lowest mean FIBI scores (2.00) equating to a 'Poor' condition rating. Sawmill Creek had the highest mean FIBI rating of the sampling units from 2019, with a 3.28 mean equating to a 'Fair' biological condition rating. No sites visited during the summer of 2019 were dry but

two sites in Sawmill Creek did not have a confined stream channels and were more representative of a wetland-stream complex. These sites were sampled qualitatively and no FIBI calculation was made.

Physical habitat conditions were assessed twice in 2019 through the utilization of the RBP method during the spring season, and the PHI method during the summer season. Spring physical habitat assessment results indicate that two of the five sampling units, as determined by the sampling unit mean, received ratings of 'Supporting', while the remaining three received ratings of 'Partially Supporting' (RBP; Table 16). Approximately half (19 of 40; 47.5%) of the total sites sampled resulted in a RBP rating of 'Partially Supporting,' and another 40% of the sites (10 of 40) received a 'Supporting' rating (Figure 3). Only three sites were rated as 'Non-Supporting' (7.5%), and the remaining two sites (5%) were rated as 'Comparable to Reference'

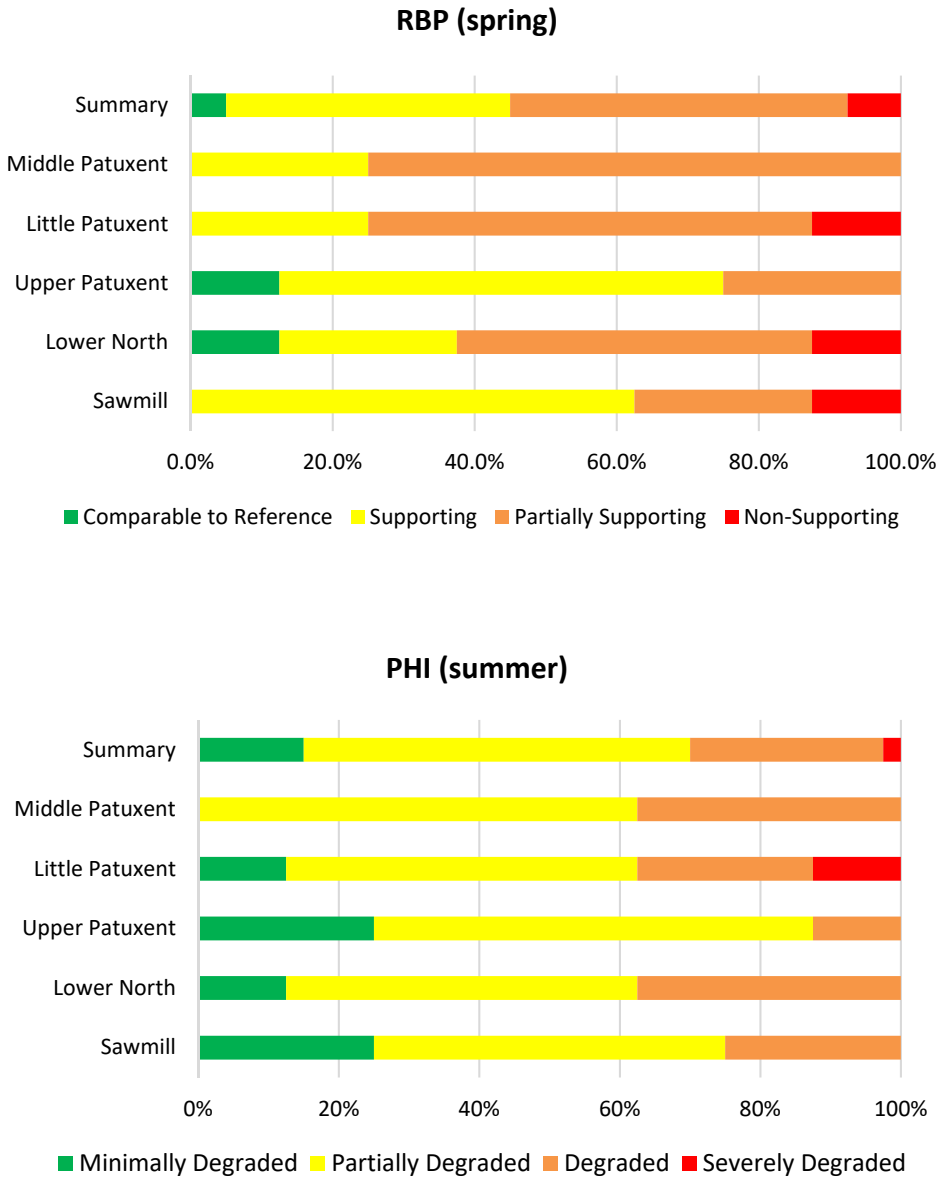

Figure 3- Summary of physical habitat conditions for sites assessed in 2019 (RBP n=40; PHI n=40)

Four sampling units assessed during the summer season received a PHI rating of 'Partially Degraded', as determined by the sampling unit mean. Only one sampling unit (Little Patuxent) received a rating of 'Degraded' (Table 16). Just over half of the total sites sampled resulted in a PHI rating of 'Partially Degraded' (55%), while slightly over one-quarter of the sites received 'Degraded' ratings (11 of 40; 27.5%). Six sites (15%) received the highest possible rating of 'Minimally Degraded', while only a single site (2.5%) received a 'Severely Degraded' rating (Figure 3).

3.1.2 Water Quality Assessment Summary

In situ water quality measurements of instantaneous turbidity exceeded COMAR standards for acute turbidity exposure (i.e., <150 NTU) at one site in the spring in the Little Patuxent River sampling unit and at one site in the summer in the Upper Patuxent River sampling unit. In the Little Patuxent River sampling unit, site 17-R3M-06-19 had a value of 242.0 NTU in the spring, and 16-L2M-01-19 in the Upper Patuxent River sampling unit had a value of 325.0 NTU in the summer. Low pH values, which were outside the acceptable range of values set forth by COMAR (i.e., 6.5-8.5 SU), were recorded at 14 sites spanning three of the five sampling units in the spring and at 20 sites spanning all sampling units in the summer. Sites that did not meet COMAR water quality standards sampled in the spring and summer had pH values that ranged from 4.45 to 6.32 SU and 4.78 to 6.47 SU, respectively. Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at 12 sites spanning three of the five sampling units in the summer. These DO values ranged from 0.29 to 4.75 mg/L in the summer, for the sites that did not meet the COMAR criterion. No sites sampled in the spring had DO levels below the COMAR criterion. For specific conductance, the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams is 247 µS/cm, based on BIBI scores (Morgan et al., 2007). Specific conductance values that exceeded 247 µS/cm were recorded at 15 sites spanning four of the five sampling units in the spring and 15 sites spanning all five sampling units in the summer. All streams were within their designated criteria (Use I) for temperature in 2019 (i.e., <32 °C).

No spring grab sample parameters tested in 2019 exceeded EPA or COMAR standards, or the MBSS water quality ranges for nutrients in the Upper Patuxent River sampling unit. Based on spring grab samples, all chloride values met EPA standards for acute (i.e., <860 mg/L) and chronic (i.e., <230 mg/L) exposure with values ranging from 1.71 to 196.61 mg/L. All 2019 sites met COMAR or EPA standards for heavy metal concentrations and turbidity in three of the five sampling units. In the Little Patuxent River sampling unit, site 17-R3M-06-19 exceeded COMAR chronic criteria for total copper (i.e., <9 µg/L) and total lead (i.e., <2.5 µg/L), as well as the acute turbidity criterion (i.e., <150 NTU). For total nitrogen, nitrate, and orthophosphate, all 2019 sites fell in the low or moderate categories used by MBSS. Average values for these parameters ranged from 0.184 to 1.387 mg/L for total nitrogen, 0.024 to 1.153 mg/L for nitrate, and 0.003 to 0.005 mg/L for orthophosphate, across all sampling units. Over 17% of sites sampled in 2019 fell in the high category used by MBSS for total ammonia (i.e., >0.07 mg/L), with values ranging from 0.008 to 0.335 mg/L. Average ammonia for the Little Patuxent River sampling unit fell in the high category used by MBSS with a value of 0.090 mg/L. Over 12% of sites sampled in 2019, all in the Sawmill Creek, Lower North River and Little Patuxent River sampling units, fell in the high category used by MBSS for total phosphorus (i.e., >0.07 mg/L) with values ranging from 0.010 to 0.190 mg/L. Five sites, located in the Sawmill Creek, Lower North River (South River), Little Patuxent River, and Middle Patuxent River sampling units, had nitrite values that fell in the high category used by MBSS (i.e., >0.01 mg/L). Nitrite values ranged from 0.005 to 0.020 mg/L; however, comparisons of nitrite levels with categories used by MBSS were limited due to analytical detection limits. No state or national water quality standards exist for dissolved organic carbon (DOC), total organic carbon (TOC), magnesium, calcium, or hardness. Average values ranged from

1.337 to 4.736 mg/L for DOC, 1.490 to 5.057 mg/L for TOC, 1.219 to 4.933 mg/L for magnesium, 2.62 to 19.56 mg/L for calcium, and 11.56 to 69.11 mg/L for hardness, across all five sampling units.

3.1.3 Geomorphic Assessment Summary

There was high variability in stream types throughout the sampling units in 2019. The largest portion of the sites were E and G type channels (22.5% and 20%, respectively; Figure 4). Across all sampling units, approximately 17.5% of the sites were classified as F type channels. The entrenched F type channels were most frequent in the Little Patuxent River and Middle Patuxent River sampling units. Across all sampling units, 15% of sites were classified as moderately entrenched B type channels, which mostly occurred in the Lower North River sampling unit. Approximately 10% of sites were classified as C type channels (4 total), with one in each sampling unit, except for Lower North River. Another 10% of all sites were classified as DA type channels, with the sites being limited to the Sawmill Creek and Lower North River sampling units. The remaining 5% of sites were placed into the 'Not Determined' category due to considerable anthropogenic modification (e.g., channel alteration, hardened banks) or due to natural influences that inhibit channel classification (e.g., beaver dams). A major assumption of the Rosgen characterization system is that the stream channel has the ability to adjust its dimensions naturally. Thus, reaches that have been heavily channelized or unnaturally modified violate this assumption and the channel dimensions may not be representative of natural conditions. None of the sites assessed in 2019 were considered transitional between two classification types.

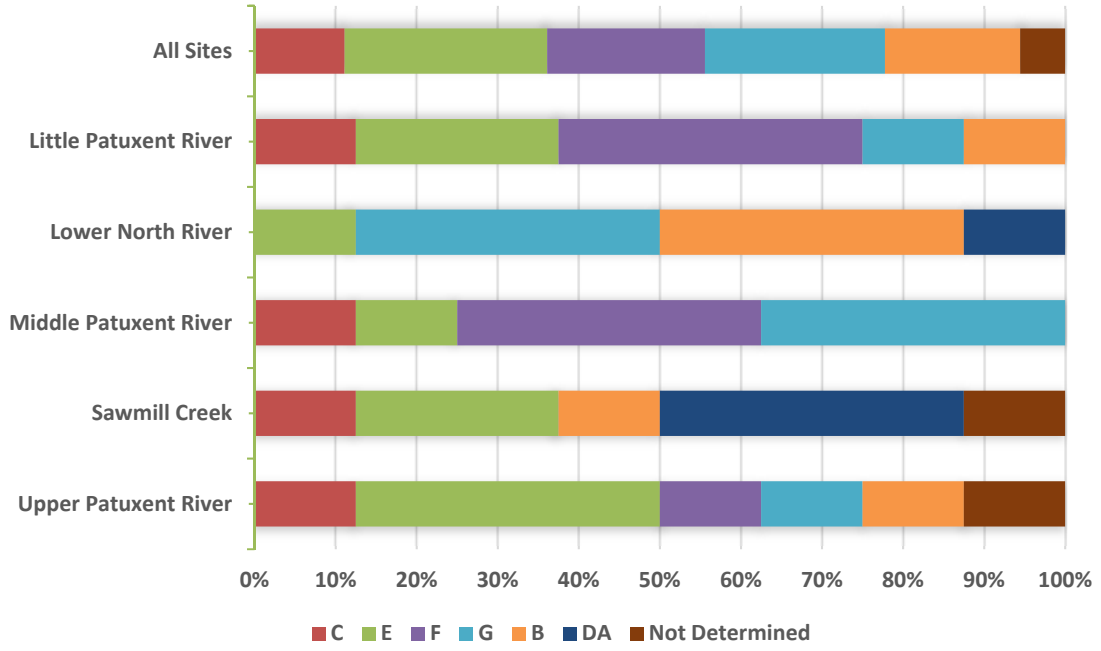

Figure 4 - Distribution of Rosgen stream types for sites assessed in 2019 (n=40)

Over half of the sites sampled in 2019 had channel substrate composed primarily of sand or finer material (55%). Gravel-dominated streams comprised 25% of all sites, while gravel/sand systems comprised 17.5% of sites. One site, 3.5% of the total surveyed sites, was a concrete trapezoidal channel and classified as artificial substrate.

Stream slopes in the reaches assessed in 2019 were generally low (i.e., below 1%). The average slope of all reaches assessed was 0.51%. Average slopes for the sampling units ranged from 0.36% in the Sawmill Creek sampling unit to 0.77% in the Upper Patuxent River sampling unit.

3.1.4 Land Use Analysis and Impervious Surface Summary

A summary of land use and impervious surface across each sampling unit assessed in 2019 is presented in Table 17.

Table 17 - Summary of land use and impervious surface across sampling units

Sampling Unit	Total Acreage	% Impervious	Land Use			
			% Developed	% Forested	% Agriculture	% Open
Little Patuxent River	28,196	18.0	39.9	44.5	2.9	12.6
Lower North River	23,681	16.4	54.8	33.3	4.9	7.0
Middle Patuxent River	6,332	6.3	30.1	38.1	20.1	11.7
Sawmill Creek	11,044	32.7	62.2	20.1	0.4	17.3
Upper Patuxent River	6,957	6.9	19.0	69.8	0.5	10.8

At the sampling unit scale, Sawmill Creek had the highest percentage of developed land at 62.2% of the total acreage, followed by the Lower North River at 54.8% (Table 17). The Little Patuxent River and Middle Patuxent River sampling units had moderate development, with developed land comprising 39.9% and 30.1%, respectively. In contrast, the Upper Patuxent River sampling unit was the least developed, with 19.0% of the sampling unit attributed to developed land. The Upper Patuxent River had the highest proportion of forested land at 69.8%, while the Little Patuxent River, Middle Patuxent River, and Lower North River had moderate forested land cover (44.5%, 38.1%, and 33.3%, respectively). Sawmill Creek had the lowest forested cover, at 20.1%. The highest proportion of agricultural land use occurred in the Middle Patuxent River at 20.1%, followed by the Lower North River at 4.9% and the Little Patuxent River at 2.9%. Agricultural land uses comprised less than 1% for the Upper Patuxent River and Sawmill Creek. Figure 5 shows land use for the entire County based on the County's 2017 Land Cover GIS layer. The sampling units with the highest percentage of impervious surface were Sawmill Creek (32.7%), followed by Little Patuxent River (18.0%) and Lower North River (16.4%); while Upper Patuxent River and Middle Patuxent River had the lowest percentages of impervious surface (6.9% and 6.3%, respectively). Figure 6 shows impervious surface for the entire County based on the County's 2017 Impervious GIS layer.

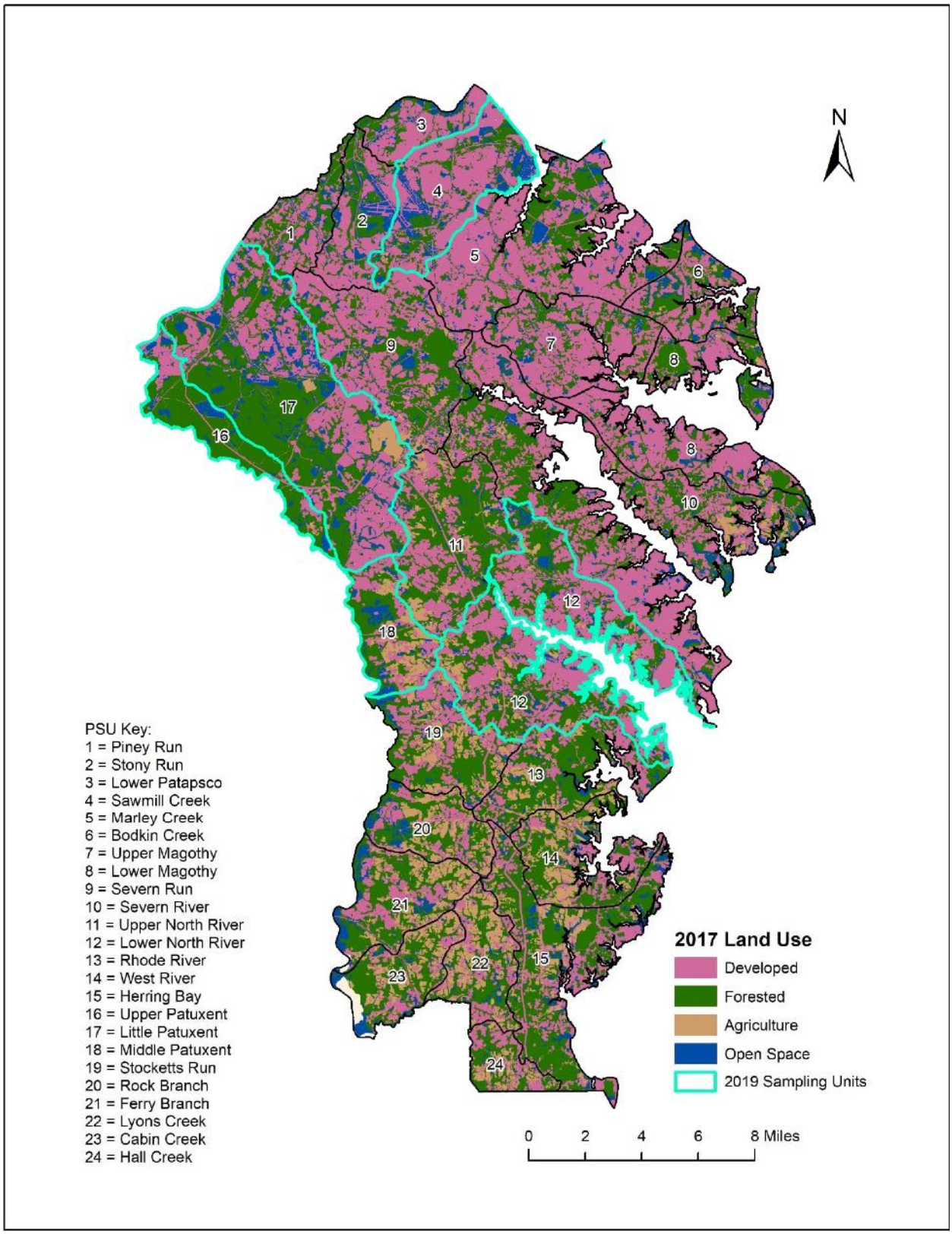

Figure 5 - Summarized land use in Anne Arundel County (2017)

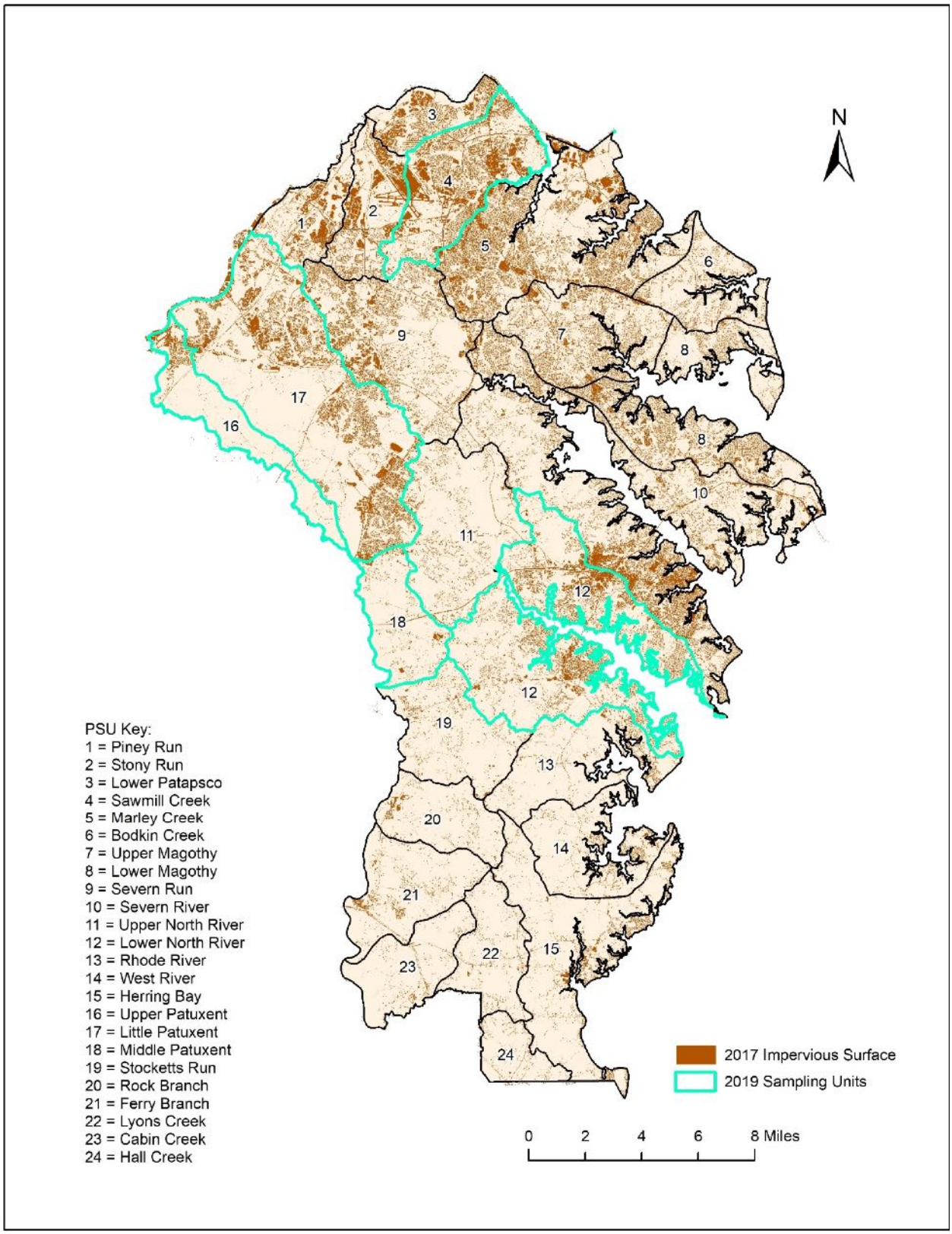

Figure 6 - Impervious surface in Anne Arundel County (2017)

4 Individual Sampling Unit Discussions

The following section summarizes the conditions within each of the five sampling units assessed during 2019. Site-specific data and assessment results can be found in Appendix D.

4.1 Little Patuxent River

The Little Patuxent River sampling unit is located along the northwestern edge of the county and borders Howard County (Figure 1). The Little Patuxent River has a total drainage area of 28,196 acres and drains directly into the Patuxent River, which then drains into the Chesapeake Bay just north of Naval Air Station Patuxent River. The eight sampling sites have drainage areas ranging from 78 to 752 acres (Figure 10).

4.1.1 Land Use

The dominant land use for the Little Patuxent River sampling unit is forested land (45%), followed by developed land (40%), open land (13%), and agriculture (3%) (Table 17). The land use distribution within the sampling unit differed when compared to the average land use among sampling sites, which had higher average development and lower forest cover. Developed land dominated five of the eight sites, with forest dominating the remaining three, and only one of the eight sites followed the same composition as the overall sampling unit (Figure 7). On average, land use among the eight sampling sites was comprised of 56% developed land, 37% forested land, and 8% open space. Impervious surfaces comprise 18% of the overall Little Patuxent River sampling unit (Table 17), with individual sites ranging from 6% to 37% impervious surfaces.

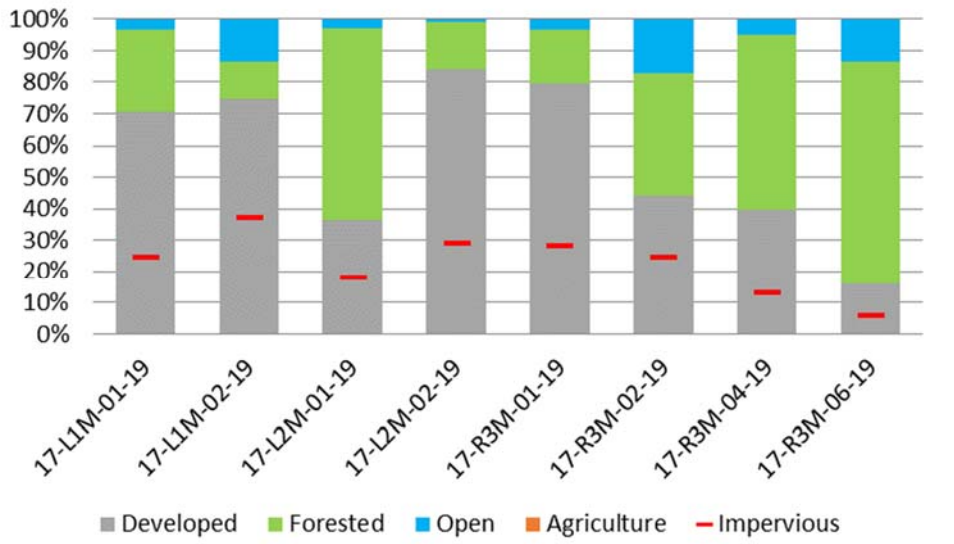

Figure 7 – Little Patuxent River land use (n=8)

4.1.2 Physical Habitat

Physical habitat conditions were relatively consistent for this sampling unit during the spring season. Based on the RBP scores, 62.5% of the Little Patuxent River sites received a rating of 'Partially Supporting,' 25.0% of sites received a 'Supporting', and the remaining 12.5% were rated 'Non-Supporting' (Figure 8). The average RBP score for the Little Patuxent River sampling unit was 115.50 ± 12.52, and the

corresponding narrative rating was 'Partially Supporting'. Individual site scores ranged from 89 ('Non-Supporting') to 127 ('Supporting'). Little Patuxent River had the lowest mean scores for both the spring RBP habitat assessment and the summer PHI habitat assessment.

According to the PHI assessment (summer season), 50% of the Little Patuxent sites were rated as 'Partially Degraded', 25% were rated as 'Degraded', and the remaining one-quarter of sites were evenly split between 'Minimally Degraded' and 'Severely Degraded' (Figure 8). The average PHI rating was 'Partially Degraded' with a score of 64.31 ± 11.71. Individual site scores ranged from 47.74 ('Severely Degraded') to 82.57 ('Minimally Degraded'). Instream habitat and epifaunal substrate generally scored in the 'Marginal' and 'Poor' categories; high-quality habitat for benthic macroinvertebrates was lacking at all Little Patuxent sites. The scaled metric for number of rootwads and woody debris scored above 90% at six of the eight sites. Bank stability exceeded 70% at half of the sites. Percent shading also scored above 70% at half of the sites.

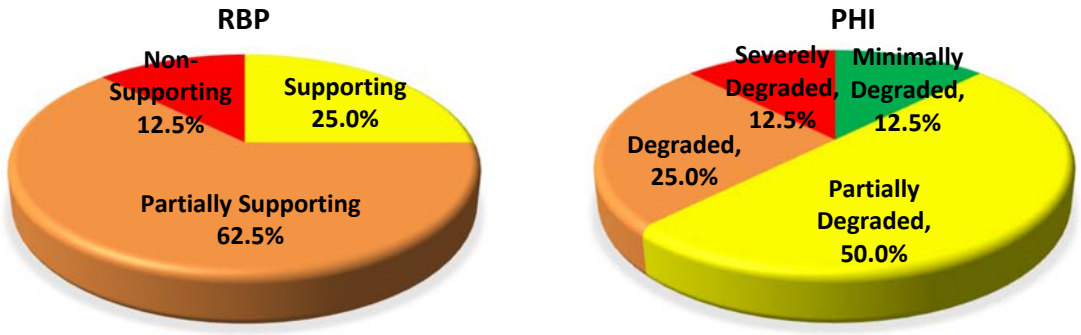

Figure 8 – Little Patuxent River Physical Habitat Conditions (RBP n=8; PHI n=8)

4.1.3 Benthic Macroinvertebrates

Of the eight sites sampled in Little Patuxent River, 50% of sites received a BIBI rating of 'Poor' while the remaining 50% of the sites were rated as 'Very Poor' (Figure 9). The average BIBI score for the Little Patuxent River sampling unit is 2.00 ± 0.48, with an average biological condition of 'Poor'. This sampling unit had the lowest mean BIBI score and the second highest proportion of sites in the 'Very Poor' category. Individual BIBI scores ranged from 1.57 ('Very Poor') to 2.71 ('Poor'). Site-specific data and assessment results can be found in Appendix D.

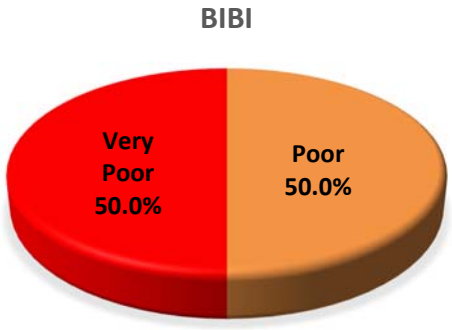

Figure 9 – Little Patuxent River BIBI Conditions (n=8)

Four sites (Figure 10) received the second lowest BIBI score of 2019 at 1.57. These four sites received a biological rating of 'Very Poor' and RBP ratings of 'Partially Supporting.' The low scoring sites all shared similar BIBI metric scores with zero or one EPT taxa, low diversity with between six (6) and 13 taxa, and less than 2.0% intolerant organisms. The higher scoring sites had more taxa (18-31), and typically more

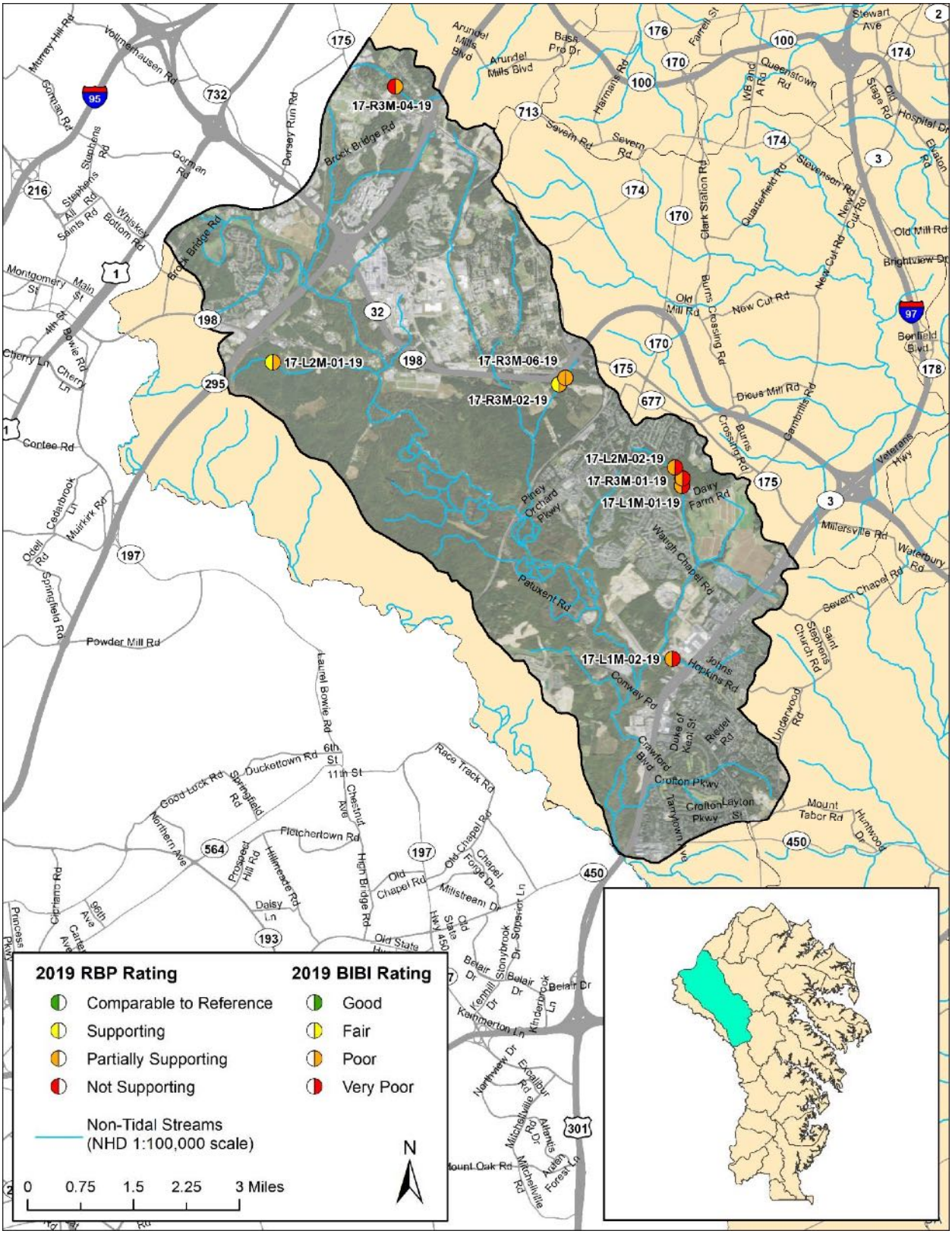

Figure 10 – Little Patuxent River Sampling Sites (BIBI and RBP)

scraper taxa and a higher proportion of climbers. All sites in the Little Patuxent River sampling unit lacked Ephemeroptera taxa and had few if any individuals intolerant to urbanization, with the max percentage of any sample at 6.4%.

4.1.4 Fish

The Little Patuxent River sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.83 ± 0.89. The majority of the sites in this sampling unit received a biological condition rating of either 'Fair' (37.5%) or 'Poor' (37.5%), with the remaining 25% split evenly between 'Good' and 'Very Poor' (Figure 11). Individual FIBI scores ranged from 1.33 ('Very Poor') to 4.00 ('Good'). Site-specific data and assessment results can be found in Appendix D.

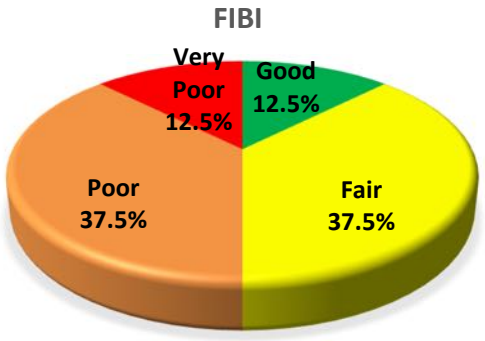

Figure 11 – Little Patuxent River FIBI Conditions (n=8)

One site, 17-R3M-04-19, received the lowest FIBI score of Little Patuxent Creek sites (1.33) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all metrics except percent abundance of dominant taxon. In contrast, site 17-R3M-01-19 received the highest FIBI score (4.00) in the Little Patuxent River sampling unit, which resulted in a biological rating of 'Good'. This site scored in the highest category for abundance per square meter, adjusted number of benthic species, percent generalist, omnivores, and invertivores, and abundance of dominate taxon. This site had the highest diversity in the sampling unit with 10 species observed.

Pumpkinseed (*Lepomis gibbosus*) and Blacknose Dace (*Rhinichthys atratulus*) were the most widely distributed species in the sampling unit, present at five of the eight sites. Creek Chub (*Semotilus atromaculatus*), Eastern Mudminnow (*Umbra pygmaea*), Rosyside Dace (*Clinostomus funduloides*) and White Sucker (*Catostomus commersonii*) were found at four of the eight sites. The least common species were Golden Shiner (*Notemigonus crysoleucas)*, Tessellated Darter (*Etheostoma olmstedi*), Largemouth Bass (*Micropterus salmoides*), and Cyprinid hybrid, all of which were found at only a single site in this sampling unit. Sixteen species were observed in the sampling unit with five non-native species [Fathead Minnow (*Pimephales promelas*), Golden Shiner, Largemouth Bass, Green Sunfish (*Lepomis cyanellus)* and Bluegill (*Lepomis macrochirus*)]. Eleven native species were also observed [American Eel (*Anguilla rostrata*), Blacknose Dace, Creek Chub, Cyprinid hybrid, Eastern Mudminnow, Eastern Mosquitofish (*Gambusia holbrooki*), Least Brook Lamprey (*Lampetra aepyptera*), Pumpkinseed, Rosyside Dace, Tessellated Darter, and White Sucker]. Two benthic fishes, Tessellated Darter and Least Brook Lamprey, were present in this sampling unit. No round-bodied suckers, nor any species considered intolerant to pollution were observed in this sampling unit.

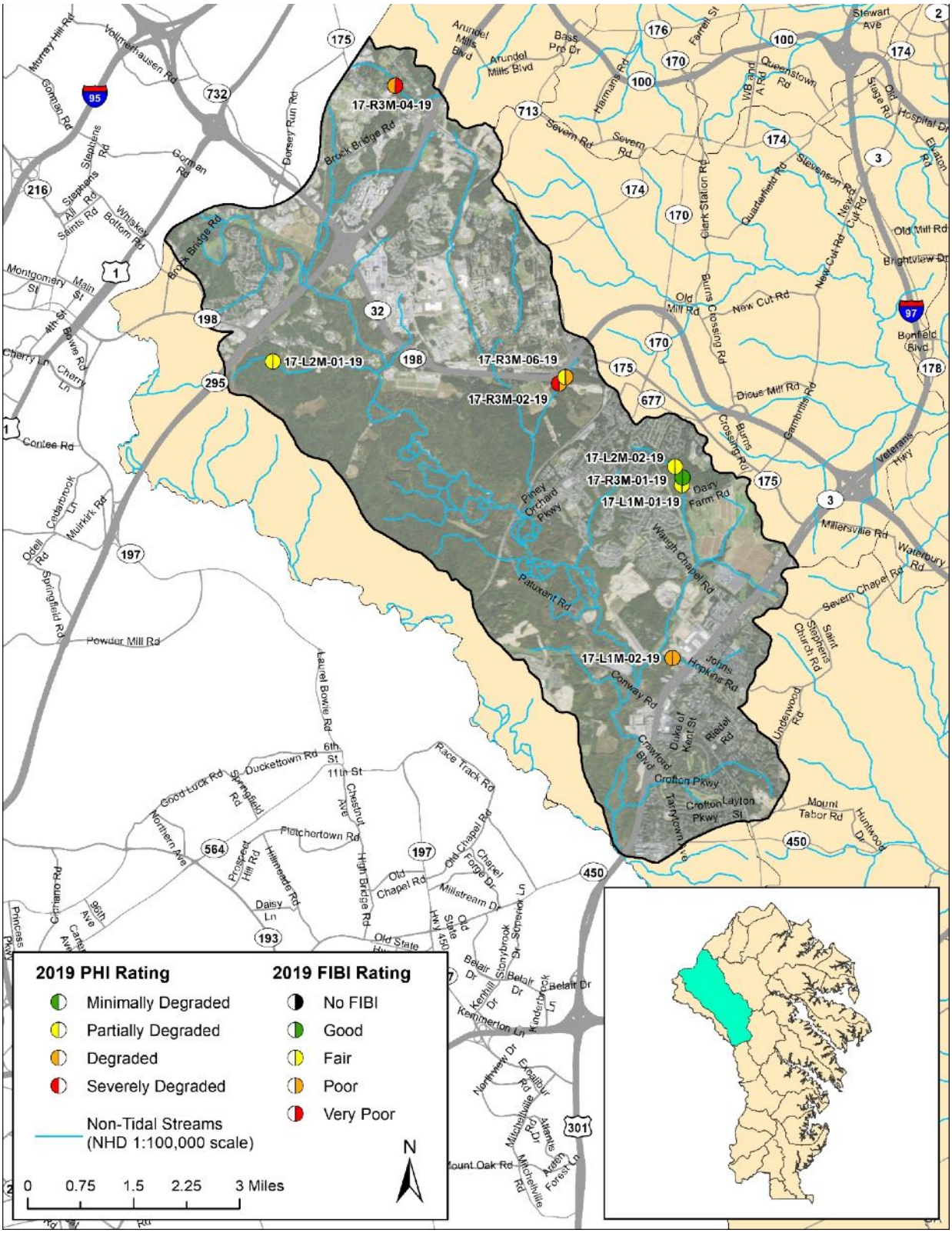

Figure 12 – Little Patuxent River (FIBI and PHI)

4.1.5 Water Quality

Average spring and summer in situ water quality values for the Little Patuxent River sites are provided in Table 18. Seven of the eight sites sampled met COMAR standards for water quality in the spring. Site 17-R3M-06-19 exceeded the COMAR standard for acute turbidity exposure (i.e., <150 NTU) with a value of 242.00 NTU. Water temperature ranged from 5.70 to 19.00 °C; DO ranged from 8.60 to 17.41 mg/L; pH ranged from 6.62 to 7.60 SU; specific conductance ranged from 221.0 to 856.0 µS/cm; and, turbidity ranged from 3.85 to 242.00 NTU.

In the summer, all eight Little Patuxent River sites were sampleable with seven sites not meeting COMAR standards for water quality. Sites 17-R3M-02-19, 17-R3M-04-19, 17-L1M-02-19, and 17-R3M-06-19 measured outside the acceptable COMAR range for DO (i.e., >5.0 mg/L), with values of 2.44, 2.68, 3.80, and 4.36 mg/L, respectively. Sites 17-R3M-01-19, 17-L1M-01-19, 17-L2M-01-19, and 17-R3M-06-19 measured outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with values of 6.47, 6.41, 5.88, and 5.65, respectively. Site 17-L2M-02-19 was the only site that met all COMAR standards for water quality in the summer. Summer water temperature ranged from 17.20 to 24.80 °C; DO ranged from 2.44 to 8.46 mg/L; pH ranged from 5.65 to 7.25 SU; specific conductance ranged from 148.00 to 1093.0 µS/cm; and turbidity ranged from 4.82 to 22.40 NTU.

Table 18 - Average in situ water quality values – Little Patuxent River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	11.73 ± 4.56	10.82 ± 2.92	7.21 ± 0.32	420.4 ± 208.2	39.12 ± 82.20
Summer	21.48 ± 2.29	5.25 ± 2.25	6.56 ± 0.59	434.4 ± 357.6	10.96 ± 6.60

The average spring grab sample water quality values for the Little Patuxent River sites are provided in Table 19. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for zinc. Site 17-R3M-06-19 did not meet COMAR standards for chronic copper (i.e., <9 µg/L) and lead (i.e., <2.5 µg/L) and acute turbidity (i.e., <150 NTU), with values of 11.964 µg/L, 12.254 µg/L, and 431.0 NTU, respectively. All Little Patuxent River sites fell in the low to moderate categories used by MBSS for total nitrogen, orthophosphate, and nitrate. For ammonia, sites 17-R3M-02-19, 17-R3M-04-19, and 17-R3M-06-19, fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.156, 0.146, and 0.335 mg/L, respectively. All other Little Patuxent River sites fell in the low category used by MBSS (i.e., <0.03 mg/L) for ammonia. Sites 17-R3M-04-19 and 17-L1M-02-19 had nitrite concentrations that fell in the high category used by MBSS (i.e., >0.01 mg/L) with values of 0.020 and 0.010 mg/L, respectively. All other sites had nitrite concentrations that fell below the method detection limit (MDL) of 0.0052 mg/L and could not be further categorized. Comparisons of nitrite levels with categories used by MBSS were limited due to 2019 analytical detection limits. One site, 17-R3M-06-19, had a total phosphorus level in the high category used by MBSS (i.e., >0.07 mg/L) with a value of 0.190 mg/L. All other total phosphorus values were in the low or moderate categories used by MBSS. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.017 to 8.077 mg/L; TOC ranged from 2.004 to 17.075 mg/L; magnesium ranged from 3.400 to 7.732 mg/L; calcium ranged from 11.92 to 35.39 mg/L; and, hardness ranged from 43.77 to 120.21 mg/L.

Table 19 - Average grab sample water quality values – Little Patuxent River

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
82.42 ± 59.16	0.040 ± 0.061	1.064 ± 0.561	0.004 ± 0.002	0.090 ± 0.116	0.008 ± 0.005	0.726 ± 0.727	3.844 ± 1.855
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
5.057 ± 4.909	4.933 ± 1.442	19.56 ± 8.12	69.11 ± 26.11	2.658 ± 3.847	18.18 ± 8.57	1.881 ± 4.231	61.9 ± 149.3

4.1.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. Half of the sites (50%) assessed in the Little Patuxent River sampling unit were entrenched F and G type channels (37.5% and 12.5%, respectively; Figure 13). The remaining sites were mostly slightly entrenched C and E type channels (12.5% and 25%, respectively). Moderately entrenched B type channels represented 12.5% of the sites surveyed.

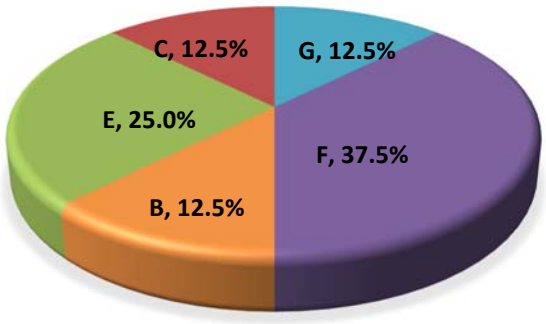

Figure 13 - Rosgen stream types observed in Little Patuxent River (n=8)

The majority of the streams in this sampling unit had sand or a mix of sand and gravel dominated substrate (75%) with the remainder of the sites being gravel dominated substrate (25%). The average D_{50} was 1.12 mm (very coarse sand). Individual site slopes ranged from 0.012% to 1.10%, with an average slope of 0.41%.

4.2 Lower North River

The Lower North River sampling unit, which drains directly to the South River near Edgewater, Maryland, is located at the eastern central edge of the county (Figure 1), and has a drainage area of 23,681 acres. The eight sampling sites have drainage areas ranging from 102 to 2,211 acres.

4.2.1 Land Use

Land use in the Lower North River sampling unit is primarily comprised of developed land (55%), followed by forested land (33%) and open space (7%), and agriculture (5%) (Table 17). The land use distribution within the sampling unit differed when compared to the average land use among sampling sites, which had lower average development. Developed land was only dominant for three of the sites, with the remaining five sites being more forested. On average, the sites sampled in the Lower North River sampling

unit have approximately equal percentages of developed land cover (39%) and forested land cover (39%), with agriculture (17%) and open space (5%) higher than the sampling unit (Figure 14). Impervious surfaces comprise 16% of the Lower North River, with individual sites ranging from 3% to 11% impervious surfaces.

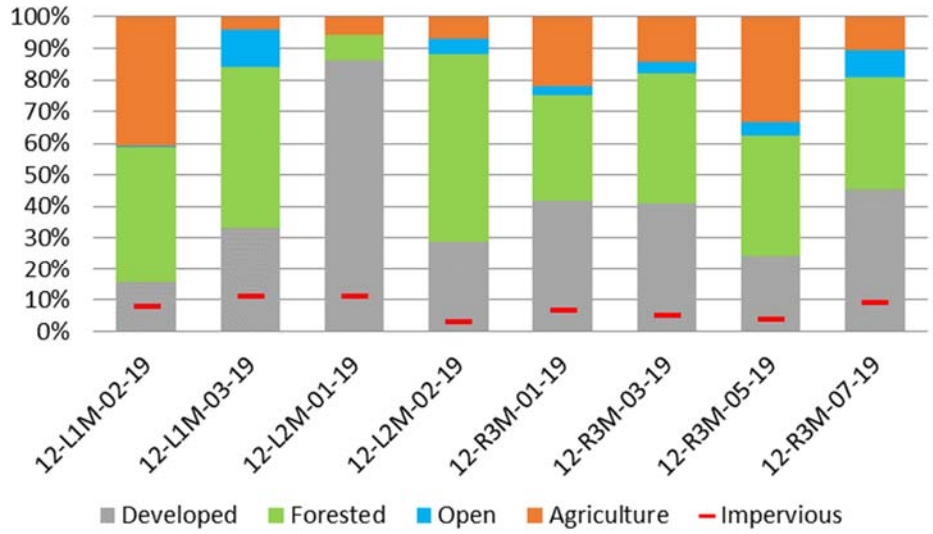

Figure 14 – Lower North River land use (n=8)

4.2.2 Physical Habitat

Physical habitat conditions during the spring season were variable for this sampling unit. Based on the RBP scores, 50.0% of the Lower North River sites received a rating of 'Partially Supporting', 25.0% were 'Supporting,' and the remaining 25.0% were evenly split between 'Comparable to Reference' and 'Non-Supporting' (Figure 15). The average RBP score for the Lower North River sampling unit was 122.63 ± 17.48 (Table 16), and the corresponding narrative rating was 'Partially Supporting'. Individual site scores ranged from 152 ('Comparable to Reference') to 96 ('Non-Supporting').

According to the PHI (summer), 50.0% of the Lower North River sites were rated as 'Partially Degraded', 37.5% received a rating of 'Degraded', and 12.5% were rated as 'Minimally Degraded' (Figure 15). The average PHI rating was 'Partially Degraded' with a score of 69.19 ± 7.05. Individual site scores ranged from 62.63 ('Degraded') to 82.33 ('Minimally Degraded'). Lower North River did not have any sites scoring in the lowest 'Severely Degraded' category. Instream habitat and epifaunal substrate generally scored in the 'Marginal' and 'Poor' categories; however, high-quality habitat for fish and benthic macroinvertebrates was observed at one site 12-R3M-01-19. Remoteness was mostly in the 'Marginal' or 'Sub-optimal' categories with one site in the 'Poor' category. The scaled metric for number of rootwads and woody debris scored above 80% at five of the eight sites. Bank stability exceeded 70% at half of the sites. Percent shading metric also scored above 70% at half of the sites. Embeddedness was consistent across all sites at 100%.

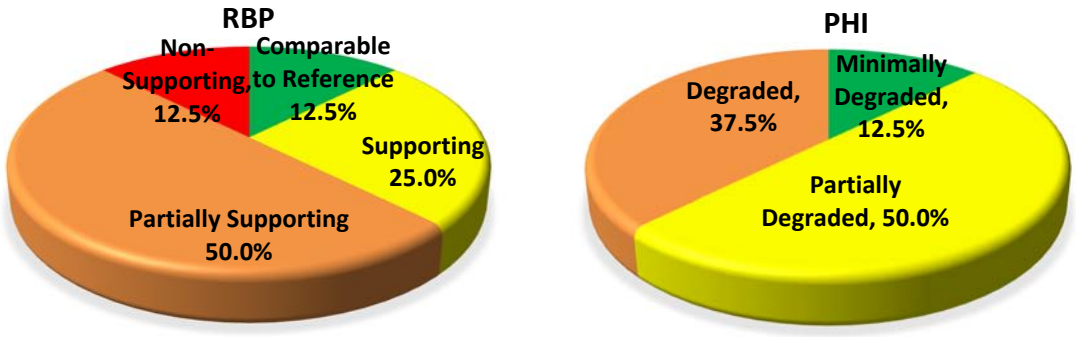

Figure 15 – Lower North River Physical Habitat Conditions (RBP n=8; PHI n=8)

4.2.3 Benthic Macroinvertebrates

The Lower North River sampling unit received a BIBI narrative rating of 'Poor' with an average score of 2.39 ± 0.74 (Table 16). The majority of individual sites (62.5%) received a biological condition rating of 'Poor', 25.0% received a 'Very Poor' rating, and the remaining 12.5% of sites were rated as 'Fair' (Figure 16). Individual BIBI scores ranged from 1.00 ('Very Poor') to 3.57 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

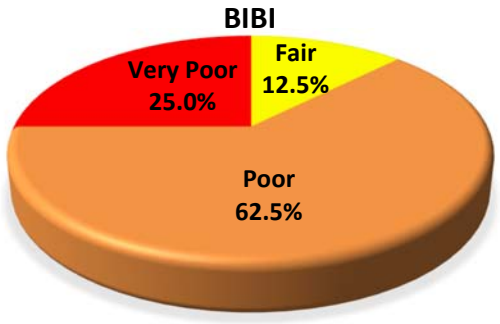

Figure 16 – Lower North River BIBI Conditions (n=8)

Site 12-L2M-01-19 received the lowest BIBI score of all Lower North River sites (1.00) with a narrative rating of 'Very Poor' (Figure 17). This site had only 12 total taxa, none of which were EPT, Ephemeroptera, or scraper taxa, and very small percentages of intolerant taxa and climbers. One additional site received a 'Very Poor' biological rating (12-L1M-02-19), where Ephemeroptera and scraper taxa were absent and only one (1) EPT taxon was present. Site 12-R3M-01-19 received the highest BIBI score (3.57; 'Fair') in the Lower North River sampling unit. This site had four EPT taxa, one Ephemeroptera taxa, and two scraper taxa from a total of 23 taxa present, with 13.2% of the sample consisting of climber taxa.

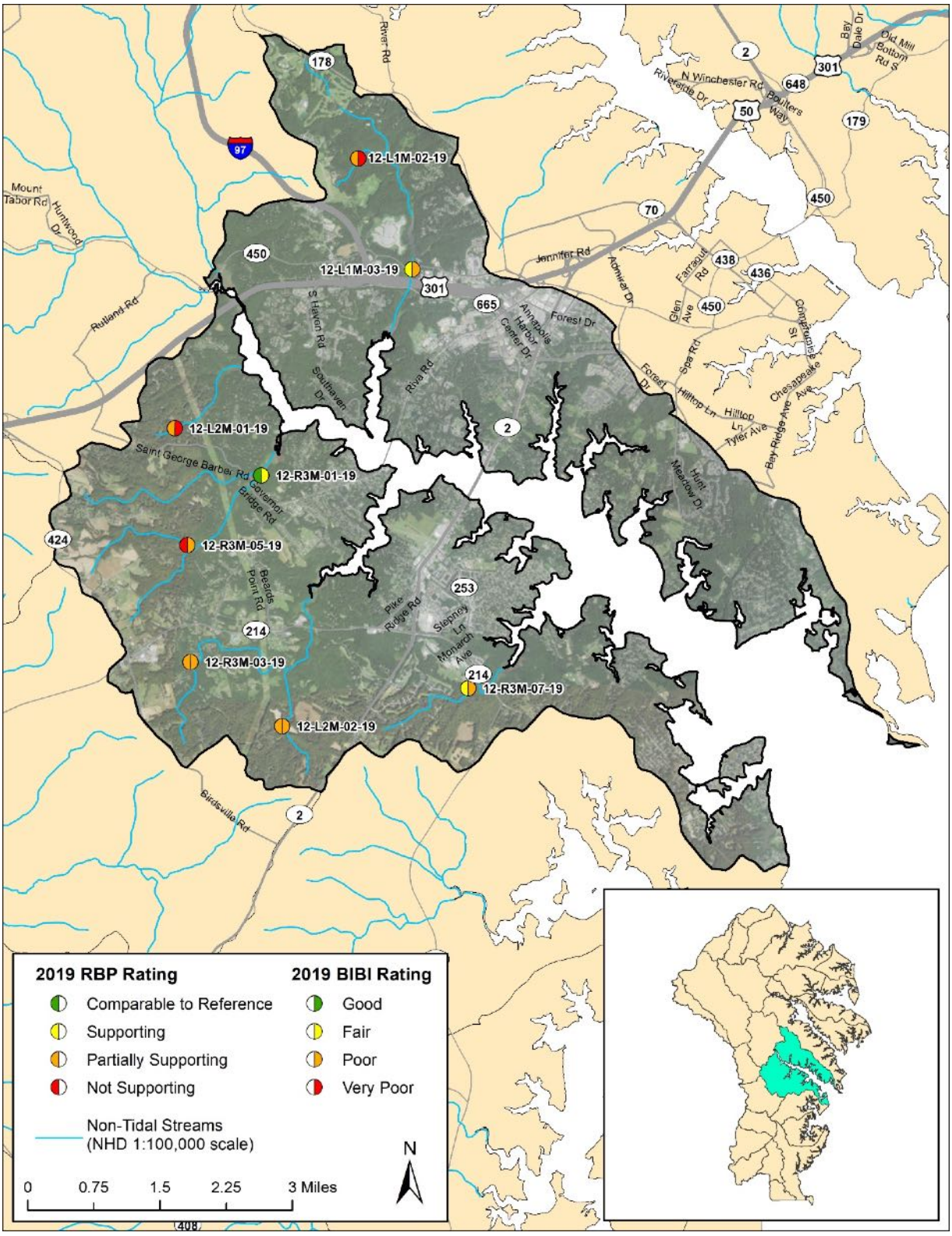

Figure 17 – Lower North River Sampling Sites (BIBI and RBP)

4.2.4 Fish

The Lower North River sampling unit was tied with the Upper Patuxent sampling unit for the lowest mean FIBI score during 2019. The Lower North River received a FIBI narrative rating of 'Poor' with an average score of 2.00 ± 0.89 (Table 16). Fifty percent of the individual sites sampled in this unit received a biological condition rating of 'Very Poor', 25.0% received a 'Fair' rating, and the remaining 25.0% of sites were rated as 'Poor' (Figure 18). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

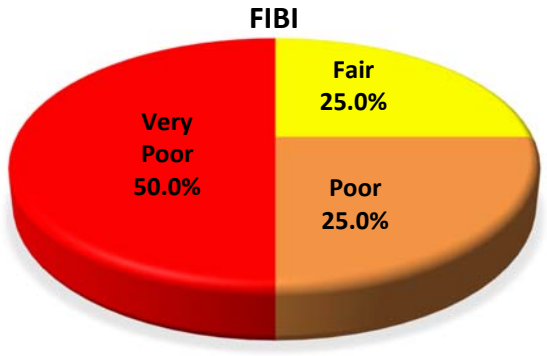

Figure 18 – Lower North River FIBI Conditions (n=8)

Site 12-L2M-01-19 received the lowest FIBI score of all Lower North River sites (1.00) with a narrative rating of 'Very Poor.' This site scored a 1.00 because the stream was flowing at the time of sampling but no fish were encountered during either electrofishing pass. MBSS scores sites as 1.00 where no fish were encountered during sampling even though there was water in the stream channel. Sites 12-L1M-03-19 and 12-R3M-01-19 both received the highest FIBI score (3.33; 'Fair') of sites sampled during 2019 in the Lower North River sampling unit. Both sites scored in the highest category for abundance per square meter and adjusted number of benthic species. Site 12-R3M-01-19 scored in the middle category for percent tolerant, percent round bodied suckers, and percent abundance of dominant taxon; and in the lowest category for percent generalist, omnivores, and invertivores. Site 12-L1M-03-19 scored in the middle category for percent tolerant, percent generalist, omnivores, and invertivores, and percent abundance of dominant taxon; and in the lowest category for percent round bodied suckers. This site also had the highest diversity in the sampling unit with 12 species observed.

Blacknose Dace was the most widely distributed species in the sampling unit, present at six of the eight sites, followed by American Eel which was found at five sites. The least common species in this sampling unit, only present at one site, were Eastern Mosquitofish, Eastern Mudminnow, Golden Shiner, Green Sunfish, Largemouth Bass, Mummichog (*Fundulus heteroclitus*), Pumpkinseed, Warmouth (*Lepomis gulosus*), and White Crappie (*Pomoxis annularis*). Sixteen species were observed in the sampling unit with four non-native species [Bluegill, Largemouth Bass, Green Sunfish, and White Crappie], and twelve native species [American Eel, Blacknose Dace, Brown Bullhead (*Ameiurus nebulosus*), Creek Chubsucker (*Erimyzon oblongus*), Eastern Mosquitofish, Eastern Mudminnow, Golden Shiner, Mummichog, Pumpkinseed, and Tessellated Darter, Warmouth, and Yellow Perch (*Perca flavescens*)]. One round-bodied sucker species (Creek Chubsucker) was present, along with one benthic fish (Tessellated Darter) in this sampling unit. No species considered intolerant to urban stressors were found in this sampling unit.

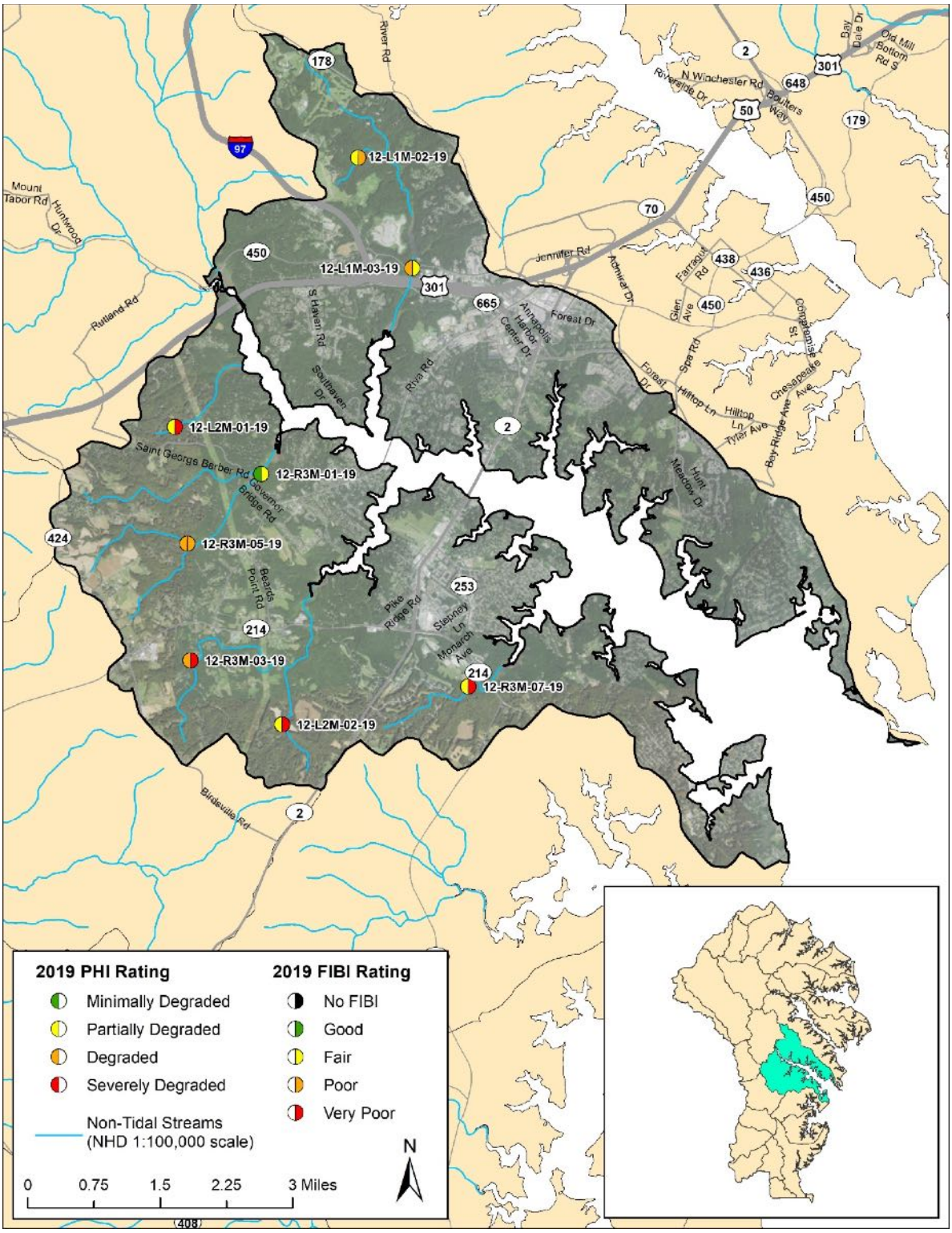

Figure 19 – Lower North River Sampling Sites (FIBI and PHI)

4.2.5 Water Quality

Average spring and summer *in situ* water quality values for the Lower North River sites are provided in Table 20. Of the eight sites sampled, three sites did not meet COMAR standards for water quality in the spring. Sites 12-R3M-05-19, 12-L2M-01-19, and 12-L2M-02-19 measured outside the acceptable COMAR range for pH (i.e., 6.5–8.5 SU), with values of 6.23, 6.14, and 6.05 SU, respectively. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 4.60 to 18.90 °C; DO ranged from 7.94 to 12.64 mg/L; pH ranged from 6.05 to 6.89 SU; specific conductance ranged from 101.0 to 368.0 µS/cm; and, turbidity ranged from 2.80 to 8.90 NTU.

In the summer, all eight Lower North River sites were sampleable. Three sites did not meet COMAR standards for water quality in the summer. Sites 12-R3M-05-19, 12-R3M-07-19, and 12-L2M-01-19 measured outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with values of 6.20, 5.79, and 6.05, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 18.10 to 26.20 °C; DO ranged from 6.35 to 9.06 mg/L; pH ranged from 5.79 to 7.37 SU; specific conductance ranged from 121.0 to 437.0 µS/cm; and, turbidity ranged from 2.40 to 15.70 NTU.

Table 20 - Average in-situ water quality values – Lower North River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	10.96 ± 5.50	10.93 ± 1.80	6.54 ± 0.34	213.6 ± 79.7	5.29 ± 1.92
Summer	20.95 ± 2.52	7.86 ± 1.04	6.62 ± 0.56	234.3 ± 97.1	6.51 ± 4.59

Average spring grab sample water quality values for the Lower North River sites are provided in Table 21. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen, orthophosphate, and nitrate, all values for Lower North River sites fell in the low to moderate categories used by MBSS. Site 12-L2M-01-19 fell into the high category used by MBSS (i.e., >0.01 mg/L) for nitrite with a value of 0.010 mg/L, while all other nitrite values were below the MDL and could not be further categorized. Comparisons of nitrite levels with categories used by MBSS were limited due to 2019 analytical detection limits. For total ammonia, sites 12-R3M-01-19 and 12-L2M-01-19 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.103 and 0.120 mg/L, respectively. For total phosphorus, sites 12-R3M-03-19, 12-R3M-05-19, and 12-L2M-01-19 fell in the high category used by MBSS (i.e., >0.07 mg/L) with values of 0.084, 0.072, and 0.094 mg/L, respectively. All other Lower North River sites fell in the low to moderate categories used by MBSS for total ammonia and total phosphorus. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.805 to 2.678 mg/L; TOC ranged from 0.953 to 2.752 mg/L; magnesium ranged from 2.950 to 5.440 mg/L; calcium ranged from 7.99 to 17.26 mg/L; and, hardness ranged from 33.57 to 57.49 mg/L.

Table 21 - Average grab sample water quality values – Lower North River

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
38.94 ± 24.87	0.058 ± 0.026	0.952 ± 0.419	0.005 ± 0.003	0.056 ± 0.037	0.006 ± 0.002	0.856 ± 0.465	1.437 ± 0.670
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
1.568 ± 0.638	3.745 ± 0.792	11.86 ± 2.98	45.04 ± 7.99	0.245 ± 0.084	16.98 ± 6.00	0.130 ± 0.063	11.6 ± 5.9

4.2.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results are presented in Appendix A. The majority of sites in the Lower North River sampling unit were evenly split between entrenched G type channels (37.5%; Figure 20) and moderately entrenched B type channels (37.5%). Slightly entrenched E type channels comprised 12.5% of the sites. The remaining 12.5% of sites were classified as DA type channels, with multiple channels present at the site.

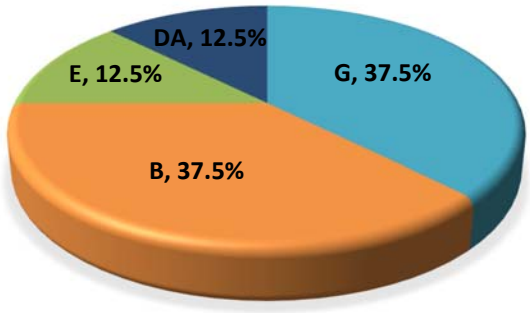

Figure 20- Rosgen stream types observed in Lower North River (n=8)

The majority of sites within the Lower North River sampling unit had stream bed substrate dominated by sand or finer material (75%). The remaining 25% of sites had substrate dominated by gravel and gravel/sand. The average D_{50} within the Lower North River sampling unit was 0.24 mm (fine sand). Streams in this sampling unit had an average slope of 0.54%, with individual slopes ranging from 0.16% to 1.10%.

4.3 Middle Patuxent River

The Middle Patuxent River sampling unit is located on the western edge of the county near Crofton, Maryland, beginning at the confluence of the Little Patuxent River and Patuxent River, which then drains into the Chesapeake Bay just north of Naval Air Station Patuxent River (Figure 1). The sampling unit has a total drainage area of 6,332 acres, the smallest of the 2019 sampling units, with the nine sampling sites having drainage areas ranging from 217 to 734 acres.

4.3.1 Land Use

Land use in the Middle Patuxent River sampling unit is comprised primarily of forested land (38%), followed by developed land (30%) and agriculture (20%), with open space comprising 12% (Table 17). Sampling sites were split in land cover dominance, with four sampling sites dominated by forested land, two sites dominated by agriculture, and two sites dominated by developed land. (Figure 21). On average, land use among the eight sites was like that of the sampling unit, with 36% forested land, 27% developed land, 25% agriculture, and 12% open space. Impervious surfaces account for only 6% of the Middle Patuxent River sampling unit, the lowest percentage of the 2019 sampling units, with individual sites ranging from less than 1% to 6% impervious surfaces.

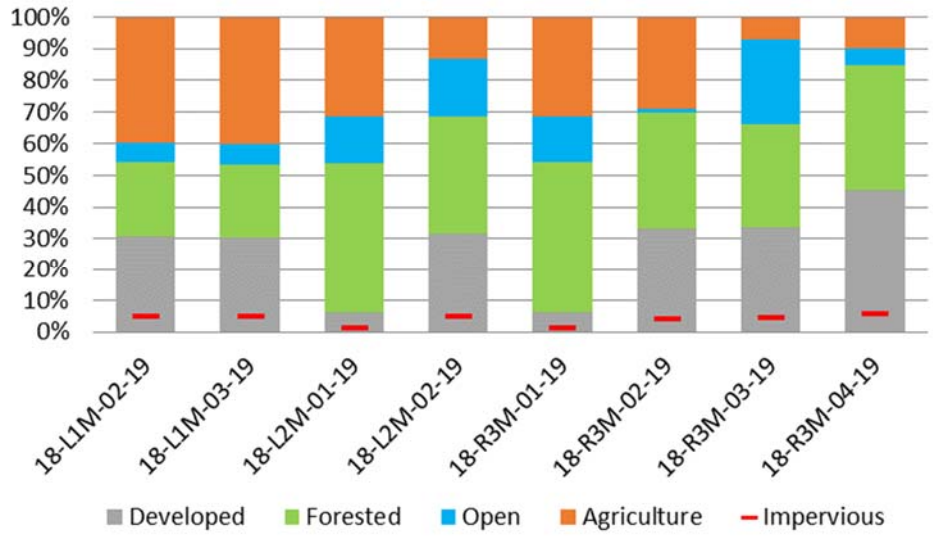

Figure 21 – Middle Patuxent River land use (n=8)

4.3.2 Physical Habitat

Based on the RBP scores, 75.0% of the Middle Patuxent sites received a rating of 'Partially Supporting,' while 25.0% of sites were classified as 'Supporting' (Figure 22). The average RBP score for the Middle Patuxent sampling unit was 121.00 ± 10.65, and the corresponding narrative rating was 'Partially Supporting.' Individual site scores ranged from 108 ('Partially Supporting') to 137 ('Supporting'). This sampling unit had no sites rated as 'Non-Supporting' or 'Comparable to Reference' in 2019. Mean scores for both spring RBP and summer PHI fell within the lower range of the five sampling units from 2019.

According to the PHI (summer), 62.5% of the Middle Patuxent sites were rated as 'Partially Degraded' and 37.5% were rated as 'Degraded' (Figure 22). The average PHI rating was 'Partially Degraded' with a score of 68.13 ± 7.49. Individual site scores ranged from 57.01 ('Degraded') to 78.26 ('Partially Degraded'). The majority of sites sampled received 'Marginal' to 'Poor' scores for both instream habitat and epifaunal substrate. Bank stability scored in the 'Poor' to 'Marginal' categories for most sites, with one site each scoring in the 'Sub-Optimal' and 'Optimal' categories. Embeddedness scored 100% at four of the eight sites and ranged from 30% - 60% at the remaining sites.

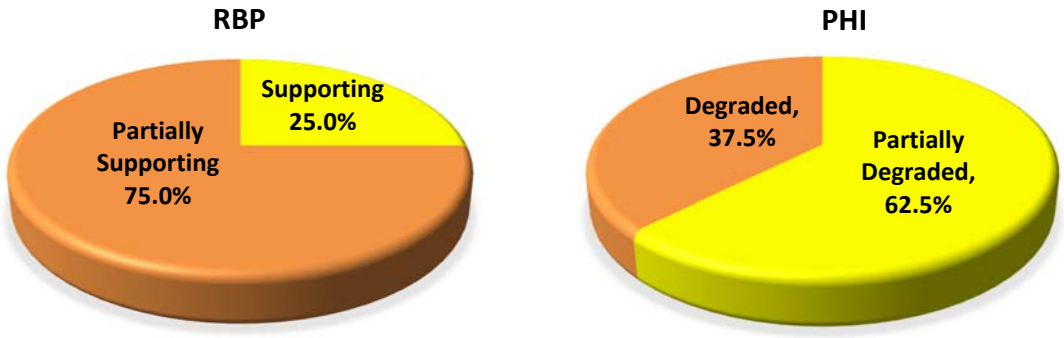

Figure 22 – Middle Patuxent Physical Habitat Conditions (RBP n=8; PHI n=8)

4.3.3 Benthic Macroinvertebrates

The average BIBI rating for the Middle Patuxent sampling unit is 'Poor' with an average BIBI score of 2.68 ± 0.84 (Table 16), and individual sites ranging from a low of 1.57 ('Very Poor') to 4.14 ('Good'). Half of sites (50.0%) received a BIBI rating of 'Poor', 25.0% of the sites were rated as 'Fair', and the remaining 25.0% of sites were evenly split between 'Good' and 'Very Poor' ratings (Figure 23). Middle Patuxent was the sampling unit with the second highest mean BIBI score. Site-specific data and assessment results can be found in Appendix D.

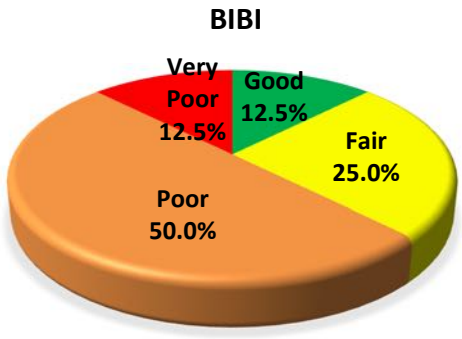

Figure 23 – Middle Patuxent BIBI Conditions (n=8)

Site 18-L1M-03-19 received the lowest score in the Middle Patuxent sampling unit of 1.86 with a 'Very Poor' narrative rating (Figure 24). The site had relatively low taxa diversity (12 taxa), only had one EPT taxa and completely lacked both Ephemeroptera sp. and taxa considered intolerant to urbanization. In contrast, site 18-R3M-03-19 received the highest BIBI score of 4.14, primarily due to a relatively high number of total taxa (25), five EPT taxa, two scraper taxa, and 16.0% of the sample consisting of climbers. Additionally, one Ephemeroptera taxon was present and the sample was comprised of 17.9% intolerant taxa.

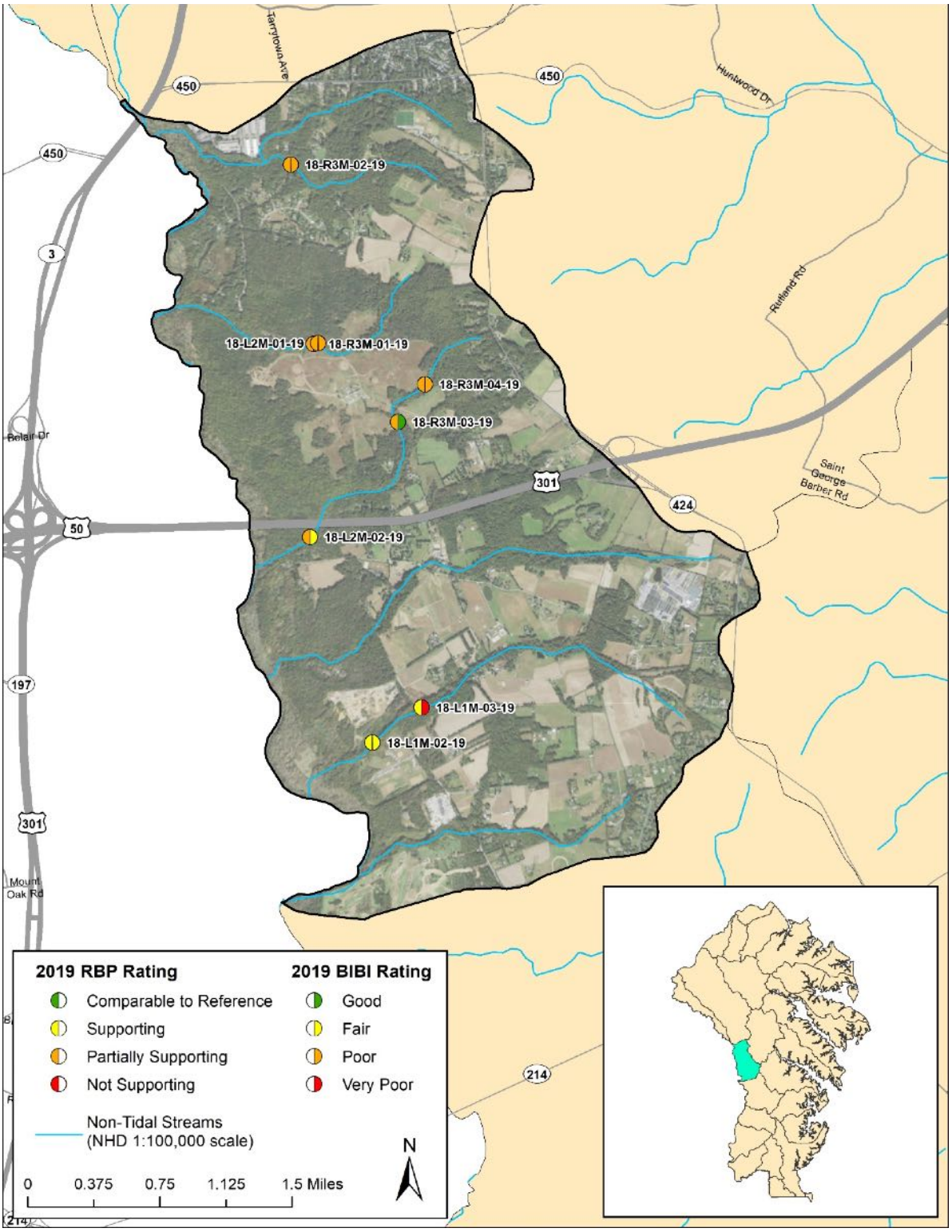

Figure 24 – Middle Patuxent River Sampling Sites (BIBI and RBP)

4.3.4 Fish

The Middle Patuxent sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.75 ± 0.83 (Table 16). One-half of the sites in this sampling unit received a biological condition rating of 'Fair', while 37.5% received a rating of 'Poor' and 12.5% received a 'Very Poor' rating (Figure 25). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.67 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

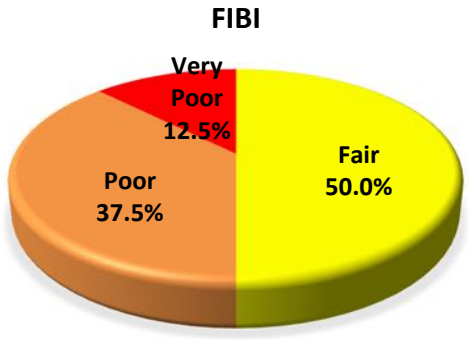

Figure 25 – Middle Patuxent FIBI Conditions (n=8)

Site 18-L2M-01-19 received the lowest FIBI scores of Middle Patuxent sites (1.00) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all six metrics. Site 18-R3M-03-19 received the highest FIBI score (3.67; 'Fair') in the Middle Patuxent sampling unit. This site scored in the highest category for abundance per square meter, adjusted number of benthic species, percent generalist, omnivores, and invertivores; in the middle category for percent tolerant, and percent abundance of dominant taxon; and in the lowest category for percent round bodied suckers. Site 18-L1M-03-19 had the highest diversity in the sampling unit with seven species observed.

Blacknose Dace was the most widely distributed species in the Middle Patuxent sampling unit, present at all eight sites. Least Brook Lamprey was found at seven of the eight sites. The least common species in this sampling unit were Bluegill, Eastern Mudminnow, Rosyside Dace, and White Sucker, each found only at a single site. Eleven species were observed in the sampling unit with two non-native species (Green Sunfish and Bluegill), and nine native species (American Eel, Blacknose Dace, Creek Chub, Eastern Mudminnow, Fallfish (*Semotilus corporalis*), Least Brook Lamprey, Rosyside Dace, Tessellated Darter, and White Sucker). One species considered intolerant to pollution (Fallfish) was present in this sampling unit, along with two benthic fish species (Least Brook Lamprey and Tessellated Darter). No round-bodied suckers were observed in this sampling unit.

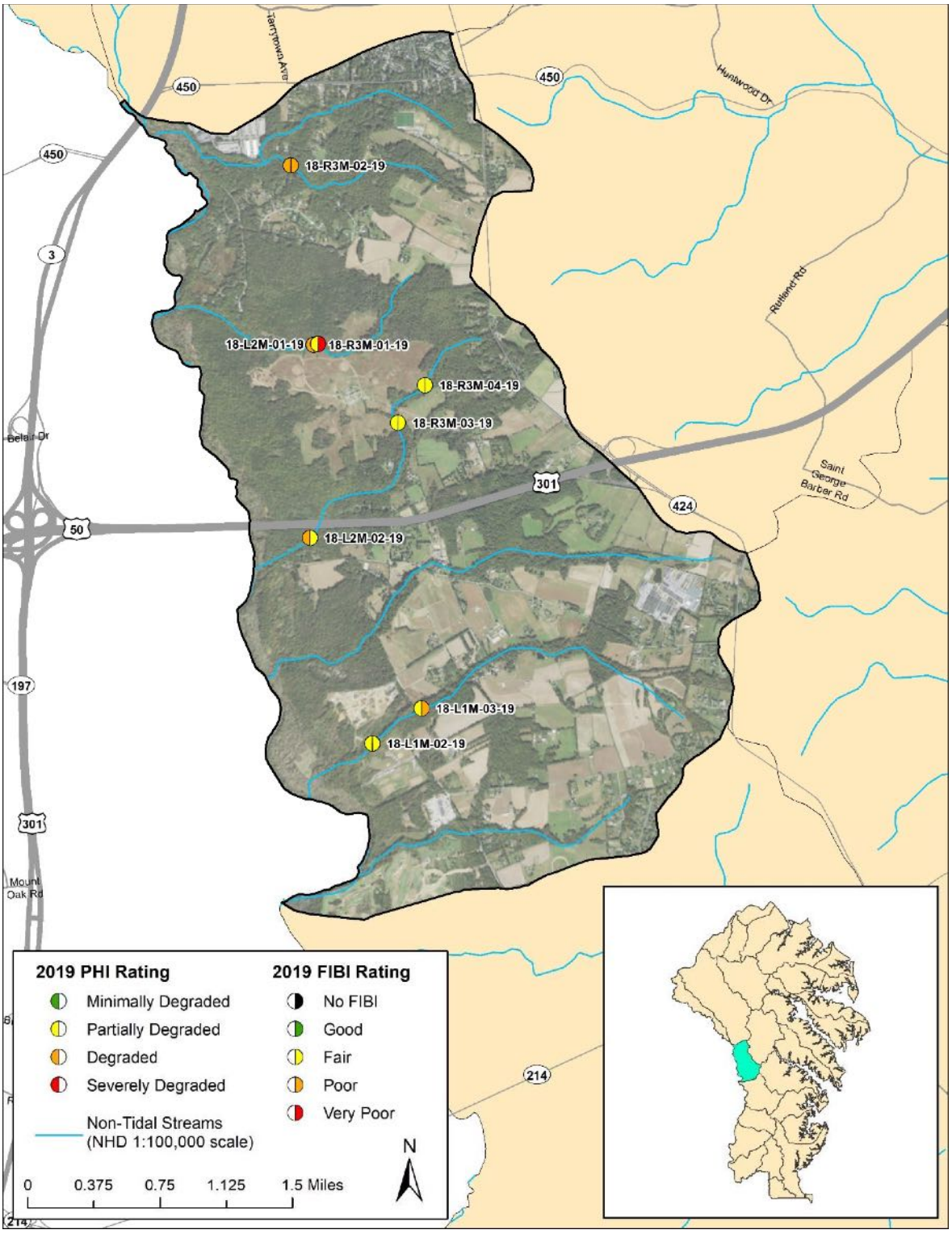

Figure 26 – Middle Patuxent River Sampling Sites (FIBI and PHI)

4.3.5 Water Quality

Average spring and summer *in situ* water quality values for the Middle Patuxent River sites are provided in Table 22. Of the eight sites sampled, four sites did not meet COMAR standards for water quality in the spring. Sites 18-R3M-01-19, 18-R3M-03-19, 18-R3M-04-19, and 18-L2M-01-19 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) with values of 6.32, 6.28, 6.24, and 6.28, respectively. All other parameters sampled met COMAR standards for water quality. In the spring, water temperature ranged from 5.40 to 15.60 °C; DO ranged from 9.32 to 12.73 mg/L; pH ranged from 6.24 to 7.64 SU; specific conductance ranged from 54.0 to 245.0 µS/cm; and, turbidity ranged from 1.70 to 16.80 NTU.

In the summer, five sites in the Middle Patuxent River sampling unit met COMAR standards for water quality. Sites 18-R3M-03-19, 18-R3M-04-19, 18-L1M-03-19 had measured values outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) with values of 5.94, 5.94, and 6.27 SU, respectively. Water temperature ranged from 18.40 to 21.90 °C; DO ranged from 8.05 to 8.81 mg/L; pH ranged from 5.94 to 7.67 SU; specific conductance ranged from 75.0 to 256.0 µS/cm; and, turbidity ranged from 0.00 to 11.10 NTU.

Table 22 - Average in-situ water quality values – Middle Patuxent River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	10.25 ± 3.89	11.19 ± 1.25	6.76 ± 0.55	140 ± 73	5.47 ± 4.84
Summer	19.70 ± 1.10	8.44 ± 0.26	6.71 ± 1.00	153.8 ± 72.1	3.85 ± 3.79

Average spring grab sample water quality values for the Middle Patuxent River sites are provided in Table 23. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. All eight sites sampled had ammonia, total nitrogen, total phosphorus, orthophosphate, and nitrate concentrations in the low or moderate categories used by MBSS. Comparisons of nitrite levels with categories used by MBSS were limited due to 2019 analytical detection limits. Site 18-L1M-03-19 had nitrite concentrations that fell in the high category used by MBSS (i.e., >0.01 mg/L) with a value of 0.010 mg/L, while all other sites fell in the low or moderate categories used by MBSS. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.836 to 2.130 mg/L; TOC ranged from 0.814 to 2.263 mg/L; magnesium ranged from 1.359 to 3.854 mg/L; calcium ranged from 3.79 to 22.71 mg/L; and, hardness ranged from 15.05 to 72.58 mg/L.

Table 23 - Average grab sample water quality values – Middle Patuxent

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
19.59 ± 10.96	0.026 ± 0.007	0.972 ± 0.740	0.004 ± 0.001	0.013 ± 0.006	0.006 ± 0.002	0.935 ± 0.746	1.337 ± 0.412
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
1.490 ± 0.465	2.569 ± 1.010	10.06 ± 7.97	35.68 ± 23.69	0.343 ± 0.499	9.14 ± 2.62	0.117 ± 0.082	6.5 ± 3.8

4.3.6 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. The majority of sites in the Middle Patuxent River sampling unit were classified as entrenched F and G type channels (37.5% each, Figure 27). The remaining 25% of sites were slightly entrenched C and E type channels (12.5% each).

The majority of streams in this sampling unit had predominantly gravel or gravel/sand substrate (25% and 62.5%, respectively) with the remaining sites dominated sand (12.5%). The average D_{50} for the Middle Patuxent River sampling unit was 2.9 mm (very fine gravel). The average slope was 0.74%, with individual sites ranging from 0.42% to 1.40%.

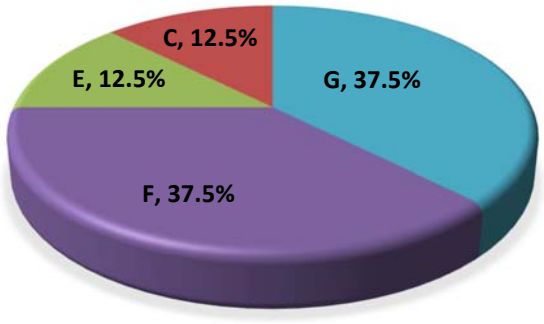

Figure 27 - Rosgen stream types observed in Middle Patuxent (n=8)

4.4 Sawmill Creek

The Sawmill Creek sampling unit is located at the northern edge of the county (Figure 1)) in Glen Burnie, Maryland, and drains into Furnace Creek, which continues to Curtis Creek before draining to the Patapsco River near Curtis Bay in Baltimore County. The sampling unit has a total drainage area of 11,044 acres, with the eight sampling sites shown in Figure 31 have drainage areas ranging from 48 to 3,091 acres.

4.4.1 Land Use

The Sawmill Creek sampling unit is the most developed of the 2019 sampling units, with 62% developed land and 17% open space, with the open space comprised primarily of open developed areas such as the BWI airport and the US Army Depot. As such, forested land was the lowest of all 2019 sampling units, at only 20%, and there was less than 1% of agricultural land cover (Table 17). On average, sampling sites followed a similar trend, and were dominated by developed land (44%). However, the sampling sites were, on average, more forested (29%) and open (23%), and had higher average agriculture (4%) (Figure 28). For all but two of the sites, developed land was the most dominant land cover. In keeping with high levels of developed land cover, Sawmill Creek had the highest impervious surface of the 2019 sampling units, with 33% impervious surfaces, and the individual sites ranged from 11% to 56% impervious surfaces.

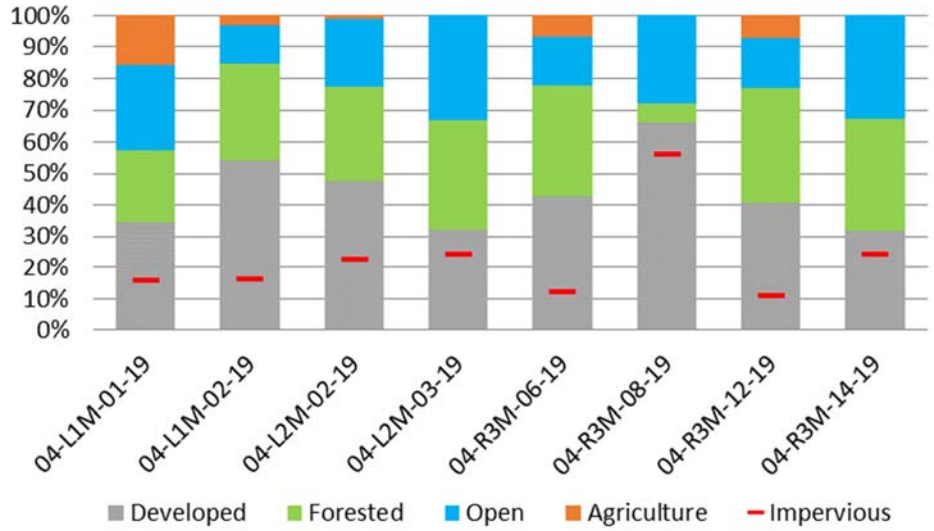

Figure 28 - Sawmill Creek land use (n=8)

4.4.2 Physical Habitat

Based on the RBP index assessed during the spring season, the majority of sites were rated as 'Supporting' (62.5%), 25.0% were rated as 'Partially Supporting', and 12.5% were 'Non-Supporting' (Figure 29). With an average RBP score of 126.13 ± 19.77 and a narrative rating of 'Supporting', Sawmill Creek had the second highest mean RBP score in 2019. Individual RBP scores ranged from a minimum of 90 ('Non-Supporting') to a maximum of 150 ('Supporting').

The PHI (summer season) rated 50.0% of sites as 'Partially Degraded', 25.0% of sites as ' Degraded', and 25.0% as 'Minimally Degraded' (Figure 29). The average PHI rating was 'Partially Degraded' with a score of 74.60 ± 7.76 and was the second highest mean PHI rating of the PSUs sampled during 2019. Individual PHI scores ranged from 63.31 ('Degraded') to 81.77 ('Minimally Degraded'). The majority of sites assessed received 'Marginal' to 'Suboptimal' scores for instream habitat, epifaunal substrate, and pool/glide/eddy quality. Bank stability was rated as 'Optimal' or 'Suboptimal' for all sites. Embeddedness was variable at the Sawmill Creek sites, with half of sites scoring 100% and the remaining scoring between 40% and 95%.

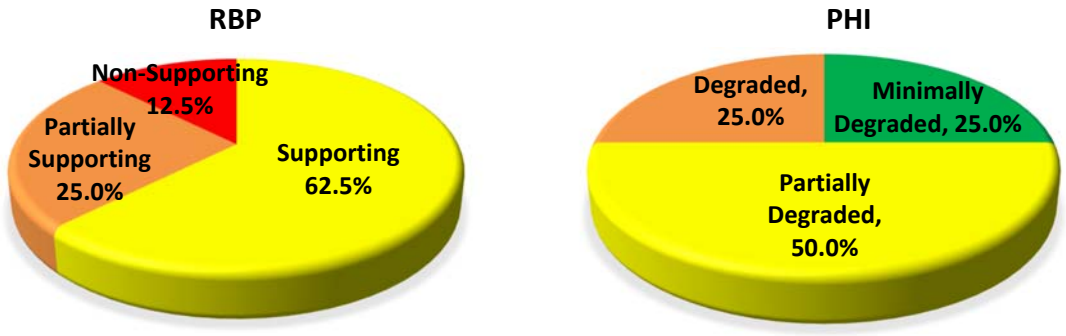

Figure 29 – Sawmill Creek Physical Habitat Conditions (RBP n=8; PHI n=8)

4.4.3 Benthic Macroinvertebrates

Among the Sawmill Creek sampling unit sites, 37.5% of the sites received 'Fair' BIBI ratings, 25.0% were rated as 'Poor', 25.0% were rated 'Very Poor' and the remaining 12.5% of sites received a 'Good' rating (Figure 30). The average BIBI score for the sampling unit was 2.93 ± 1.17, resulting in a 'Poor' biological condition rating (Table 16). This sampling unit had the highest mean BIBI of all PSUs evaluated in 2019. Individual BIBI scores ranged from 1.00 ('Very Poor') to 4.14 ('Good'). Individual site data and assessment results can be found in Appendix D.

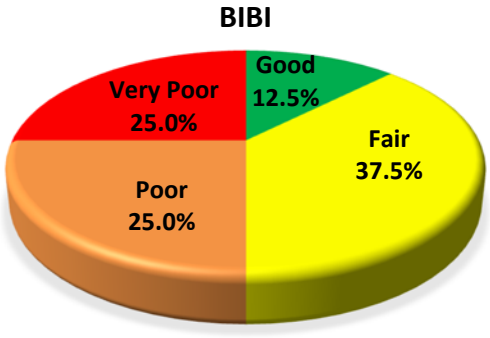

Figure 30 – Sawmill Creek BIBI Conditions (n=8)

Site 04-R3M-08-19 received the lowest BIBI score of 1.00 with a 'Very Poor' rating. Fewer than 60 organisms were contained in the subsample; therefore, this site was assigned the lowest possible score of 1.00. Only 12 taxa were present in this sample, none of which were EPT or Ephemeroptera, and only one of which was a scraper taxa. In contrast, site 04-R3M-12-19 received the highest BIBI score for this sampling unit of 4.14, resulting in a 'Good' biological condition rating. This site had 27 total taxa, including five EPT taxa, one Ephemeroptera taxon, two scraper taxa, and over 50.9% of intolerant taxa. Ephemeroptera taxa were present at half of sites sampled during 2019 in the Sawmill Creek sampling unit, with percentages ranging from 0.88% to 8.85%.

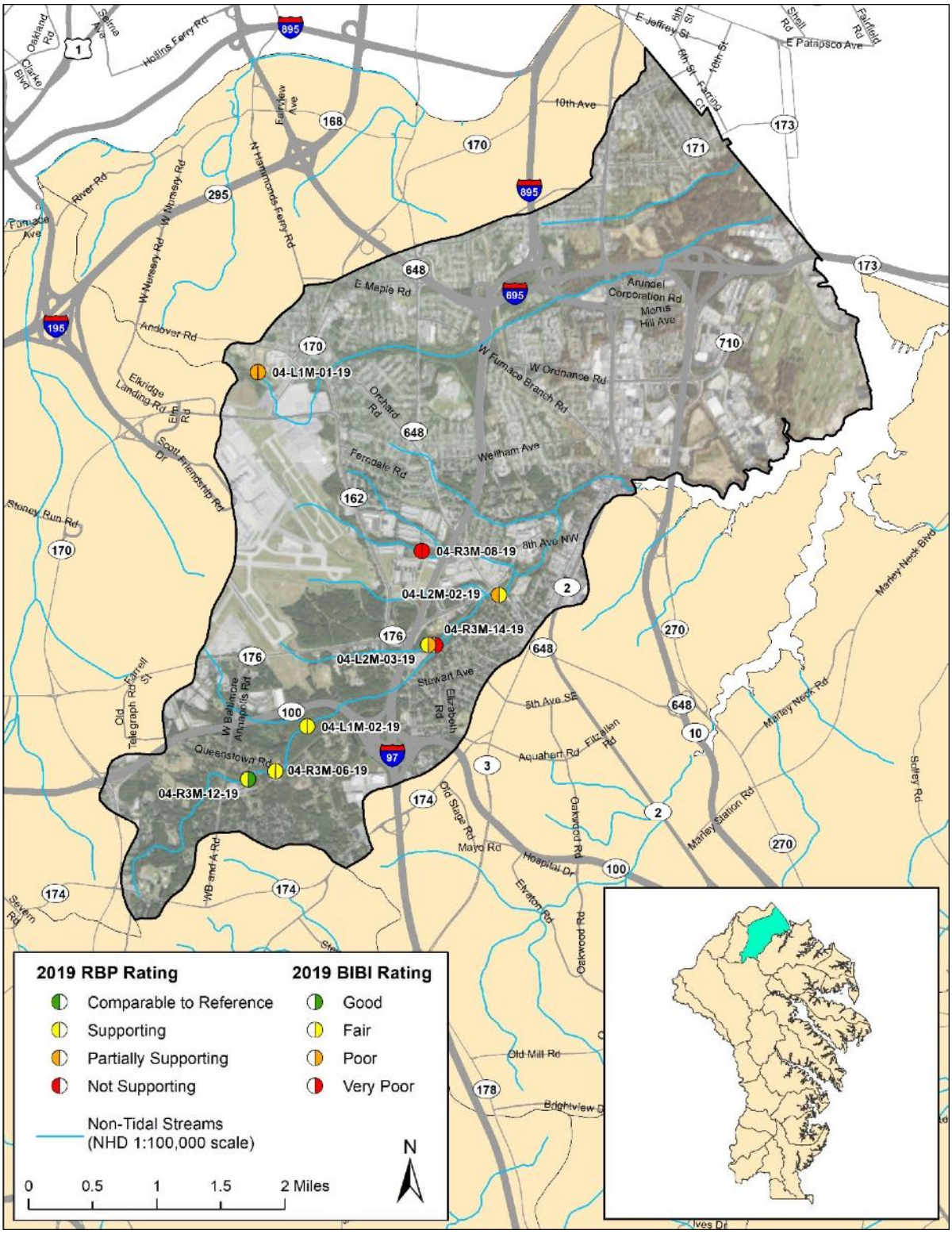

Figure 31 - Sawmill Creek Sampling Sites (BIBI and RBP)

4.4.4 Fish

The Sawmill Creek sampling unit received a FIBI narrative rating of 'Fair' with an average score of 3.28 ±1.02 (Table 16). A biological condition rating of 'Good' was given to 50.0% of the sites, while the remaining 50.0% was evenly split between sites rated as either 'Fair', 'Poor' or 'Very Poor' (Figure 32). It should also be mentioned that only six of eight sites in the sampling unit had FIBI scores calculated, since two sites were sampled qualitatively. Individual FIBI scores ranged from 1.67 ('Very Poor') to 4.00 ('Good'). Site-specific data and assessment results can be found in Appendix D.

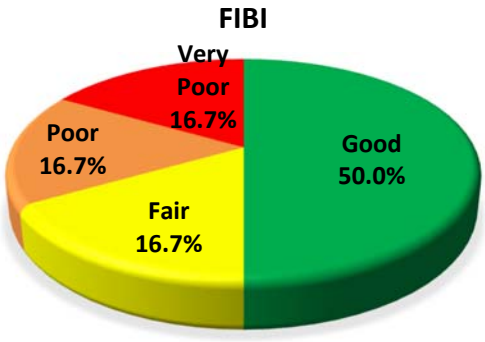

Figure 32 – Sawmill Creek FIBI Conditions (n=6)

Sites 04-L1M-02-19, 04-L2M-02-19, and 04-L2M-03-19 each received the highest FIBI score (4.00; 'Good') in the Sawmill Creek sampling unit. These sites all scored in the highest category (5) for adjusted number of benthic species, percent generalist, omnivores, invertivores, and percent abundance of dominant taxon metrics. These sites had the highest diversity in the sampling unit with between nine and 14 species observed. Site 04-R3M-08-19 received the lowest FIBI score of Sawmill Creek sites (1.67) with a narrative rating of 'Very Poor.' This site received the lowest possible score for all metrics with the exception of adjusted number of benthic species (5). Only four species were found at this site, all of which are tolerant species.

White Sucker, and Tessellated Darter were the most widely distributed species in the sampling unit, present at seven of the eight sites. The least common species in this sampling unit were Fathead Minnow, Blacknose Dace, Brown Bullhead, and Redbreast Sunfish (*Lepomis auritus*), each found at only one site. Seventeen species were observed in the sampling unit with three non-native species (Fathead Minnow, Bluegill, Largemouth Bass), and fourteen native species (Least Brook Lamprey, American Eel, Brown Bullhead, Redbreast Sunfish, Creek Chubsucker, Blacknose Dace, Eastern Mudminnow, Eastern Mosquitofish, Bluespotted Sunfish (*Enneacanthus gloriosus*), Pumpkinseed, Tessellated Darter, Redfin Pickerel (*Esox americanus*), Sea Lamprey (*Petromyzon marinus*), and White Sucker. One round-bodied sucker (Creek Chubsucker) was present, along with three benthic fish species (Least Brook Lamprey, Sea Lamprey, and Tessellated Darter), and one species considered intolerant to pollution (Sea Lamprey).

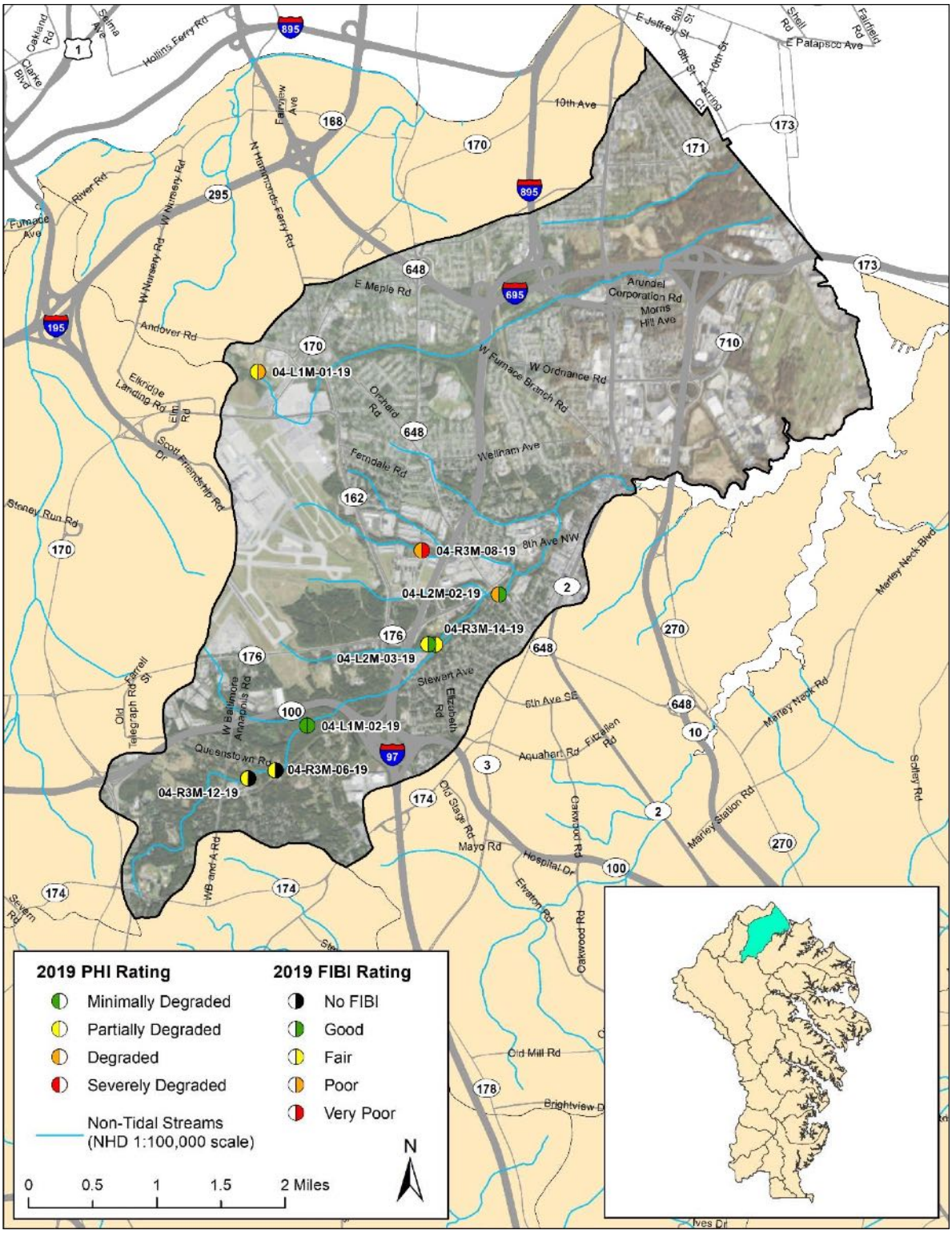

Figure 33 – Sawmill Creek Sampling Sites (FIBI and PHI)

4.4.5 Water Quality

Average spring and summer *in situ* water quality values for the Sawmill Creek sites are provided in Table 24. All of the eight sites sampled in the spring met COMAR standards for water quality. Spring water temperature ranged from 8.40 to 16.40 °C; DO ranged from 8.83 to 10.82 mg/L; pH ranged from 6.63 to 7.56 SU; specific conductance ranged from 196.0 to 496.8 µS/cm; and turbidity ranged from 0.90 to 14.5 NTU.

In the summer, all eight Sawmill Creek sites were sampleable; however, four sites did not meet COMAR standards for water quality. Sites 04-R3M-06-19, 04-R3M-12-19, and 04-L1M-02-19 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with values of 6.25, 6.00, and 6.33 SU, respectively. Sites 04-L1M-01-19 and 04-R3M-12-19 measured outside of the acceptable COMAR range for DO (i.e., >5.0 mg/L), with values of 0.29 and 4.01 mg/L, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 17.70 to 24.50 °C; DO ranged from 0.29 to 8.17 mg/L; pH ranged from 6.00 to 7.42 SU; specific conductance ranged from 192.0 to 458.0 µS/cm; and, turbidity ranged from 2.50 to 19.30 NTU.

Table 24 - Average *in situ* water quality values – Sawmill Creek

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	11.29 ± 2.74	10.00 ± 0.65	6.95 ± 0.33	343.7 ± 120.0	5.83 ± 5.21
Summer	19.75 ± 2.17	6.22 ± 2.73	6.69 ± 0.49	335.2 ± 111.6	6.97 ± 5.51

The average spring grab sample water quality values for the Sawmill Creek sites are provided in Table 25. All eight sites sampled met EPA standards for chloride concentration and COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen, orthophosphate, and nitrate, all values at Sawmill Creek sites fell in the low or moderate categories used by MBSS. For total phosphorus, site 04-L1M-01-19 slightly exceeded the high category threshold used by MBSS (i.e., >0.07 mg/L), with a value of 0.078 mg/L. For the remaining Sawmill Creek sites, one fell in the low category used by MBSS for total phosphorus, while the remaining sites fell in the moderate category. For total ammonia, sites 04-R3M-08-19 and 04-L1M-01-19 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.167 and 0.129 mg/L, respectively. The remaining sites sampled had ammonia values in the low or moderate categories used by MBSS. Site 04-L1M-01-19 fell into the high category used by MBSS (i.e., >0.01 mg/L) for nitrite with a value of 0.015 mg/L, while all other nitrite values were below the MDL and could not be further categorized. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.293 to 7.318 mg/L; TOC ranged from 2.500 to 7.611 mg/L; magnesium ranged from 2.539 to 5.085 mg/L; calcium ranged from 10.90 to 34.41 mg/L; and, hardness ranged from 38.37 to 103.73 mg/L.

Table 25 - Average grab samples water quality values – Sawmill Creek

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
57.68 ± 28.84	0.029 ± 0.021	1.387 ± 0.564	0.005 ± 0.004	0.068 ± 0.051	0.007 ± 0.003	1.153 ± 0.624	4.091 ± 1.522
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
4.303 ± 1.575	3.686 ± 1.006	18.59 ± 8.31	61.62 ± 24.24	1.366 ± 0.338	17.41 ± 6.64	0.757 ± 0.289	8.2 ± 3.4

4.4.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. In the Sawmill Creek sampling unit, 37.5% of the sites were classified as DA type channels. An additional 37.5% of the sites were classified as slightly entrenched E and C type channels (25% and 12.5%, respectively; Figure 34). Moderately entrenched B channels made up 12.5% of sites. The remaining 12.5% of the sites assessed were labeled as 'Not Determined' (ND) as they were unable to be classified within the Rosgen stream types.

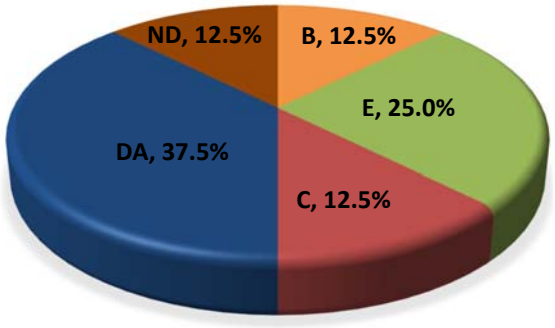

Figure 34 - Rosgen stream types observed in Sawmill Creek (n=8)

The majority of streams in this sampling unit had a sand or sand/silt dominated substrate (87.5%). The remaining 12.5% was dominated by gravel. The average D_{50} for the sampling unit was 0.36 mm (medium sand) and slopes ranged from 0.01% to 1.10%, with an average slope of 0.36%. The Sawmill Creek sampling unit had the widest range of slopes observed among the 2019 sampling units.

4.5 Upper Patuxent River

The Upper Patuxent River sampling unit is along the western edge of the county, beginning near Laurel, Maryland and draining the Patuxent River, until becoming the Middle Patuxent sampling unit near Crofton, Maryland (Figure 1). Overall, the sampling unit has a drainage area of 6,957 acres, and the eight sampling sites shown in Figure 38 have drainage areas ranging from 122 to 371 acres.

4.5.1 Land Use

The Upper Patuxent River sampling unit is the most heavily forested (70%) and the least developed (19%) of the 2019 sampling units. The sampling unit also has low open land (11%) and less than 1% of agricultural land (Table 17). On average, individual site drainage areas followed a similar trend, with high forested land cover (72%), lower average open land (20%), and even lower average development (9%). As with the overall sampling unit, agriculture was less than 1% (Figure 35). Six of eight sites were dominated by forested land, one site was dominated by open space, and one was a roughly equal mix of forest and open space (Figure 35). Impervious surfaces comprise only 7% of the overall sampling unit, with individual sites ranging from less than 1% to 13% impervious cover.

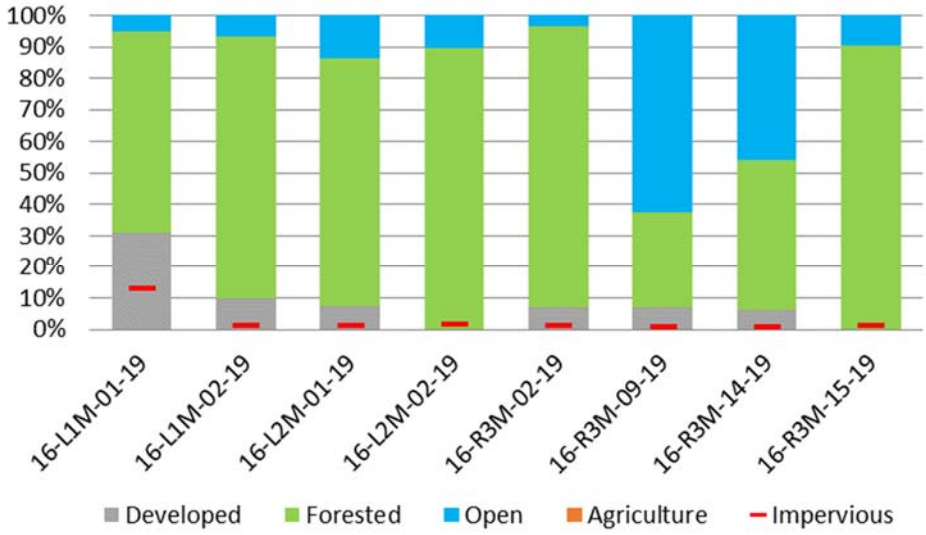

Figure 35 – Upper Patuxent River land use (n=8)

4.5.2 Physical Habitat

Nearly two-thirds of the sites sampled during the spring season in the Upper Patuxent sampling unit (62.5%) received a 'Supporting' narrative RBP rating, while 25.0% of the sites received a 'Partially Supporting' rating, and the remaining 12.5% received a RBP rating of 'Comparable to Reference' (Figure 36). The average RBP score for the sampling unit was 128.63 ± 13.85, and the corresponding narrative rating was 'Supporting.' Individual RBP scores ranged from a minimum of 101 ('Partially Supporting') to a maximum of 151 ('Comparable to Reference'). This sampling unit had the highest mean RBP score of all PSUs assessed in 2019.

The PHI (summer season) rated 25.0% of sites as 'Minimally Degraded', 62.5% as 'Partially Degraded', and 12.5% as 'Degraded' (Figure 36). The average PHI rating was 'Partially Degraded' with a score of 75.55 ± 6.69. Individual PHI scores ranged from 63.31 ('Degraded') to 81.77 ('Minimally Degraded'). The Upper Patuxent sampling unit had the highest mean PHI score of the sampling units from 2019. Instream habitat

and epifaunal substrate was highly variable, with scores ranging from 'Sub-optimal' to 'Poor'. The scaled scores for bank stability, shading, and woody debris/rootwads were relatively high, helping raise the overall PHI score for most sites.

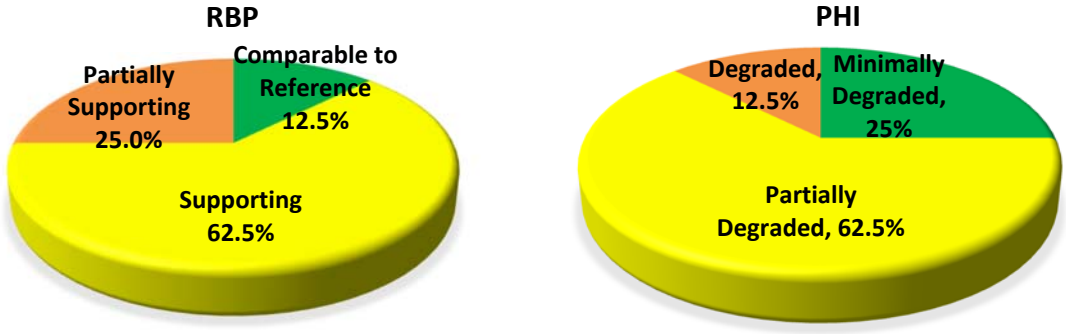

Figure 36 – Upper Patuxent Physical Habitat Conditions (RBP n=8; PHI n=8)

4.5.3 Benthic Macroinvertebrates

The majority of sites sampled within the Upper Patuxent sampling unit (62.5%) received 'Very Poor' BIBI ratings, while a quarter received 'Poor' ratings and the remaining 12.5% of sites were rated as 'Fair' (Figure 37). The average BIBI score for the sampling unit was 2.07 ± 0.52 resulting in a 'Poor' biological condition rating (Table 16). Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.00 ('Fair'). This sampling unit received the second lowest mean BIBI score in 2019, with only one site scoring in the 'Fair' category. Individual site data and assessment results can be found in Appendix D.

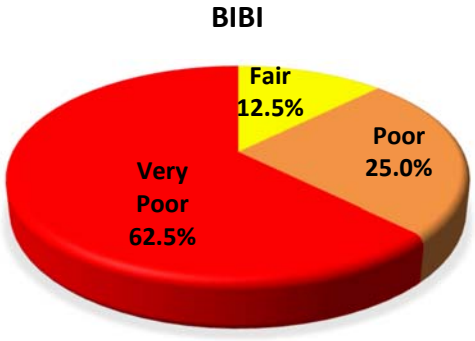

Figure 37 – Upper Patuxent BIBI Conditions (n= 8)

Located close to Maryland Route 2, site 16-R3M-15-19 received the lowest BIBI score of 1.57 with a 'Very Poor' rating (Figure 38). Only eight taxa were present in this sample, one of which was an EPT taxon, and Ephemeroptera, scraper taxa, and climber taxa were completely absent. Site 16-R3M-02-19 received the highest score (3.00) in Upper Patuxent, resulting in a biological condition rating of 'Fair.' This site had 20 taxa present, seven of which were EPT taxa and one of which was a scraper taxon, and a very high percentage of intolerant organisms (70.4%). Ephemeroptera taxa were not found at any sites in this sampling unit in 2019, and only three sites had a single scraper taxon present.

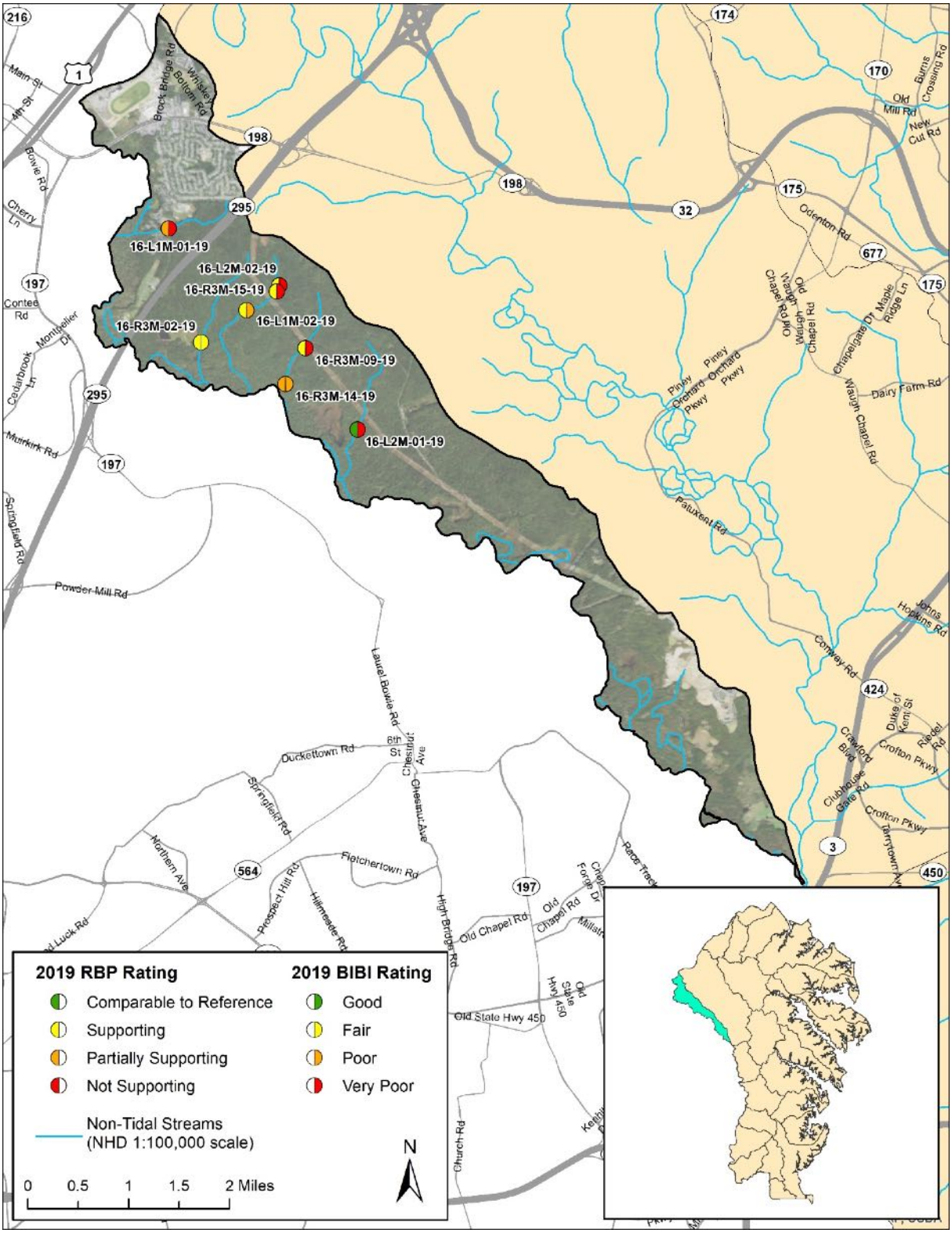

Figure 38 – Upper Patuxent Sampling Sites (BIBI and RBP)

4.5.4 Fish

The Upper Patuxent sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.00 ± 0.85 (Table 16). Fifty percent of the sites in this sampling unit received a biological condition rating of 'Very Poor', while the remaining 50.0% was equally split between 'Fair' and 'Poor' ratings (Figure 39). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

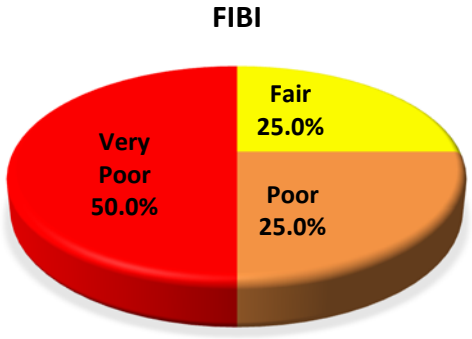

Figure 39 – Upper Patuxent FIBI Condition (n=8)

Sites 16-R3M-09-19 and 16-R3M-15-19 had the lowest FIBI scores of Upper Patuxent sites (1.00) with a narrative rating of 'Very Poor.' Both sites scored in the lowest category (1) for all six metrics and contained, at most, only one or two species. Site 16-L1M-01-19 received the highest FIBI score (3.33; 'Fair') in the sampling unit. This site scored in the highest category for abundance per square meter, percent round-bodied suckers, and percent abundance of dominant taxon; in the middle category for percent tolerant; and in the lowest category for adjusted number of benthic species and percent generalist, omnivores, and invertivores. This site had the highest diversity in the sampling unit with nine species observed.

Eastern Mudminnow was the most widely distributed species in the sampling unit, present at all eight sites. Numerous species were present at only a single site within this sampling unit including American Eel, Blacknose Dace, Eastern Mosquitofish, Pumpkinseed, Redfin Pickerel, and Rosyside Dace. Eleven species were observed in the sampling unit with one non-native species (Green Sunfish), and ten native species (American Eel, Creek Chubsucker, Eastern Mosquitofish, Rosyside Dace, Fallfish, Creek Chub, Blacknose Dace, Eastern Mudminnow, Redfin Pickerel, and Pumpkinseed). One round-bodied sucker (Creek Chubsucker) and one species considered intolerant to pollution (Fallfish) were observed in this sampling unit. No benthic species were observed in the Upper Patuxent sampling unit in 2019.

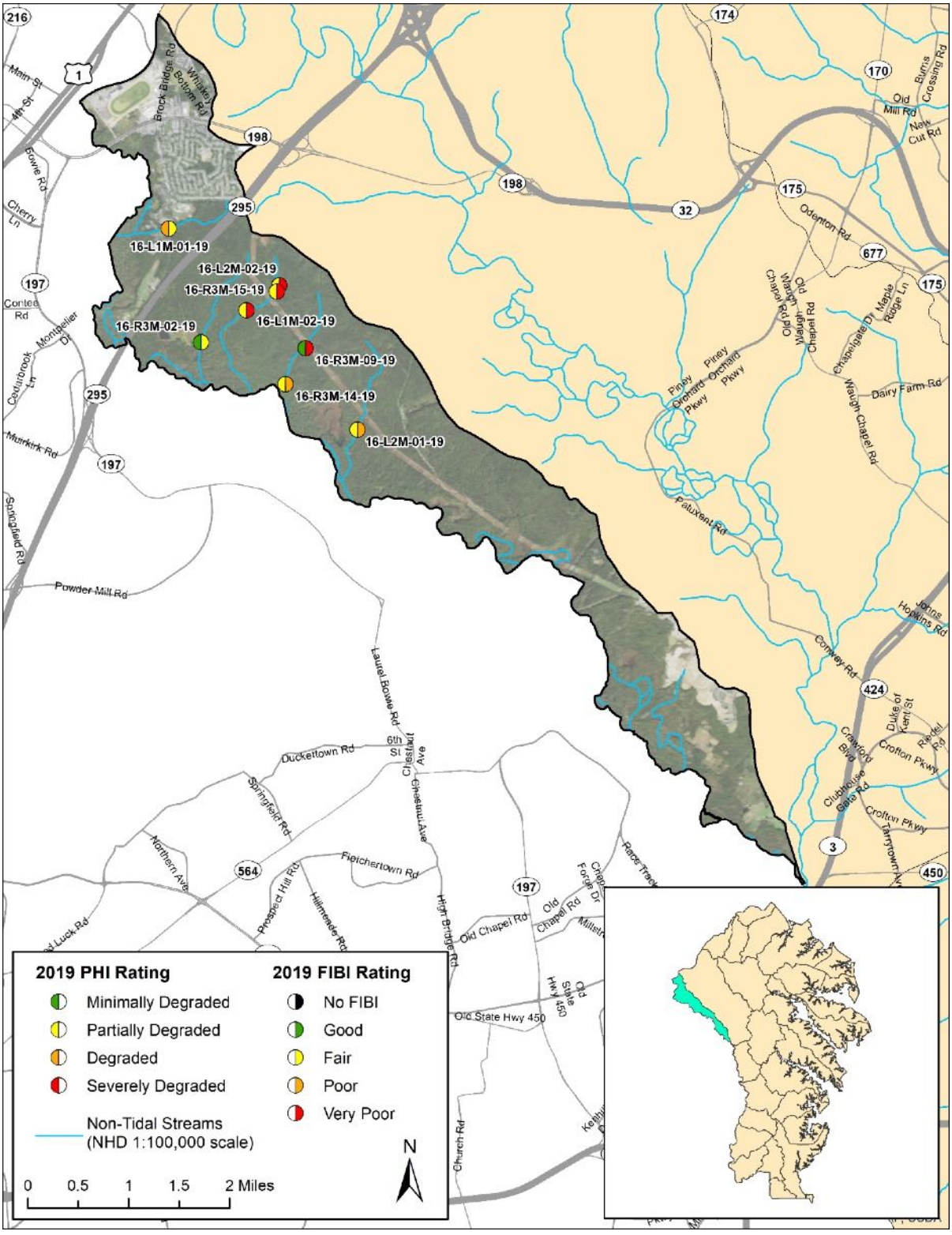

Figure 40 – Upper Patuxent Sampling Sites (FIBI and PHI)

4.5.5 Water Quality

Average spring and summer *in situ* water quality values for the Upper Patuxent River sites are provided in Table 26. Of the eight sites sampled, seven sites did not meet COMAR standards for water quality in the spring. Site 16-L1M-01-19 was the only site that measured within the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a pH of 7.10 SU. In the spring, water temperature ranged from 4.00 to 12.20 °C; DO ranged from 8.43 to 12.44 mg/L; pH ranged from 4.45 to 7.10 SU; specific conductance ranged from 31.1 to 264.3 µS/cm; and, turbidity ranged from 4.35 to 10.50 NTU.

In the summer, all eight Upper Patuxent River sites were sampleable and all eight sites did not meet COMAR standards for water quality. Sites 16-L1M-01-19, 16-L1M-02-19, 16-L2M-01-19, 16-R3M-02-19, 16-R3M-09-19, 16-R3M-14-19, and 16-R3M-15-19 measured outside of acceptable COMAR standards for pH (i.e., 6.5-8.5 SU), with values of 6.37, 5.52, 5.08, 5.43, 5.82, 5.27, and 4.78 SU, respectively. Sites 16-L1M-01-19, 16-L1M-02-19, 16-L2M-01-19, 16-L2M-02-19, 16-R3M-02-19, and 16-R3M-15-19 measured outside of the acceptable COMAR standards for DO (i.e., >5.0 mg/L), with values of 1.61, 4.43, 4.44, 4.75, 4.16, and 2.80 mg/L, respectively. Turbidity at site 16-L2M-01-19 exceeded the COMAR standard for acute exposure (i.e., <150 NTU) with a value of 325.00 NTU. In the summer, water temperature ranged from 19.50 to 24.10 °C; DO ranged from 1.61 to 7.61 mg/L; pH ranged from 4.78 to 7.32 SU; specific conductance ranged from 31.7 to 405.6 µS/cm; and, turbidity ranged from 5.40 to 325.00 NTU.

Table 26 - Average *in situ* water quality values – Upper Patuxent River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	7.98 ± 2.90	10.67 ± 1.24	5.35 ± 0.79	64.3 ± 81	6.00 ± 2.17
Summer	21.60 ± 1.38	4.55 ± 1.90	5.70 ± 0.81	82.8 ± 130.5	65.16 ± 105.89

Average spring grab sample water quality values for the Upper Patuxent River sites are provided in Table 27. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, and lead. Orthophosphate concentrations at all sites were below the MDL of 0.0032 mg/L, also falling in the low category used by MBSS. Nitrite concentrations were below the MDL of 0.0052 mg/L for all sites and could not be categorized. Additionally, all eight sites sampled had ammonia, total nitrogen, total phosphorus, and nitrate concentrations in the low or moderate categories used by MBSS. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.350 to 6.784 mg/L; TOC ranged from 2.491 to 8.009 mg/L; magnesium ranged from 0.693 to 3.358 mg/L; calcium ranged from 0.80 to 14.44 mg/L; and, hardness ranged from 4.86 to 49.88 mg/L.

Table 27 - Average grab sample water quality values – Upper Patuxent River

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
7.79 ± 15.17	0.011 ± 0.003	0.184 ± 0.061	0.003 ± 0.000*	0.019 ± 0.018	0.005 ± 0.000*	0.024 ± 0.019	4.736 ± 1.474
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
5.048 ± 1.800	1.219 ± 0.873	2.62 ± 4.76	11.56 ± 15.50	1.592 ± 0.730	17.32 ± 5.03	0.501 ± 0.253	5.0 ± 2.7

*Standard deviation is 0.000 because all values were below the detection limit of 0.0032 mg/L for orthophosphate and 0.0052 mg/L for nitrite.

4.5.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The Upper Patuxent River sampling unit had the most variability in Rosgen stream type. The largest percentage of sites were classified as slightly entrenched E and C type channels (37.5% and 12.5%, respectively; Figure 41). Entrenched F and G type channels accounted for 25% of sites (12.5% for each). Moderately entrenched B channels made up 12.5% of the sites, while the remaining 12.5% of sites were labeled as 'Not Determined' (ND) due to stream alteration.

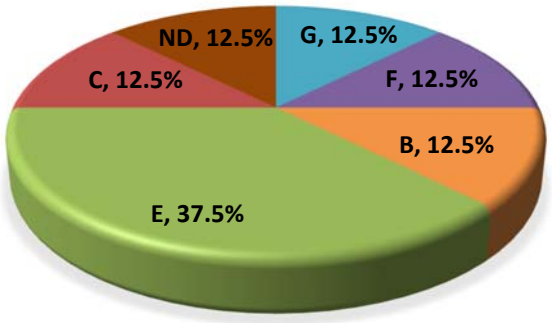

Figure 41 - Rosgen stream types observed in Upper Patuxent (n=8)

Half of the sites were dominated by gravel (50%). Twenty-five percent of the sites were dominated by sand, and 12.5% of the sites were dominated by silt/clay. The average D_{50} for the sampling unit was 9.8 mm (medium gravel). The average slope within Upper Patuxent River was 0.77%, with individual reach slopes ranging from 0.56% to 1.1%.

5 Round Comparisons for Repeated Sites

In Round Three, a subset of sites from Round One and Two (i.e., two sites from each previous round per PSU) were re-established and sampled in order to track changes through time at individual sites within each sampling unit. For these sites, cross-sectional area, Rosgen classification, substrate distribution, and BIBI scores were compared across sampling years (Table 28).

From Round One and Two to Round Three, substrate coarsened in the Middle Patuxent River, Upper Patuxent River, Little Patuxent River, and Lower North River sampling units and became finer in the Sawmill Creek sampling unit, based on the average D_{50} values. Substrate size increased from coarse sand to fine gravel in the Middle Patuxent River sampling unit, very coarse sand to fine gravel in the Upper Patuxent River sampling unit, coarse sand to very fine gravel in the Little Patuxent River sampling unit, and fine sand to very fine gravel in the Lower North River sampling unit. Trends in BIBI scores at revisit sites also varied by sampling unit. On average, BIBI scores remained the same in Upper Patuxent River, improved in Sawmill Creek, and declined in Lower North River, Middle Patuxent River, and Little Patuxent River. Overall, no clear trend was observed between changes in BIBI scores and changes in substrate distribution. In addition, no consistent trend between BIBI score and cross-sectional area were apparent for the 2019 sampling units.

Little Patuxent

Cross-section overlays at Little Patuxent River sites indicate varying magnitudes of changes since the initial assessments in Round One and Two. The three sites that were re-established all experienced decreases in cross-sectional area (Table 28). The site 17-L1M-01-19 cross-section was re-established after the Round One end pins were unable to be located. All revisited sites had increasing D_{50} values in Round Three. Site 17-L1M-02-19 changed stream classification from a G to an F type channel. This was due to the downcutting and widening of the channel that has occurred since Round One, limiting the floodplain access and increasing the overall width/depth ratio at bankfull. Site 17-L2M-02-19 has also changed stream classification since the initial Round Two assessment, transitioning from an E channel to a G channel. This was again due to downcutting and slight widening of the overall channel which caused the entrenchment ratio to exemplify that of a G type channel. Site 17-L1M-01-19 was deemed to be in transition between stream types in the Round One assessment and has since been classified as a B type channel with a lower slope modifier in Round Three.

On average, BIBI scores at Little Patuxent River revisit sites decreased slightly from previous rounds from 'Poor' to 'Very Poor' (Table 28). Both Round One revisit sites, 17-L1M-01-19 and 17-L1M-02-19, experienced no change in the BIBI scores (both 'Very Poor'). BIBI score improved at site 17-L2M-01-19 (rating unchanged) and declined from 'Poor' to 'Very Poor' at site 17-L2M-02-19. No trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size.

Lower North River

Cross-section overlays for Lower North River revisit sites revealed a loss in cross-sectional area at all sites with the exception of site 12-L1M-03-19. Site 12-L1M-03-19 experienced a slight increase in cross-sectional area, likely due to the channel shifting right and subsequent erosion on the right bank. Both of the Round One revisit sites showed changes in stream classification and dominant channel substrate. Site 12-L1M-02-19 transitioned from a F5 type channel with a dominant substrate of medium sand to a B5c

classification with a dominant substrate of fine sand. Site 12-L1M-03-19 transitioned from a B5c type channel with a dominant substrate of medium sand to a G4c classification with a dominant substrate of medium gravel.

Of the Round Two revisit sites, only one had a change in stream classification. Site 12-L2M-02-19 transitioned from an E type to a G type channel due to slight downcutting and erosion at the toe of the left bank. In 2009, this site was described as a very disturbed E type and further characterized as possibly an E type that had formed in an older F type channel, an evolutionary pathway for E types disturbed by development or other factors (Rosgen 1996). Coincident to this change in stream type was an increase in developed land, from 22% of the basin to about 29%, but a slight decrease in impervious area, from 12.5% of the basin to 10.1%. A more in-depth analysis of relationships and trends between watershed characteristics and channel characteristics will be provided following the completion of Round Three. The D_{50} for site substrate varied overall but three or the four revisit sites were dominated by sand in Round Three. Site 12-L1M-03-19 had a substrate D_{50} of medium gravel.

On average, BIBI scores at Lower North River decreased in Round Three. BIBI scores decreased at all sites resampled in Round Three, with the exception of site 12-L1M-03-19. The BIBI score at site 12-L1M-03-19 improved but remained in the 'Poor' category. This improvement coincided with an increase in cross-sectional area and an apparent lack of aggradation of the channel bottom, whereas, sites that experienced a decline in BIBI score generally had decreases in cross-sectional area concurrent with apparent burial of the original channel bottom. Although, this trend is definitely uncertain due to the loss of one monument at 12-L2M-01-19, making a direct comparison of change in the cross section impossible.

Middle Patuxent

Cross-section surveys were not completed in the first year of Round One (2004), so geomorphological comparisons could only be made with Round Two revisit sites within the Middle Patuxent River sampling unit. The sites that were revisited varied in cross-sectional area changes. On average, cross-sectional area decreased by 7.8% from Round One and Two to Round Three. At site 18-L2M-01-19, cross-sectional area increased by 13.5%; however, at site 18-L2M-02-19, cross-sectional area decreased by 29%. In Round Three, three of the four resampled sites were classified as entrenched stream types (F or G type channels). There were varying D_{50} values in Round Three ranging from coarse sand (0.5 mm) to medium gravel (12 mm). A representative cross-sectional overlay can be found in Figure 42. Individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries.

On average, BIBI scores at Middle Patuxent River revisit sites declined in Round Three compared to previous rounds. BIBI scores averaged a 'Poor' biological rating in Round Three, compared to a 'Fair' biological rating in previous rounds (Table 28). All revisit sites experienced a decrease in BIBI scores, with the exception of site 18-L1M-02-19, where the BIBI score improved slightly in Round Three ('Poor' rating to a 'Fair' rating). The BIBI score at site 18-L2M-01-19 decreased from Round Two ('Good' rating) to Round Three ('Poor' rating), which also corresponded with an increase in cross-sectional area and finer substrate. At site 18-L2M-02-19, the BIBI score decreased slightly from Round Two to Round Three, but received a 'Fair' rating in both rounds. This slight decrease in BIBI score coincided with a decrease in cross-sectional area between rounds.

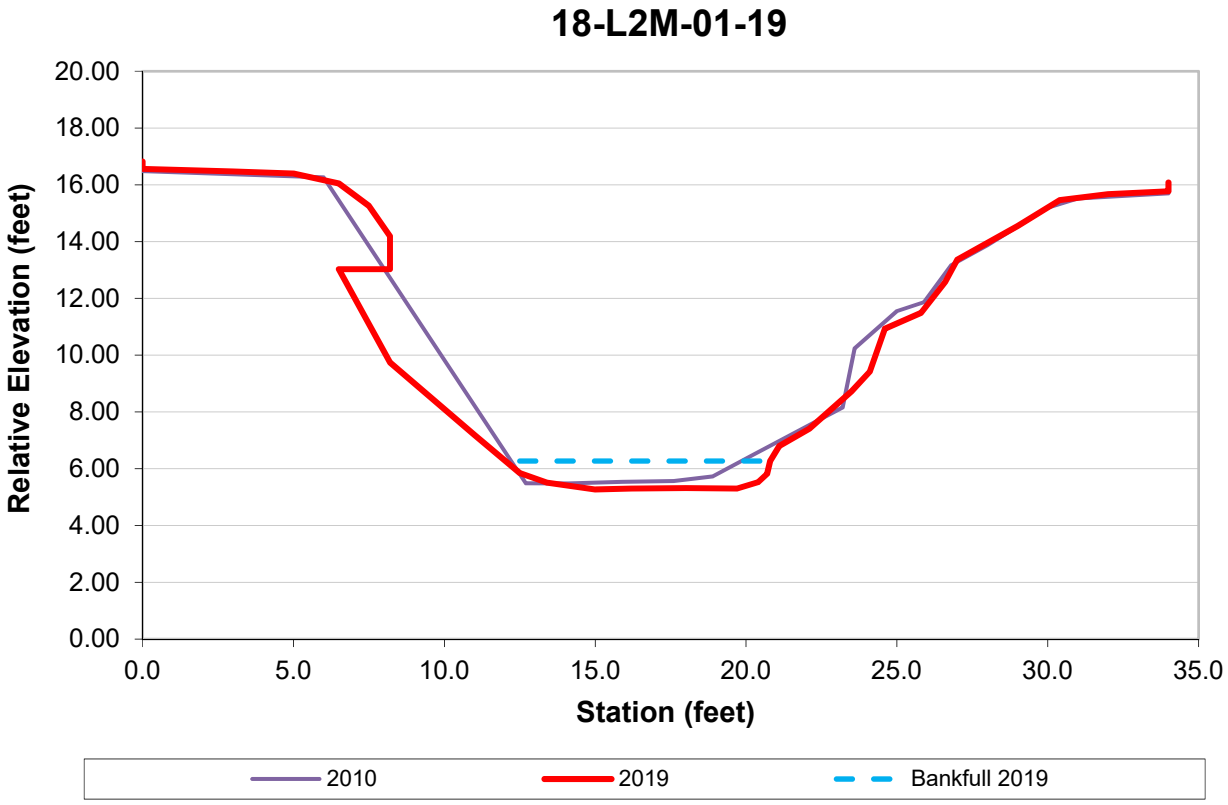

Figure 42- Representative cross-section overlay in the Middle Patuxent River sampling unit

Table 28 - Comparison of Round One and Round Two (2004 - 2013) with Round Three (2019) geomorphological and biological data

2019 Site Name	Year First Sampled	Cross-Sectional Area (ft^2)			D_{50} Substrate Classification (Size in mm)		Rosgen Classification		BIBI Narrative Ranking (Score)	
		R1/R2	R3	%Δ	R1/R2	R3	R1/R2	R3	R1/R2	R3
17-L1M-01-19	2007	10.7	8.8[2]	---[2]	fine sand (0.23)	very coarse sand (1.4)	Transitional	B5c	Very Poor (1.57)	Very Poor (1.57)
17-L1M-02-19	2007	29.8	10.3	-65.3	medium sand (0.44)	coarse sand (0.74)	G5c	F5	Very Poor (1.57)	Very Poor (1.57)
17-L2M-01-19	2009	9.1	8.3	-9.0	medium sand (0.47)	coarse sand (0.84)	E5	E5	Poor (2.43)	Poor (2.71)
17-L2M-02-19	2009	16.1	9.2	-42.7	very fine gravel (2.6)	medium gravel (8)	E4	G4c	Poor (2.43)	Very Poor (1.57)
Little Patuxent Average		16.4	9.2	-58.5	coarse sand (0.94)	very fine gravel (2.75)	---	---	Poor (2.00)	Very Poor (1.86)
12-L1M-02-19	2005	5.9	4.6	-21.6	medium sand (0.38)	fine sand (0.17)	F5	B5c	Fair (3.00)	Very Poor (1.86)
12-L1M-03-19	2005	41.8	25.9	8.7	medium sand (0.38)	medium gravel (8)	B5c	G4c	Poor (2.14)	Poor (2.43)
12-L2M-01-19	2009	4.9	2.8[2]	---[2]	fine sand (0.14)	fine sand (0.16)	B5c	B5c	Very Poor (1.29)	Very Poor (1.00)
12-L2M-02-19	2009	10	8.0	-19.9	very fine sand (0.081)	medium sand (0.3)	E6	G5c	Fair (3.00)	Poor (2.71)
Lower North River Average		11.2	10.3	-26.6	medium sand (0.25)	very fine gravel (2.16)	---	---	Poor (2.36)	Poor (2.00)
18-L1M-02-19	2004	---[1]	10.8	---	---[1]	medium gravel (12)	---[1]	C4	Poor (2.43)	Fair (3.00)
18-L1M-03-19	2004	---[1]	10.5	---	---[1]	fine gravel (7.7)	---[1]	F4	Fair (3.00)	Very Poor (1.57)
18-L2M-01-19	2010	6.5	7.4	13.5	very coarse sand (1.8)	coarse sand (0.5)	G4/5c	G5/4c	Good (4.43)	Poor (2.14)
18-L2M-02-19	2010	17.6	12.5	-29.0	very fine sand (0.12)	very coarse sand (1.8)	F5	F4/5	Fair (3.86)	Fair (3.57)
Middle Patuxent Average		12.1	10.3	-7.8	coarse sand (0.96)	fine gravel (5.5)	---	---	Fair (3.43)	Poor (2.57)
04-L1M-01-19	2008	15.8	12.5	-20.6	medium sand (0.26)	silt/clay (0.06)	E5	C5/6	Very Poor (1.29)	Poor (2.71)
04-L1M-02-19	2008	17.4	14.9	-14.1	medium sand (0.25)	medium sand (0.48)	E5	E5	Poor (2.14)	Fair (3.86)
04-L2M-02-19	2010	26.6	32.8	23.4	medium gravel (14)	medium sand (0.33)	ND	ND	Poor (2.71)	Fair (3.86)
04-L2M-03-19	2010	10.7	8.9	-17.1	medium sand (0.31)	medium sand (0.43)	Da5	Da5	Poor (2.43)	Poor (2.14)
Sawmill Creek Average		17.6	17.3	-7.1	very fine gravel (3.71)	medium sand (0.32)	---	---	Poor (2.14)	Fair (3.14)
16-L1M-01-19	2007	7.6	5.4[2]	---[2]	medium sand (0.42)	medium gravel (13)	ND	ND	Very Poor (1.86)	Very Poor (1.86)
16-L1M-02-19	2007	14.2	6.3[2]	---[2]	medium sand (0.47)	very coarse sand (1)	E5	F5	Poor (2.14)	Poor (2.14)
16-L2M-01-19	2011	14.3	8.1	-43.5	very fine sand (0.09)	very fine sand (0.09)	E5	E5	Very Poor (1.57)	Very Poor (1.86)
16-L2M-02-19	2011	4.0	4.3	8.2	very fine gravel (3.2)	medium gravel (13)	G4/5c	G4c	Very Poor (1.86)	Very Poor (1.57)
Upper Patuxent Average		10.0	6.0	-17.7	very coarse sand (1.0)	fine gravel 6.77)	---	---	Very Poor (1.86)	Very Poor (1.86)

*Table 28: [1]Geomorph survey not performed in 2004, [2]R1/R2 XS pins were not found in R3, re-established XS, comparison could not be made between the rounds, [3]No monuments established at request of landowner, Estimated value, R1 - Round One; R2 - Round Two; R3 - Round Three; %Δ = ((R3 cross-sectional area - R1 or R2 cross-sectional area)/ R1 or R2 cross-sectional area) * 100*

Sawmill Creek

Cross-section overlays at Sawmill Creek revisit sites revealed a consistent trend of aggradation occurring in the stream channel. All revisit sites experienced a decrease in cross-sectional area with the exception of site 04-L2M-02-19 (Table 28). Site 04-L2M-02-19 slightly increased in cross-sectional area due to a small area of scour on the left side of the stream bed. The decrease in cross-sectional area for the other revisited sites was due to differing amounts of aggradation that led to the loss of bankfull channel area. In Round Three, all revisit sites had a substrate D_{50} of medium sand or finer with no major changes from previous rounds. Site 04-L1M-01-19 was the only revisit to have a change in stream classification, transitioning from an E type to a C type channel. The width/depth ratio increased and the entrenchment ratio had decreased compared to Round One.

On average, BIBI scores at Sawmill Creek revisit sites improved from previous rounds to Round Three (Table 28). With the exception of one site, 04-L2M-02-19, all revisit sites had improved BIBI scores. Sites 04-L1M-02-19 and 04-L2M-02-19 both improved from 'Poor' to a 'Fair' rating in Round Three with Site 04-L1M-02-19 experiencing the single largest improvement of BIBI score from a previous round among all 2019 sampling units. Site 04-L1M-01-19 improved from 'Very Poor' to 'Poor'. No trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size.

Upper Patuxent

Cross-section overlays at the Upper Patuxent River sampling unit also support general variability in terms of site-by-site cross-sectional area changes from previous rounds. During the Round Three resurvey at sites 16-L1M-01-19 and 16-L1M-02-19, the Round One cross-section endpins were unable to be located. Thus, direct comparisons are not possible because the re-established cross-section survey results were not consistent enough. Site 16-L2M-01-19 exhibited a 43.5% decrease in cross-sectional area from Round Two to Round Three. This decrease was likely due to shifting and narrowing of the bankfull channel. Site 16-L2M-02-19 saw significant channel shifting since the Round Two sampling, although, channel dimensions were relatively stable. Site 16-L2M-02-19 had coarser D_{50} substrate from Round Two to Round Three, increasing from very fine gravel to medium gravel, while site 16-L2M-01-19 remained stable with a D_{50} of very fine sand. Rosgen stream classifications did not change for either of the Upper Patuxent River Round Two revisit sites. Round One revisit site 16-L1M-02-19 was previously classified as an E type channel but reflected an F channel in Round Three. This could have either been due to placement of the re-established cross-section since the Round One end pins were unable to be located or channel degradation from the previous survey.

On average, BIBI scores from Round Three at Upper Patuxent River revisit sites were relatively stable compared with previous rounds (Table 28). Both Round One revisit sites, 16-L1M-01-19 and 16-L1M-02-19, had no change in BIBI scores between rounds. Site 16-L2M-01-19 had an improved BIBI score in Round Three and the site 16-L2M-02-19 BIBI score decreased slightly, compared to Round Two. No trends among changes in BIBI score and substrate or cross-sectional area were apparent.

6 Comparison of Results with Previous Rounds

This section presents a brief comparison of the biological and physical habitat assessment results collected as part of Round Three, with results from Round One and Round Two for each of the five PSUs assessed in 2019. Refer to Figure 43 for box plots comparing mean BIBI, RBP, and PHI results from Rounds One, Two and Three in the Sawmill Creek, Lower North River, Upper Patuxent, Little Patuxent, and Middle Patuxent sampling units.

To compare statistical differences between mean index values from two time periods (e.g., Round One and Round Two), this report uses the method recommended by Schenker and Gentleman (2001). This is the same method used by the MBSS to evaluate changes in condition over time, and is considered a more robust test than the commonly used method, which examines the overlap between the associated confidence intervals around two means (Roseberry Lincoln et al., 2007). In this method, the 95% confidence interval for the difference in mean values $Q_1 - Q_2$ is estimated using the following formula:

$$(Q_1 - Q_2) \pm 1.96[SE_1^2 + SE_2^2]^{1/2}$$

Where Q_1 and Q_2 are two independent estimates of the mean of a variable (i.e., BIBI, RBP, PHI) and SE_1 and SE_2 are the associated standard errors. The null hypothesis that $(Q_1 - Q_2)$ is equal to zero was tested (at the 10% nominal level) by examining whether the 95% confidence interval contains zero. The null hypothesis that the two means are equal was rejected if and only if the interval did not contain zero (Schenker and Gentleman, 2001), resulting in a statistically significant difference between those two values.

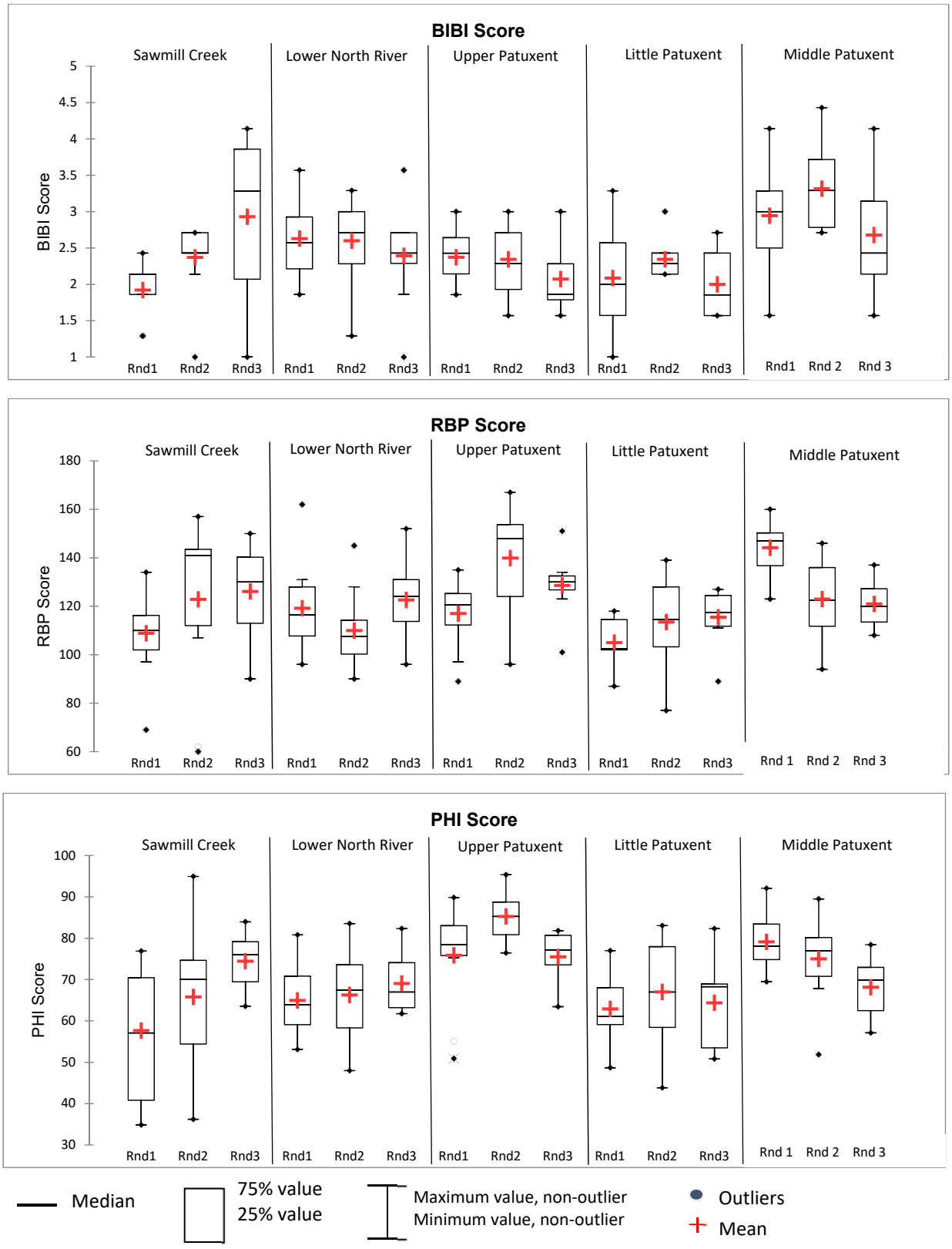

Figure 43 - Box plots comparing mean BIBI, RBP and PHI scores between Rounds One, Two and Three

6.1 Biological Conditions

A comparison of mean BIBI scores between Round Two and Round Three showed no significant changes in mean BIBI scores (Table 29). However, a significant increase was observed between Round One and Round Three in the Sawmill Creek PSU, where mean scores increased from 1.92 ±0.13 in Round One to 2.93 ±0.41 in Round Three (Table 30).

Table 29 - Difference in BIBI measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Sawmill Creek	2.93	0.41	2.35	0.16	0.29	-1.45	No
Lower North River	2.39	0.26	2.60	0.19	0.84	-0.42	No
Upper Patuxent	2.07	0.18	2.34	0.16	0.75	-0.21	No
Little Patuxent	2.00	0.17	2.34	0.09	0.72	-0.03	No
Middle Patuxent	2.68	0.30	3.32	0.19	1.33	-0.05	No

Table 30 - Differences in BIBI measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Sawmill Creek	2.93	0.41	1.92	0.13	-0.16	-1.86	Yes (Increase)
Lower North River	2.39	0.26	2.63	0.17	0.85	-0.38	No
Upper Patuxent	2.07	0.18	2.37	0.12	0.73	-0.13	No
Little Patuxent	2.00	0.17	2.09	0.25	0.68	-0.51	No
Middle Patuxent	2.68	0.30	2.94	0.22	1.00	-0.47	No

6.2 Physical Habitat Conditions

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the RBP are shown in Table 31 and Table 32, respectively. No significant differences were observed between sampling Round Two and Round Three. Comparisons between Round One and Three showed a significant decrease in one PSU, the Middle Patuxent, with the mean RBP score decreasing from 144.2 ±3.50 in Round One to 121.0 ±3.77 in Round Three.

Table 31 - Differences in RBP measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Sawmill Creek	126.1	6.99	122.9	11.15	22.57	-29.02	No
Lower North River	122.6	6.18	110.0	5.19	3.20	-28.45	No
Upper Patuxent	128.6	4.90	139.9	7.38	28.63	-6.08	No
Little Patuxent	115.5	4.43	113.5	5.97	12.57	-16.57	No
Middle Patuxent	121.0	3.77	123.0	5.16	14.52	-10.52	No

Table 32 - Differences in RBP measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Sawmill Creek	126.1	6.99	108.9	5.76	0.52	-34.97	No
Lower North River	122.6	6.18	119.2	6.09	13.58	-20.43	No
Upper Patuxent	128.6	4.90	117.0	4.70	1.67	-24.92	No
Little Patuxent	115.5	4.43	105.0	3.38	0.42	-21.42	No
Middle Patuxent	121.0	3.77	144.2	3.50	33.28	13.12	Yes (Decrease)

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the PHI are shown in Table 33 and Table 34, respectively. Only one PSU, Upper Patuxent, showed significant changes in PHI habitat conditions between sampling Rounds Two and Three. The mean PHI score decreased from 85.27 ±1.98 in Round Two to 75.55 ±2.37 in Round 3. Two PSUs, Sawmill Creek and Middle Patuxent, saw significant changes in PHI scores between Round One and Round Three. Sawmill Creek increased from 60.15 ±5.33 and a rating of "Degraded" in Round One to 74.60 ±2.74 and a rating of "Partially Degraded" in Round 3. Middle Patuxent, on the other hand, saw a decrease from 79.24 ±2.14 in Round One to 68.13 ±2.65 in Round Three.

Table 33 - Differences in PHI measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Sawmill Creek	74.60	2.74	65.87	5.13	2.67	-20.14	No
Lower North River	69.19	2.49	66.28	3.41	5.36	-11.19	No
Upper Patuxent	75.55	2.37	85.27	1.98	15.76	3.67	Yes (Decrease)
Little Patuxent	64.31	4.14	67.05	3.92	13.92	-8.44	No
Middle Patuxent	68.13	2.65	75.03	3.28	15.15	-1.36	No

Table 34 - Differences in PHI measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Sawmill Creek	74.60	2.74	60.15	5.33	-2.70	-26.19	Yes (Increase)
Lower North River	69.19	2.49	64.98	2.69	2.97	-11.40	No
Upper Patuxent	75.55	2.37	75.88	4.10	9.61	-8.95	No
Little Patuxent	64.31	4.14	62.91	2.47	8.05	-10.85	No
Middle Patuxent	68.13	2.65	79.24	2.14	17.79	4.44	Yes (Decrease)

7 Conclusions

Biological communities respond to a combination of environmental factors, commonly referred to as stressors. Stressors can be organized according to the five major determinants of biological integrity in aquatic ecosystems, which include water chemistry, energy source, habitat structure, flow regime, and biotic interactions (Karr et al., 1986; Angermeier and Karr, 1994; Karr and Chu, 1998). The cumulative effects of human activities within the County's sampling units often results in an alteration of at least one, if not several, of these factors with detrimental consequences for the aquatic biota. Determining which specific stressors are responsible for the observed degradation within a stream or PSU is a challenging task, given that many stressors co-exist and synergistic effects can occur and are poorly understood. Furthermore, an added challenge in identifying the stressors affecting stream biota is that the water quality and physical habitat data collected by the County's Program are not comprehensive (i.e., they do not include many possible stressors). For instance, virtually no data are available regarding biotic interactions and energy sources and only limited data regarding flow regime variables, such as land use and impervious cover, are included. Stressor relationships with stream biotic components, and their derived indices (i.e., BIBI, FIBI), are often difficult to partition from complex temporal–spatial data sets primarily due to the potential array of multiple stressors working at the reach to landscape scale in small streams (Helms et al. 2005; Miltner et al., 2004; Morgan and Cushman, 2005; Volstad et al., 2003; Morgan et al., 2007). Therefore, it should be noted that the current level of analysis cannot identify all stressors for the impaired watersheds, nor will the stressors identified include all of the stressors present.

7.1 Biological and Physical Habitat Conditions

Results of the 2019 assessment indicate impaired biological conditions in all five sampling units. All five sampling units had mean BIBI scores in the 'Poor' category. Four of the five had mean FIBI scores in the 'Poor' category, and one sampling unit (Sawmill Creek) had mean FIBI of 'Fair'. Changes in mean BIBI scores for sampling units were not significant between Rounds 2 and 3, and only Sawmill Creek showed a significant positive difference of mean BIBI scores between Rounds 1 and 3, the other four sampling units had no significant change in BIBI scores between these same Rounds. There were no discernable trends in PHI habitat data at two of the five sampling units. Sawmill Creek showed a statistically significant increase in mean PHI scores between Round 1 and Round 3 but no change between Round 2 and Round 3. Upper Patuxent River showed a significant decrease in mean PHI scores between Rounds 2 and 3. Mean scores for RBP between Rounds 2 and 3 and Rounds 1 and 3 for this sampling unit showed no significant trend. Middle Patuxent River showed a significant decrease in both mean PHI scores and RBP scores between Rounds 1 and 3, although no changes were observed RBP between Rounds 2 and 3. Lower North River and Little Patuxent showed no significant trends in mean PHI or RBP scores between either Round 3 and Round 2, or Round 3 and Round 1.

Overall, both physical habitat assessment methods yielded scores that did not correspond well with either of their concurrent BIBI or FIBI scores. A comparison of narrative BIBI ratings to spring-collected RBP habitat condition ratings for each site is shown in Table 35. Similarly, Table 36 compares FIBI ratings to summer-collected PHI habitat ratings. These results are similar to those found by Roberts et al. (2006) and Stribling et al. 2008, and suggest that BIBI scores are not singularly affected by habitat conditions alone and additional stressors are likely present in these systems. Analysis at the end of Round 3 will investigate relationships between habitat conditions and FIBI score as well. Results from the RBP method showed the majority of sites with 'Supporting' or 'Partially Supporting' physical habitat conditions (88%); however, nearly two-thirds of these sites (62.9%) actually resulted in biological conditions that were lower

than the habitat category may suggest is possible (Table 35). Similar to the RBP method, results from the PHI method showed the majority of sites with a 'Partially Degraded' or 'Degraded' rating (82.5%), with 24.2% of those sites resulting in biological conditions that were lower than the habitat category may suggest is possible (Table 36).

Table 35 - Comparison of BIBI to spring-collected EPA RBP habitat condition ratings.

EPA RBP Habitat Rating	BIBI Rating			
	Good	Fair	Poor	Very Poor
Comparable to Reference		12-R3M-01-19		**16-L2M-01-19**
Supporting	04-R3M-12-19	04-L1M-02-19 04-L2M-03-19 04-R3M-06-19 16-R3M-02-19 18-L1M-02-19	12-L1M-03-19 12-R3M-07-19 16-L1M-02-19 17-L2M-01-19 17-R3M-02-19	04-R3M-14-19 16-L2M-02-19 16-R3M-09-19 16-R3M-15-19 18-L1M-03-19
Partially Supporting	**18-R3M-03-19**	04-L2M-02-19 18-L2M-02-19	04-L1M-01-19 12-L2M-02-19 12-R3M-03-19 16-R3M-14-19 17-R3M-06-19 18-L2M-01-19 18-R3M-01-19 18-R3M-02-19 18-R3M-04-19	12-L1M-02-19 12-L2M-01-19 16-L1M-01-19 17-L1M-01-19 17-L1M-02-19 17-L2M-02-19 17-R3M-01-19
Non-Supporting			12-R3M-05-19 17-R3M-04-19	04-R3M-08-19

Blue cells: stations where the biological community was less impaired than the habitat scores would predict.
Gray cells: stations where biological community matched available habitat.
Orange cells: stations where the biological community was more impaired than the habitat scores would predict.
Bold type stations have biological conditions that differ by at least two qualitative habitat categories.
n=40

Table 36 - Comparison of FIBI to summer-collected MBSS PHI habitat condition ratings.

MBSS PHI Habitat Rating	FIBI Rating			
	Good	Fair	Poor	Very Poor
Minimally Degraded	19-R3M-07-18			
Partially Degraded	04-L1M-02-19 17-R3M-01-19	04-R3M-14-19 12-R3M-01-19 16-R3M-02-19		**16-R3M-09-19**
Degraded	**04-L2M-03-19**	17-L1M-01-19 17-L2M-01-19 17-L2M-02-19 18-L1M-02-19 18-R3M-03-19 18-R3M-04-19	04-L1M-01-19 12-L1M-02-19 16-L2M-01-19 16-R3M-14-19 17-R3M-06-19 18-L1M-03-19	12-L2M-01-19 12-L2M-02-19 12-R3M-07-19 16-L1M-02-19 16-L2M-02-19 16-R3M-15-19 18-L2M-01-19
Severely Degraded	**04-L2M-02-19**	12-L1M-03-19 16-L1M-01-19 18-L2M-02-19	12-R3M-05-19 17-L1M-02-19 18-R3M-01-19 18-R3M-02-19	04-R3M-08-19 12-R3M-03-19 17-R3M-04-19

Blue cells: stations where the biological community was less impaired than the habitat scores would predict.
Gray cells: stations where biological community matched available habitat.
Orange cells: stations where the biological community was more impaired than the habitat scores would predict.
Bold type stations have biological conditions that differ by at least two qualitative habitat categories.
n=38; 2 sites qualitatively sampled

Although physical habitat conditions were generally degraded in all five watersheds, degraded habitat alone cannot explain the observed biological conditions in these sampling units. Because habitat conditions did not correspond well to biological conditions at many sites, additional stressors are likely influencing the benthic macroinvertebrate assemblages in these streams. Recent research focused on urban stream restoration found that distance to source populations of benthic macroinvertebrates for recolonization after restoration plays an important role in ecological condition improvement (Southerland et al, 2018). Additional analysis at the end of Round 3 will investigate relationships between habitat and IBI scores along with confounding variables such as water quality and land use.

In developed sampling units with a higher percentage of impervious surfaces, such as Little Patuxent, Lower North River, and Sawmill Creek, water quality stressors are likely strong contributors to impaired biological conditions. Elevated specific conductance values (i.e., >247 µS/cm) were observed at 15 of 40 sites in the spring and 14 of 40 sites in the summer had specific conductance values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data. The expected pattern of increased imperviousness leading to increased specific conductance measurements was not evident in 2017 data but was observed with 2018 spring and summer data and again in the 2019 data. There was a significant trend (R^2=0.415; p<0.0001) toward increased springtime specific conductance with increased impervious surfaces for the sites sampled in 2019. There was a weaker trend (R^2=0.193; p=0.005) between summertime specific conductance and impervious surfaces for these sites. The PSU with the largest amount of imperviousness, Sawmill Creek (32.7%) had the second highest mean specific conductance (343.7 µS/cm) of the spring measurements but contrary to the expected pattern of a decrease in ecological condition with increasing specific conductance (Morgan and Cushman, 2005; Morgan et al, 2007), Sawmill Creek had the highest mean BIBI and FIBI scores during 2019. The highest mean specific

conductance was observed in Little Patuxent (420.4 µS/cm) which had the second largest amount of imperviousness (18.0%). Little Patuxent also had the highest mean specific conductance (434.4 µS/cm) during the summer. Furthermore, Little Patuxent had three of the four highest spring specific conductance measurements ranging from 471.3 µS/cm to 856.0 µS/cm. The PSU with the second lowest amount of imperviousness, Upper Patuxent (6.9%), had the lowest mean specific conductance measurement in both the spring (64.3 µS/cm) and summer (82.8 µS/cm). There was no significant negative trend between spring specific conductance and BIBI score (R^2=0.003; p=0.735) but no trend between summer specific conductance and FIBI scores (R^2=0.006; p=0.631). Continued sampling across all sampling units within the County will help create a larger dataset to investigate further the effects of specific conductance on the ecological condition of the County's streams.

It is also plausible that the biological condition of these sampling units is impaired by stressors related to past land use, commonly referred to as legacy effects, which are the consequences of past disturbances that continue to influence environmental conditions long after the initial appearance of the disturbance (Allan, 2004). Historically, nearly all of Anne Arundel County has experienced deforestation, followed by intensive agriculture, which significantly altered the landscape (Schneider, 1996). These drastic land use changes likely altered the structure and function of the stream ecosystems to a considerable extent, some of which have yet to fully recover. This notion is supported by Harding and others (1998), who found that past land use activity, in particular agriculture, may result in long-term modifications to and reductions in aquatic diversity, regardless of reforestation of riparian zones. What is not clear, however, is how long these legacy effects will persist in these subwatersheds, and consequently, what can be done to improve the biological condition of these streams.

Previous years of this study have shown drainage area may influence biological community composition with larger drainage areas providing an increased potential for full colonization by benthic macroinvertebrate communities (Hill and Pieper, 2011b). Using data from 2019 sites, drainage area has a significant positive effect on BIBI score (R^2=0.136; p=0.019) with increased drainage area. With the addition of fish data in Round 3, similar correlation can be investigated for the drainage area effect on the FIBI in Anne Arundel County. Similar to results from 2017 and 2018, data from 2019 sampling shows a significant correlation between increasing drainage area and FIBI score (R^2=0.228; p=0.002). This relationship is consistent with patterns observed throughout Maryland by the MBSS (Southerland et al, 2005).

7.2 Geomorphologic Conditions

The geomorphic assessment field data were compared to the MCP regional relationships of bankfull channel geometry versus drainage area (McCandless, 2003), which were derived from E type and C type streams, in order to determine how channel dimensions observed in the field compare to those predicted for rural/suburban subwatersheds. Comparisons of bankfull width, mean bankfull depth, and bankfull cross-sectional area, stratified by Rosgen Level I stream type, are shown in Figure 44, Figure 45, and Figure 46, respectively. Channels where Rosgen classifications could not be determined (ND, two sites with channelization, culverts, and riprap stabilization) or were considered transitional were not included in these analyses. There was one site (04-L1M-01-19) which had a much smaller drainage area than any other site. This site was left in the analysis since excluding it did not notably improve the C type channel correlations when comparing to the MCP curve.

Comparisons of bankfull width values show the trendline for E (R^2 = 0.30) and G (R^2 = 0.88) channels as the closest to matching the MCP curve (Figure 44). Trendlines for F (R^2 = 0.83) and G (R^2 = 0.88) channels contained the least variability, with data points scattered mostly above or in line with the MCP curve. The lack of variability for the F and G channels was likely due to not having definitive bankfull indicators present in these incised channels, thus forcing increased reliance on the regional curve data to make bankfull calls in these situations. The correlation supports that generally the F and G type channels had a bankfull width that was wider than the MCP curve would suggest. The trendline for E (R^2 = 0.30) type channels was slightly below the MCP curve, indicating narrower channels than predicted by the regional curve. The DA channels fell well above the MCP curve. These results are somewhat expected given that F type channels tend to have greater width/depth ratios as compared to E and G type channels (Rosgen, 1996).

Mean bankfull depth values showed the trendline for E type channels (R^2 = 0.44) closely matching the MCP curve, with the exception of a few outliers above and below the curve (Figure 45). For F type channels (R^2 = 0.18), points were scattered below the curve, indicating that mean bankfull depths were shallower than predicted by the MCP. The DA channels fell well below the MCP curve, which suggests the large variance in width/depth ratios as the sites were well above the mean width MCP curve. The G type channels closely match the MCP curve, but this was due to reliance on the curve while doing the field assessment in an incised channel with limited bankfull indicators. As with bankfull width, the channel types follow the expected mean bankfull depth relationship (Rosgen, 1996). Overall, with the exception of F and DA type channels, most sites sampled in 2019 were fairly close to the predicted MCP curve for mean bankfull depth.

Comparisons of bankfull cross-sectional area values show the trendlines for all stream types closely match the MCP curve, with the exception of C type channels due to the outlier with a smaller drainage area (Figure 46). The trendlines for G (R^2 = 0.97), F (R^2 = 0.85), B (R^2 = 0.89), and DA (R^2 = 0.89) had the smallest amount of variability. Very few channel cross-sectional areas, mainly E type channels, fell below the MCP curve. Somewhat unexpectedly, E type and C type channels had the most variability in cross-sectional area. This could be due to site specific conditions as it relates to bankfull indicators, whereas many of the other stream types relied heavily on the MCP curve. Overall, most sites assessed in 2019 were below one square mile drainage areas and are therefore much smaller than sites used to create the MCP regional regression.

Sediment deposition as a result of bank erosion and channel instability may be a significant stressor on the benthic macroinvertebrate communities in these sampling units; however, the extent of these impacts was not clear in Rounds One and Two. Typically, reaches classified as unstable G and F type streams would be expected to have more impaired biological communities than reaches classified as more stable stream types (such as E, C, and B channels). However, geomorphic and biological results from this sampling period, as well as those from Rounds One and Two, do not support this notion as degraded stream types do not necessarily result in degraded biological conditions, based on BIBI scores. For example, of the sites classified as F type and G type channels in 2019 (n=15), four sites (26.7%) received a 'Very Poor' biological rating, 9 sites (60.0%) received a 'Poor' rating, 1 site (6.7%) received a 'Fair' rating, and the remaining site (6.7%) received a 'Good' rating. When compared across all channel types sampled in 2019, a similar proportion of sites had BIBI scores in the 'Very Poor' and 'Poor' categories (86.7% for F and G type channels and 77.5% for all channel types sampled), indicating degraded benthic macroinvertebrate communities regardless of channel type. A more detailed analysis will be conducted at the end of Round Three sampling.

An analysis of the Round One data set found that many geomorphic variables did not correlate strongly with biological variables (Hill and Pieper, 2011b). Conversely, the Round Two data showed highly significant ($p < 0.001$), positive correlations between mean depth, bankfull area, and estimated bankfull discharge and the overall BIBI score (Hill et al., 2014). Round Two geomorphic variables such as width, depth, and estimated discharge were likely potential drivers of the drainage area effect observed with benthic macroinvertebrate metrics and the BIBI score (i.e., sites with larger drainage areas typically had higher BIBI scores). Furthermore, land use characteristics, while significantly correlated with variables such as entrenchment ratio and flood-prone width, showed relationships that were the opposite of what would have be expected (i.e., positively correlated with percent developed land and negatively correlated with percent agriculture), suggesting a more complex interaction between land use and geomorphic characteristics (Hill and Pieper, 2011b; Hill et al., 2014). In general, variability in channel evolution was observed within all sampling units, whereas some sites are stable, some are actively degrading, and some are stabilizing. In many cases, each of these states are occurring within specific sampling units, indicating a range of stream conditions in a given watershed. Depending on the individual site, aggradation, deposition, and erosion are all occurring throughout the 2019 sampling units. Floodplain access is improving at some sites, while becoming more limited at others. This range of stability and channel evolution can be attributed to changes in site-specific watershed characteristics, as there is no overall trend applicable to the small set of revisit sites.

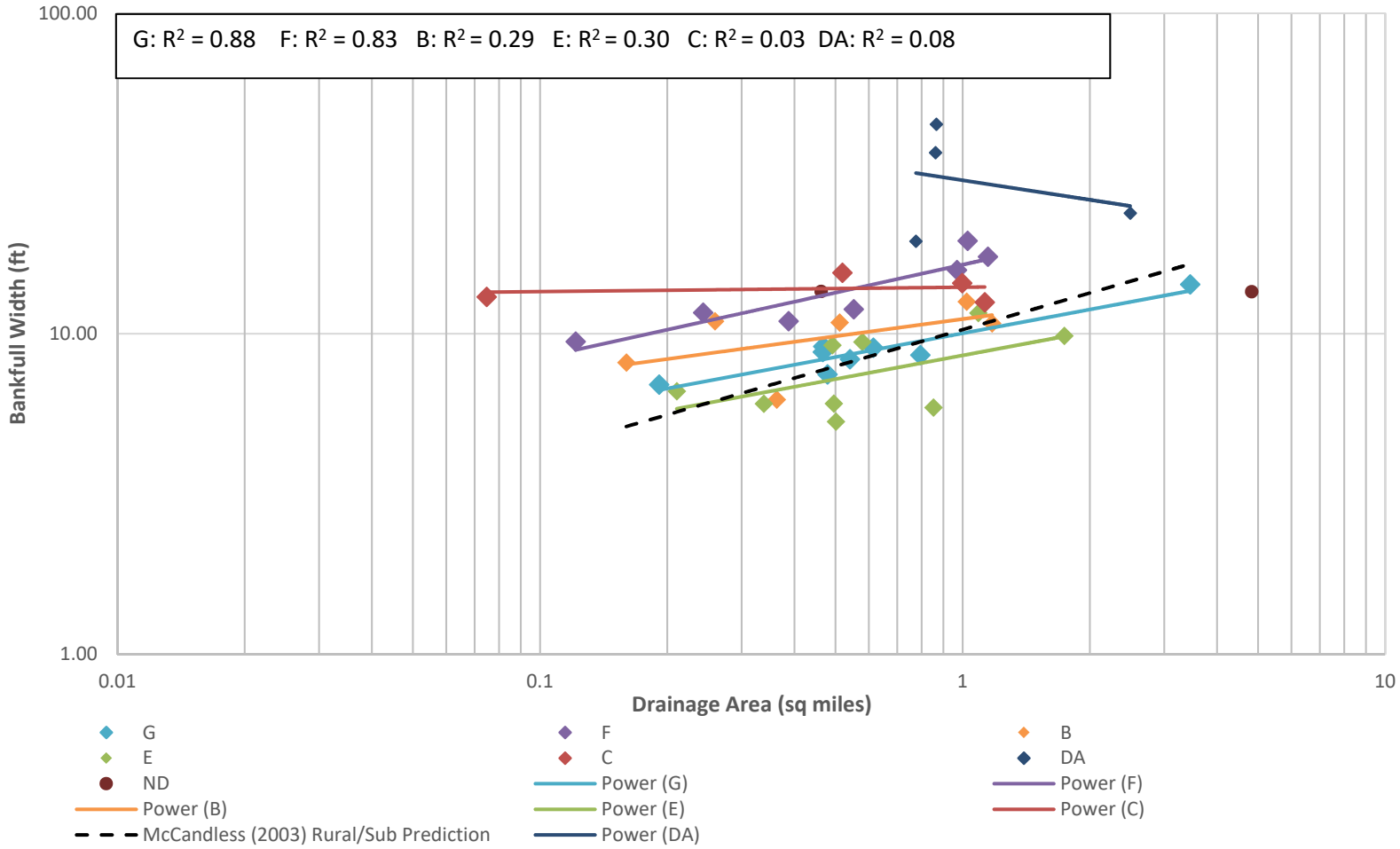

Figure 44- Comparison of bankfull width - Drainage area relationship between field data and regional curve data

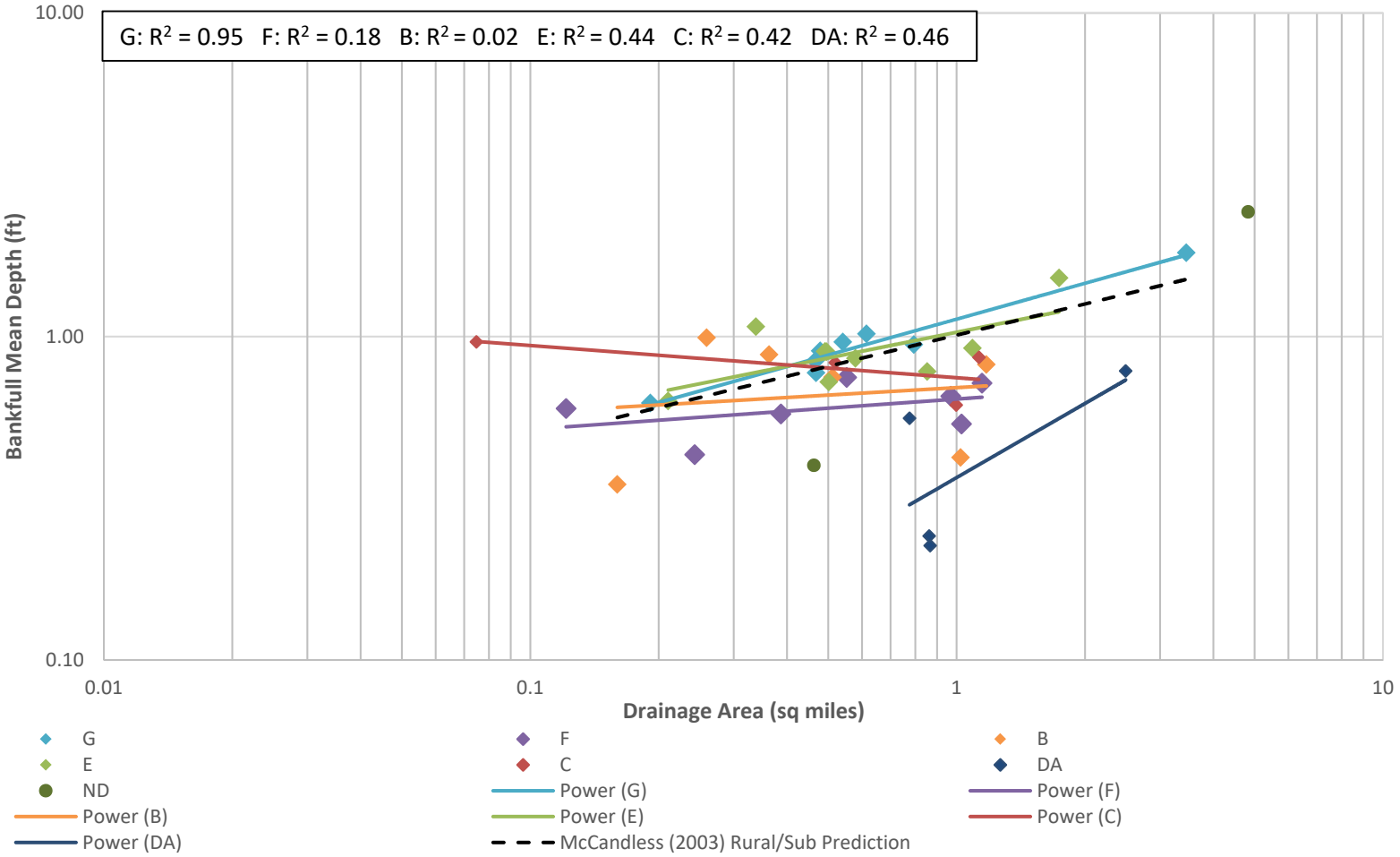

Figure 45 - Comparison of mean bankfull depth - Drainage area relationship between field data and regional curve data

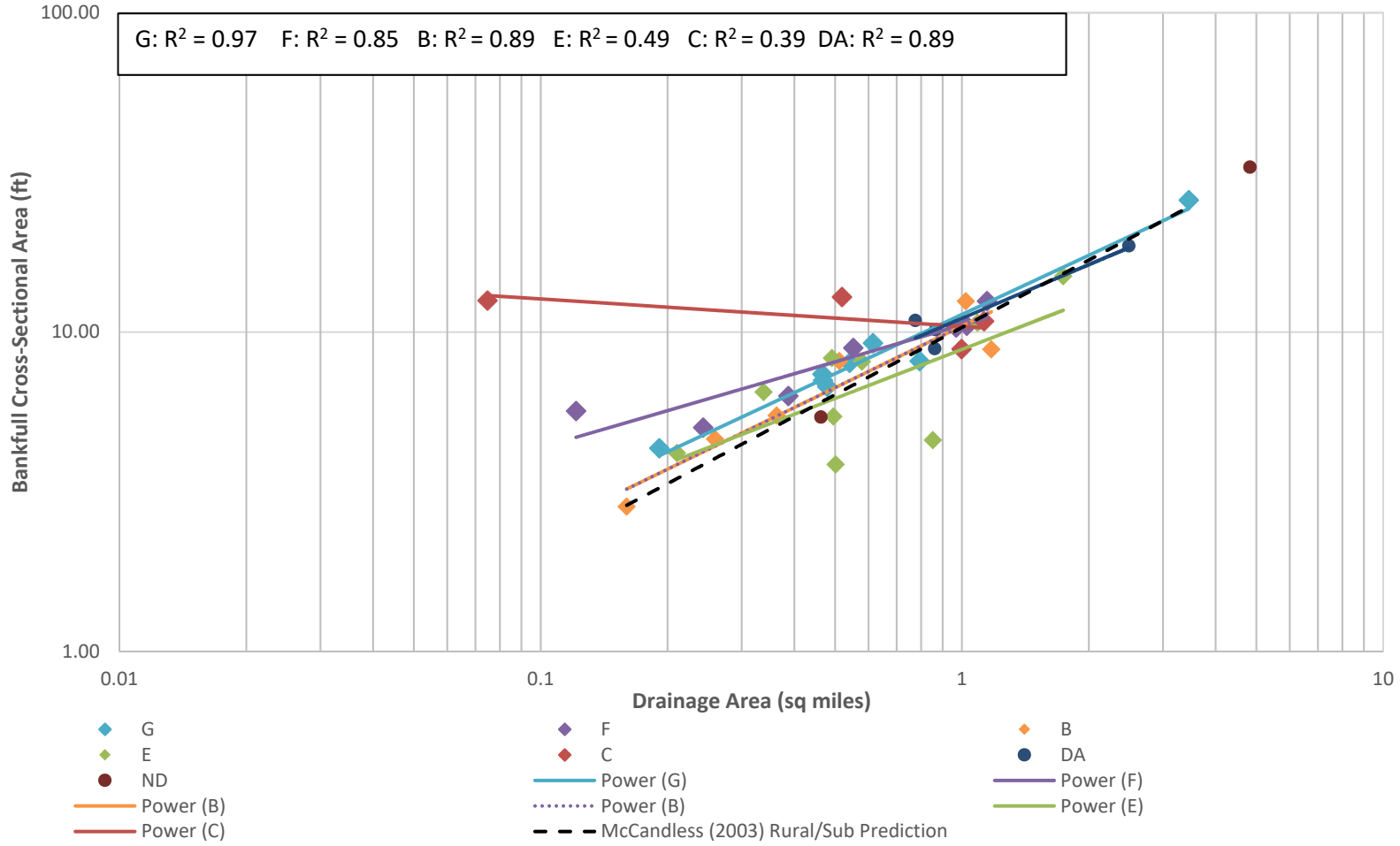

Figure 46 - Comparison of the bankfull cross-sectional area - Drainage area relationship between field data and regional curve data

7.3 Water Quality Conditions

In situ water quality measurements were within COMAR standards for temperature at all sites during both the spring and summer monitoring periods. High turbidity values, which exceeded the acceptable COMAR standards for acute turbidity exposure (i.e., <150 NTU) were recorded at one site in the spring and at one site in the summer. Although the average monthly turbidity standard was exceeded at these sites, turbidity measurements from a single point in time do not provide sufficient data on average monthly turbidity.

One site in the Little Patuxent sampling unit sampled in the spring and one site in the Upper Patuxent sampling unit sampled in the summer, had turbidity values above the COMAR standard for acute exposure (i.e., < 150 NTU). Low pH values, which were outside the acceptable range of values set forth by COMAR (i.e., 6.5-8.5 SU), were recorded at approximately 35% of the sites spanning three of the five sampling units in the spring. Fifty percent of sites sampled in the summer, spanning all five sampling units, had values that fell below COMAR standards for pH. Low pH values are likely the result of soils within the 2019 sampling units being generally strongly to very strongly acidic (NRCS 2019).

Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at 30% of the sites spanning three of the five sampling units in the summer. Approximately 37% of the sites spanning four of the five sampling units in the spring and 37% of the sites spanning all five of the sampling units in the summer had specific conductance values that exceeded 247 µS/cm, which is the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams, based on BIBI scores (Morgan et al., 2007). Despite elevated specific conductance levels at a large portion of sites sampled in 2019, there was no significant trend between specific conductance and BIBI or FIBI scores. Analysis of the entire Round 3 data set after 2021 will help clarify the relationship between specific conductance and stream ecological condition in Anne Arundel County.

Except for one site, all 2019 sites met COMAR or EPA standards based on grab sample parameters. In the Little Patuxent River sampling unit, site 17-R3M-06-19 exceeded the acceptable COMAR range for chronic copper (i.e., 9 µg/L) and lead exposure (i.e., 2.5 µg/L) with values of 12.0 µg/L and 12.3 µg/L, respectively. The same site also exceeded the COMAR standard for acute turbidity (i.e., <150 NTU), with a value of 431.0 NTU. For total nitrogen, nitrate, and orthophosphate, all 2019 sites fell in the low or moderate categories used by MBSS, suggesting low to moderate anthropogenic stress based on these parameters. Total phosphorus, ammonia, and nitrite fell in the low to moderate categories used by MBSS in the Upper Patuxent River and Middle Patuxent River sampling units. Five sites total had total phosphorus values that fell in the high category used by MBSS (i.e., > 0.07 mg/L). Three of those sites were in the Lower North River sampling unit. Over 17% of sites sampled in 2019 fell in the high category used by MBSS for ammonia (i.e., >0.07 mg/L), all of which fell in the Sawmill Creek, Lower North River, and Little Patuxent River sampling units. Point source discharge and nutrient enrichment are both common sources of elevated ammonia in surface waters (USEPA, 2000). Because pH levels were generally acidic or neutral in the Sawmill Creek, Lower North River, and Little Patuxent River sampling units, un-ionized ammonia was likely not found in high concentrations. The un-ionized form of ammonia is generally considered the most toxic form to aquatic biota. Three sites, all in the Sawmill Creek or Little Patuxent River sampling units, fell in the high category used by MBSS for nitrite concentration (i.e., >0.01 mg/L). All chloride values met EPA standards for acute (i.e., <230 mg/L) and chronic (i.e., <860 mg/L) exposure for sites sampled in 2019.

There was a strong positive correlation between specific conductance and chloride concentration for all sampling units sampled in 2019 (R^2 = 0.92; Figure 47). Elevated levels of chloride and magnesium are commonly associated with either runoff from roadways, particularly following winter roadway de-icing periods, or runoff carrying fertilizers (Williams 2001; Stranko et al. 2013).

No state or federal water quality criteria exist for dissolved organic carbon (DOC), however, DOC concentrations can be used to characterize different stream types. Blackwater streams are characterized by sluggish flow, low pH, high DOC levels, and low DO levels, and are identified as key wildlife habitats based on information from Maryland DNR (DNR 2016). Although several sites in the Upper Patuxent River and Little Patuxent River met some blackwater stream criteria such as low pH (i.e., < 6), low gradient (i.e., < 1%), and high DOC (i.e., > 8 mg/L), no sites met all required criteria. Additionally, low pH was observed throughout all sampling units and is likely the result of strongly to very strongly acidic soils dominating drainage areas within the 2019 sampling units (NRCS 2019).

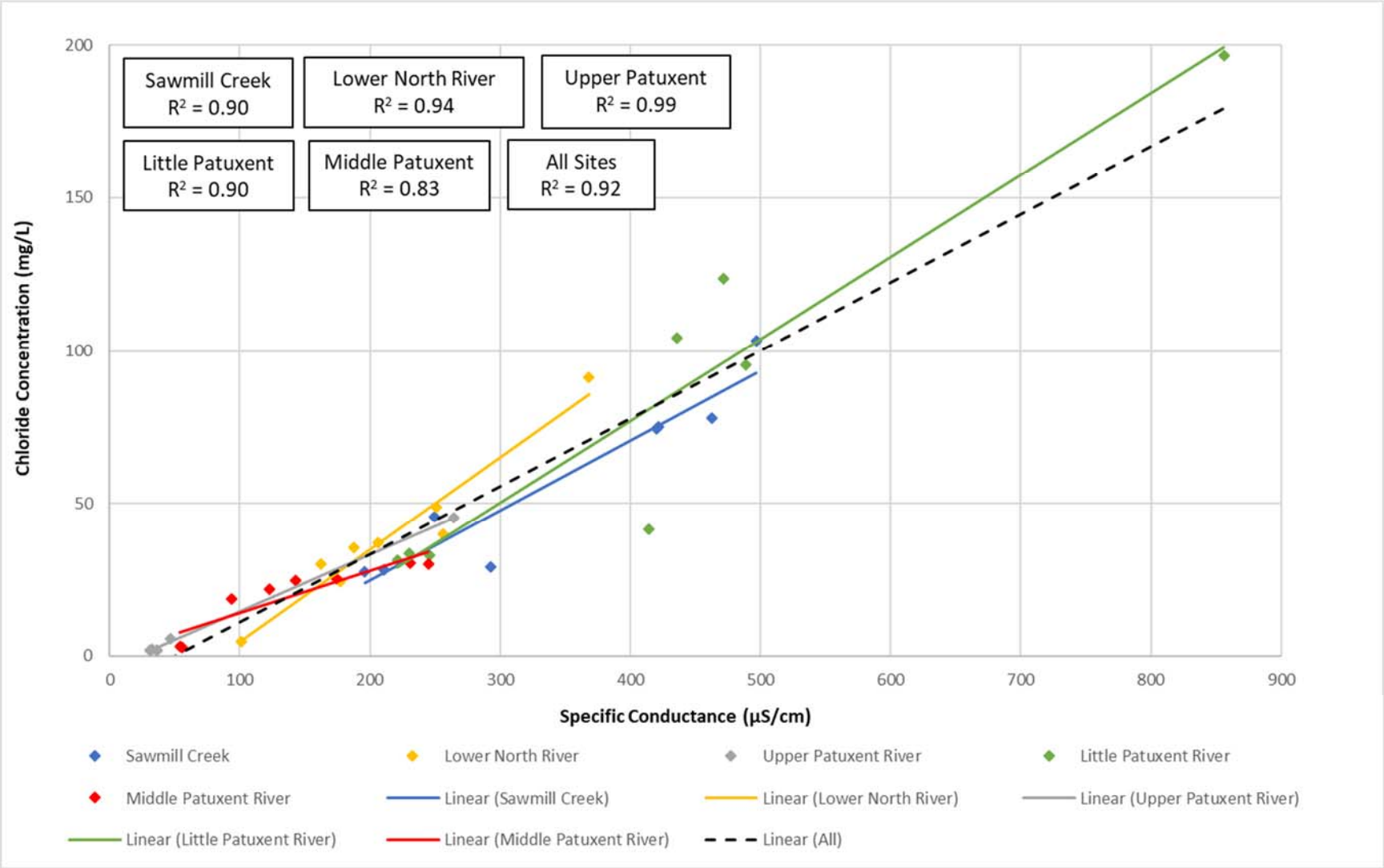

Figure 47 – Relationship between specific conductance and chloride concentration for each PSU

7.4 Recommendations

Based upon the conclusions discussed in the previous section, the following recommendations are made for these sampling units:

Stream Channel Evolution and Trajectory

Based on the analysis of Round One data, it was shown that many geomorphic variables such as bankfull channel dimensions, dimensionless ratios, and water surface slope were not significantly correlated with BIBI scores (Hill and Pieper, 2011b). However, some geomorphic variables correlated significantly with individual metrics of the BIBI, most notably bankfull area correlated with the percent intolerant metric. Sinuosity and D50 were the only geomorphic variables correlated with the overall BIBI score (0.05 level). On the other hand, the Round Two data showed highly significant ($p < 0.001$) correlations between mean depth, bankfull area, and estimated bankfull discharge and the overall BIBI score, although this was primarily attributed to the positive correlation between drainage area and the BIBI score (Hill et al., 2014). As a result, it is recommended that subsequent assessment efforts should focus more on the dominant geomorphologic processes or channel evolution stage, since these processes are more likely influencing the benthic macroinvertebrate communities than merely channel dimensions and stream type as classified by the Rosgen approach. In a study relating stream geomorphic state to ecological integrity, Sullivan et al. (2004) recommend that stream channels be evaluated in terms of dynamic stability and adjustment rather than simply categorized as stable or unstable. Round Three includes revisits of a subset of sites assessed in Rounds One and Two, which allows for evaluating changes in dimensions and adjustments over time along with the response of the biological communities. At the completion of Round Three, the revisit site data set should be analyzed to look for trends and relationships between channel evolution and biological response to determine if patterns exist throughout the County or within various sampling units. This would help to validate stability assumptions and corresponding biological responses, providing the County with a better understanding of how land use changes impact streams and biological communities over time. Ultimately, this may allow for fine tuning of zoning and development regulations toward maximum protection of stream channel stability.

Stressor Identification Studies

While it is assumed that water quality stressors are impacting biota in some of these streams, a more focused stressor identification technique such as the U.S. Environmental Protection Agency's Stressor Identification (SI) process (USEPA, 2000), is necessary to correctly associate biological impacts with their most probable causes. This typically involves the collection of additional data (e.g., expanded water quality grab sampling, storm sampling), which can be both costly and time consuming on a large scale. Therefore, in an effort to optimize the use of limited resources it is recommended that the County prioritize which streams and/or subwatersheds require a more detailed analysis of stressors and sources, whether the goal is for protection, preservation, or enhancement.

Best Management Practices

Stormwater Management

Three of the sampling units, Little Patuxent River, Lower North River, and Sawmill Creek have been developed extensively (40% - 62% developed land use) and could benefit from retrofitting existing development and/or increasing stormwater best management practices (BMPs) to treat larger volumes of stormwater runoff. It is recommended that the County consider improving existing BMPs and/or

installing new BMPs, wherever practical and feasible, in these subwatersheds, given that they appear to be widely impacted by urban stormwater runoff.

Agricultural Lands

While the Middle Patuxent sampling unit contained less developed land, individual BIBI scores still show signs of impairment. This subwatershed may be impacted by current and historical agricultural land use and may benefit from increasing BMPs to treat agricultural runoff. It is recommended that the County consider working with current landowners to improve existing agricultural BMPs and/or initiate new BMPs, wherever practical and feasible, in the rural subwatersheds.

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Appendix A: Geomorphic Assessment Results

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
04-L1M-01-19	0.07	13.0	1.0	128.0	9.8	13.5	12.5	0.68	1.1	0.065	C5/6	Adjusted Sin +0.2. Found original cross section pins. Left pin did not have a cap on it. Did not reinstall a cap to avoid pounding the xs pin in deeper, throwing off the revisit xs comparison. Channel oversized compared to regional curve, likely widened in past.
04-L1M-02-19	1.86	9.9	1.5	234.0	23.8	6.5	14.9	0.11	1.1	0.48	E5	Adjusted Sin +0.4. Minor erosion along undercut banks. Thick vegetation on both banks. Walking path bridge just downstream of midpoint. Same reach as AA Co site SM-06. Surveyed existing XS using County-installed monuments.
04-L2M-02-19	5.05	13.5	2.4	78.0	5.8	5.6	32.8	0.01	1.2	0.33	ND	Reach midpoint is just upstream of road culvert at 648. Rip rap and concrete stabilization throughout. No buffer on left bank, very minimal buffer on right bank. Located monuments from R2 visit and re-surveyed the XS.
04-L2M-03-19	0.87	36.7	0.2	48.7	1.3	152.0	8.9	0.10	1.5	0.43	DA5	Round 2 revisit, XS pins were located and re-surveyed at long pro station 130. Channel slightly widened, but same stream classification. Modified pebble count.
04-R3M-06-19	0.94	5.9	0.8	104.0	17.7	7.5	4.6	0.34	1.2	0.13	E5	Adjusted Sin +0.4. Stream channel flows within mucky wetland. Sandy bottom channel, wide mucky floodplain. Moved site upstream from original mid point to match site sampled in 2017 and SM-07, per AA Co instructions. Re-surveyed existing County-installed XS. Stream splits upstream of 75m reach and two reaches converge within upstream portion of reach.
04-R3M-08-19	1.07	12.6	1.0	18.6	1.5	12.7	12.5	0.34	1.1	1.1	B5/4c	Adjusted Sin +0.2. Moderately entrenched channel, about 130 feet of site runs through a large CMP culvert. Iron flock extensive throughout reach.
04-R3M-12-19	0.87	19.4	0.6	120.0	6.2	34.8	10.9	0.21	1.4	0.39	DA5	Site located along Sawmill mainstem in braided/wetland area. Modified 3 transect pebble count.
04-R3M-14-19	0.87	45.0	0.2	45.0	1.0	199.5	10.2	1.10	1.3	0.33	DA5	Braided stream, unclear which channel is the main, although left most channel is lower in elevation therefore BKF dimensions were calculated using this channel. No perfect place to put XS, monumented on the most straight section of reach where pins could be placed outside the wetland.
04-R3S-01-19	0.86	15.5	0.8	17.6	1.1	18.2	13.1	0.13	1.4	0.58	F5	Very incised channel, heavily urbanized area around the site, evidence of recent high flows.
04-R3S-02-19	0.05	4.8	0.3	6.9	1.4	15.4	1.5	1.60	1.1	0.45	B5c	Adjusted Sin +0.1. Small sandy stream. Channel becomes more incised at upstream end of site, wider channel and lower banks at downstream end of site. Cross section located at the midpoint.
04-R3S-06-19	0.79	16.8	0.7	18.0	1.1	25.6	11.0	0.46	1.0	12	F5/4	Adjusted Sin +0.2. Incised channel, raw eroded banks, several sections of rip rap stabilization, possible SWM facility/wetland on right bank. Heavily urbanized stream in poor condition.
04-R3S-07-19	0.27	9.5	0.4	11.8	1.2	25.8	3.5	1.70	1.0	---	ND	Straight concrete trapezoid channel, XS monumented just outside limits of concrete channel due to adjacent residental properties. No pebble count due to lack of natural substrate. Channel is not natural, therefore no channel type can be assigned.
04-R3S-10-19	0.07	3.6	0.5	10.7	3.0	7.2	1.8	2.40	1.0	0.53	E5b	Adjusted Sin +0.5. Small sandy stream. Limited habitat. Stream is culverted under paved walking path at approximately 178 ft, for approximately 20 feet. Added 20 ft to upstream end of reach. Multiple root jams causing small head cuts.
04-R3S-13-19	0.09	3.3	0.5	60.5	18.5	6.9	1.5	1.10	1.3	0.34	E5	Adjusted Sin +0.2. Small slightly entrenched "E" channel stream with sand substrate. Modified 3 transect pebble count. QC site downstream. Forested riparian with majority regen deciduous. Sinousity slightly lower than typical for type "E" streams may be due to vegetation.
04-R3S-16-19	0.11	4.7	0.5	7.5	1.6	9.1	2.4	1.50	1.1	---	ND	Concrete trapezoid channel located in ditch on side of Route 10/695 merge. XS monumented just up from limits of concrete. Pin on right bank is almost flush with ground to avoid mowing. No pebble count done due to lack of natural substrate. Concrete channel artifical substrate for entire site. Classification as N/A since the channel is not natural
04-R3S-18-19	0.27	11.4	0.5	19.9	1.7	23.5	5.5	2.30	1.1	7.6	ND	Entrenched channel with eroded banks, urban setting. Remnant restoration or channel armoring present. High W/D, entenched. XS located just downstream of CMP outfall. Sinuosity measured from 0m to midpoint given that the upper half of the site is piped underground.
12-L1M-02-19	0.26	10.9	0.4	16.4	1.5	25.9	4.6	0.38	1.3	0.17	B5c	Revisit site R1-12-01. Seems previous field crew placed bankfull call at LTOB, however, field call from this year is closer to regional regression equations .
12-L1M-03-19	4.16	14.3	1.8	14.3	1.0	7.9	25.9	0.46	1.2	8	G4c	Round 1 revisit, XS pins located and resurveyed. Channelized stream downstream of Annapolis Water Works Park reservoir. FPA measured via GIS. LB pin placed in floodprone.

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
12-L2M-01-19	0.16	8.1	0.3	12.2	1.5	23.3	2.8	0.27	1.1	0.16	B5c	Adjusted Sin +0.2. Round 2 revisit, both XS pins found and surveyed. Modified 3 transect pebble count. Access to floodplain for entire site, reach is very straight confined against the left valley wall.
12-L2M-02-19	0.57	8.3	1.0	10.5	1.3	8.7	8.0	0.58	1.4	0.3	G5c	Round 2 revisit. Both pins located and resurveyed. Dirt road access all the way to site on parcel property. Incised channel with silt and clay banks and moderate active erosion throughout entire site.
12-R3M-01-19	2.49	23.8	0.8	700.0	29.4	30.4	18.6	0.53	1.1	0.062	DA6	Flat Creek, expansive floodplain/wetland network that is well connected to the stream. XS left bank pin was placed about 2.5ft from ground through dead tree trunk. Channel dominated by silt/clay, mostly soft clay with some coarse/med sand. Modified pebble count. FPA measured in GIS.
12-R3M-03-19	0.52	10.8	0.7	16.7	1.5	14.5	8.1	1.10	1.7	0.57	B5/4c	Channel is very entrenched with some areas of healing present. Most of downstream end very sinuous and unstable. Evidence of flows near top of banks (rack lines).
12-R3M-05-19	0.79	8.6	0.9	10.9	1.3	9.1	8.1	0.16	1.4	0.32	G5/6c	Incised old channel, evidence of healing and depositional bench features on both meander bends and straight segments. Severe active erosion on outer bends that averages 6ft in height . Substrate is majority sand and finer (clay/silt) modified pebble count (3 transects) was conducted.
12-R3M-07-19	1.08	11.6	0.9	175.0	15.1	12.6	10.7	0.81	1.3	0.13	E5/6	Adjusted Sin +0.2. Slightly entrenched stream channel with access to expansive floodplain through wetland. Modified 3 transect pebble count. FPA measured on GIS.
12-R3S-01-19	0.04	4.6	0.4	6.9	1.5	12.5	1.7	1.80	1.4	0.062	B6c	Stream is confined by valley walls with most areas incised and lacking a floodplain. Substrate is majority silt/clay as are many of the exposed banks in the more confined segments of the reach. Modified pebble count.
12-R3S-03-19	0.19	8.3	0.6	8.5	1.0	14.1	4.9	2.00	1.1	0.18	F6	Adjusted Sin +0.2. Incised channel downstream of pond outfall. Heavily rip-rap supported upstream 25m. Mostly clay/silt bank material. Bed mostly clay with small gravel and sand.
12-R3S-04-19	0.06	6.6	0.2	8.4	1.3	30.7	1.4	5.10	1.0	20	B4/5a	Adjusted Sin +0.2 and ER +0.2. Confined stream within steep valley walls. Stabilized banks and grade in upper half of stream, lower half experiencing downcutting and erosion.
12-R3S-07-19	0.13	7.2	0.4	9.2	1.3	18.5	2.8	1.80	1.3	0.19	F5	Moderately entrenched channel with little stability among bed features. Headcut at long pro station 144'.
12-R3S-08-19	0.15	8.7	0.5	94.7	10.9	17.2	4.4	0.39	1.5	0.29	DA5	Low gradient stream with well connected floodplain and expansive wetland system. Multiple flow channels at or above bankfull. Modified pebble count. Multiple channels at bankfull, one channel at baseflow.
12-R3S-11-19	0.04	9.9	0.2	34.8	3.5	42.4	2.3	1.70	1.2	0.15	C5	Sand dominated stream bed, confined valley at top, but widens at downstream end. Debris jam downstream of study reach if deflecting flow out of channel and into wide floodplain wetland. Fallen trees and woody debris are controlling grade.
12-R3S-13-19	0.08	7.7	0.3	12.4	1.6	22.2	2.6	0.43	1.0	0.18	B6/5c	Adjusted Sin +0.2. Moved midpoint of site DS to perform QC upstream. Moderately entrenched channel that looks to have been straightened and ditched at one point
12-R3S-14-19	0.29	6.2	0.8	19.7	3.2	8.3	4.7	0.22	1.4	0.52	E5	Adjusted Sin +0.2. Low gradient stream , slightly entrenched . Some moderate erosion throughout reach, evidence of out of bank flows.
16-L1M-01-19	0.45	13.6	0.4	16.6	1.2	33.9	5.4	0.80	1.1	13	ND	Revisit site. Midpoint was at DS side of Brock Bridge Rd. Culvert is unsampleable and upstream of road has 2 more unsampleable culverts under hiking trails, therefore site was measured down 75m from culvert where midpoint was before. A lot of erosion has occured since 2007 when comparing photos. XS rebar was not found but put in similar location according to photos. Full XS in 2007 was 23 feet wide, now top of bank to top of bank is 30 feet; XS pins likely lost due to erosion. Incised channel with major erosion. Channelized top 8m DS of culvert with riprap stabilization.
16-L1M-02-19	0.42	10.9	0.6	252.0	23.0	19.0	6.3	0.64	1.8	1	F5	Site located on Patuxent Research Refuge. No monuments installed at the request/direction of the refuge. No R1 monuments were located, believe none were installed. Used pictures from R1 visit to match up XS location. No stationing listed on R1 Meck sheet. XS in transverse riffle.
16-L2M-01-19	0.54	9.4	0.9	115.0	12.2	11.0	8.1	0.56	1.1	0.088	E5	Adjusted Sin +0.4. Site located on Patuxent Research Refuge. No monuments installed at the request/direction of the refuge. Placed cross section in approximately the same location based on profile stationing and photos. Cross section now located approximately 7 feet downstream from a beaver dam. Upper 208 feet of site in beaver impoundment.

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
16-L2M-02-19	0.20	6.9	0.6	7.9	1.1	11.1	4.3	1.10	1.5	13	G4c	Site on Patuxent Research Refuge. No pins installed at request of refuge, no pins installed during R2 either. Matched up location using R2 pictures, GPS locations did not match with pictures. Started survey 9 feet from top of left bank, same as R2 visit. Incised channel, does not appear to access floodplain during high flows.
16-R3M-02-19	0.51	15.5	0.8	99.0	6.4	18.7	12.9	0.70	1.5	12	C4	Site located on Patuxent Research Refuge. No monuments installed at the request/direction of the refuge. Nice Coastal Plain stream. Evidence of recent high flows on floodplain. Gravel and sand bottomed riffle/run/pool stream. All riffles at site were transverse.
16-R3M-09-19	0.37	6.2	0.9	12.1	1.9	7.1	5.5	0.79	1.4	17	B4c	Adjusted W/D. Site is on Patuxent Research Refuge. No monuments installed at the request of the refuge. Very incised channel, downstream of a power line ROW. Upper 52 ft of site in ROW.
16-R3M-14-19	0.51	6.1	0.9	85.0	14.0	6.7	5.4	0.99	1.3	0.062	E6	Adjusted Sin +0.2. Site on Patuxent Research Refuge. No monuments installed at request of refuge. Small incised channel within wetland floodplain. Evidence of high water getting out of banks. Trib comes in at about 50m mark. US of site more wetland characteristics.
16-R3M-15-19	0.25	6.6	0.6	20.0	3.0	10.5	4.2	0.59	1.5	7.6	E4	Site on Patuxent Research Refuge. No monuments installed at request of refuge. Decent site, ok bankfull indicators. Very high degree of meandering.
16-R3S-01-19	0.06	8.1	0.2	10.1	1.2	44.1	1.5	2.00	1.2	0.19	F5	Site located on small incised channel. Along power line right of way. Sandy bottom, lots of leaves and woody debris in channel. Trees fallen and crossing channel.
16-R3S-07-19	0.86	20.6	1.2	185.0	9.0	17.2	24.7	0.01	1.6	2	C4c-	Site located on Patuxent Research Refuge. Site starts at confluence with a braid of the mainstem Patuxent River. Site obviously receives backwater from Patuxent River in lower half to two-thirds. Entire site in pool.
16-R3S-09-19	0.12	8.3	0.3	119.0	14.3	32.1	2.2	0.64	1.4	0.19	ND	Site located on Patuxent Research Refuge. No monuments installed at the request/direction of the refuge. Site is very odd, lower ~200 ft in what appears to be perpendicular to channel borrow pits or tank/jeep tracks connected by short riffle/runs. Upper ~50 ft in braided area with lateral wetlands. Should not be classified. Cross section set in upper braided area over channel that carries almost the entire flow.
16-R3S-14-19	0.05	13.3	0.2	32.2	2.4	58.2	3.1	0.53	1.1	0.16	DA5	Site on Patuxent Research Refuge. No monuments installed at request of refuge. Very small headwater stream running through wetland with skunk cabbage growing on banks. Well-connected to its floodplain. Dry leaves covering all bank surfaces above water surface, no evidence of high flows. XS shows single thread but other parts of reach use mutiple flow paths through wetland.
16-R3S-19-19	0.39	6.2	0.8	8.7	1.4	7.8	4.9	1.00	1.2	7.8	G4c	Adjusted Sin +0.1. Site on Patuxent Research Refuge. No monuments installed at request of refuge. Incised channel with steep banks. Much greater slope with larger riffles.
16-R3S-26-19	0.12	6.6	0.5	7.4	1.1	12.3	3.5	2.10	1.4	12	G4	Adjusted W/D -1.0. Small site below storm water pond draining residential construction. Adjusted WD -1.0 units.
16-R3S-27-19	0.37	5.4	1.0	5.6	1.0	5.2	5.6	1.10	1.3	0.47	G5c	Site on Patuxent Research Refuge. No monuments installed at request of refuge. Incised channel.
16-R3S-30-19	0.14	9.6	0.1	65.0	6.8	173.6	0.5	0.82	1.2	0.062	DA6	Site on Patuxent Research Refuge. No monuments installed at request of refuge. Flowing stream in a very small channel within wetland under powerlines.
17-L1M-01-19	1.05	10.8	0.8	16.4	1.5	13.1	8.8	0.27	1.4	1.4	B5c	Stream located close to new development. Incised channel with erosion on all outer meanders. Significant bar formation throughout channel consisisting of sand and small gravel. Good wooded buffer on RB, ok buffer on LB with houses less than 100m away.
17-L1M-02-19	0.85	15.8	0.7	18.4	1.2	24.2	10.3	0.80	1.4	0.74	F5	Very incised channel. Tons of erosion with steep banks on LB. Two severe erosion spots with raw banks measuring 30-40 feet tall. Located R1 XS.
17-L2M-01-19	0.50	9.2	0.9	16.5	1.8	10.2	8.3	0.01	1.4	0.84	E5	Adjusted Sin +0.1 and ER +0.2. Round 2 site, could not find XS pins within site. Found photo locations but no pins after 10 minute search. On walk out located R2 XS and resurveyed, two XS at this site. Beaver activity DS of site. A lot of sand deposition in the channel and on banks. Site is continuous pool with a couple high points due to sediment deposition. Evidence of water gettting outside of banks.
17-L2M-02-19	0.64	9.0	1.0	10.4	1.1	8.9	9.2	0.49	1.3	8	G4c	Incised channel. RB slope is very steep from the running path. Found both Round 2 XS pins. Site is located in floodplain between two steep slopes.
17-R3M-01-19	1.05	14.4	0.6	32.5	2.3	23.4	8.8	0.41	1.3	4	C4/5	Nice channel, similar to 17-L1M-01-19. Extensive bar formation of sand and gravel. Sand is soft in pools. Good forest buffer. Small buffer break of bike path on LB but minor in severity.

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
17-R3M-02-19	0.26	5.3	0.7	73.0	13.7	7.4	3.8	0.22	1.2	0.44	E5	Adjusted Sin +0.3. Site on Ft Meade. Site moved slightly upstream of culvert to avoid restricted area. Site downstream of a power line ROW and directly upstream of a culvert.
17-R3M-04-19	0.29	11.6	0.4	12.7	1.1	27.0	5.0	1.10	1.1	14	F4	Adjusted Sin +0.1. Could not extend cross section on right bank due to fence at property line.
17-R3M-06-19	0.24	9.4	0.6	11.0	1.2	15.8	5.7	0.02	1.2	0.31	F5	Fort Meade property. Site backwatered throughout reach.
17-R3S-01-19	0.07	3.2	0.6	16.6	5.2	5.2	2.0	1.10	1.0	0.19	ND	Site on Ft Meade. Stream in ditch below SWM facility. M. Keiler says this is usually dry, thinks stream holding water only due to unusually wet conditions the past 8-10 months. Heavily modified, should not be classified.
17-R3S-02-19	0.49	10.2	0.8	17.4	1.7	13.5	7.6	0.56	1.3	22	B4c	Incised channel with eroded meander bends. Exposed clay bed in some areas. Riffle habitat present. Site Located within Patuxent Wildlife Resuge. No monuments installed at request of refuge.
17-R3S-03-19	0.07	16.6	0.3	49.5	3.0	65.7	4.2	0.54	1.2	0.14	DA5	Small channel within large floodplain. Evidence of high water floods from recent rain. Standing water in depressions all around channel. DS 35 meters of site opens up into large flooded wetland.
17-R3S-04-19	0.14	8.4	0.7	158.7	18.8	11.4	6.2	0.24	1.1	0.062	ND	Small channel along sewer right of way. Very straight channel with erosion throughout, likely straightened and dredged. Wetted width exceeds regional curve estimated Abkf. Water reaches floodplain very easily. Standing water in floodplain after recent rains. Homeowner complained about flooding and debris blockages downstream of site.
17-R3S-05-19	---	12.9	0.4	17.5	1.4	34.9	4.8	0.57	1.2	0.11	F5	Adjusted Sin +0.1. Incised stream with eroded banks. Bank height decreases as you go upstream through the site. Site is very close to mainstem Little Patuxent, looks like this site experiences backwater from main river. Channel dimensions likely influenced by Little Patuxent flood waters. Site not on StreamStats, very small drainage area.
17-R3S-06-19	0.20	7.1	1.0	9.4	1.3	7.5	6.8	1.20	1.5	4	G4c	Steep banks on both sides. Nice stream with mix of riffle, pool, runs. Riffles have small cobble and gravel. Major erosion on outer meander bends with some healed erosion on straight sections.
17-R3S-07-19	0.29	8.7	0.5	53.0	6.1	18.8	4.1	0.29	1.3	0.13	C5	Nice headwater Coastal Plain stream, well connected to its floodplain. Very few bed features in site, all features created by woody debris in channel.
17-R3S-14-19	0.04	24.9	0.2	203.0	8.2	113.5	5.4	0.49	1.2	0.062	DA6	Small Coastal Plain stream in a wetland. Defined stream channel well-connected to the floodplain. Few bedform features, those that exist are all created by rootwads or woody debris in channel.
18-L1M-02-19	1.09	12.5	0.9	38.2	3.0	14.5	10.8	0.75	1.2	12	C4	Round 1 revisit. No geomorph done in 2004. Established XS at midpoint on well defined riffle. Channel is not incised, sediment deposition all throughout floodplain. End pins monumented on slopes of walking path and field berm to prevent future burial from deposition and capture FPA.
18-L1M-03-19	1.00	19.5	0.5	23.2	1.2	36.4	10.5	0.42	1.4	7.7	F4	Incised channel, some inset benches and floodplain present throughout reach. Erosion limited to outside meanders, lots of sediment deposition (gravel/sand).
18-L2M-01-19	0.45	8.8	0.8	8.8	1.0	10.4	7.4	1.40	2.0	0.5	G5/4c	Round 2 revisit. XS pins located, LB cap was off rebar, recapped. Severe undercut occuring on left bank at XS, difficult to survey the undercut due to height of bank. Bank is easily erodable due to unconsolidated sand.
18-L2M-02-19	1.29	17.4	0.7	19.4	1.1	24.2	12.5	0.52	1.2	1.8	F4/5	Right end pin was out of ground and leaning against fallen tree. Re-monumented according to 2010 Round 2 XS length and pin height. Channel is downstream of RT. 301, very incised but healing and obvious benches created within overall incised channel.
18-R3M-01-19	0.46	9.1	0.8	10.3	1.1	11.8	7.0	0.97	1.4	4	G4/5	Very entrenched stream, benches result of slumped banks. Banks mostly sand, with severe erosion.
18-R3M-02-19	0.54	11.9	0.7	14.8	1.2	16.0	8.9	0.91	1.2	1.6	F4/5	Incised stream within confined valley. Stream channel showing signs of healing with benches inside old incised channel. Active freeze thaw slumping occuring throughout site, mostly on LB.
18-R3M-03-19	0.47	7.5	0.9	10.5	1.4	8.3	6.7	0.53	1.6	5.7	G4/5	Entrenched channel for most of reach. Significant erosion on outer meanders, the lone point bar within the reach harboring a large sediment load (mostly sand).
18-R3M-04-19	0.34	6.1	1.1	11.5	1.9	5.6	6.5	0.45	1.6	0.42	E5	Adjusted ER +0.2. Air Force property. Slightly entrenched channel with evidence of healing, benches within incised channel. Low W/D ratio, moderate sinuosity.
18-R3S-02-19	0.18	3.6	1.0	5.2	1.5	3.6	3.5	2.20	1.2	0.4	G5	Adjusted Sin +0.1 and ER -0.2. Stream is in confined valley with steep valley walls along both banks for the majority of the reach. Banks comprised of hard clay.

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
18-R3S-04-19	0.13	20.2	0.2	42.6	2.1	87.1	4.7	1.40	1.6	0.43	D5	Braided system at bankfull/flood stage, evidence suggests very flashy and highly impervious drainage. Muiltple abandon channels choked off by influx of sediment, very fluid stream channel/wetland complex. XS set up through main channel at time of sampling, but pins are monumented out wide enough to capture abandoned/flood stage braids.
18-R3S-05-19	0.09	3.8	0.6	6.0	1.6	6.0	2.4	0.93	1.1	0.32	G5c	Adjusted Sin +0.2 and ER -0.2. Active downcutting channel, entrenched. Some areas of healing and bench forming inside incised channel. Small headcut/debris jam upstream of the 75m. Modified pebble count. Low W/D ratio.
18-R3S-07-19	0.14	3.8	0.5	4.6	1.2	7.2	2.0	1.70	1.3	0.58	G5c	Stream in confined valley with steep valley walls . Upstream end of reach seems to be actively downcutting, as evident by headcut upstream of the 75m.
18-R3S-10-19	0.15	12.1	0.4	280.0	23.2	30.5	4.8	0.10	1.6	0.062	C6	XS/trib in floodplain of Mid-Pax. FPA very wide, calc from GIS. XS placed pins exposed ~1ft to prevent burial. Stream is all silt material, with access to FP. Modified pebble count.
18-R3S-12-19	0.19	8.3	0.5	16.4	2.0	16.0	4.3	2.40	1.3	5.2	B4	Confined valley, some stretches have steep valley walls on both banks, some alternating low benches. Grade influenced by woody debris in several locations.
18-R3S-17-19	0.20	7.7	0.5	9.9	1.3	15.8	3.7	2.00	1.2	3.6	B4	Adjusted ER +0.2. Confined valley, wetland seeps on fringes, woody debris in-stream is common. Woody debris jam near mid-point holding grade. Only very high flows access floodplains. Cross section may be influenced slightly by debris jam downstream.
18-R3S-20-19	0.16	5.8	0.6	7.1	1.2	10.1	3.3	1.10	1.1	0.33	G5/4c	Adjusted Sin +0.1. Air Force property. Stream looks to have been channelized in the past, old concrete structure at the midpoint. Channel is entrenched with intermitent access to floodplain.

Appendix B: Quality Control Summary

Appendix B: Quality Assurance/Quality Control Procedures and Results

A quality assurance and quality control analysis was completed for the assessment work conducted in the Countywide Aquatic Biological Assessment following the methods described by Hill and Pieper (2011). This analysis included performance characteristics of precision, accuracy, bias, sensitivity, and completeness, with comparisons to Measurement Quality Objectives MQOs. Performance measures include:

- Precision (consistency) of field sampling and overall site assessments using intra-team site duplication
  - median relative percent difference (mRPD)
  - root mean square error (RMSE)
  - coefficient of variability (CV)
- Sensitivity of overall site assessments
  - 90% confidence interval (CI)
- Bias of sample sorting and subsampling
  - percent sorting efficiency (PSE)
- Precision of taxonomic identification and enumeration
  - percent taxonomic disagreement (PTD)
  - percent difference in enumeration (PDE)

Data that do not meet performance or acceptable criteria are re-evaluated to correct any problems or investigated further to determine the reason behind the results.

Field Sampling

All field crew leaders were recently trained in MBSS Spring and Summer sampling protocols prior to the start of each field sampling season. Benthic macroinvertebrate sampling was conducted only by crew members certified in MBSS benthic macroinvertebrate sampling. Fish sampling was performed under the leadership of a crew member certified as Fish Sampling Crew Leader and fish taxonomic identification was performed only by crew members certified as Fish Taxonomist. In addition, field crew members leading the geomorphic assessments have either completed Rosgen Level II training or completed a previous season of geomorphic assessments.

All subjective scoring of physical habitat assessment parameters was completed with the input of all team members at the sampling site to reduce individual sampler bias.

Field water quality measurements and grab samples were collected at all monitoring sites according to methods in the County QAPP. Water quality equipment was regularly inspected, maintained, and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

Sample buckets contained both internal and external labels. All chain-of-custody procedures were followed for transfer of the samples between the field and the identification lab.

Replicate (duplicate) samples were collected at one site per strata (i.e., large streams, small streams) within each of the five primary sampling units (PSUs) sampled in 2019, for a total of 10 duplicates. These samples were collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was field-selected rather than randomly selected to ensure that the QC sites maintained similar habitat conditions to the original site, and no obvious stressors or unusual conditions were present that may affect the biota. Duplicate

samples included collection and analysis of the benthic macroinvertebrate community, completion of the RBP and the PHI habitat assessments, water quality grabs and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites.

Precision

Performance characteristics calculated for the consistency of field sampling and overall site assessments using intra-team site duplication were:

- Relative Percent Difference (RPD)
- Root Mean Square Error (RMSE)
- Coefficient of Variability (CV)

Programmatic measurement quality objectives are listed in Table 1. Results of performance characteristics using individual metric values are presented in Table 2. Results are shown for sites where a duplicate sample (i.e., sample pair) was collected and analyzed.

Table 1 – Measurement quality objectives for metric values and index scores

Attribute	MQO[1]		
	Median RPD	RMSE	CV
Total Number of Taxa	20	4.3	20
Number of EPT Taxa	30	1.7	50
Number of Ephemeroptera Taxa	30	2.8	100
Percent Intolerant Urban	80	15.9	80
Percent Ephemeroptera	30	0.5	100
Number of Scraper Taxa	30	0.9	100
Percent Climber	30	6.9	70
B-IBI	20	0.6	22

[1]Values derived from Hill and Pieper, 2011

Both metric values and index scores were compared to MQOs to determine exceedances. Four metrics, Total Taxa, Number of EPT Taxa, Number of Scraper Taxa, and Percent Climbers, exceeded the MQO for mRPD.

The high RPD values for Number of EPT Taxa and Number of Scraper Taxa was due to relatively few EPT and Scraper taxa present in the samples which tend to skew RPD values upward when comparing small values as compared to large values. For example, a sample pair with 1 vs 0 taxa yielded an RPD of 200, while a sample pair with 3 vs 4 taxa had an RPD of 29, despite the same difference of only 1 taxon between sample pairs. The high mRPD for the Percent Climber metric was likely due to the variability within this metric between sites sampled in which values range from 0.9% to 19.8%, most of which were below 10%.

Percent Intolerant exceeded the MQO for RMSE and CV, but passed for mRPD, while Total Taxa and EPT Taxa exceeded the MQO for RMSE and CV in addition to median RPD. This is primarily due to the low overall mean values for Percent Intolerant (19.2) in the QC data set, which was smaller than the RMSE values of 22.4 and resulted in an elevated CV value of 116.9%, exceeding the threshold of 100%.

The BIBI narrowly exceeded the MQOs for mRPD, RMSE, and CV in the QC dataset. It should be noted that one sample pair (12-R3M-05-19 and 12-R3M-05-19QC) was removed since sample 12-R3M-05-19QC had fewer than 60 organisms present in the subsample and the BIBI could not be calculated. The BIBI narrowly exceeded the thresholds primarily due to one small stream sample pair (04-R3S-13-19 & 04-R3S-13-19QC) with a relatively large difference in BIBI scores of 1.57 and 3.00, respectively. The overall taxonomic composition between the samples prior to rarefaction was quite similar with both samples dominated by *Parametriocnemus* (a chironomid), although the presence of a few rare scraper taxa skewed the difference. During the rarefaction process, site 04-R3S-13-19 went from 15 to 13 Total Taxa and from 4 to 3 EPT taxa. This reduced the metric score for Total Taxa from a '3' to a '1'. The difference in EPT between pairs resulted in scoring differences of '5' and '3' because the QC sample pair fell just above the threshold for '5'. A similar occurrence was observed for the Percent Intolerant metric, whereby the percentage between samples was minimal (10.1% vs. 8.1%), but the QC sample was just above the 10% threshold and received a score of '3' while the other sample scored a '1'. The largest scoring discrepancy occurred with the Scraper Taxa metric, where the QC sample had 2 individuals that accounted for 2 scraper taxa and the other sample had none. This resulted in a scoring difference of '5' vs '1' since the threshold for a '5' is only 2 taxa. Without rarefaction, site 04-R3S-13-19 would have received a BIBI score of 1.86, which is slightly higher than the rarefied sample.

Six metrics and the BIBI exceeded the MQO for CV. Number of Ephemeroptera Taxa and Percent Ephemeroptera were the only metrics that exceeded CV only, while the remaining four metrics (Total Taxa, EPT Taxa, Percent Intolerant, Percent Climbers) and the BIBI had already exceeded either mRPD or RMSE as explained above. This is primarily due to the low overall mean values for Ephemeroptera Taxa (0.40) and Percent Ephemeroptera (0.91) in the QC data set, which was smaller than the corresponding RMSE values of 0.44 and 0.93 and resulted in elevated CV values of 109.1% and 103%, respectively.

It is important to note that these results show the innate variability that is possible within a given sampling reach and throughout the sample processing and data reduction. Although all samples were collected by a certified benthic macroinvertebrate sampler, variation within a reach (primary site vs. field replicate) is probable due to slight variations in habitat availability (e.g., instream woody debris, quality of leaf packs and riffles) and sample processing and subsampling within the laboratory. It should also be noted that inclusion of small streams into this data set is likely to introduce additional variability in the results given that only larger streams were used to develop the MQOs.

Table 2 – Individual Metric Values and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa	EPT Taxa	Ephem Taxa	% Intol	% Ephem	Scraper Taxa	% Climbers	BIBI	Rating
17-R3M-01-19	9	1	0	0.0	0.0	1	1.7	1.57	Very Poor
17-R3M-01-19-QC	6	0	0	0.0	0.0	1	0.9	1.57	Very Poor
17-R3S-02-19	26	6	2	35.6	1.9	4	2.9	3.57	Fair
17-R3S-02-19-QC	32	9	1	41.1	1.9	3	3.7	4.14	Good
12-R3M-05-19	26	1	1	5.5	1.1	0	19.8	2.71	Poor
12-R3M-05-19-QC	17	3	1	10.0	5.0	0	7.5	1.00*	Very Poor
12-R3S-13-19	22	1	0	0.0	0.0	2	18.2	2.71	Poor
12-R3S-13-19-QC	14	1	0	1.0	0.0	1	12.7	2.14	Poor
18-L1M-02-19	20	2	1	4.2	2.5	1	17.6	3	Fair
18-L1M-02-19-QC	15	1	0	0.0	0.0	1	12.6	2.14	Poor
18-R3S-05-19	27	1	0	5.0	0.0	0	7.0	1.86	Very Poor
18-R3S-05-19-QC	27	1	0	4.5	0.0	1	13.4	2.43	Poor
04-R3S-13-19	13	3	0	8.8	0.0	0	4.4	1.57	Very Poor
04-R3S-13-19-QC	18	5	0	10.1	0.0	2	7.6	3	Fair
04-L1M-02-19	28	10	1	21.3	0.9	1	8.3	3.86	Fair
04-L1M-02-19-QC	28	7	1	14.4	4.8	3	4.8	3.86	Fair
16-L2M-01-19	8	0	0	92.0	0.0	0	2.7	1.86	Very Poor
16-L2M-01-19-QC	14	0	0	62.0	0.0	0	11.1	2.43	Poor
16-R3S-07-19	27	3	0	4.7	0.0	2	11.2	3	Fair
16-R3S-07-19-QC	20	3	0	63.5	0.0	1	7.0	2.71	Poor
Median RPD	**31.0**	**37.6**	0.0	38.7	0.0	**47.6**	**53.4**	**23.5**	-
RMSE	**5.7**	**2.4**	0.9	**22.4**	0.9	**1.1**	6.5	0.7	-
CV	**28.7**	**82.3**	**109.1**	**116.9**	**103.0**	95.3	**74.0**	**26.5**	-

*BIBI score not calculated due to <60 organisms in sample, value not included in comparison

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, 100% (90 samples) underwent quality control procedures for sorting, exceeding the ten percent requirement. Average percent sorting efficiency was 97.2% (n=90). All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked, while a minimum of ten percent of samples sorted by experienced laboratory personnel were also checked. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters.

Taxonomic Identification and Enumeration

Nine samples (12-R3M-01-19, 12-R3S-04-19, 12-R3S-07-19, 17-R3S-04-19, 18-R3M-03-19, 04-R3M-06-19, 04-L1M-01-19, 04-R3S-18-19, 16-R3M-09-19) were randomly selected for QC identification and enumeration by an independent lab. Initial identification was performed by EcoAnalysts[1] (ESC). Re-identification of the randomly selected samples was completed by Ellen

[1] Address: 1420 S. Blaine St., Suite 14 Moscow, ID 83843

Friedman, former lead benthic macroinvertebrate taxonomist at the Maryland Department of Natural Resources. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

Precision

Measures of precision were calculated for the identification consistency for the samples selected at random. These include percent difference in enumeration (PDE) and percent taxonomic disagreement (PTD).

The PDE compares the final specimen counts between the two taxonomy labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the QAPP, the PDE for each sample must be equal to or less than 5%, and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD for all nine samples are found in Table 6Table 6 through Table 14. Dashes shown in the '# of agreements' column signify hierarchical disagreements, which counts as an agreement for PTD calculations. For example, if the primary laboratory identified a specimen as Naididae and the secondary laboratory identified the same specimen as *Dero* (genus of the family Naididae) this would be considered a hierarchical disagreement.

All but one (1) sample fell below the allowable thresholds for both PDE and PTD measures. Sample 03-R3M-05-18 had fewer than 30 specimens present; therefore, a slight difference of five (5) taxa resulted in a skewed PDE value since there were fewer than 100 organisms present. Since MQO targets were based on a 100-organism subsample, comparisons of outlier samples with less than 30 organisms are present will not provide results that are representative of the larger data set. The average PDE for all samples was 1.5% with a range between 0.0% and 5.9%. The average PTD was 10.6% with a range between 1.6% and 45.8%.

Water Quality Sampling

A QA/QC analysis was completed for the water quality grab sampling following the procedures used for MBSS and described by Mercurio et al. (2003), due to a lack of established MQOs developed specifically for Anne Arundel County. This analysis includes an evaluation of precision (repeatability) of water quality grab sampling.

A total of 8 duplicate water quality grab sample pairs were collected during the spring index period according to methods detailed in the County QAPP. To evaluate the consistency of water quality sampling using duplicate samples, the following performance characteristic was calculated:

- Relative Percent Difference (RPD)

Results of performance characteristics using individual parameter values are presented in Table 3a and Table 3b. Results are shown for sites where a duplicate sample (i.e., sample pair) was collected and analyzed.

In 2019, there were only two parameters that exceeded 20% mRPD (median RPD), orthophosphate and turbidity. Only two sample pairs for orthophosphate yielded values above the detection limit; thus, mRPD was skewed by a single high value of 65.8 which resulted in an

mRPD of 36.0. Five out of eight pairs exceeded 20% RPD for turbidity, mostly due to minor differences in small values, which has a tendency to skew mRPD upward more so than similar differences between larger values. Nonetheless, these results are in line with those reported by MBSS in the 2001 Quality Assurance Report (Mercurio et al. 2003).

Field blanks containing deionized water were also collected at two sites during 2019. Results of individual parameter values for both field blank samples are presented in Table 4. At site 04-L1M-02-19QC, five individual parameters had values slightly above the method detection limit, which include chloride, Nitrate-N, DOC, TOC, hardness and turbidity. At site 04-R3S-13-19QC, values for DOC, TOC, hardness and turbidity fell slightly above the method detection limit, with all other parameter values falling below. No metals were detected above the detection limits at either site.

Table 3a - Individual Grab Sample Parameter Values and Measures of Precision. Bold values exceed MQOs. All values are in mg/L.

Sample ID	Chloride	Total Phosphorus	Total Nitrogen	Ortho-phosphate	Total Ammonia Nitrogen	Nitrite-N	Nitrate-N	Dissolved Organic Carbon
12-R3M-05-19	24.29	0.0722	1.841	BDL	0.0676	BDL	1.8039	0.8176
12-R3M-05-19-QC	24.64	0.0694	1.852	0.0034	0.0678	BDL	1.8313	0.8451
12-R3S-13-19	55.26	0.0300	0.6978	0.0053	0.0252	BDL	0.3712	5.9859
12-R3S-13-19-QC	58.22	0.0491	0.7305	0.0105	0.0346	BDL	0.3528	5.6715
17-R3M-01-19	33.60	BDL	1.780	BDL	0.0177	BDL	1.7519	3.6582
17-R3M-01-19-QC	35.10	0.0117	1.819	BDL	0.0105	BDL	1.8147	3.7752
17-R3S-02-19	2.07	BDL	0.2413	BDL	0.0105	BDL	0.0997	3.4220
17-R3S-02-19-QC	2.09	BDL	0.2187	BDL	0.0126	BDL	0.0968	3.4736
18-R3S-05-19	4.55	0.0534	4.811	BDL	0.0461	0.0073	4.6955	2.5674
18-R3S-05-19-QC	4.89	0.0358	5.077	BDL	0.0388	0.0082	4.7470	2.8587
18-L1M-02-19	30.04	0.0305	2.053	0.0050	0.0111	0.0088	2.0069	1.5734
18-L1M-02-19-QC	30.23	0.0313	2.077	0.0047	0.0100	0.0088	2.0485	1.5269
16-R3S-07-19	2.11	0.0184	0.1865	BDL	0.0141	BDL	0.0186	4.2473
16-R3S-07-19-QC	2.20	BDL	0.1522	0.0037	0.0123	BDL	0.0165	4.3064
16-L2M-01-19	1.88	BDL	0.1622	BDL	0.0085	BDL	BDL	5.1172
16-L2M-01-19-QC	1.84	BDL	0.1568	BDL	BDL	BDL	BDL	5.0173
Median RPD	2.1	3.3	4.0	**36.0**	17.7	5.8	3.0	3.1

BDL signifies “below detection limit”

Table 3b - Individual Sample Parameter Values and Measures of Precision (Continued). All values are in mg/L, unless otherwise noted.

Sample ID	Total Organic Carbon	Magnesium	Calcium	Hardness	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
12-R3M-05-19	0.9533	3.34	12.1	44.06	0.300	23.7	0.238	15.2
12-R3M-05-19-QC	0.9075	3.34	12.1	43.93	0.277	23.3	0.199	14.8
12-R3S-13-19	6.1512	5.47	22.0	77.51	1.44	190.6	0.172	5.6
12-R3S-13-19-QC	5.7263	5.50	23.3	80.74	1.71	199.0	0.364	9.5
17-R3M-01-19	3.7355	3.95	12.9	48.33	1.13	20.4	0.238	5.6
17-R3M-01-19-QC	3.8834	3.99	13.2	49.35	1.17	19.8	0.224	4.5
17-R3S-02-19	3.4865	1.28	1.59	9.22	1.57	12.8	0.450	4.4
17-R3S-02-19-QC	3.5352	1.26	1.60	9.19	1.54	12.5	0.460	4.5
18-R3S-05-19	2.6773	3.63	8.05	35.05	0.590	12.0	0.425	15.5
18-R3S-05-19-QC	2.9801	3.69	8.24	35.74	0.511	11.3	0.310	10.4
18-L1M-02-19	1.7303	3.85	22.7	72.58	0.139	8.91	0.058	5.9
18-L1M-02-19-QC	1.6515	3.87	23.0	73.25	0.132	7.93	0.049	6.0
16-R3S-07-19	4.6790	1.37	1.45	9.28	0.976	19.5	0.398	7.1
16-R3S-07-19-QC	5.5471	1.37	1.43	9.19	0.935	18.9	0.372	3.0
16-L2M-01-19	5.2055	0.69	0.80	4.86	1.09	17.1	0.410	2.5
16-L2M-01-19-QC	5.1422	0.69	0.85	4.97	1.11	17.5	0.385	1.9
Median RPD	4.8	0.6	2.0	1.4	4.7	3.1	11.8	**24.8**

BDL signifies “below detection limit”

Table 4 - Individual Grab Sample Parameter Values for Field Blanks. All Values are in mg/L, unless otherwise noted.

Parameter	04-R3S-13-19-QC	04-L1M-02-19-QC	Parameter	04-R3S-13-19-QC	04-L1M-02-19-QC
Chloride	BDL	BDL	Total Organic Carbon	0.1461	0.1553
Total Phosphorus	BDL	BDL	Magnesium	BDL	BDL
Total Nitrogen	BDL	BDL	Calcium	BDL	BDL
Orthophosphate	BDL	BDL	Hardness	0.37	0.37
Total Ammonia Nitrogen	BDL	BDL	Total Copper (µg/L)	BDL	BDL
Nitrite-N	BDL	BDL	Total Zinc (µg/L)	BDL	BDL
Nitrate-N	BDL	0.0144	Total Lead (µg/L)	BDL	BDL
Dissolved Organic Carbon	0.1654	0.1751	Turbidity (NTU)	0.22	0.27

Summary

A summary of QC results for this sampling period, as compared to established MQOs, for each activity in the biological sampling process is displayed below in Table 6. Several individual metrics had exceeded measures for mRPD, RMSE and CV, including the overall BIBI. Laboratory sorting and subsampling measures indicated acceptable levels of bias, while taxonomic identification measures demonstrated acceptable precision. The overall sensitivity of the site assessment was slightly greater than the desired 90% confidence interval for the BIBI, 1.14 compared to the MQO of ≤0.96. One QC site pair, with BIBI scores of 1.57 and 3.00, contributes greatly to the variability of the BIBI. The benthic samples from these sites were similar, although several metrics fell on either side of the scoring thresholds because of a small change in species composition, exaggerating differences in overall BIBI scores. When analyzing the BIBI MQOs without this pair included, the mRPD decreases to 14.8, the RMSE decreases to 0.55, and the confidence interval decreases to 0.90, all within the MQOs for field sampling precision and sensitivity of the site assessment.

As mentioned in Hill and Pieper, 2011, there are generally two forms of error: systematic and random. Systematic error is error associated with a particular method, which can to a certain extent, be controlled by using an appropriate quality assurance program. Random error, however, is the error that results from the sample itself of the population from which it is derived and can only partly be controlled through a careful sampling design. What we are seeing when comparing the field replicate and primary samples is a combination of both systematic and random error. As certified samplers, the field crew is taking steps to minimize systematic error by following the exact same procedures at every site. Therefore, the MQO exceedances for Field Sampling and Site Assessment are not likely due to systematic error, and are possibly random error due to the spatial heterogeneity of habitats and taxa distribution between adjacent reaches. MBSS uses a QC site approach were the duplicate benthic sample is collected within the same reach as the non-QC sample, in as similar proportions of best available habitat as possible. While the institutional history of this decision is not published, MBSS staff feel this was done in an attempt to limit or control as much variability between the QC and non-QC samples as possible (Boward, D., 2020). Potential future research into differences between the two QC site approaches may help Anne Arundel County identify external influences or variability across the two QC site and sample approaches.

All remaining MQOs were met during the 2019 sampling period, and subsequently, the data are of acceptable quality as specified by the QAPP.

Table 5 - Summary comparison of QC results and measurement quality objectives[1].

Activity	Performance Indicator	Measure	MQO	2019 Results
Field Sampling	Precision	mRPD (BIBI)	<20	23.5
		RMSE (BIBI)	<0.6	0.7
Laboratory Sorting/Subsampling	Bias	PSE	>90	97.2
Taxonomic Identification	Precision	PDE	<5	1.5
		PTD	<15	10.6
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	1.14

[1] MQOs are derived from Hill and Pieper, 2011

Table 6 - Taxonomic Identification and Enumeration Results: 12-R3M-01-19

Order	Family	Tribe	Sample ID	12-R3M-01-19		
				Taxonomist 1	Taxonomist 2	# of agreements
Basommatophora	Physidae	-	Physa	1	1	1
Diptera	Chironomidae	Tanytarsini	Tanytarsini	1	1	1
	Chironomidae	Pentaneurini	Ablabesmyia	1	0	0
	Chironomidae	-	Cricotopus	8	6	6
	Chironomidae	-	Diplocladius	1	1	1
	Chironomidae	-	Hydrobaenus	3	3	3
	Chironomidae	-	Nanocladius	1	1	1
	Chironomidae	-	Orthocladius	8	10	8
	Chironomidae	-	Parametriocnemus	1	1	1
	Chironomidae	Chironomini	Polypedilum	11	11	11
	Chironomidae	-	Pseudorthocladius	1	1	1
	Chironomidae	-	Rheocricotopus	7	7	7
	Chironomidae	Tanytarsini	Rheotanytarsus	28	28	28
	Chironomidae	-	Thienemannimyia group	1	0	0
	Chironomidae	-	Xylotopus	1	0	0
	Simuliidae	Simuliini	Simulium	2	2	2
Ephemeroptera	Baetidae	-	Acerpenna	1	1	1
Odonata	Calopterygidae	-	Calopteryx	1	1	1
Trichoptera	Hydropsychidae	-	Cheumatopsyche	2	2	2
	Hydropsychidae	-	Hydropsyche	1	1	1
	Limnephilidae	-	Limnephilidae	1	0	1
			Ironoquia	0	1	-
Amphipoda	not identified	-	Amphipoda	2	1	1
	Gammaridae	-	Gammarus	21	0	20
			Gammaridae	0	20	-
	CRANGONYCTIDAE		CRANGONYCTIDAE	0	1	0
			Synurella	0	1	0
Decapoda	Cambaridae	-	Cambaridae	1	0	1
			Faxonius	0	1	-

Order	Family	Tribe	Sample ID		12-R3M-01-19	
				Taxonomist 1	Taxonomist 2	# of agreements
			Total	106	103	99
			PDE			1.44
			PTD			6.60

Table 7 - Taxonomic Identification and Enumeration Results: 12-R3S-04-19

Order	Family	Tribe	Sample ID	12-R3S-04-19 Taxonomist 1	Taxonomist 2	# of agreements
Lumbricina	not identified	-	Lumbricina	1	0	0
			LUMBRICULIDAE	0	1	0
Haplotaxida	Naididae	-	Naididae	5	4	4
Diptera	Chironomidae	-	Orthocladiinae	1	2	1
	Chironomidae	-	Chaetocladius	94	93	93
	Chironomidae	-	Cricotopus/Orthocladius	1	1	1
	Chironomidae	-	Diplocladius	4	4	4
	Chironomidae	-	Eukiefferiella	3	3	3
	Chironomidae	-	Parametriocnemus	1	1	1
	Chironomidae	-	Rheocricotopus	1	1	1
Amphipoda	not identified	-	Amphipoda	1	-	-
	Crangonyctidae	-	Synurella	1	1	1
Isopoda	Asellidae	-	Caecidotea	3	3	3
not identified	not identified	-	Turbellaria	2	2	2
			Total	118	116	114
			PDE			0.85
			PTD			3.39

Table 8 - Taxonomic Identification and Enumeration Results: 12-R3S-07-19

Order	Family	Tribe	Sample ID	12-R3S-07-19 Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae	-	Enchytraeidae	1	1	1
	Naididae	-	Naididae	7	10	7
Lumbricina	not identified	-	Lumbricina	3	0	0
			LUMBRICULIDAE	0	7	0
Diptera	Ceratopogonidae	-	Dasyhelea	1	0	0
	Chironomidae	-	Chaetocladius	1	1	1
	Chironomidae	-	Limnophyes	1	0	0
			Orthocladinae	0	1	0
	Chironomidae	-	Parachaetocladius	1	1	1
	Chironomidae	Diamesini	Potthastia	3	0	0
	Chironomidae	-	Pseudorthocladius	1	1	1
	Chironomidae	Pentaneurini	Zavrelimyia	1	0	-
			Tanypodinae	0	1	0
	Tipulidae	-	Pilaria	1	1	1
Amphipoda	not identified	-	Amphipoda	1	-	-
	Crangonyctidae	-	Synurella	1	0	0
			Crangonyx	0	2	0
Isopoda	Asellidae	-	Caecidotea	1	1	1
			Total	24	27	13
			PDE			5.88
			PTD			45.83

Table 9 - Taxonomic Identification and Enumeration Results: 17-R3S-04-19

Order	Family	Tribe	Sample ID	17-R3S-04-19 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae	0	Pisidium	1	-	-
			PISIDIIDAE	-	1	1
Lumbricina	not identified	0	Lumbricina	2	0	0
			LUMBRICULIDAE	0	2	0
Haplotaxida	Naididae	0	Naididae	15	15	15
Basommatophora	Lymnaeidae	0	Lymnaeidae	3	3	3
	Physidae	0	Physa	26	26	26
Diptera	Chironomidae	0	Cricotopus/Orthocladius	9	-	7
			Orthocladinae	-	5	-
	Chironomidae	0	Eukiefferiella	36	35	35
	Chironomidae	0	Orthocladius	27	31	27
	Chironomidae	Chironomini	Polypedilum	1	1	1
	Chironomidae	0	Pseudosmittia	1	0	0
	Chironomidae	Pentaneurini	Thienemannimyia	1	1	1
	Chironomidae		Tvetenia	1	1	0
Trichoptera	HYDROPSYCHIDAE		Hydropsyche	1	1	1
			Total	124	96	91
			PDE			0.81
			PTD			4.10

Table 10 - Taxonomic Identification and Enumeration Results: 18-R3M-03-19

Order	Family	Tribe	Sample ID	18-R3M-03-19 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae	-	Sphaeriidae	1	0	0
			Musculium	0	1	0

Order	Family	Tribe	Sample ID	18-R3M-03-19 Taxonomist 1	Taxonomist 2	# of agreements
Coleoptera	Elmidae	-	Stenelmis	1	1	1
	Ptilodactylidae	-	Anchytarsus	1	1	1
Diptera	Chironomidae	-	Brillia	6	0	6
			Orthocladinae	0	8	0
			Chironomini	0	1	0
	Chironomidae	-	Chaetocladius	3	3	3
	Chironomidae	-	Corynoneura	1	0	0
	Chironomidae	-	Diplocladius	11	10	10
	Chironomidae	-	Eukiefferiella	1	1	1
	Chironomidae	Chironomini	Microtendipes	1	1	1
	Chironomidae	-	Orthocladius	22	22	22
	Chironomidae	-	Orthocladius	2	0	0
	Chironomidae	-	Parametriocnemus	1	2	1
	Chironomidae	Chironomini	Polypedilum	18	18	18
	Chironomidae	-	Rheocricotopus	4	4	4
	Chironomidae	Tanytarsini	Rheotanytarsus	5	5	5
	Chironomidae	Tanytarsini	Rheotanytarsus	1	0	1
			Tanytarsini	0	1	-
	Chironomidae	-	Thienemannimyia grp	3	3	3
			Thienemanniella	0	1	0
	Empididae	Hemerodromiini	Hemerodromia	4	4	4
	Simuliidae	Simuliini	Simulium	6	6	6
Ephemeroptera	Baetidae	-	Acerpenna	5	5	5
Megaloptera	Corydalidae	-	Nigronia	1	1	1
Plecoptera	Capniidae	-	Capniidae	3	0	0
	Leuctridae	-	Leuctra	14	16	14
	Nemouridae	-	Amphinemura	5	5	5
Trichoptera	Hydropsychidae	-	Diplectrona	1	1	1
	Psychomyiidae	-	Lype	1	1	1
			Total	122	122	114

Order	Family	Tribe	Sample ID	18-R3M-03-19 Taxonomist 1	Taxonomist 2	# of agreements
			PDE			0.00
			PTD			6.56

Table 11 - Taxonomic Identification and Enumeration Results: 04-R3M-06-19

Order	Family	Tribe	Sample ID	04-R3M-06-19 Taxonomist 1	Taxonomist 2	# of agreements
Lumbriculida	Lumbriculidae	-	Lumbriculidae	1	2	1
Haplotaxida	Naididae	-	Naididae	1	1	1
Basommatophora	Physidae	-	Physa	2	2	2
Diptera	Chironomidae	-	Cricotopus	9	14	14
	Chironomidae	-	Cricotopus/Orthocladius	11	6	6
	Chironomidae	-	Parametriocnemus	3	3	3
	Chironomidae	Chironomini	Polypedilum	1	1	1
	Chironomidae	Diamesini	Potthastia	4	4	4
	Chironomidae	-	Rheocricotopus	2	2	2
	Chironomidae	Tanytarsini	Rheotanytarsus	12	12	12
	Chironomidae	Pentaneurini	Thienemannimyia	5	4	4
	Empididae	Hemerodromiini	Hemerodromia	4	4	4
	Simuliidae	Simuliini	Simulium	13	13	13
	Tipulidae	-	Tipula	1	0	0
Ephemeroptera	Baetidae	-	Acerpenna	10	10	10
Odonata	Cordulegastridae	-	Cordulegaster	1	1	1
Plecoptera	Perlidae	Acroneuriini	Eccoptura	3	3	3
Trichoptera	Hydropsychidae	-	Cheumatopsyche	6	5	5
	Hydropsychidae	-	Diplectrona	2	3	2
	Hydropsychidae	-	Hydropsyche	3	3	3
	Philopotamidae	-	Chimarra	8	8	8
	Psychomyiidae	-	Lype	1	1	1

Order	Family	Tribe	Sample ID	04-R3M-06-19 Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	not identified	-	Amphipoda	2	2	2
	Crangonyctidae	-	Synurella	5	5	5
	Hyalellidae	-	Hyalella	1	1	1
Isopoda	Asellidae	-	Caecidotea	2	2	2
			Total	113	112	110
			PDE			0.44
			PTD			1.79

Table 12 - Taxonomic Identification and Enumeration Results: 04-L1M-01-19

Order	Family	Tribe	Sample ID	04-L1M-01-19 Taxonomist 1	Taxonomist 2	# of agreements
			Nematoda	2	0	0
Veneroida	Pisidiidae	-	Pisidium	1	0	0
			Musculium	0	1	0
Haplotaxida	Naididae	-	Naididae	4	3	3
			OLIGOCHAETA	0	1	0
Basommatophora	Lymnaeidae	-	Stagnicola	8	8	8
Diptera	Chironomidae	-	Tanypodinae	1	6	1
	Chironomidae	Chironomini	Chironomus	3	3	3
			Chironomini	0	1	0
	Chironomidae	Tanytarsini	Cladotanytarsus	1	1	1
	Chironomidae	Chironomini	Cryptochironomus	2	1	1
			Orthocladinae	0	1	0
	Chironomidae	-	Diplocladius	1	1	1
	Chironomidae	Pentaneurini	Larsia	5	0	0
	Chironomidae	-	Metriocnemus	1	0	0
	Chironomidae	Tanytarsini	Micropsectra	45	43	43
	Chironomidae	Chironomini	Paratendipes	1	1	1

Order	Family	Tribe	Sample ID	04-L1M-01-19 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	Chironomini	Polypedilum	13	13	13
	Chironomidae	Tanytarsini	Rheotanytarsus	4	1	1
	Chironomidae	Chironomini	Stenochironomus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	21	19	19
			Tanytarsini	0	6	0
	Chironomidae	Pentaneurini	Thienemannimyia	2	2	2
Amphipoda	Crangonyctidae		Crangonyx	1	1	1
			Turbellaria	3	3	3
			Total	120	117	102
			PDE			1.27
			PTD			12.82

Table 13 - Taxonomic Identification and Enumeration Results: 04-R3S-18-19

Order	Family	Tribe	Sample ID	04-R3S-18-19 Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae		Enchytraeidae	2	2	2
Lumbriculida	Lumbriculidae		Lumbriculidae	16	31	16
Lumbricina	not identified		Lumbricina	8	0	0
Basommatophora	Physidae		Physa	6	6	6
Diptera	Chironomidae	-	Chaetocladius	50	48	48
	Chironomidae	-	Chaetocladius	1	1	1
			Orthocladinae	0	3	2
	Chironomidae	-	Cricotopus/Orthocladius	1	1	1
	Chironomidae	-	Eukiefferiella	2	2	2
	Chironomidae	-	Limnophyes	1	1	1
	Chironomidae	-	Orthocladius	26	26	26
	Chironomidae	Chironomini	Phaenopsectra	1	1	1

Order	Family	Tribe	Sample ID	04-R3S-18-19 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	Chironomini	Polypedilum	1	1	1
	Chironomidae	Pentaneurini	Zavrelimyia	6	5	5
			Tanypodinae	0	1	0
Trichoptera	Hydropsychidae		Hydropsyche	1	1	1
Amphipoda			Amphipoda	1	1	1
			Turbellaria	1	0	0
			Total	124	131	114
			PDE			2.75
			PTD			12.98

Table 14 - Taxonimic Identification and Enumeration Results: 16-R3M-09-19

Order	Family	Tribe	Sample ID	16-R3M-09-19 Taxonomist 1	Taxonomist 2	# of agreements
Diptera	Ceratopogonidae	-	Ceratopogoninae	8	9	8
	Ceratopogonidae	-	Dasyhelea	1	0	0
	Chironomidae	-	Parametriocnemus	1	1	1
	Chironomidae	-	Thienemanniella	1	1	1
	Simuliidae	Simuliini	Simulium	9	7	7
	Simuliidae	Prosimuliini	Stegopterna	138	138	138
			Prosimulium	0	1	0
			SIMULIIDAE	0	1	0
	Tipulidae	-	Hexatoma	1	1	1
Plecoptera	Leuctridae	-	Leuctridae	4	26	4
	Leuctridae	-	Leuctra	22	-	22
Trichoptera	Hydropsychidae	-	Diplectrona	2	2	2
Amphipoda	Crangonyctidae		Stygobromus	1	1	1

Order	Family	Tribe	Sample ID	16-R3M-09-19 Taxonomist 1	Taxonomist 2	# of agreements
			Total	188	188	185
			PDE			0.00
			PTD			1.60

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Appendix C: Master Taxa List

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4	447	10.42%	11	27.5%
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2	402	9.37%	12	30.0%
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2	311	7.25%	25	62.5%
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	213	4.97%	11	27.5%
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	210	4.90%	23	57.5%
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	210	4.90%	29	72.5%
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	163	3.80%	9	22.5%
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	152	3.54%	4	10.0%
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	137	3.19%	17	42.5%
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	134	3.12%	21	52.5%
Diptera	Chironomidae	Diamesa	Diamesa	Collector	sp	8.5	119	2.77%	17	42.5%
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	114	2.66%	15	37.5%
Diptera	Ceratopogonidae	not identified	Ceratopogoninae	0	0	na	112	2.61%	17	42.5%
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	103	2.40%	17	42.5%
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4	90	2.10%	8	20.0%
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	82	1.91%	17	42.5%
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7	80	1.87%	19	47.5%
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	71	1.66%	9	22.5%
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	56	1.31%	16	40.0%
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1	55	1.28%	7	17.5%
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	53	1.24%	17	42.5%
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	46	1.07%	13	32.5%
Amphipoda	Crangonyctidae	Synurella	Synurella	0	0	0.4	40	0.93%	11	27.5%
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1	37	0.86%	5	12.5%
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	37	0.86%	7	17.5%
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	36	0.84%	9	22.5%
Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	Predator	sp	6.7	35	0.82%	10	25.0%
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6	35	0.82%	9	22.5%
Amphipoda	not identified	not identified	Amphipoda	0	sp	6	28	0.65%	10	25.0%
0	0	not identified	Nematoda	0	0	na	28	0.65%	7	17.5%
Ephemeroptera	Baetidae	Acerpenna	Acerpenna	Collector	sw, cn	2.6	27	0.63%	8	20.0%
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	23	0.54%	6	15.0%
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	23	0.54%	11	27.5%
Plecoptera	Chloroperlidae	not identified	Chloroperlidae	Predator	cn	1.6	23	0.54%	2	5.0%
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	22	0.51%	9	22.5%
Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	Collector	bu	6.6	20	0.47%	6	15.0%
Diptera	Simuliidae	Prosimulium	Prosimulium	Filterer	cn	2.4	20	0.47%	4	10.0%
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9	18	0.42%	8	20.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	17	0.40%	8	20.0%
Isopoda	not identified	not identified	Isopoda	Collector	0	3.3	17	0.40%	6	15.0%
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7	16	0.37%	8	20.0%
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3	15	0.35%	7	17.5%
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	15	0.35%	9	22.5%
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	14	0.33%	10	25.0%
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4	13	0.30%	4	10.0%
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	13	0.30%	6	15.0%
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	12	0.28%	8	20.0%
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.01	12	0.28%	3	7.5%
Coleoptera	Ptilodactylidae	Anchytarsus	Anchytarsus	Shredder	cn	3.1	12	0.28%	5	12.5%
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	11	0.26%	4	10.0%
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7	10	0.23%	6	15.0%
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	10	0.23%	7	17.5%
Plecoptera	Chloroperlidae	Haploperla	Haploperla	Predator	cn	1.6	9	0.21%	4	10.0%
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	8	0.19%	2	5.0%
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	8	0.19%	6	15.0%
Diptera	Chironomidae	Natarsia	Natarsia	Predator	sp	6.6	8	0.19%	2	5.0%
Veneroida	Pisidiidae	not identified	Sphaeriidae	Filterer	bu	6.5	8	0.19%	6	15.0%
Basommatophora	Lymnaeidae	Stagnicola	Stagnicola	Scraper	cb	7.8	8	0.19%	1	2.5%
Plecoptera	Capniidae	not identified	Capniidae	Shredder	sp, cn	3.7	7	0.16%	4	10.0%
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7	7	0.16%	4	10.0%
Amphipoda	Hyalellidae	Hyalella	Hyalella	Shredder	sp	4.2	7	0.16%	2	5.0%
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7	6	0.14%	4	10.0%
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator	0	7.3	6	0.14%	4	10.0%
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	6	0.14%	4	10.0%
Diptera	Chironomidae	Larsia	Larsia	Predator	sp	8.5	6	0.14%	2	5.0%
Diptera	Chironomidae	Georthocladius	Georthocladius	0	sp	na	6	0.14%	2	5.0%
Diptera	Chironomidae	Apsectrotanypus	Apsectrotanypus	Predator	bu, sp	6.6	6	0.14%	1	2.5%
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	5	0.12%	3	7.5%
Diptera	Tipulidae	Erioptera	Erioptera	Collector	bu	4.8	5	0.12%	4	10.0%
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	5	0.12%	2	5.0%
Plecoptera	Perlidae	Eccoptura	Eccoptura	Predator	cn	0.6	5	0.12%	2	5.0%
Diptera	Chironomidae	Stilocladius	Stilocladius	Collector	sp	6.6	5	0.12%	2	5.0%
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3	4	0.09%	3	7.5%
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	4	0.09%	2	5.0%
Diptera	Tipulidae	Hexatoma	Hexatoma	Predator	bu, sp	1.5	4	0.09%	4	10.0%
Megaloptera	Corydalidae	Nigronia	Nigronia	Predator	cn, cb	1.4	4	0.09%	4	10.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Chironomidae	Odontomesa	Odontomesa	Collector	sp	6.6	4	0.09%	3	7.5%
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6	4	0.09%	4	10.0%
Diptera	Chironomidae	Pseudorthocladius	Pseudorthocladius	Collector	sp	6	4	0.09%	4	10.0%
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	4	0.09%	3	7.5%
not identified	not identified	not identified	Turbellaria	Predator	sp	4	4	0.09%	2	5.0%
Veneroida	not identified	not identified	Veneroida	0	0	na	4	0.09%	2	5.0%
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1	4	0.09%	1	2.5%
Trichoptera	Psychomyiidae	Lype	Lype	Scraper	cn	4.7	4	0.09%	4	10.0%
Diptera	Chironomidae	Clinotanypus	Clinotanypus	Predator	bu	6.6	4	0.09%	1	2.5%
Trichoptera	Leptoceridae	Oecetis	Oecetis	Predator	cn, sp, cb	4.7	4	0.09%	2	5.0%
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	3	0.07%	3	7.5%
Plecoptera	Nemouridae	not identified	Nemouridae	Shredder	sp, cn	2.9	3	0.07%	1	2.5%
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	3	0.07%	2	5.0%
Amphipoda	Crangonyctidae	Stygobromus	Stygobromus	Collector	0	4	3	0.07%	3	7.5%
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	3	0.07%	3	7.5%
Diptera	Chironomidae	Xylotopus	Xylotopus	Shredder	bu	6.6	3	0.07%	2	5.0%
Diptera	Chironomidae	not identified	Tanypodinae	Predator	0	7.5	3	0.07%	3	7.5%
Coleoptera	Hydrophilidae	Hydrobius	Hydrobius	Collector	cb, cn, sp	4.1	3	0.07%	2	5.0%
Isopoda	Asellidae	not identified	Asellidae	0	0	3.3	3	0.07%	2	5.0%
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	2	0.05%	1	2.5%
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9	2	0.05%	1	2.5%
Basommatophora	Lymnaeidae	not identified	Lymnaeidae	Scraper	cb	6.9	2	0.05%	2	5.0%
Diptera	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	2	0.05%	2	5.0%
Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	Collector	sp	4	2	0.05%	2	5.0%
Diptera	Tipulidae	Pilaria	Pilaria	Predator	bu	4.8	2	0.05%	1	2.5%
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1	2	0.05%	1	2.5%
Diptera	Tipulidae	Pseudolimnophila	Pseudolimnophila	Predator	bu	2.8	2	0.05%	2	5.0%
Diptera	Chironomidae	Saetheria	Saetheria	Collector	bu	6.6	2	0.05%	1	2.5%
Diptera	Tabanidae	not identified	Tabanidae	Predator	0	2.8	2	0.05%	3	7.5%
Diptera	Chironomidae	Tribelos	Tribelos	Collector	bu	7	2	0.05%	1	2.5%
Diptera	Chironomidae	Rheosmittia	Rheosmittia	0	0	6.6	2	0.05%	2	5.0%
Odonata	0	not identified	Anisoptera	Predator	0	na	2	0.05%	2	5.0%
Plecoptera	Perlodidae	Diploperla	Diploperla	Predator	cn	2.2	2	0.05%	2	5.0%
Trichoptera	Lepidostomatidae	Lepidostoma	Lepidostoma	Shredder	cb, sp, cn	0.01	2	0.05%	2	5.0%
Diptera	Chironomidae	Trissopelopia	Trissopelopia	Predator	sp	4.1	2	0.05%	1	2.5%
Trichoptera	Molannidae	Molanna	Molanna	Scraper	sp, cn	6	2	0.05%	1	2.5%
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	1	0.02%	1	2.5%
Decapoda	Cambaridae	not identified	Cambaridae	Shredder	sp	2.8	1	0.02%	1	2.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9	1	0.02%	1	2.5%
Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus	Filterer	-	6.6	1	0.02%	1	2.5%
Odonata	Coenagrionidae	not identified	Coenagrionidae	Predator	cb	9	1	0.02%	1	2.5%
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7	1	0.02%	1	2.5%
Diptera	Ceratopogonidae	Dasyhelea	Dasyhelea	Collector	sp	3.6	1	0.02%	1	2.5%
Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	Filterer	cn	1.7	1	0.02%	1	2.5%
Basommatophora	Ancylidae	Ferrissia	Ferrissia	Scraper	cb	7	1	0.02%	1	2.5%
Tubificida	Haplotaxidae	not identified	Haplotaxidae	0	0	na	1	0.02%	1	2.5%
Ephemeroptera	Leptophlebiidae	not identified	Leptophlebiidae	Collector	sw, cn	1.7	1	0.02%	1	2.5%
Lumbricina	not identified	not identified	Lumbricina	Collector	bu	na	1	0.02%	1	2.5%
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	1	0.02%	1	2.5%
Coleoptera	Elmidae	Oulimnius	Oulimnius	Scraper	cn	2.7	1	0.02%	1	2.5%
Trichoptera	Dipseudopsidae	Phylocentropus	Phylocentropus	Collector	bu	5	1	0.02%	1	2.5%
Basommatophora	Planorbidae	not identified	Planorbidae	Scraper	cb	7.6	1	0.02%	1	2.5%
Trichoptera	Polycentropodidae	not identified	Polycentropodidae	0	cn	0.2	1	0.02%	1	2.5%
Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	Shredder	cb	4.3	1	0.02%	1	2.5%
Diptera	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	1	0.02%	1	2.5%
Coleoptera	Haliplidae	Peltodytes	Peltodytes	Shredder	cb, cn	8.9	1	0.02%	1	2.5%
Diptera	Chironomidae	not identified	Tanytarsini	Collector	0	3.5	1	0.02%	1	2.5%
Coleoptera	Hydrophilidae	Helochares	Helochares	0	0	na	1	0.02%	1	2.5%
Diptera	Psychodidae	not identified	Psychodidae	0	0	4	1	0.02%	1	2.5%
Rhynchobdellida	Glossiphoniidae	Helobdella	Helobdella	Predator	sp	6	1	0.02%	1	2.5%
Diptera	Chironomidae	Hydrosmittia	Hydrosmittia	0	0	na	1	0.02%	1	2.5%
Diptera	Tipulidae	Ormosia	Ormosia	Collector	bu	6.3	1	0.02%	1	2.5%
Trichoptera	Philopotamidae	Wormaldia	Wormaldia	Filterer	cn	1.8	1	0.02%	1	2.5%
Ephemeroptera	Caenidae	Caenis	Caenis	Collector	sp	2.1	1	0.02%	1	2.5%
Diptera	Ephydridae	not identified	Ephydridae	Collector	bu, sp	na	1	0.02%	1	2.5%
Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	Predator	bu	2.4	1	0.02%	1	2.5%
Diptera	Chironomidae	Metriocnemus	Metriocnemus	0	0	na	1	0.02%	1	2.5%
Diptera	Chironomidae	Sympotthastia	Sympotthastia	Collector	sp	8.2	1	0.02%	1	2.5%
Diptera	Dolichopodidae	not identified	Dolichopodidae	Predator	sp, bu	7.5	1	0.02%	1	2.5%
Diptera	Empididae	Neoplasta	Neoplasta	Predator	0	na	1	0.02%	1	2.5%
Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila	Predator	cn	2.1	1	0.02%	1	2.5%
Hemiptera	Corixidae	not identified	Corixidae	Predator	sw	5.6	1	0.02%	1	2.5%
Diptera	Chironomidae	Procladius	Procladius	Predator	sp	1.2	1	0.02%	1	2.5%
Diptera	Muscidae	not identified	Muscidae	Predator	sp	7	1	0.02%	1	2.5%
Diptera	Chironomidae	Robackia	Robackia	Collector	0	na	1	0.02%	1	2.5%
Coleoptera	Elmidae	Microcylloepus	Microcylloepus	Collector	0	4.8	1	0.02%	1	2.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Trichoptera	Calamoceratidae	Heteroplectron	Heteroplectron	Shredder	sp	3	1	0.02%	1	2.5%
Plecoptera	Capniidae	Allocapnia	Allocapnia	Shredder	cn	4.2	1	0.02%	1	2.5%

1) Habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer
2) Tolerance Values, based on Hilsenhoff, modified for Maryland (Bressler et al., 2004)
An entry of "0" indicates information was not available in the MBSS Master Taxa List

Common Name	Scientific Name	Tolerance	Trophic Status	Lithophilic Spawner	Composition	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Blacknose dace	*Rhinichthys atratulus*	T	OM	N	NOTYPE	1710	26.1%	21	53%
Green sunfish	*Lepomis cyanellus*	T	GE	N	NOTYPE	751	11.5%	11	28%
Eastern mudminnow	*Umbra pygmaea*	T	IV	N	NOTYPE	665	10.1%	20	50%
Eastern mosquitofish	*Gambusia holbrooki*	NOTYPE	IV	N	NOTYPE	631	9.6%	7	18%
Creek chub	*Semotilus atromaculatus*	T	GE	Y	NOTYPE	606	9.2%	10	25%
Fathead Minnow	*Pimephales promelas*	NOTYPE	OM	N	NOTYPE	307	4.7%	3	8%
Tessellated darter	*Etheostoma olmstedi*	T	IV	N	B	305	4.7%	14	35%
Least brook lamprey	*Lampetra aepyptera*	NOTYPE	FF	N	B	288	4.4%	16	40%
Rosyside dace	*Clinostomus funduloides*	NOTYPE	IV	Y	NOTYPE	252	3.8%	6	15%
Bluegill	*Lepomis macrochirus*	T	IV	N	NOTYPE	240	3.7%	11	28%
Golden shiner	*Notemigonus crysoleucas*	T	OM	N	NOTYPE	215	3.3%	2	5%
White sucker	*Catostomus commersonii*	T	OM	Y	NOTYPE	137	2.1%	12	30%
American eel	*Anguilla rostrata*	NOTYPE	GE	N	NOTYPE	132	2.0%	19	48%
Pumpkinseed	*Lepomis gibbosus*	T	IV	N	NOTYPE	92	1.4%	10	25%
Brown bullhead	*Ameiurus nebulosus*	T	OM	N	NOTYPE	77	1.2%	3	8%
Creek chubsucker	*Erimyzon oblongus*	NOTYPE	IV	N	R	43	0.7%	7	18%
Redfin pickerel	*Esox americanus*	T	TP	N	NOTYPE	42	0.6%	7	18%
Fallfish	*Semotilus corporalis*	I	GE	Y	NOTYPE	27	0.4%	4	10%
Mummichog	*Fundulus heteroclitus*	NOTYPE	IV	N	NOTYPE	15	0.2%	1	3%
Largemouth bass	*Mictopterus salmoides*	T	TP	N	NOTYPE	12	0.2%	5	13%
Sea Lamprey	*Petromyzon marinus*	I	FF	N	NOTYPE	2	0.0%	2	5%
Yellow perch	*Perca flavescens*	NOTYPE	GE	N	B	2	0.0%	2	5%
Redbreast Sunfish	*Lepomis auritus*	NOTYPE	GE	N	NOTYPE	1	0.0%	1	3%
Warmouth	*Lepomis gulosus*	NOTYPE	GE	N	NOTYPE	1	0.0%	1	3%
White crappie	*Pomoxis annularis*	NOTYPE	GE	N	NOTYPE	1	0.0%	1	3%
Bluespotted Sunfish	*Enneacanthus gloriosus*	NOTYPE	IV	N	NOTYPE	1	0.0%	2	5%
Cyprinid Hybrid	*Cyprinid Hybrid*	NOTYPE	NOTYPE	NOTYPE	NOTYPE	1	0.0%	1	3%

Note: Two sites were qualitatively sampled and are not included in total number organisms counts.

Tolerance: I = intolerant, T = tolerant; NOTYPE = no category assigned

Trophic groups: FF = filter feeder, TP = top predator, GE = generalist, IV = invertivore, IS = insectivore, OM = omnivore, AL = algivore, HE = herbivore

Lithophilic spawner: Y = Yes, N = No, NOTYPE = no categopry assigned

Composition: B = Benthic, R = Round-Bodied Sucker, NOTYPE = no category assigned

Crayfish

Common Name	Scientific Name	Total Number of Sites	% of Sites
Spinycheek Crayfish	*Orconectes limosus*	8	20%
Devil Crawfish	*Cambarus diogenes*	5	13%
Red Swamp Crawfish	*Procambarus clarkii*	3	8%
n/a	*Cambarus sp.*	1	3%
Virile Crayfish	*Orconectes virilis*	1	3%

Herpetofauna

Common Name	Scientific Name	Total Number of Sites	% of Sites
Northern Green Frog	*Lithobates clamitans*	36	90%
Pickerel Frog	*Lithobates palustris*	15	38%
Northern Two-lined Salamander	*Eurycea bislineata*	14	35%
Northern Spring Peeper	*Pseudacris crucifer*	6	15%
Wood Frog	*Lithobates sylvaticus*	6	15%
Northern Red Salamander	*Pseudotriton ruber ruber*	6	15%
American Bullfrog	*Lithobates catesbeianus*	5	13%
Eastern American Toad	*Anaxyrus americanus*	3	8%
Eastern Cricket Frog	*Acris crepitans*	3	8%
Gray Treefrog	*Hyla versicolor*	3	8%
Fowler's Toad	*Anaxyrus fowleri*	3	8%
Northern Dusky Salamander	*Desmognathus fuscus*	3	8%
Cope's Gray Treefrog	*Hyla chrysoscelis*	1	3%
Eastern Red-backed Salamander	*Plethodon cinereus*	1	3%
Eastern Box Turtle	*Terrapene carolina*	1	3%
Eastern Painted Turtle	*Chrysemys picta*	1	3%
Eastern Gartersnake	*Thamnophis sirtalis*	1	3%
Northern Black Racer	*Coluber constrictor*	1	3%
Common Ribbonsnake	*Thamnophis sauritus*	1	3%

Non-native Riparian Plants

Common Name	Scientific Name	Total Number of Sites	% of Sites
Japanese Stiltgrass	*Microstegium vimineum*	33	83%
Japanese Honeysuckle	*Lonicera japonica*	23	58%
Multiflora Rose	*Rosa multiflora*	22	55%
Oriental Bittersweet	*Celastrus orbiculatus*	15	38%
Mile-a-Minute	*Persicaria perfoliata*	11	28%
Japanese Barberry	*Berberis thunbergii*	9	23%
Garlic Mustard	*Alliaria petiolata*	6	15%
English Ivy	*Hedera helix*	5	13%
Ground Ivy	*Glechoma hederacea*	5	13%
Beefsteak Plant	*Perilla frutescens*	4	10%
Autumn Olive	*Elaeagnus umbellata*	3	8%
Chinese Silk Tree	*Albizia julibrissin*	3	8%
Porcelain Berry	*Ampelopsis brevipedunculata*	3	8%
Common Ragweed	*Ambrosia artemisiifolia*	2	5%
Phragmites	*Phragmites australis*	2	5%
Privet sp.	*Ligustrum sp.*	2	5%
Rose of Sharon	*Hibiscus syriacus*	2	5%
Wineberry	*Rubus phoenicolasius*	2	5%
Asiatic Dayflower	*Commelina communis*	1	3%
Marsh Dayflower	*Murdannia keisak*	1	3%
Mugwort	*Artemisia vulgaris*	1	3%
Oriental Lady's Thumb	*Persicaria longiseta*	1	3%
Tree of Heaven	*Ailanthus altissima*	1	3%
Winged Euoynmus	*Euonymus alatus*	1	3%
Wintercreeper	*Euonymus fortunei*	1	3%

Freshwater Mussels/Corbicula

Common Name	Scientific Name	Total Number of Sites	% of Sites
None Observed			

Appendix D: Individual Site Summaries

Note: Cross-section overlays for revisit sites where the graph background is yellow denotes sites where one or both end pins could not be relocated

Site ID 04-L1M-01-19

Revist of site R1-04-07

Upstream View - 2019

Downstream View - 2019

Upstream View - 2008

Downstream View - 2008

Summary Results

	2019 Data	2008 Data
Benthic Macroinvertebrate Community	Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 47.84

Land Cover	2019 Acres	2008 Acres	2019 % Area	2008 % Area
Developed Land	16.62	23.34	34.74	34.55
Forested Land	10.78	9.87	22.53	14.61
Open Land	12.89	34.35	26.93	50.84
Agricultural Land	7.55	0.00	15.79	0.00

Impervious Surface	2019 Acres	2008 Acres	2019 % Area	2008 % Area
Impervious Land	7.64	16.21	15.98	24.00

Site ID 04-L1M-01-19

Revist of site R1-04-07

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2008 Spring
Dissolved Oxygen (mg/L)	9.61	0.29	11.29
Turbidity (NTU)	9.51	19.3	n/a
Temperature (°C)	13.2	24.5	4.69
pH (Standard Units)	7.56	7.42	7.5
Specific Conductivity (µS/cm)	292.5	368.7	432

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.078	Chloride (mg/L)	29.139
Total Nitrogen (mg/L)	1.216	Magnesium (mg/L)	4.324
Orthophosphate (mg/L)	0.013	Calcium (mg/L)	34.41
Total Ammonia N (mg/L)	0.129	Total Copper (µg/L)	1.027
Nitrite-N (mg/L)	0.015	Total Zinc (µg/L)	6.001
Nitrate-N (mg/L)	0.602	Total Lead (µg/L)	0.505
Total Kjehldal N (mg/L)	0.599	Turbidity (NTU)	9.3
Dissolved Organic C (mg/L)	7.318		
Total Organic C (mg/L)	7.611		
Hardness (mg eq. $CaCO_3$/L)	103.73		

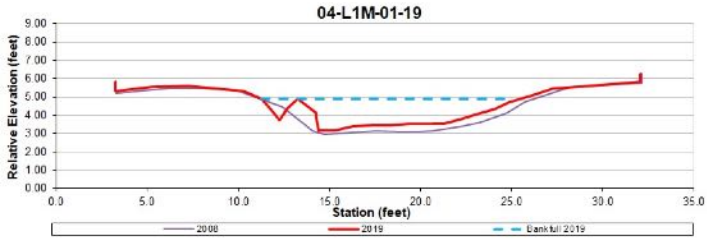
Geomorphic Assessment

Rosgen Level II Classification Data

	2019	2008		2019	2008
Drainage Area (mi²)	0.07		Sinuosity	1.06	1.00
Bankfull Width (ft)	13.0	13.5	D50 (mm)	0.07	0.26
Mean Bankfull Depth (ft)	1.0	1.2	Adjustments?	Sin +0.2	None
Floodprone Width (ft)	128.0	150.0			
Entrenchment Ratio	9.8	11.1			
Width to Depth Ratio	13.5	11.5			
Cross Sectional Area (ft²)	12.5	15.8			
Water Surface Slope (%)	0.680	0.095			

Rosgen Stream Type	
2019	2008
C5/6	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	10.48	56.42	5.00	26.93
Shading	90	91.34	80	78.67
Epifaunal Substrate	4	54.25	3	46.19
Instream Habitat	5	68.85	11	98.61
Instream Woody Debris	14	100.00	5	88.81
Bank Stability	17.67	93.99	12.00	77.46

	2019 Score	2008 Score
MPHI Habitat Score	77.47	69.44
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2008 Score		2019 Score	2008 Score
Epifaunal Substrate/Available Cover	4	11	Bank Stability - Right Bank	9	6
Pool Substrate Characterization	8	7	Bank Stability - Left Bank	9	6
Pool Variability	6	7	Vegetative Protection - Right Bank	7	7
Sediment Deposition	8	9	Vegetative Protection - Left Bank	9	7
Channel Flow Status	10	15	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	18	17	Riparian Veg. Zone Width - Left Bank	8	6
Channel Sinuosity	7	6			

	2019 Score	2008 Score
RBP Habitat Score	113	114
RBP Rating	Partially Supporting	Partially Supporting

Site ID 04-L1M-01-19

Revist of site R1-04-07

Biological Assessments

BIBI Metric Values	2019	2008
Total Taxa	19	14
EPT Taxa	0	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	37.50	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	72.50	0.00

FIBI Metric Values (2019 only)	
Abundance per m²	2.77
Adj. No. of Benthic Species	0.00
% Tolerant	0.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	98.69

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	5	1
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	5	1

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.71	1.29
BIBI Rating	Poor	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Eastern Gartersnake

Northern Green Frog

Fish Taxa	Number
American eel	4
Fathead Minnow	302

Benthic Macroinvertebrate Taxa

2019	Number
Chironomus	3
Cladotanytarsus	1
Crangonyx	1
Cryptochironomus	2
Diplocladius	1
Larsia	5
Metriocnemus	1
Micropsectra	45
Naididae	4
Nematoda	2
Paratendipes	1
Pisidium	1
Polypedilum	13
Rheotanytarsus	4
Stagnicola	8
Stenochironomus	1
Tanypodinae	1
Tanytarsus	21
Thienemannimyia	2
Turbellaria	3

Original Visit	Number
Natarsia	1
Tubificinae	15
Tubifex	3
Pseudosmittia	1
Physa	2
Orthocladius/Cricotopus	15
Nemata	26
Nais	2
Limnephilidae	1
Diplocladius	3
Culicoides	4
Enchytraeidae	27
Corynoneura	2
Ormosia	1

Site ID 04-L1M-02-19

Revist of site R1-04-12A

Upstream View - 2019

Downstream View - 2019

Upstream View - 2008

Downstream View - 2008

Summary Results

	2019 Data	2008 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Minimally Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1113.30

Land Cover	2019 Acres	2008 Acres	2019 % Area	2008 % Area
Developed Land	601.72	567.41	54.05	48.16
Forested Land	340.79	442.12	30.61	37.53
Open Land	134.83	163.90	12.11	13.91
Agricultural Land	35.96	4.77	3.23	0.40

Impervious Surface	2019 Acres	2008 Acres	2019 % Area	2008 % Area
Impervious Land	180.79	215.61	16.24	18.30

Site ID 04-L1M-02-19

Revist of site R1-04-12A

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2008 Spring
Dissolved Oxygen (mg/L)	10.82	8.17	11.1
Turbidity (NTU)	10.1	9.64	n/a
Temperature (°C)	8.8	18.3	6.59
pH (Standard Units)	6.8	6.33	6.64
Specific Conductivity (µS/cm)	249.2	221.2	248

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.021	Chloride (mg/L)	45.646
Total Nitrogen (mg/L)	1.722	Magnesium (mg/L)	2.539
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	11.18
Total Ammonia N (mg/L)	0.038	Total Copper (µg/L)	1.524
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	19.874
Nitrate-N (mg/L)	1.470	Total Lead (µg/L)	0.840
Total Kjehldal N (mg/L)	0.246	Turbidity (NTU)	6.8
Dissolved Organic C (mg/L)	4.487		
Total Organic C (mg/L)	4.710		
Hardness (mg eq. $CaCO_3$/L)	38.37		

Geomorphic Assessment

Rosgen Level II Classification Data

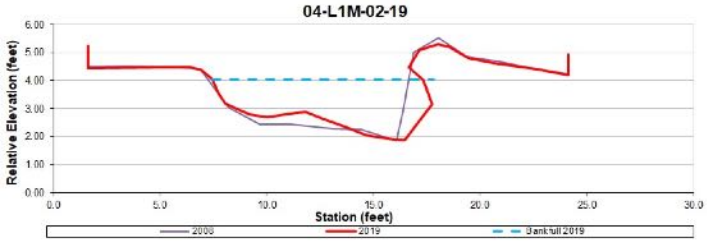
	2019	2008
Drainage Area (mi²)	1.74	
Bankfull Width (ft)	9.9	9.8
Mean Bankfull Depth (ft)	1.5	1.8
Floodprone Width (ft)	234.0	245.0
Entrenchment Ratio	23.8	25.1
Width to Depth Ratio	6.5	5.5
Cross Sectional Area (ft²)	14.9	17.4
Water Surface Slope (%)	0.110	0.419

	2019	2008
Sinuosity	1.12	1.10
D50 (mm)	0.48	0.25
Adjustments?	Sin +0.4	None

Rosgen Stream Type

2019	2008
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	11.59	62.39	9.00	48.47
Shading	85	84.56	100	100.00
Epifaunal Substrate	14	91.84	12	79.86
Instream Habitat	15	92.12	16	97.09
Instream Woody Debris	42	100.00	8	65.32
Bank Stability	10.93	73.94	10.00	70.71

	2019 Score	2008 Score
MPHI Habitat Score	84.14	76.91
MPHI Rating	Minimally Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2008 Score		2019 Score	2008 Score
Epifaunal Substrate/Available Cover	7	16	Bank Stability - Right Bank	5	5
Pool Substrate Characterization	7	9	Bank Stability - Left Bank	5	5
Pool Variability	8	10	Vegetative Protection - Right Bank	9	5
Sediment Deposition	17	8	Vegetative Protection - Left Bank	9	5
Channel Flow Status	19	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	17	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	10			

	2019 Score	2008 Score
RBP Habitat Score	130	130
RBP Rating	Supporting	Supporting

Site ID 04-L1M-02-19

Revist of site R1-04-12A

Biological Assessments

BIBI Metric Values	2019	2008
Total Taxa	28	27
EPT Taxa	10	1
Ephemeroptera Taxa	1	0
% Intolerant to Urban	21.30	6.86
% Ephemeroptera	0.93	0.00
Scraper Taxa	1	0
% Climbers	8.33	27.45

FIBI Metric Values (2019 only)	
Abundance per m²	0.49
Adj. No. of Benthic Species	1.10
% Tolerant	55.84
% Gen., Omni., Invert.	57.14
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	37.66

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	5	1
Ephemeroptera Taxa	3	1
% Intolerant to Urban	3	1
% Ephemeroptera	3	1
Scraper Taxa	3	1
% Climbers	5	5

FIBI Metric Scores (2019 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.86	2.14
BIBI Rating	Fair	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Fauna (2019 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Northern Green Frog

American Bullfrog

Fish Taxa

Fish Taxa	Number
American Eel	3
Bluegill	19
Bluespotted Sunfish	1
Eastern Mudminnow	1
Least brook Lamprey	29
Redfin Pickerel	3
Sea Lamprey	1
Tessellated Darter	17
White Sucker	3

Benthic Macroinvertebrate Taxa

2019	Number
Acerpenna	1
Amphinemura	2
Amphipoda	2
Brillia	1
Caecidotea	4
Calopteryx	1
Cheumatopsyche	10
Chimarra	2
Cricotopus/Orthocladius	6
Diplectrona	1
Eccoptura	2
Eukiefferiella	1
Hemerodromia	1
Hydropsyche	1
Lepidostoma	1
Naididae	9
Nanocladius	1
Oecetis	3
Polypedilum	3
Potthastia	7
Ptilostomis	1
Rheotanytarsus	23
Robackia	1
Simulium	7
Stenelmis	2
Stenochironomus	4
Synurella	5
Thienemannimyia	5
Tvetenia	1

Original Visit	Number
Corynoneura	2
Polypedilum	5
Ablabesmyia	2
Zavrelimyia	1
Rheocricotopus	2
Rheotanytarsus	11
Pisidiidae	3
Stegopterna	3
Stempellinella	7
Stenelmis	1
Stenochironomus	1
Stilocladius	1
Synurella	2
Tanytarsus	15
Alluaudomyia	1
Tvetenia	4
Ancyronyx	1
Thienemannimyia genus	3
Paratendipes	1
Parametriocnemus	27
Paralauterborniella	1
Nigronia	1
Macronychus	3
Leptoceridae	1
Larsia	1
Gomphidae	1
Thienemanniella	1

Site ID 04-L2M-02-19

Revist of site R2-04-01

Upstream View - 2019

Downstream View - 2019

Upstream View - 2010

Downstream View - 2010

Summary Results

	2019 Data	2010 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3091.44

Land Cover	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Developed Land	1474.33	1351.50	47.69	43.60
Forested Land	920.57	1030.60	29.78	33.20
Open Land	660.57	5.50	21.37	0.20
Agricultural Land	35.96	712.20	1.16	23.00

Impervious Surface	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Impervious Land	704.85	727.66	22.80	23.50

Site ID 04-L2M-02-19

Revist of site R2-04-01

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2010 Spring
Dissolved Oxygen (mg/L)	10.68	8.06	9.89
Turbidity (NTU)	7.1	6.94	5.08
Temperature (°C)	8.4	19.1	10.9
pH (Standard Units)	7.31	7.22	7.41
Specific Conductivity (µS/cm)	496.8	375.3	717.3

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.019	Chloride (mg/L)	103.353
Total Nitrogen (mg/L)	1.645	Magnesium (mg/L)	3.296
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	14.04
Total Ammonia N (mg/L)	0.029	Total Copper (µg/L)	1.250
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	24.373
Nitrate-N (mg/L)	1.470	Total Lead (µg/L)	0.858
Total Kjehldal N (mg/L)	0.169	Turbidity (NTU)	6.3
Dissolved Organic C (mg/L)	2.293		
Total Organic C (mg/L)	2.500		
Hardness (mg eq. $CaCO_3$/L)	48.63		

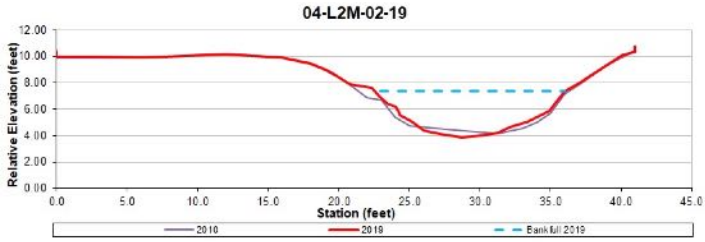
Geomorphic Assessment

Rosgen Level II Classification Data

	2019	2010		2019	2010
Drainage Area (mi²)	4.83		Sinuosity	1.23	1.20
Bankfull Width (ft)	13.5	13.8	D50 (mm)	0.33	14.00
Mean Bankfull Depth (ft)	2.4	1.9	Adjustments?	None	None
Floodprone Width (ft)	78.0	22.5			
Entrenchment Ratio	5.8	1.6			
Width to Depth Ratio	5.6	7.2			
Cross Sectional Area (ft²)	32.8	26.6			
Water Surface Slope (%)	0.011	0.120			

Rosgen Stream Type	
2019	2010
ND	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	0.62	3.31	1.00	5.39
Shading	70	68.32	70	68.32
Epifaunal Substrate	10	61.95	10	61.93
Instream Habitat	16	87.22	9	48.35
Instream Woody Debris	16	78.06	10	60.28
Bank Stability	14.47	85.05	17.00	92.20

	2019 Score	2010 Score
MPHI Habitat Score	63.99	56.08
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2019 Score	2010 Score		2019 Score	2010 Score
Epifaunal Substrate/Available Cover	7	10	Bank Stability - Right Bank	9	9
Pool Substrate Characterization	9	9	Bank Stability - Left Bank	4	8
Pool Variability	13	7	Vegetative Protection - Right Bank	7	7
Sediment Deposition	17	13	Vegetative Protection - Left Bank	7	4
Channel Flow Status	19	18	Riparian Veg. Zone Width - Right Bank	2	1
Channel Alteration	8	6	Riparian Veg. Zone Width - Left Bank	3	4
Channel Sinuosity	8	11			

	2019 Score	2010 Score
RBP Habitat Score	113	107
RBP Rating	Partially Supporting	Partially Supporting

Site ID 04-L2M-02-19

Revist of site R2-04-01

Biological Assessments

BIBI Metric Values	2019	2010
Total Taxa	23	15
EPT Taxa	5	6
Ephemeroptera Taxa	1	0
% Intolerant to Urban	3.51	1.70
% Ephemeroptera	0.88	0.00
Scraper Taxa	3	3
% Climbers	9.65	3.50

FIBI Metric Values (2019 only)	
Abundance per m²	0.67
Adj. No. of Benthic Species	0.78
% Tolerant	84.42
% Gen., Omni., Invert.	91.46
% Round-bodied Suckers	1.01
% Abund. Dominant Taxon	28.14

BIBI Metric Scores		
Total Taxa	5	3
EPT Taxa	5	5
Ephemeroptera Taxa	3	1
% Intolerant to Urban	1	1
% Ephemeroptera	3	1
Scraper Taxa	5	5
% Climbers	5	3

FIBI Metric Scores (2019 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	3
% Abund. Dominant Taxon	5

BIBI Score	3.86	2.71
BIBI Rating	Fair	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Fauna (2019 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Pickerel Frog

Northern Two-lined Salamander

Fish Taxa	Number
American Eel	20
Blacknose Dace	1
Bluegill	45
Brown Bullhead	2
Creek Chubsucker	2
Eastern Mudminnow	2
Largemouth Bass	7
Least Brook Lamprey	7
Pumpkinseed	12
Redbreast Sunfish	1
Redfin Pickerel	2
Sea Lamprey	1
Tessellated Darter	41
White Sucker	56

Benthic Macroinvertebrate Taxa

2019	Number
Acerpenna	1
Amphipoda	2
Brillia	2
Caloptervx	1
Cricotopus	15
Dubiraphia	2
Eukiefferiella	1
Gammarus	56
Heteroplectron	1
Hydropsyche	2
Lepidostoma	1
Microcylloepus	1
Naididae	1
Nanocladius	1
Oecetis	1
Oulimnius	1
Paratendipes	1
Physa	1
Polypedilum	3
Rheotanytarsus	11
Simulium	2
Tanytarsus	2
Thienemanniella	2
Thienemannimyia	3

Original Visit	Number
Amphipoda	5
Caloptervx	3
Cheumatopsyche	1
Cricotopus	1
Diplectrona	1
Gammarus	91
Libellulidae	1
Lumbricina	1
Macronychus	1
Neophylax	1
Optioservus	1
Platycentropus	1
Prostoma	1
Pycnopsyche	2
Triaenodes	2
Tubificidae	2

Site ID 04-L2M-03-19

Revist of site R2-04-02

Upstream View - 2019

Downstream View - 2019

Upstream View - 2010

Downstream View - 2010

Summary Results

	2019 Data	2010 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated nitrogen; High conductivity	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 551.79

Land Cover	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Developed Land	177.00	157.00	32.08	28.80
Forested Land	192.14	194.10	34.82	35.60
Open Land	182.65	0.00	33.10	0.00
Agricultural Land	0.00	193.70	0.00	35.60

Impervious Surface	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Impervious Land	135.12	126.75	24.49	23.30

Site ID 04-L2M-03-19

Revist of site R2-04-02

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2010 Spring
Dissolved Oxygen (mg/L)	10.32	7.56	9.49
Turbidity (NTU)	1.3	3.6	12.7
Temperature (°C)	10.9	19.9	11.53
pH (Standard Units)	6.96	6.64	7.96
Specific Conductivity (µS/cm)	420	429	436.4

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.022	Chloride (mg/L)	74.469
Total Nitrogen (mg/L)	0.811	Magnesium (mg/L)	4.543
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	21.99
Total Ammonia N (mg/L)	0.051	Total Copper (µg/L)	1.121
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	14.164
Nitrate-N (mg/L)	0.667	Total Lead (µg/L)	0.564
Total Kjehldal N (mg/L)	0.137	Turbidity (NTU)	5.4
Dissolved Organic C (mg/L)	3.156		
Total Organic C (mg/L)	3.211		
Hardness (mg eq. $CaCO_3$/L)	73.62		

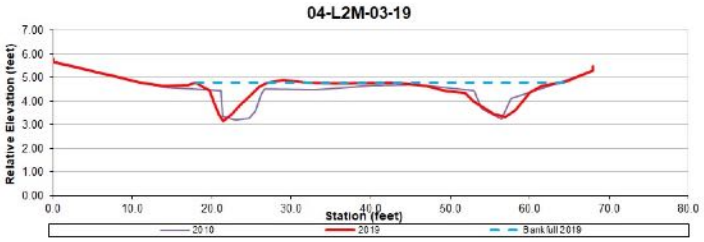
Geomorphic Assessment

Rosgen Level II Classification Data

	2019	2010		2019	2010
Drainage Area (mi²)	0.86		Sinuosity	1.52	1.10
Bankfull Width (ft)	36.7	26.9	D50 (mm)	0.43	0.31
Mean Bankfull Depth (ft)	0.2	0.4	Adjustments?	None	None
Floodprone Width (ft)	48.7	75.0			
Entrenchment Ratio	1.3	2.8			
Width to Depth Ratio	152.0	68.0			
Cross Sectional Area (ft²)	8.9	10.7			
Water Surface Slope (%)	0.100	0.450			

Rosgen Stream Type	
2019	2010
DA5	**DA5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	7.25	39.06	6.00	32.31
Shading	75	73.32	60	58.94
Epifaunal Substrate	12	84.80	14	86.46
Instream Habitat	11	77.11	13	72.57
Instream Woody Debris	9	76.86	4	44.78
Bank Stability	18.40	95.92	20.00	100.00

	2019 Score	2010 Score
MPHI Habitat Score	74.51	73.05
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2010 Score		2019 Score	2010 Score
Epifaunal Substrate/Available Cover	10	13	Bank Stability - Right Bank	8	10
Pool Substrate Characterization	15	8	Bank Stability - Left Bank	8	10
Pool Variability	10	8	Vegetative Protection - Right Bank	7	9
Sediment Deposition	11	16	Vegetative Protection - Left Bank	7	9
Channel Flow Status	16	19	Riparian Veg. Zone Width - Right Bank	10	9
Channel Alteration	19	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	9	7			

	2019 Score	2010 Score
RBP Habitat Score	139	148
RBP Rating	Supporting	Supporting

Site ID 04-L2M-03-19

Revist of site R2-04-02

Biological Assessments

BIBI Metric Values	2019	2010
Total Taxa	16	19
EPT Taxa	3	4
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.88	2.70
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	2
% Climbers	2.63	3.50

FIBI Metric Values (2019 only)	
Abundance per m²	0.78
Adj. No. of Benthic Species	1.53
% Tolerant	87.50
% Gen., Omni., Invert.	86.67
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	31.67

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	5
% Climbers	3	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.14	2.43
BIBI Rating	Poor	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Fauna (2019 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Fish Taxa	Number
American eel	5
Bluegill	15
Eastern mosquitofish	6
Eastern mudminnow	34
Largemouth bass	2
Least brook lamprey	4
Redfin pickerel	10
Tessellated darter	38
White sucker	6

Benthic Macroinvertebrate Taxa

2019	Number
Amphipoda	2
Cheumatopsyche	1
Chimarra	2
Diamesa	5
Diplectrona	1
Diplocladius	1
Gammarus	16
Hemerodromia	3
Lumbricina	1
Orthocladius	72
Polypedilum	2
Rheotanytarsus	4
Stenelmis	1
Tanytarsus	1
Thienemannimyia group	2

Original Visit	Number
Amphipoda	2
Amphipoda	1
Calopteryx	2
Chironomidae	2
Curculionidae	1
Elmidae	1
Enchytraeidae	1
Gammarus	76
Ironoquia	1
Lumbricina	1
Lype	1
Nigronia	1
Cricotopus/Orthocladius	1
Orthocladius	1
Parametriocnemus	2
Physa	2
Polycentropus	2
Prodiamesa	1
Prodiamesa	1
Pycnopsyche	2
Rheotanytarsus	1
Thienemannimyia	1
Tipula	3
Tubificidae	6

Site ID: 04-R3M-06-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Qualitative
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 545.76

Land Cover

	Acres	% Area
Developed Land	233.46	42.78
Forested Land	191.49	35.09
Open Land	84.84	15.55
Agricultural Land	35.96	6.59

Impervious Surface

	Acres	% Area
Impervious Land	66.56	12.20

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.7
Turbidity (NTU)	14.5
Temperature (°C)	16.4
pH (Standard Units)	6.66
Specific Conductivity (µS/cm)	210.4

Laboratory Measurements

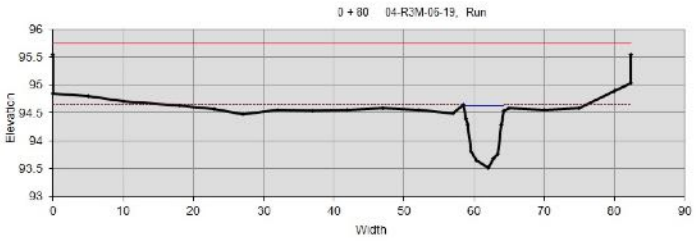
Total Phosphorus (mg/L)	0.023	Chloride (mg/L)	28.250
Total Nitrogen (mg/L)	2.083	Magnesium (mg/L)	2.622
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	11.27
Total Ammonia N (mg/L)	0.038	Total Copper (µg/L)	1.906
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	23.150
Nitrate-N (mg/L)	1.868	Total Lead (µg/L)	1.361
Total Kjehldal N (mg/L)	0.211	Turbidity (NTU)	9.9
Dissolved Organic C (mg/L)	4.152		
Total Organic C (mg/L)	4.480		
Hardness (mg eq. $CaCO_3$/L)	38.94		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.85	Sinuosity	1.19
Bankfull Width (ft)	5.9	D50 (mm)	0.13
Mean Bankfull Depth (ft)	0.8	Adjustments?	Sin +0.4
Floodprone Width (ft)	104.0		
Entrenchment Ratio	17.7		
Width to Depth Ratio	7.5	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	4.6		
Water Surface Slope (%)	0.34		

Cross-sectional Survey



Site ID: 04-R3M-06-19

Biological Assessments

BIBI Metric Values

Total Taxa	25
EPT Taxa	7
Ephemeroptera Taxa	1
% Intolerant to Urban	23.89
% Ephemeroptera	8.85
Scraper Taxa	2
% Climbers	2.65

FIBI Metric Values

Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	3
% Intolerant to Urban	3
% Ephemeroptera	3
Scraper Taxa	5
% Climbers	3

FIBI Metric Scores

Abundance per m²
Adj. No. of Benthic Species
% Tolerant
% Gen., Omni., Invert.
% Round-bodied Suckers
% Abund. Dominant Taxon

BIBI Score	3.86
BIBI Rating	Fair

FIBI Score	
FIBI Rating	Qualitative

Benthic Macroinvertebrate Taxa

Acerpenna	10
Amphipoda	2
Caecidotea	2
Cheumatopsyche	6
Chimarra	8
Cordulegaster	1
Cricotopus	9
Cricotopus/Orthocladius	11
Diplectrona	2
Eccoptura	3
Hemerodromia	4
Hyalella	1
Hydropsyche	3
Lumbriculidae	1
Lype	1
Naididae	1
Parametriocnemus	3
Physa	2
Polypedilum	1
Potthastia	4
Rheocricotopus	2
Rheotanytarsus	12
Simulium	13
Synurella	5
Thienemannimyia	5
Tipula	1

Fish Taxa

- Creek Chubsucker
- Eastern Mudminnow
- Least Brook Lamprey
- Pumpkinseed
- Redfin Pickerel
- Tessellated Darter
- White Sucker

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	6
Pool Variability	3
Sediment Deposition	15
Channel Flow Status	18
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	8
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	130
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.41	39.92
Shading	40	40.96
Epifaunal Substrate	15	100.00
Instream Habitat	15	99.42
Instream Woody Debris	0	50.36
Bank Stability	19.87	99.67

MPHI Habitat Score	71.72
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

- Orconectes limosus

Herpetofauna

- Northern Spring Peeper
- Northern Green Frog
- Pickerel Frog

Mussels

None Observed

Site ID: 04-R3M-08-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 653.96

Land Cover

	Acres	% Area
Developed Land	430.17	65.78
Forested Land	41.95	6.41
Open Land	181.84	27.81
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	367.32	56.17

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.83
Turbidity (NTU)	2.1
Temperature (°C)	9.8
pH (Standard Units)	6.63
Specific Conductivity (µS/cm)	463

Laboratory Measurements

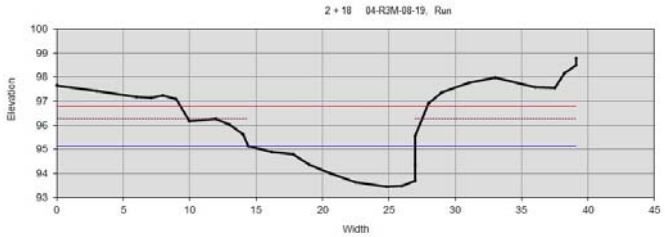
Total Phosphorus (mg/L)	0.035	Chloride (mg/L)	77.884
Total Nitrogen (mg/L)	0.742	Magnesium (mg/L)	5.085
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	23.94
Total Ammonia N (mg/L)	0.167	Total Copper (µg/L)	1.259
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	12.287
Nitrate-N (mg/L)	0.451	Total Lead (µg/L)	0.704
Total Kjehldal N (mg/L)	0.285	Turbidity (NTU)	15.5
Dissolved Organic C (mg/L)	3.618		
Total Organic C (mg/L)	3.901		
Hardness (mg eq. $CaCO_3$/L)	80.72		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.02	Sinuosity	1.10
Bankfull Width (ft)	12.6	D50 (mm)	1.10
Mean Bankfull Depth (ft)	1.0	Adjustments?	Sin +0.2
Floodprone Width (ft)	18.6		
Entrenchment Ratio	1.5		
Width to Depth Ratio	12.7	**Rosgen Stream Type**	**B5/4c**
Cross Sectional Area (ft²)	12.5		
Water Surface Slope (%)	0.34		

Cross-sectional Survey



Site ID: 04-R3M-08-19

Biological Assessments

BIBI Metric Values

Total Taxa	<60 orgs
EPT Taxa	<60 orgs
Ephemeroptera Taxa	<60 orgs
% Intolerant to Urban	<60 orgs
% Ephemeroptera	<60 orgs
Scraper Taxa	<60 orgs
% Climbers	<60 orgs

FIBI Metric Values

Abundance per m²	0.18
Adj. No. of Benthic Species	0.70
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	85.11

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.00
BIBI Rating	Very Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Cricotopus/Orthocladius	1
Diamesa	4
Dicrotendipes	2
Enchytraeidae	1
Lumbriculidae	2
Naididae	9
Natarsia	5
Nematoda	3
Physa	1
Polypedilum	4
Stygobromus	1
Thienemannimyia group	14

Fish Taxa

Bluegill	2
Pumpkinseed	3
Tessellated darter	2
White sucker	40

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	7
Pool Variability	8
Sediment Deposition	7
Channel Flow Status	15
Channel Alteration	6
Channel Sinuosity	6
Bank Stability - Right Bank	8
Bank Stability - Left Bank	8
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	6
Riparian Veg. Zone Width - Right Bank	3
Riparian Veg. Zone Width - Left Bank	3

RBP Habitat Score	90
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	1.88	10.15
Shading	85	84.56
Epifaunal Substrate	6	48.83
Instream Habitat	8	58.73
Instream Woody Debris	13	86.77
Bank Stability	17.47	93.46

MPHI Habitat Score	63.75
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Procambarus clarkii

Herpetofauna

Northern Spring Peeper

Northern Green Frog

Mussels

None Observed

Site ID: 04-R3M-12-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Qualitative
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 496.18

Land Cover	Acres	% Area
Developed Land	202.78	40.87
Forested Land	179.82	36.24
Open Land	77.62	15.64
Agricultural Land	35.96	7.25

Impervious Surface	Acres	% Area
Impervious Land	55.06	11.10

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.23
Turbidity (NTU)	0.9
Temperature (°C)	13.1
pH (Standard Units)	6.69
Specific Conductivity (µS/cm)	196

Laboratory Measurements

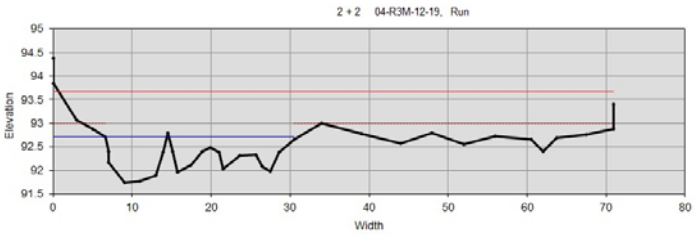
Total Phosphorus (mg/L)	0.015	Chloride (mg/L)	27.507
Total Nitrogen (mg/L)	2.061	Magnesium (mg/L)	2.722
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	10.94
Total Ammonia N (mg/L)	0.035	Total Copper (µg/L)	1.788
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	24.325
Nitrate-N (mg/L)	2.021	Total Lead (µg/L)	0.786
Total Kjehldal N (mg/L)	0.035	Turbidity (NTU)	7.0
Dissolved Organic C (mg/L)	4.626		
Total Organic C (mg/L)	4.858		
Hardness (mg eq. $CaCO_3$/L)	38.53		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.78	Sinuosity	1.37
Bankfull Width (ft)	19.4	D50 (mm)	0.39
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	120.0		
Entrenchment Ratio	6.2		
Width to Depth Ratio	34.8	**Rosgen Stream Type**	**DA5**
Cross Sectional Area (ft²)	10.9		
Water Surface Slope (%)	0.21		

Cross-sectional Survey



Site ID: 04-R3M-12-19

Biological Assessments

BIBI Metric Values

Total Taxa	27
EPT Taxa	5
Ephemeroptera Taxa	1
% Intolerant to Urban	50.91
% Ephemeroptera	1.82
Scraper Taxa	2
% Climbers	6.36

FIBI Metric Values

Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	3
% Intolerant to Urban	5
% Ephemeroptera	3
Scraper Taxa	5
% Climbers	3

FIBI Metric Scores

Abundance per m²	
Adj. No. of Benthic Species	
% Tolerant	
% Gen., Omni., Invert.	
% Round-bodied Suckers	
% Abund. Dominant Taxon	

BIBI Score	4.14
BIBI Rating	Good

FIBI Score	
FIBI Rating	Qualitative

Benthic Macroinvertebrate Taxa

Acerpenna	2
Amphipoda	8
Apsectrotanypus	6
Caecidotea	32
Caloptervx	1
Ceratopogoninae	1
Chrysops	1
Clinotanypus	4
Corixidae	1
Hyalella	6
Ironoquia	1
Lumbriculidae	2
Muscidae	1
Phylocentropus	1
Physa	5
Pisidium	4
Planorbidae	1
Polycentropodidae	1
Polycentropus	2
Procladius	1
Rheocricotopus	1
Rheotanytarsus	1
Stygobromus	1
Synurella	16
Tanypodinae	1
Thienemannimyia group	2
Trissopelopia	2
Turbellaria	1
Veneroida	2
Wormaldia	1
Zavrelimyia	1

Fish Taxa

- American eel
- Bluespotted sunfish
- Creek Chubsucker
- Eastern mudminnow
- Least brook lamprey
- Redfin pickerel
- Tessellated darter
- White sucker

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	12
Pool Variability	10
Sediment Deposition	11
Channel Flow Status	19
Channel Alteration	19
Channel Sinuosity	10
Bank Stability - Right Bank	10
Bank Stability - Left Bank	10
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	150
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.37	39.70
Shading	55	54.42
Epifaunal Substrate	13	91.30
Instream Habitat	12	83.75
Instream Woody Debris	47	100.00
Bank Stability	20.00	100.00

MPHI Habitat Score	78.19
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

- Northern Spring Peeper
- Northern Green Frog
- Pickerel Frog

Mussels

None Observed

Site ID: 04-R3M-14-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Fair
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 554.66

Land Cover	Acres	% Area
Developed Land	177.00	31.91
Forested Land	195.02	35.16
Open Land	182.65	32.93
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	135.21	24.38

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.8
Turbidity (NTU)	1.1
Temperature (°C)	9.7
pH (Standard Units)	7.02
Specific Conductivity (µS/cm)	422

Laboratory Measurements

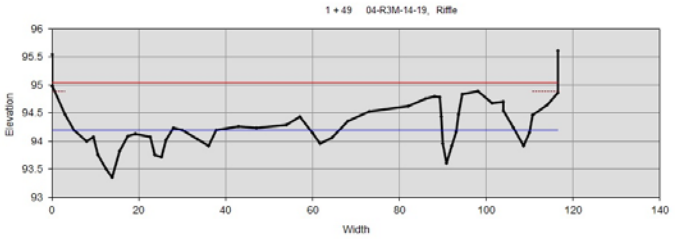
Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	75.164
Total Nitrogen (mg/L)	0.813	Magnesium (mg/L)	4.359
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	21.02
Total Ammonia N (mg/L)	0.063	Total Copper (µg/L)	1.048
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	14.979
Nitrate-N (mg/L)	0.676	Total Lead (µg/L)	0.441
Total Kjehldal N (mg/L)	0.131	Turbidity (NTU)	5.0
Dissolved Organic C (mg/L)	3.075		
Total Organic C (mg/L)	3.154		
Hardness (mg eq. $CaCO_3$/L)	70.44		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.87	Sinuosity	1.26
Bankfull Width (ft)	45.0	D50 (mm)	0.33
Mean Bankfull Depth (ft)	0.2	Adjustments?	None
Floodprone Width (ft)	45.0		
Entrenchment Ratio	1.0		
Width to Depth Ratio	199.5	**Rosgen Stream Type**	**DA5**
Cross Sectional Area (ft²)	10.2		
Water Surface Slope (%)	1.1		

Cross-sectional Survey



Site ID: 04-R3M-14-19

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	6.36

FIBI Metric Values

Abundance per m²	0.39
Adj. No. of Benthic Species	1.53
% Tolerant	89.90
% Gen., Omni., Invert.	72.73
% Round-bodied Suckers	2.02
% Abund. Dominant Taxon	43.43

BIBI Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	5
% Abund. Dominant Taxon	3

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	3.67
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Chimarra	1
Cricotopus/Orthocladius	23
Diamesa	4
Diplocladius	3
Gammarus	21
Hemerodromia	1
Ironoquia	1
Limnephilidae	2
Lumbriculidae	2
Orthocladius	34
Physa	3
Pisidium	3
Polypedilum	2
Simulium	1
Sphaeriidae	3
Thienemannimyia group	4
Veneroida	2

Fish Taxa

American eel	1
Creek chubsucker	2
Eastern mosquitofish	4
Eastern mudminnow	19
Largemouth bass	1
Least brook lamprey	3
Redfin pickerel	23
Tessellated darter	43
White sucker	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	13
Pool Variability	8
Sediment Deposition	15
Channel Flow Status	18
Channel Alteration	16
Channel Sinuosity	8
Bank Stability - Right Bank	9
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	144
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.44	50.84
Shading	70	68.32
Epifaunal Substrate	14	96.38
Instream Habitat	12	82.61
Instream Woody Debris	35	100.00
Bank Stability	20.00	100.00

MPHI Habitat Score	83.02
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Orconectes limosus

Herpetofauna

Northern Two-lined Salamander

Pickerel Frog

Northern Green Frog

Mussels

None Observed

Site ID: 12-L1M-02-19

Revist of site R1-12-01

Upstream View - 2019

Downstream View - 2019

Upstream View - 2005

Downstream View - 2005

Summary Results

	2019 Data	2005 Data
Benthic Macroinvertebrate Community	Very Poor	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Within acceptable ranges	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 165.96

Land Cover	2019 Acres	2005 Acres	2019 % Area	2005 % Area
Developed Land	25.99	17.56	15.66	10.20
Forested Land	71.43	97.47	43.04	56.60
Open Land	0.61	0.00	0.37	0.00
Agricultural Land	67.93	57.34	40.93	33.30

Impervious Surface	2019 Acres	2005 Acres	2019 % Area	2005 % Area
Impervious Land	13.15	7.06	7.92	4.10

Site ID: 12-L1M-02-19

Revist of site R1-12-01

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2005 Spring
Dissolved Oxygen (mg/L)	8.79	8.49	6.04
Turbidity (NTU)	3.9	4.4	17.7
Temperature (°C)	18.9	20.6	6.83
pH (Standard Units)	6.76	7.02	6.65
Specific Conductivity (µS/cm)	101	121	70

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.021	Chloride (mg/L)	4.712
Total Nitrogen (mg/L)	0.628	Magnesium (mg/L)	3.005
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	8.49
Total Ammonia N (mg/L)	0.023	Total Copper (µg/L)	0.230
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	11.807
Nitrate-N (mg/L)	0.544	Total Lead (µg/L)	0.118
Total Kjehldal N (mg/L)	0.079	Turbidity (NTU)	8.5
Dissolved Organic C (mg/L)	1.488		
Total Organic C (mg/L)	1.717		
Hardness (mg eq. $CaCO_3$/L)	33.57		

Geomorphic Assessment

Rosgen Level II Classification Data

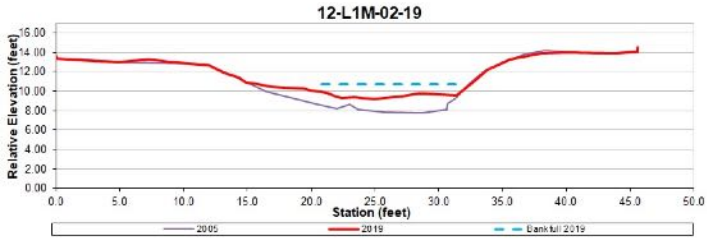
	2019	2005
Drainage Area (mi²)	0.26	
Bankfull Width (ft)	10.9	10.2
Mean Bankfull Depth (ft)	0.4	0.6
Floodprone Width (ft)	16.4	13.6
Entrenchment Ratio	1.5	1.3
Width to Depth Ratio	25.9	17.6
Cross Sectional Area (ft²)	4.6	5.9
Water Surface Slope (%)	0.380	0.400

	2019	2005
Sinuosity	1.26	1.20
D50 (mm)	0.17	0.38
Adjustments?	None	None

Rosgen Stream Type

2019	2005
B5c	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	12.99	69.95	n/a	100.00
Shading	95	99.94	90	91.34
Epifaunal Substrate	5	51.96	6	57.53
Instream Habitat	3	45.02	6	61.29
Instream Woody Debris	7	84.55	8	87.09
Bank Stability	17.20	92.74	n/a	87.56

	2019 Score	2005 Score
MPHI Habitat Score	74.03	80.80
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2005 Score		2019 Score	2005 Score
Epifaunal Substrate/Available Cover	7	6	Bank Stability - Right Bank	8	8
Pool Substrate Characterization	7	6	Bank Stability - Left Bank	9	6
Pool Variability	5	0	Vegetative Protection - Right Bank	9	9
Sediment Deposition	12	14	Vegetative Protection - Left Bank	9	9
Channel Flow Status	9	9	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	15			

	2019 Score	2005 Score
RBP Habitat Score	123	121
RBP Rating	Partially Supporting	Partially Supporting

Site ID: 12-L1M-02-19

Revist of site R1-12-01

Biological Assessments

BIBI Metric Values	2019	2005
Total Taxa	20	27
EPT Taxa	1	4
Ephemeroptera Taxa	0	0
% Intolerant to Urban	6.15	15.53
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	15.38	15.50

FIBI Metric Values (2019 only)	
Abundance per m²	0.35
Adj. No. of Benthic Species	2.37
% Tolerant	97.14
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	45.71

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	1	3
% Climbers	5	5

FIBI Metric Scores (2019 only)	
Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.86	3.00
BIBI Rating	Very Poor	Fair

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Gray Treefrog

Fowler's Toad

Fish Taxa

Fish Taxa	Number
American eel	1
Blacknose dace	16
Eastern mudminnow	2
Tessellated darter	16

Benthic Macroinvertebrate Taxa

2019	Number
Amphipoda	3
Caecidotea	2
Calopteryx	5
Ceratopogoninae	7
Chaetocladius	13
Corynoneura	2
Diamesa	1
Diplocladius	2
Enchytraeidae	1
Hydrobius	1
Ironoquia	4
Isopoda	4
Limnophyes	1
Naididae	2
Nigronia	1
Parametriocnemus	4
Polypedilum	3
Prostoma	1
Rheocricotopus	3
Synurella	1
Thienemanniymyia group	3
Tipulidae	1

Original Visit	Number
Micropsectra	3
Calopteryx	1
Cordulegaster	1
Agabus	1
Hydrobius	1
Chaetocladius	3
Corynoneura	2
Diplocladius	8
Natarsia	2
Orthocladius	7
Parametriocnemus	29
Paraphaenocladius	5
Polypedilum	2
Rheotanytarsus	3
Thienemanniella	1
Thienemannimyia	5
Chelifera	1
Ormosia	1
Probezzia	1
Pseudolimnophila	2
Simulium	1
Hydatophylax	9
Lype	2
Phylocentropus	3
Polycentropus	1
Caecidotea	1
Synurella	7

Site ID: 12-L1M-03-19

Revist of site R1-12-09

Upstream View - 2019

Downstream View - 2019

Upstream View - 2005

Downstream View - 2005

Summary Results

	2019 Data	2005 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2211.48

Land Cover	2019 Acres	2005 Acres	2019 % Area	2005 % Area
Developed Land	734.24	791.08	33.20	30.50
Forested Land	1122.06	1478.41	50.74	57.00
Open Land	268.49	212.68	12.14	8.20
Agricultural Land	86.68	114.12	3.92	4.40

Impervious Surface	2019 Acres	2005 Acres	2019 % Area	2005 % Area
Impervious Land	249.33	287.90	11.27	11.10

Site ID: 12-L1M-03-19

Revist of site R1-12-09

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2005 Spring
Dissolved Oxygen (mg/L)	10.14	6.35	5.42
Turbidity (NTU)	6.3	2.4	7.4
Temperature (°C)	16.9	26.2	6.26
pH (Standard Units)	6.83	6.83	6.74
Specific Conductivity (µS/cm)	162	163	200

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.029	Chloride (mg/L)	29.958
Total Nitrogen (mg/L)	0.550	Magnesium (mg/L)	3.816
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	7.99
Total Ammonia N (mg/L)	0.033	Total Copper (µg/L)	0.312
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	5.497
Nitrate-N (mg/L)	0.321	Total Lead (µg/L)	0.120
Total Kjehldal N (mg/L)	0.224	Turbidity (NTU)	13.3
Dissolved Organic C (mg/L)	2.678		
Total Organic C (mg/L)	2.752		
Hardness (mg eq. $CaCO_3$/L)	35.67		

Geomorphic Assessment

Rosgen Level II Classification Data

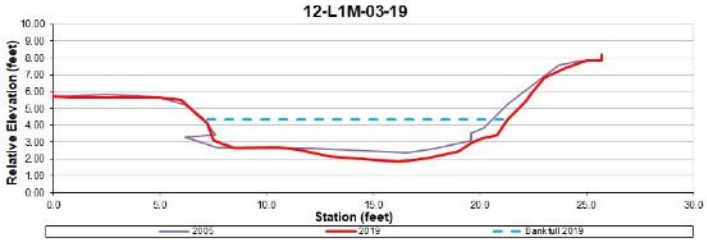
	2019	2005
Drainage Area (mi²)	3.46	
Bankfull Width (ft)	14.3	16.8
Mean Bankfull Depth (ft)	1.8	2.5
Floodprone Width (ft)	14.3	25.7
Entrenchment Ratio	1.0	1.5
Width to Depth Ratio	7.9	6.8
Cross Sectional Area (ft²)	25.9	41.8
Water Surface Slope (%)	0.460	0.300

	2019	2005
Sinuosity	1.25	1.07
D50 (mm)	8.00	0.38
Adjustments?	None	Increased Sin

Rosgen Stream Type

2019	2005
G4c	**B5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	1.35	7.26	n/a	3.31
Shading	80	78.67	45	45.47
Epifaunal Substrate	11	69.94	11	68.91
Instream Habitat	11	62.90	12	66.82
Instream Woody Debris	15	78.90	12	68.22
Bank Stability	12.20	78.10	n/a	83.67

	2019 Score	2005 Score
MPHI Habitat Score	62.63	56.07
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2019 Score	2005 Score		2019 Score	2005 Score
Epifaunal Substrate/Available Cover	14	11	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	16	12	Bank Stability - Left Bank	3	7
Pool Variability	10	14	Vegetative Protection - Right Bank	8	7
Sediment Deposition	15	13	Vegetative Protection - Left Bank	8	7
Channel Flow Status	19	19	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	7	12	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	1			

	2019 Score	2005 Score
RBP Habitat Score	130	129
RBP Rating	Supporting	Supporting

Site ID: 12-L1M-03-19

Revist of site R1-12-09

Biological Assessments

BIBI Metric Values	2019	2005
Total Taxa	12	14
EPT Taxa	2	3
Ephemeroptera Taxa	1	0
% Intolerant to Urban	0.85	1.94
% Ephemeroptera	0.85	0.00
Scraper Taxa	0	1
% Climbers	18.64	6.80

FIBI Metric Values (2019 only)	
Abundance per m²	1.19
Adj. No. of Benthic Species	0.86
% Tolerant	74.43
% Gen., Omni., Invert.	99.62
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	40.46

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	3	3
Ephemeroptera Taxa	3	1
% Intolerant to Urban	1	1
% Ephemeroptera	3	1
Scraper Taxa	1	3
% Climbers	5	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.43	2.14
BIBI Rating	Poor	Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

None Observed

Fish Taxa	Number
American eel	62
Blacknose dace	2
Bluegill	106
Brown bullhead	72
Eastern mosquitofish	2
Golden shiner	11
Green sunfish	1
Largemouth bass	1
Tessellated darter	2
Warmouth	1
White crappie	1
Yellow perch	1

Benthic Macroinvertebrate Taxa

2019	Number
Amphipoda	3
Caenis	1
Ceratopogoninae	1
Cheumatopsyche	1
Cricotopus	1
Diamesa	1
Gammarus	19
Isopoda	1
Naididae	64
Nematoda	1
Polypedilum	20
Rheotanytarsus	3
Tanytarsus	2

Original Visit	Number
Argia	1
Nanocladius	5
Cricotopus/orthocladius	3
Rheotanytarsus	33
Thienemanniella	1
Cheumatopsyche	18
Hydropsyche	3
Oecetis	1
Physella	3
Oligochaeta	4
Caecidotea	2
Gammarus	23
Turbellaria	4
Polypedilum	2

Site ID 12-L2M-01-19

Revist of site R2-12-06

Upstream View - 2019

Downstream View - 2019

Upstream View - 2009

Downstream View - 2009

Summary Results

	2019 Data	2009 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Low pH; High conductivity; Elevated nutrients	High conductivity, low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 102.42

Land Cover	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Developed Land	88.12	83.19	86.03	63.98
Forested Land	8.63	44.07	8.43	33.89
Open Land	0.00	0.00	0.00	0.00
Agricultural Land	5.67	2.77	5.54	2.13

Impervious Surface	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Impervious Land	11.39	15.30	11.12	11.80

Site ID 12-L2M-01-19

Revist of site R2-12-06

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2009 Spring
Dissolved Oxygen (mg/L)	7.94	6.36	8.31
Turbidity (NTU)	6.2	4.8	n/a
Temperature (°C)	15.6	18.4	7.74
pH (Standard Units)	6.14	6.05	6.27
Specific Conductivity (µS/cm)	368	437	417

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.094	Chloride (mg/L)	91.384
Total Nitrogen (mg/L)	0.679	Magnesium (mg/L)	5.440
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	12.06
Total Ammonia N (mg/L)	0.120	Total Copper (µg/L)	0.085
Nitrite-N (mg/L)	0.010	Total Zinc (µg/L)	20.969
Nitrate-N (mg/L)	0.563	Total Lead (µg/L)	0.020
Total Kjehldal N (mg/L)	0.106	Turbidity (NTU)	23.4
Dissolved Organic C (mg/L)	0.805		
Total Organic C (mg/L)	1.090		
Hardness (mg eq. $CaCO_3$/L)	52.52		

Geomorphic Assessment

Rosgen Level II Classification Data

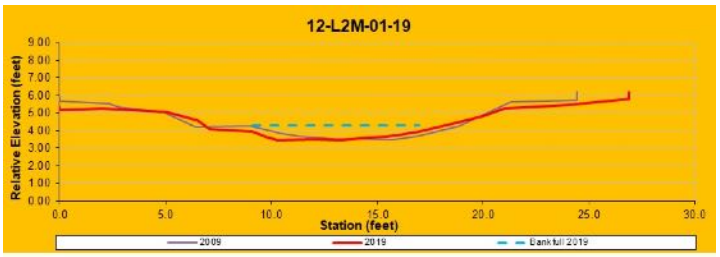
	2019	2009
Drainage Area (mi²)	0.16	
Bankfull Width (ft)	8.1	9.6
Mean Bankfull Depth (ft)	0.3	0.5
Floodprone Width (ft)	12.2	15.0
Entrenchment Ratio	1.5	1.6
Width to Depth Ratio	23.3	18.9
Cross Sectional Area (ft²)	2.8	4.9
Water Surface Slope (%)	0.270	0.220

	2019	2009
Sinuosity	1.08	1.00
D50 (mm)	0.16	0.14
Adjustments?	Sin +0.2	Increased Sin

Rosgen Stream Type

2019	2009
B5c	**B5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	7.09	38.17	3.00	16.16
Shading	90	91.34	100	100.00
Epifaunal Substrate	3	43.48	2	36.12
Instream Habitat	3	49.96	7	69.71
Instream Woody Debris	4	81.14	11	99.15
Bank Stability	19.53	98.83	16.00	89.45

	2019 Score	2009 Score
MPHI Habitat Score	67.15	68.43
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2009 Score		2019 Score	2009 Score
Epifaunal Substrate/Available Cover	4	7	Bank Stability - Right Bank	9	8
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	9	8
Pool Variability	6	6	Vegetative Protection - Right Bank	9	8
Sediment Deposition	13	7	Vegetative Protection - Left Bank	8	8
Channel Flow Status	14	10	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	5	3			

	2019 Score	2009 Score
RBP Habitat Score	125	112
RBP Rating	Partially Supporting	Partially supporting

Site ID 12-L2M-01-19

Revist of site R2-12-06

Biological Assessments

BIBI Metric Values	2019	2009
Total Taxa	12	18
EPT Taxa	0	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	1.67	9.52
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	0.83	0.00

FIBI Metric Values (2019 only)	
Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	1	1

FIBI Metric Scores (2019 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.00	1.29
BIBI Rating	Very Poor	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern Box Turtle

Northern Red Salamander

Wood Frog

Pickerel Frog

Fish Taxa	Number
NO FISH	

Benthic Macroinvertebrate Taxa

2019	Number
Ceratopogoninae	1
Chaetocladius	3
Chironomus	98
Dicranota	1
Ephydridae	1
Erioptera	1
Limnophyes	9
Micropsectra	1
Naididae	1
Odontomesa	2
Prostoma	1
Sphaeriidae	1

Original Visit	Number
Caecidotea	10
Crangonyx	6
Enchytraeidae	1
Ilyodrilus	7
Limnodrilus	2
Mallochohelea	1
Odontomesa	1
Parametriocnemus	1
Paratendipes	18
Pisidiidae	13
Pisidium	11
Planariidae	1
Prostoma	2
Rheocricotopus	1
Serromvia	2
Sphaerium	1
Stilocladius	4
Tubificinae	23

Site ID 12-L2M-02-19

Revist of site R2-12-13A

Upstream View - 2019

Downstream View - 2019

Upstream View - 2009

Downstream View - 2009

Summary Results

	2019 Data	2009 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Low pH; High conductivity; Elevated nutrients	High conductivity, low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 346.23

Land Cover	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Developed Land	98.79	79.06	28.53	21.22
Forested Land	206.20	242.26	59.56	65.02
Open Land	16.78	26.33	4.85	7.07
Agricultural Land	24.46	24.95	7.06	6.70

Impervious Surface	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Impervious Land	10.09	12.50	2.91	3.40

Site ID 12-L2M-02-19

Revist of site R2-12-13A

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2009 Spring
Dissolved Oxygen (mg/L)	12.46	8.07	11.01
Turbidity (NTU)	4.5	8.2	n/a
Temperature (°C)	4.6	21.5	5.86
pH (Standard Units)	6.05	7.13	6.06
Specific Conductivity (µS/cm)	251	251	274

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.063	Chloride (mg/L)	48.757
Total Nitrogen (mg/L)	1.017	Magnesium (mg/L)	2.954
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	14.03
Total Ammonia N (mg/L)	0.032	Total Copper (µg/L)	0.339
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	19.045
Nitrate-N (mg/L)	0.960	Total Lead (µg/L)	0.189
Total Kjehldal N (mg/L)	0.052	Turbidity (NTU)	5.9
Dissolved Organic C (mg/L)	1.237		
Total Organic C (mg/L)	1.298		
Hardness (mg eq. $CaCO_3$/L)	47.20		

Geomorphic Assessment

Rosgen Level II Classification Data

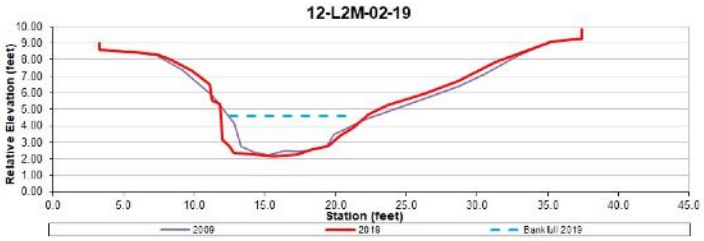
	2019	2009
Drainage Area (mi²)	0.54	
Bankfull Width (ft)	8.3	8.2
Mean Bankfull Depth (ft)	1.0	1.2
Floodprone Width (ft)	10.5	17.0
Entrenchment Ratio	1.3	2.1
Width to Depth Ratio	8.7	6.6
Cross Sectional Area (ft²)	8.0	10.0
Water Surface Slope (%)	0.580	0.730

	2019	2009
Sinuosity	1.36	1.00
D50 (mm)	0.30	0.08
Adjustments?	None	Increased ER,Sin

Rosgen Stream Type

2019	2009
G5c	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	12.66	68.17	13.00	70.01
Shading	95	99.94	95	99.94
Epifaunal Substrate	3	35.55	5	46.68
Instream Habitat	4	43.04	9	70.02
Instream Woody Debris	13	93.97	12	90.17
Bank Stability	7.60	61.65	10.00	70.71

	2019 Score	2009 Score
MPHI Habitat Score	67.05	74.59
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2009 Score		2019 Score	2009 Score
Epifaunal Substrate/Available Cover	11	9	Bank Stability - Right Bank	2	5
Pool Substrate Characterization	8	9	Bank Stability - Left Bank	2	5
Pool Variability	10	7	Vegetative Protection - Right Bank	5	5
Sediment Deposition	10	8	Vegetative Protection - Left Bank	5	5
Channel Flow Status	12	10	Riparian Veg. Zone Width - Right Bank	7	2
Channel Alteration	18	14	Riparian Veg. Zone Width - Left Bank	6	5
Channel Sinuosity	8	6			

	2019 Score	2009 Score
RBP Habitat Score	104	90
RBP Rating	Partially Supporting	Non-supporting

Site ID 12-L2M-02-19

Revist of site R2-12-13A

Biological Assessments

BIBI Metric Values	2019	2009
Total Taxa	22	22
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	27.88	39.64
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	9.62	14.41

FIBI Metric Values (2019 only)	
Abundance per m²	0.49
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	3	5
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	5	5

FIBI Metric Scores (2019 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.71	3.00
BIBI Rating	Poor	Fair

FIBI Score	1.33
FIBI Rating	Very Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

Northern Two-lined Salamander

Northern Red Salamander

Northern Green Frog

Eastern Cricket Frog

Fish Taxa	Number
Blacknose dace	42

Benthic Macroinvertebrate Taxa

2019	Number
Amphinemura	3
Caecidotea	21
Chaetocladius	1
Corynoneura	10
Diplocladius	15
Dolophilodes	1
Enchytraeidae	1
Gammarus	1
Ironoquia	2
Isopoda	3
Limnephilidae	7
Limnophyes	1
Naididae	2
Parametriocnemus	13
Phaenopsectra	1
Polypedilum	3
Rheocricotopus	6
Rheotanytarsus	1
Stegopterna	3
Synurella	1
Thienemanniella	3
Thienemannimyia group	2
Zavrelimyia	3

Original Visit	Number
Amphinemura	1
Caecidotea	4
Corynoneura	4
Crangonyx	1
Diplocladius	4
Gammarus	1
Limnephilidae	3
Limnodrilus	6
Nais	4
Parametriocnemus	22
Paranemoura	4
Pisidium	3
Polypedilum	11
Potamothrix	1
Prosimulium	9
Pseudolimnophila	1
Serromyia	1
Stegopterna	25
Tanytarsus	2
Tipula	1
Tubificinae	2
Zavrelimyia	1

Site ID: 12-R3M-01-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Comparable to Reference
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1594.54

Land Cover	Acres	% Area
Developed Land	667.84	41.88
Forested Land	531.89	33.36
Open Land	44.87	2.81
Agricultural Land	349.94	21.95

Impervious Surface	Acres	% Area
Impervious Land	104.26	6.54

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.35
Turbidity (NTU)	5.8
Temperature (°C)	7.4
pH (Standard Units)	6.72
Specific Conductivity (µS/cm)	188

Laboratory Measurements

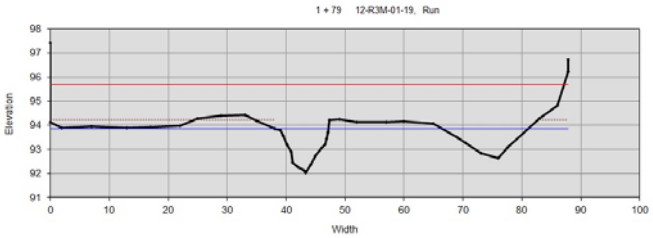
Total Phosphorus (mg/L)	0.044	Chloride (mg/L)	35.364
Total Nitrogen (mg/L)	1.130	Magnesium (mg/L)	3.851
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	10.69
Total Ammonia N (mg/L)	0.103	Total Copper (µg/L)	0.186
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	17.405
Nitrate-N (mg/L)	1.072	Total Lead (µg/L)	0.118
Total Kjehldal N (mg/L)	0.053	Turbidity (NTU)	12.4
Dissolved Organic C (mg/L)	0.938		
Total Organic C (mg/L)	1.085		
Hardness (mg eq. $CaCO_3$/L)	42.55		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.49	Sinuosity	1.12
Bankfull Width (ft)	23.8	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	700.0		
Entrenchment Ratio	29.4		
Width to Depth Ratio	30.4	**Rosgen Stream Type**	**DA6**
Cross Sectional Area (ft²)	18.6		
Water Surface Slope (%)	0.53		

Cross-sectional Survey



Site ID: 12-R3M-01-19

Biological Assessments

BIBI Metric Values

Total Taxa	23
EPT Taxa	4
Ephemeroptera Taxa	1
% Intolerant to Urban	1.89
% Ephemeroptera	0.94
Scraper Taxa	2
% Climbers	13.21

FIBI Metric Values

Abundance per m²	1.09
Adj. No. of Benthic Species	0.96
% Tolerant	77.25
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.60
% Abund. Dominant Taxon	59.88

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
% Intolerant to Urban	1
% Ephemeroptera	3
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	3
% Abund. Dominant Taxon	3

BIBI Score	3.57
BIBI Rating	Fair

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Ablabesmyia	1
Acerpenna	1
Amphipoda	2
Caloptervx	1
Cambaridae	1
Cheumatopsyche	2
Cricotopus	8
Diplocladius	1
Gammarus	21
Hydrobaenus	3
Hydropsyche	1
Limnephilidae	1
Nanocladius	1
Orthocladius	8
Parametriocnemus	1
Physa	1
Polypedilum	11
Pseudorthocladius	1
Rheocricotopus	7
Rheotanytarsus	28
Simulium	2
Tanytarsini	1
Thienemannimyia group	1
Xylotopus	1

Fish Taxa

American eel	21
Blacknose dace	25
Bluegill	1
Brown bullhead	3
Creek chubsucker	1
Mummichog	15
Tessellated darter	100
Yellow perch	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	15
Pool Variability	16
Sediment Deposition	13
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	7
Bank Stability - Left Bank	7
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	152
RBP Rating	Comparable to Reference

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	13.10	70.53
Shading	65	63.55
Epifaunal Substrate	16	100.00
Instream Habitat	16	93.99
Instream Woody Debris	12	73.73
Bank Stability	17.00	92.20

MPHI Habitat Score	82.33
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

Northern Spring Peeper

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 12-R3M-03-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 327.32

Land Cover	Acres	% Area
Developed Land	133.37	40.75
Forested Land	135.47	41.39
Open Land	11.18	3.42
Agricultural Land	47.29	14.45

Impervious Surface	Acres	% Area
Impervious Land	17.27	5.28

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.64
Turbidity (NTU)	3.9
Temperature (°C)	5.1
pH (Standard Units)	6.74
Specific Conductivity (µS/cm)	256

Laboratory Measurements

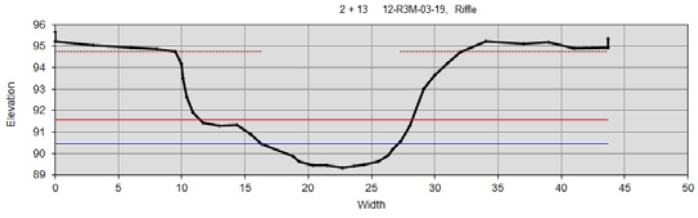
Total Phosphorus (mg/L)	0.084	Chloride (mg/L)	40.064
Total Nitrogen (mg/L)	1.050	Magnesium (mg/L)	3.494
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	17.26
Total Ammonia N (mg/L)	0.039	Total Copper (µg/L)	0.213
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	22.024
Nitrate-N (mg/L)	0.992	Total Lead (µg/L)	0.129
Total Kjehldal N (mg/L)	0.052	Turbidity (NTU)	8.2
Dissolved Organic C (mg/L)	1.368		
Total Organic C (mg/L)	1.392		
Hardness (mg eq. $CaCO_3$/L)	57.49		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.51	Sinuosity	1.70
Bankfull Width (ft)	10.8	D50 (mm)	0.57
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	16.7		
Entrenchment Ratio	1.5		
Width to Depth Ratio	14.5	**Rosgen Stream Type**	**B5/4c**
Cross Sectional Area (ft²)	8.1		
Water Surface Slope (%)	1.1		

Cross-sectional Survey



Site ID: 12-R3M-03-19

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	5.50
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	18.35

FIBI Metric Values

Abundance per m²	0.96
Adj. No. of Benthic Species	0.00
% Tolerant	97.78
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	97.78

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	2
Amphipoda	1
Asellidae	1
Caecidotea	3
Capniidae	1
Chaetocladius	6
Corynoneura	3
Dubiraphia	1
Enchytraeidae	2
Erioptera	1
Gammarus	12
Hemerodromia	2
Limnephilidae	3
Naididae	24
Orthocladius	20
Parametriocnemus	6
Polypedilum	15
Rheocricotopus	3
Tabanidae	1
Tanytarsus	1
Thienemannimyia group	1

Fish Taxa

American eel	2
Blacknose dace	88

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	9
Pool Variability	6
Sediment Deposition	11
Channel Flow Status	15
Channel Alteration	20
Channel Sinuosity	14
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	117
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.13	43.76
Shading	85	84.56
Epifaunal Substrate	5	47.53
Instream Habitat	6	54.71
Instream Woody Debris	12	91.65
Bank Stability	6.80	58.31

MPHI Habitat Score	63.42
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Cambarus sp

Herpetofauna

Northern Two-lined Salamander

Fowler's Toad

Northern Green Frog

Mussels

None Observed

Site ID: 12-R3M-05-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Low pH; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 508.05

Land Cover	Acres	% Area
Developed Land	123.56	24.32
Forested Land	193.24	38.04
Open Land	20.95	4.12
Agricultural Land	170.30	33.52

Impervious Surface	Acres	% Area
Impervious Land	20.20	3.98

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.08
Turbidity (NTU)	8.9
Temperature (°C)	9.1
pH (Standard Units)	6.23
Specific Conductivity (µS/cm)	177

Laboratory Measurements

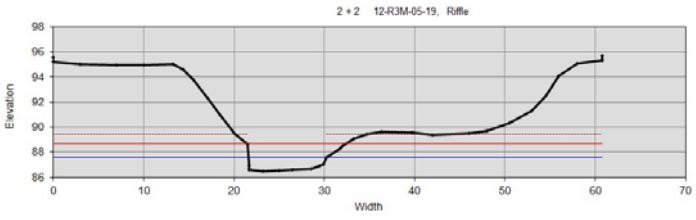
Total Phosphorus (mg/L)	0.072	Chloride (mg/L)	24.289
Total Nitrogen (mg/L)	1.841	Magnesium (mg/L)	3.343
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	12.13
Total Ammonia N (mg/L)	0.068	Total Copper (µg/L)	0.300
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	23.679
Nitrate-N (mg/L)	1.804	Total Lead (µg/L)	0.238
Total Kjehldal N (mg/L)	0.031	Turbidity (NTU)	15.2
Dissolved Organic C (mg/L)	0.818		
Total Organic C (mg/L)	0.953		
Hardness (mg eq. $CaCO_3$/L)	44.06		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.79	Sinuosity	1.39
Bankfull Width (ft)	8.6	D50 (mm)	0.32
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	10.9		
Entrenchment Ratio	1.3		
Width to Depth Ratio	9.1	**Rosgen Stream Type**	**G5/6c**
Cross Sectional Area (ft²)	8.1		
Water Surface Slope (%)	0.16		

Cross-sectional Survey



Site ID: 12-R3M-05-19

Biological Assessments

BIBI Metric Values

Total Taxa	26
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	5.49
% Ephemeroptera	1.10
Scraper Taxa	0
% Climbers	19.78

FIBI Metric Values

Abundance per m²	0.18
Adj. No. of Benthic Species	0.80
% Tolerant	88.89
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	85.19

BIBI Metric Scores

Total Taxa	5
EPT Taxa	1
Ephemeroptera Taxa	3
% Intolerant to Urban	1
% Ephemeroptera	3
Scraper Taxa	1
% Climbers	5

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Asellidae	2
Caecidotea	3
Calopteryx	1
Ceratopogoninae	5
Chaetocladius	1
Diplocladius	3
Enchytraeidae	2
Erioptera	2
Gammarus	10
Haplotaxidae	1
Hydrobius	2
Isopoda	5
Leptophlebiidae	1
Naididae	11
Odontomesa	1
Ormosia	1
Parametriocnemus	5
Paraphaenocladius	1
Phaenopsectra	1
Polypedilum	14
Rheocricotopus	1
Simuliidae	1
Simulium	2
Stilocladius	1
Synurella	1
Tanytarsus	1
Thienemannimyia group	6
Tipula	4
Xylotopus	2

Fish Taxa

American eel	3
Blacknose dace	23
Tessellated darter	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	6
Pool Variability	5
Sediment Deposition	5
Channel Flow Status	14
Channel Alteration	19
Channel Sinuosity	11
Bank Stability - Right Bank	1
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	4
Vegetative Protection - Left Bank	4
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	96
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.36	61.19
Shading	85	84.56
Epifaunal Substrate	4	38.86
Instream Habitat	5	44.67
Instream Woody Debris	9	77.80
Bank Stability	9.60	69.28

MPHI Habitat Score	62.73
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Spring Peeper

Wood Frog

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 12-R3M-07-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated phosphorus

Land Use/Land Cover Analysis

Total Drainage Area (acres) 696.91

Land Cover	Acres	% Area
Developed Land	315.92	45.33
Forested Land	246.41	35.36
Open Land	60.16	8.63
Agricultural Land	74.41	10.68

Impervious Surface	Acres	% Area
Impervious Land	63.74	9.15

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.05
Turbidity (NTU)	2.8
Temperature (°C)	10.1
pH (Standard Units)	6.89
Specific Conductivity (µS/cm)	206

Laboratory Measurements

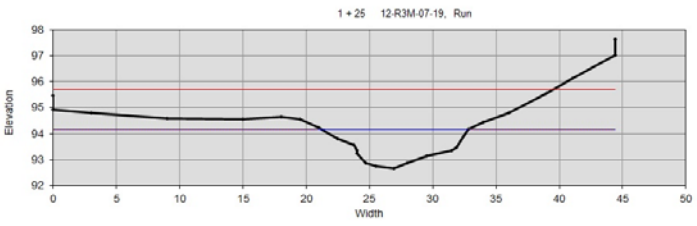
Total Phosphorus (mg/L)	0.056	Chloride (mg/L)	37.003
Total Nitrogen (mg/L)	0.720	Magnesium (mg/L)	4.056
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	12.22
Total Ammonia N (mg/L)	0.029	Total Copper (µg/L)	0.294
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	15.398
Nitrate-N (mg/L)	0.596	Total Lead (µg/L)	0.110
Total Kjehldal N (mg/L)	0.119	Turbidity (NTU)	5.7
Dissolved Organic C (mg/L)	2.162		
Total Organic C (mg/L)	2.261		
Hardness (mg eq. $CaCO_3$/L)	47.22		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.09	Sinuosity	1.32
Bankfull Width (ft)	11.6	D50 (mm)	0.13
Mean Bankfull Depth (ft)	0.9	Adjustments?	Sin +0.2
Floodprone Width (ft)	175.0		
Entrenchment Ratio	15.1		
Width to Depth Ratio	12.6	**Rosgen Stream Type**	**E5/6**
Cross Sectional Area (ft²)	10.7		
Water Surface Slope (%)	0.81		

Cross-sectional Survey



Site ID: 12-R3M-07-19

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	2.68
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	17.86

FIBI Metric Values

Abundance per m²	0.59
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	70.24

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	1.33
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Cheumatopsyche	7
Diplocladius	9
Hemerodromia	1
Hydrobaenus	6
Ironoquia	1
Limnephilidae	1
Naididae	1
Orthocladius	24
Parametriocnemus	1
Polypedilum	15
Rheocricotopus	19
Rheotanytarsus	9
Stegopterna	3
Tanytarsus	4
Thienemannimyia group	5
Tipula	6

Fish Taxa

Bluegill	25
Pumpkinseed	59

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	9
Pool Variability	9
Sediment Deposition	9
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	8
Bank Stability - Left Bank	8
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	134
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.04	48.66
Shading	95	99.94
Epifaunal Substrate	7	54.23
Instream Habitat	6	46.98
Instream Woody Debris	23	100.00
Bank Stability	18.20	95.40

MPHI Habitat Score	74.20
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Wood Frog

Cope's Gray Treefrog

Mussels

None Observed

Site ID 16-L1M-01-19

Revist of site R1-16-03

Upstream View - 2019

Downstream View - 2019

Upstream View - 2007

Downstream View - 2007

Summary Results

	2019 Data	2007 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-supporting
MPHI Habitat Condition	Degraded	Severely Degraded
Water Quality Conditions	High conductivity	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 296.11

Land Cover	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Developed Land	91.88	93.28	31.03	30.87
Forested Land	189.02	190.35	63.83	62.99
Open Land	15.22	18.58	5.14	6.15
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Impervious Land	38.09	40.96	12.86	13.55

Site ID 16-L1M-01-19

Revist of site R1-16-03

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2007 Spring
Dissolved Oxygen (mg/L)	12.44	1.61	12.74
Turbidity (NTU)	8.13	5.4	n/a
Temperature (°C)	5	19.5	5.67
pH (Standard Units)	7.1	6.37	n/a
Specific Conductivity (µS/cm)	264.3	405.6	265

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	<0.004	Chloride (mg/L)	45.179
Total Nitrogen (mg/L)	0.206	Magnesium (mg/L)	3.358
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	14.44
Total Ammonia N (mg/L)	0.009	Total Copper (µg/L)	1.182
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	6.362
Nitrate-N (mg/L)	0.062	Total Lead (µg/L)	0.405
Total Kjehldal N (mg/L)	0.139	Turbidity (NTU)	7.3
Dissolved Organic C (mg/L)	3.770		
Total Organic C (mg/L)	3.883		
Hardness (mg eq. $CaCO_3$/L)	49.88		

Geomorphic Assessment

Rosgen Level II Classification Data

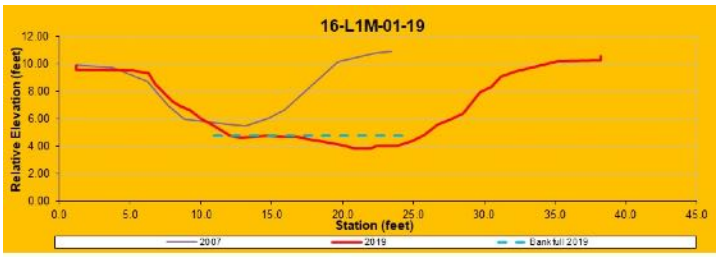
	2019	2007
Drainage Area (mi²)	0.46	
Bankfull Width (ft)	13.6	8.1
Mean Bankfull Depth (ft)	0.4	0.9
Floodprone Width (ft)	16.6	11.8
Entrenchment Ratio	1.2	1.5
Width to Depth Ratio	33.9	8.6
Cross Sectional Area (ft²)	5.4	7.6
Water Surface Slope (%)	0.800	0.200

	2019	2007
Sinuosity	1.06	n/a
D50 (mm)	13.00	0.42
Adjustments?	None	None

Rosgen Stream Type

2019	2007
ND	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	4.76	25.64	0.00	0.00
Shading	80	78.67	50	49.95
Epifaunal Substrate	5	48.19	6	53.86
Instream Habitat	9	72.39	7	61.08
Instream Woody Debris	9	83.91	2	62.97
Bank Stability	10.10	71.07	12.00	77.46

	2019 Score	2007 Score
MPHI Habitat Score	63.31	50.89
MPHI Rating	Degraded	Severely Degraded

Rapid Bioassessment Protocol

	2019 Score	2007 Score		2019 Score	2007 Score
Epifaunal Substrate/Available Cover	11	7	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	13	8	Bank Stability - Left Bank	4	6
Pool Variability	8	10	Vegetative Protection - Right Bank	5	3
Sediment Deposition	11	7	Vegetative Protection - Left Bank	6	3
Channel Flow Status	10	15	Riparian Veg. Zone Width - Right Bank	4	4
Channel Alteration	14	8	Riparian Veg. Zone Width - Left Bank	5	5
Channel Sinuosity	7	7			

	2019 Score	2007 Score
RBP Habitat Score	101	89
RBP Rating	Partially Supporting	Non-supporting

Site ID 16-L1M-01-19

Revist of site R1-16-03

Biological Assessments

BIBI Metric Values	2019	2007
Total Taxa	12	17
EPT Taxa	3	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.87	3.85
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	3.48	0.96

FIBI Metric Values (2019 only)	
Abundance per m²	1.81
Adj. No. of Benthic Species	0.00
% Tolerant	79.71
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	11.59
% Abund. Dominant Taxon	23.19

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	3	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	5
% Abund. Dominant Taxon	5

BIBI Score	1.86	1.86
BIBI Rating	Very Poor	Very Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

Procambarus clarkii

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
Blacknose Dace	15
Creek Chub	29
Creek Chubsucker	16
Eastern Mosquitofish	3
Eastern Mudminnow	32
Fallfish	8
Green Sunfish	32
Pumpkinseed	2
Rosyside Dace	1

Benthic Macroinvertebrate Taxa

2019	Number
Anisoptera	1
Cheumatopsyche	4
Diamesa	20
Hydrobaenus	60
Hydropsyche	1
Limnephilidae	1
Naididae	9
Orthocladius	7
Paratanytarsus	1
Polypedilum	3
Rheocricotopus	7
Stegopterna	1

Original Visit	Number
Nais	3
Eiseniella	1
Tubificinae	8
Limnodrilus	3
Neoporus	4
Dicrotendipes	5
Diplocladius	2
Hydrobaenus	28
Phaenopsectra	2
Polypedilum	1
Rheocricotopus	3
Zavrelimyia	37
Stegopterna	1
Nemoura	2
Limnephilidae	2
Cambaridae	1
Physa	1

Site ID 16-L1M-02-19

Revist of site R1-16-02

Upstream View - 2019

Downstream View - 2019

Upstream View - 2007

Downstream View - 2007

Summary Results

	2019 Data	2007 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Low pH	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 247.80

Land Cover	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Developed Land	24.42	28.23	9.85	11.08
Forested Land	206.37	223.24	83.28	87.61
Open Land	17.02	3.33	6.87	1.31
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Impervious Land	3.49	6.40	1.41	2.51

Site ID 16-L1M-02-19

Revist of site R1-16-02

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2007 Spring
Dissolved Oxygen (mg/L)	11.25	4.43	9.55
Turbidity (NTU)	5.05	33	n/a
Temperature (°C)	7.5	24.1	7
pH (Standard Units)	5.16	5.52	n/a
Specific Conductivity (µS/cm)	31.4	34.5	34

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	<0.004	Chloride (mg/L)	1.732
Total Nitrogen (mg/L)	0.129	Magnesium (mg/L)	0.934
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	0.82
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	1.547
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	20.799
Nitrate-N (mg/L)	0.010	Total Lead (µg/L)	0.350
Total Kjehldal N (mg/L)	0.114	Turbidity (NTU)	3.3
Dissolved Organic C (mg/L)	3.894		
Total Organic C (mg/L)	3.940		
Hardness (mg eq. $CaCO_3$/L)	5.89		

Geomorphic Assessment

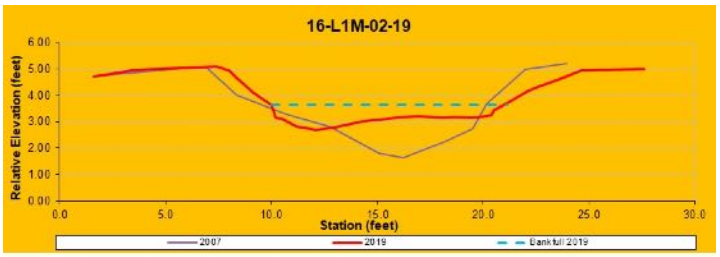
Rosgen Level II Classification Data

	2019	2007		2019	2007
Drainage Area (mi²)	0.39		Sinuosity	1.84	1.50
Bankfull Width (ft)	10.9	9.0	D50 (mm)	1.00	0.47
Mean Bankfull Depth (ft)	0.6	1.3	Adjustments?	ER	Sin
Floodprone Width (ft)	15.1	193.0			
Entrenchment Ratio	1.4	17.0			
Width to Depth Ratio	19.0	9.0			
Cross Sectional Area (ft²)	6.3	14.2			
Water Surface Slope (%)	0.640	0.470			

Rosgen Stream Type

2019	2007
F5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	10.09	54.32	14.00	75.39
Shading	85	84.56	100	100.00
Epifaunal Substrate	4	43.54	8	66.59
Instream Habitat	6	57.56	11	85.02
Instream Woody Debris	11	91.84	6	76.74
Bank Stability	10.80	73.49	8.00	63.25

	2019 Score	2007 Score
MPHI Habitat Score	67.55	77.83
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2007 Score		2019 Score	2007 Score
Epifaunal Substrate/Available Cover	13	11	Bank Stability - Right Bank	3	4
Pool Substrate Characterization	12	8	Bank Stability - Left Bank	1	4
Pool Variability	8	8	Vegetative Protection - Right Bank	9	4
Sediment Deposition	13	11	Vegetative Protection - Left Bank	8	4
Channel Flow Status	16	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	9	12			

	2019 Score	2007 Score
RBP Habitat Score	132	122
RBP Rating	Supporting	Partially Supporting

Site ID 16-L1M-02-19

Revist of site R1-16-02

Biological Assessments

BIBI Metric Values	2019	2007
Total Taxa	13	21
EPT Taxa	3	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	66.98	50.59
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	1.89	3.53

FIBI Metric Values (2019 only)	
Abundance per m²	1.40
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	3	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	5	5
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	3	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14	2.14
BIBI Rating	Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

American Toad

Fish Taxa	Number
Eastern Mudminnow	118

Benthic Macroinvertebrate Taxa

2019	Number
Allocapnia	1
Ceratopogoninae	17
Diplectrona	3
Leuctra	14
Limnophyes	1
Nigronia	1
Polypedilum	1
Prosimulium	8
Pseudolimnophila	1
Simulium	12
Stegopterna	44
Thienemanniella	2
Tipula	1

Original Visit	Number
Lumbriculidae	2
Enchytraeidae	5
Tubificinae	3
Limnodrilus	1
Alluaudomyia	1
Culicoides	1
Ablabesmyia	3
Corynoneura	1
Limnophyes	2
Paratendipes	1
Polypedilum	1
Rheocricotopus	3
Rheosmittia	8
Stenochironomus	1
Thienemannimyia	1
Tribelos	1
Zavrelimyia	3
Tanytarsus	2
Simulium	1
Stegopterna	43

Site ID 16-L2M-01-19

Revist of site R2-16-05

Upstream View - 2019

Downstream View - 2019

Upstream View - 2011

Downstream View - 2011

Summary Results

	2019 Data	2011 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Comparable to Reference	Comparable to Reference
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Low pH	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 370.59

Land Cover	2019 Acres	2011 Acres	2019 % Area	2011 % Area
Developed Land	26.67	27.80	7.20	7.40
Forested Land	292.68	344.70	78.98	91.30
Open Land	51.24	3.20	13.83	0.80
Agricultural Land	0.00	2.00	0.00	0.50

Impervious Surface	2019 Acres	2011 Acres	2019 % Area	2011 % Area
Impervious Land	4.54	4.20	1.22	1.10

Site ID 16-L2M-01-19

Revist of site R2-16-05

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2011 Spring
Dissolved Oxygen (mg/L)	9.98	4.44	5.58
Turbidity (NTU)	4.51	325	4.21
Temperature (°C)	6.5	21.7	12.27
pH (Standard Units)	4.45	5.08	4.29
Specific Conductivity (µS/cm)	36.5	32.4	53

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	<0.004	Chloride (mg/L)	1.884
Total Nitrogen (mg/L)	0.162	Magnesium (mg/L)	0.693
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	0.80
Total Ammonia N (mg/L)	0.009	Total Copper (µg/L)	1.085
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	17.119
Nitrate-N (mg/L)	<0.050	Total Lead (µg/L)	0.410
Total Kjehldal N (mg/L)	0.150	Turbidity (NTU)	2.5
Dissolved Organic C (mg/L)	5.117		
Total Organic C (mg/L)	5.206		
Hardness (mg eq. $CaCO_3$/L)	4.86		

Geomorphic Assessment

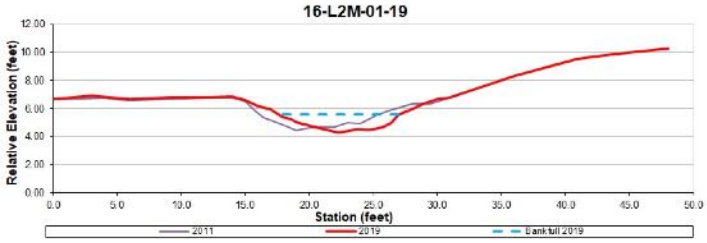
Rosgen Level II Classification Data

	2019	2011		2019	2011
Drainage Area (mi²)	0.58		Sinuosity	1.13	1.04
Bankfull Width (ft)	9.4	12.7	D50 (mm)	0.09	0.10
Mean Bankfull Depth (ft)	0.9	1.1	Adjustments?	Sin +0.4	None
Floodprone Width (ft)	115.0	88.0			
Entrenchment Ratio	12.2	6.9			
Width to Depth Ratio	11.0	11.3			
Cross Sectional Area (ft²)	8.1	14.3			
Water Surface Slope (%)	0.560	0.920			

Rosgen Stream Type

2019	2011
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	12.13	65.35	20.00	100.00
Shading	60	58.94	75	73.32
Epifaunal Substrate	10	75.77	11	81.46
Instream Habitat	13	92.28	12	86.54
Instream Woody Debris	44	100.00	10	84.12
Bank Stability	16.20	90.00	20.00	100.00

	2019 Score	2011 Score
MPHI Habitat Score	80.39	87.57
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2019 Score	2011 Score		2019 Score	2011 Score
Epifaunal Substrate/Available Cover	15	11	Bank Stability - Right Bank	6	10
Pool Substrate Characterization	14	14	Bank Stability - Left Bank	7	10
Pool Variability	9	12	Vegetative Protection - Right Bank	9	9
Sediment Deposition	17	15	Vegetative Protection - Left Bank	9	9
Channel Flow Status	18	17	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	16	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	7			

	2019 Score	2011 Score
RBP Habitat Score	151	150
RBP Rating	Comparable to Reference	Comparable to Reference

Site ID 16-L2M-01-19

Revist of site R2-16-05

Biological Assessments

BIBI Metric Values	2019	2011
Total Taxa	8	11
EPT Taxa	0	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	91.96	2.90
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	2.68	16.20

FIBI Metric Values (2019 only)	
Abundance per m²	1.40
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	97.33
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	97.33

BIBI Metric Scores		
Total Taxa	1	1
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	5	1
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	3	5

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.86	1.57
BIBI Rating	Very Poor	Very Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Fauna (2019 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Common Ribbonsnake

Pickerel Frog

Northern Green Frog

Fish Taxa	Number
Eastern Mudminnow	146
Redfin Pickerel	4

Benthic Macroinvertebrate Taxa

2019	Number
Caecidotea	1
Polypedilum	3
Rheosmittia	1
Simulium	2
Stegopterna	100
Synurella	2
Thienemannimyia	1
Tribelos	2

Original Visit	Number
Caecidotea	2
Chironomini	1
Crangonyctidae	1
Eriopterini	2
Lepidoptera	1
Orthocladiinae	1
Orthocladius	1
Polypedilum	17
Psectrocladius	30
Simulium	46
Stegopterna	1
Thienemannimyia group	1
Tribelos	1

Site ID 16-L2M-02-19

Revist of site R2-16-11A

Upstream View - 2019

Downstream View - 2019

Upstream View - 2011

Downstream View - 2011

Summary Results

	2019 Data	2011 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Low pH	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 122.41

Land Cover	2019 Acres	2011 Acres	2019 % Area	2011 % Area
Developed Land	0.00	4.50	0.00	3.40
Forested Land	109.73	123.70	89.64	93.10
Open Land	12.67	0.00	10.35	0.00
Agricultural Land	0.00	4.60	0.00	3.50

Impervious Surface	2019 Acres	2011 Acres	2019 % Area	2011 % Area
Impervious Land	1.85	1.50	1.51	1.20

Site ID 16-L2M-02-19

Revist of site R2-16-11A

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2011 Spring
Dissolved Oxygen (mg/L)	10.7	4.75	8.52
Turbidity (NTU)	4.75	47.7	1.16
Temperature (°C)	9.2	22.7	15.1
pH (Standard Units)	5.09	7.32	4.43
Specific Conductivity (µS/cm)	31.1	31.7	70.7

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	<0.004	Chloride (mg/L)	1.714
Total Nitrogen (mg/L)	0.137	Magnesium (mg/L)	0.831
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	0.88
Total Ammonia N (mg/L)	0.019	Total Copper (µg/L)	1.638
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	19.837
Nitrate-N (mg/L)	0.017	Total Lead (µg/L)	0.455
Total Kjehldal N (mg/L)	0.115	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	4.358		
Total Organic C (mg/L)	4.480		
Hardness (mg eq. $CaCO_3$/L)	5.62		

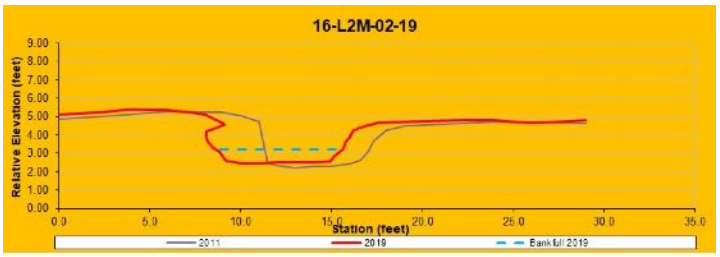
Geomorphic Assessment

Rosgen Level II Classification Data

	2019	2011		2019	2011
Drainage Area (mi²)	0.19		Sinuosity	1.48	1.32
Bankfull Width (ft)	6.9	5.6	D50 (mm)	13.00	3.20
Mean Bankfull Depth (ft)	0.6	0.7	Adjustments?	None	None
Floodprone Width (ft)	7.9	6.6			
Entrenchment Ratio	1.1	1.2			
Width to Depth Ratio	11.1	7.9			
Cross Sectional Area (ft²)	4.3	4.0			
Water Surface Slope (%)	1.100	0.990			

Rosgen Stream Type	
2019	2011
G4c	**G4/5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	12.06	64.97	15.00	80.78
Shading	95	99.94	90	91.34
Epifaunal Substrate	5	53.94	11	88.26
Instream Habitat	5	59.23	10	86.14
Instream Woody Debris	15	100.00	2	72.28
Bank Stability	12.90	80.31	14.00	83.67

	2019 Score	2011 Score
MPHI Habitat Score	76.40	83.74
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2019 Score	2011 Score		2019 Score	2011 Score
Epifaunal Substrate/Available Cover	14	11	Bank Stability - Right Bank	2	7
Pool Substrate Characterization	13	11	Bank Stability - Left Bank	1	7
Pool Variability	5	10	Vegetative Protection - Right Bank	8	9
Sediment Deposition	13	12	Vegetative Protection - Left Bank	8	9
Channel Flow Status	14	15	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	11	14			

	2019 Score	2011 Score
RBP Habitat Score	129	145
RBP Rating	Supporting	Supporting

Site ID 16-L2M-02-19

Revist of site R2-16-11A

Biological Assessments

BIBI Metric Values	2019	2011
Total Taxa	11	10
EPT Taxa	1	4
Ephemeroptera Taxa	0	0
% Intolerant to Urban	71.43	90.80
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	0.00	0.00

FIBI Metric Values (2019 only)	
Abundance per m²	0.96
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores		
Total Taxa	1	1
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	5	5
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	1	1

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57	1.86
BIBI Rating	Very Poor	Very Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
Eastern Mudminnow	43

Benthic Macroinvertebrate Taxa

2019	Number
Ceratopogoninae	8
Georthocladius	2
Hexatoma	1
Leuctra	3
Naididae	1
Prosimulium	1
Simulium	16
Stegopterna	70
Tabanidae	0
Thienemannimyia	1
Tipula	1
Tipulidae	1

Original Visit	Number
Bezzia/Palpomyia	2
Caecidotea	1
Enchytraeidae	1
Leuctra	29
Lumbricina	2
Nemouridae	5
Rhyacophila	2
Simuliidae	4
Simulium	2
Stegopterna	71
Wormaldia	1

Site ID: 16-R3M-02-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 332.26

Land Cover	Acres	% Area
Developed Land	23.12	6.96
Forested Land	297.52	89.55
Open Land	11.61	3.49
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	3.85	1.16

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.81
Turbidity (NTU)	5.19
Temperature (°C)	4
pH (Standard Units)	5.57
Specific Conductivity (µS/cm)	46.6

Laboratory Measurements

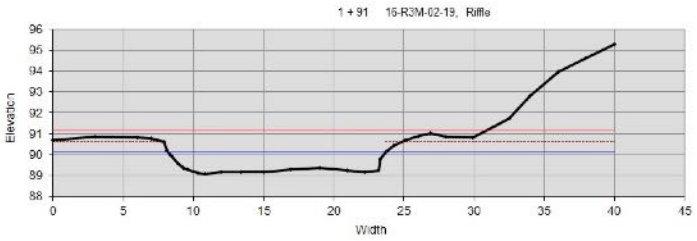
Total Phosphorus (mg/L)	<0.012	Chloride (mg/L)	5.803
Total Nitrogen (mg/L)	0.122	Magnesium (mg/L)	1.081
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	1.06
Total Ammonia N (mg/L)	<0.008	Total Copper (µg/L)	0.722
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	22.007
Nitrate-N (mg/L)	0.041	Total Lead (µg/L)	0.211
Total Kjehldal N (mg/L)	0.076	Turbidity (NTU)	4.2
Dissolved Organic C (mg/L)	2.350		
Total Organic C (mg/L)	2.491		
Hardness (mg eq. $CaCO_3$/L)	7.09		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.52	Sinuosity	1.46
Bankfull Width (ft)	15.5	D50 (mm)	12.00
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	99.0		
Entrenchment Ratio	6.4		
Width to Depth Ratio	18.7	**Rosgen Stream Type**	**C4**
Cross Sectional Area (ft²)	12.9		
Water Surface Slope (%)	0.7		

Cross-sectional Survey



Site ID: 16-R3M-02-19

Biological Assessments

BIBI Metric Values

Total Taxa	20
EPT Taxa	7
Ephemeroptera Taxa	0
% Intolerant to Urban	70.37
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	2.78

FIBI Metric Values

Abundance per m²	1.17
Adj. No. of Benthic Species	0.00
% Tolerant	86.06
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	13.33
% Abund. Dominant Taxon	55.76

BIBI Metric Scores

Total Taxa	3
EPT Taxa	5
Ephemeroptera Taxa	1
% Intolerant to Urban	5
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	5
% Abund. Dominant Taxon	3

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	3.00
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Amphinemura	1
Capniidae	2
Ceratopogoninae	17
Chaetocladius	1
Eukiefferiella	1
Hexatoma	1
Leuctra	4
Limnephilidae	1
Lumbriculidae	2
Lype	1
Nemouridae	3
Orthocladius	1
Polypedilum	2
Prosimulium	10
Pseudolimnophila	1
Pseudorthocladius	1
Rheocricotopus	2
Rhyacophila	1
Stegopterna	55
Tipula	1

Fish Taxa

American Eel	1
Creek Chubsucker	22
Eastern Mudminnow	50
Green Sunfish	92

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	13
Pool Substrate Characterization	11
Pool Variability	8
Sediment Deposition	9
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	11
Bank Stability - Right Bank	6
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	134
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.97	69.83
Shading	90	91.34
Epifaunal Substrate	7	59.05
Instream Habitat	12	87.85
Instream Woody Debris	21	100.00
Bank Stability	13.63	82.57

MPHI Habitat Score	81.77
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

American Toad

Mussels

None Observed

Site ID: 16-R3M-09-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 232.41

Land Cover	Acres	% Area
Developed Land	15.86	6.82
Forested Land	71.26	30.66
Open Land	145.29	62.51
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	1.55	0.67

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.75
Turbidity (NTU)	4.35
Temperature (°C)	7.9
pH (Standard Units)	4.86
Specific Conductivity (µS/cm)	36.1

Laboratory Measurements

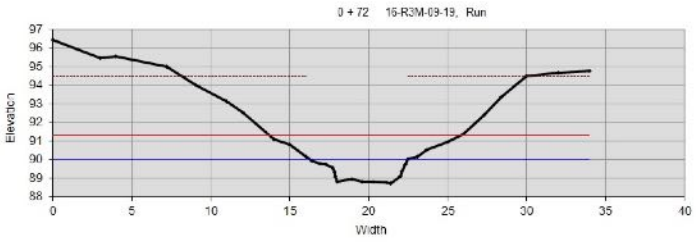
Total Phosphorus (mg/L)	<0.012	Chloride (mg/L)	1.947
Total Nitrogen (mg/L)	0.195	Magnesium (mg/L)	0.987
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	0.98
Total Ammonia N (mg/L)	0.019	Total Copper (µg/L)	1.513
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	18.557
Nitrate-N (mg/L)	0.026	Total Lead (µg/L)	0.536
Total Kjehldal N (mg/L)	0.164	Turbidity (NTU)	3.1
Dissolved Organic C (mg/L)	5.066		
Total Organic C (mg/L)	5.234		
Hardness (mg eq. $CaCO_3$/L)	6.52		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.36	Sinuosity	1.44
Bankfull Width (ft)	6.2	D50 (mm)	17.00
Mean Bankfull Depth (ft)	0.9	Adjustments?	W/D
Floodprone Width (ft)	12.1		
Entrenchment Ratio	1.9		
Width to Depth Ratio	7.1	**Rosgen Stream Type**	**B4c**
Cross Sectional Area (ft²)	5.5		
Water Surface Slope (%)	0.79		

Cross-sectional Survey



Site ID: 16-R3M-09-19

Biological Assessments

BIBI Metric Values

Total Taxa	8
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	84.40
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	0.00

FIBI Metric Values

Abundance per m²	0.19
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	95.00

BIBI Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	5
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	6
Dasyhelea	1
Diplectrona	1
Hexatoma	1
Leuctra	14
Parametriocnemus	1
Simulium	8
Stegopterna	76
Thienemanniella	1

Fish Taxa

Eastern Mudminnow	19
Green Sunfish	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	9
Pool Variability	6
Sediment Deposition	13
Channel Flow Status	13
Channel Alteration	18
Channel Sinuosity	10
Bank Stability - Right Bank	5
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	8
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	128
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.51	45.82
Shading	70	68.32
Epifaunal Substrate	12	90.43
Instream Habitat	14	100.00
Instream Woody Debris	21	100.00
Bank Stability	13.30	81.55

MPHI Habitat Score	81.02
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 16-R3M-14-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 317.05

Land Cover

	Acres	% Area
Developed Land	19.50	6.15
Forested Land	152.26	48.03
Open Land	145.29	45.82
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	2.34	0.74

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.43
Turbidity (NTU)	10.5
Temperature (°C)	11.5
pH (Standard Units)	5.5
Specific Conductivity (µS/cm)	36.2

Laboratory Measurements

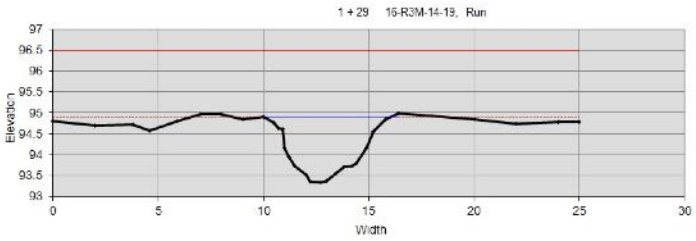
Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	1.932
Total Nitrogen (mg/L)	0.305	Magnesium (mg/L)	0.982
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	0.87
Total Ammonia N (mg/L)	0.063	Total Copper (µg/L)	3.164
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	19.717
Nitrate-N (mg/L)	0.021	Total Lead (µg/L)	1.063
Total Kjehldal N (mg/L)	0.279	Turbidity (NTU)	10.6
Dissolved Organic C (mg/L)	6.784		
Total Organic C (mg/L)	8.009		
Hardness (mg eq. $CaCO_3$/L)	6.21		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.50	Sinuosity	1.26
Bankfull Width (ft)	6.1	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.9	Adjustments?	Sin +0.2
Floodprone Width (ft)	85.0		
Entrenchment Ratio	14.0		
Width to Depth Ratio	6.7	**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)	5.4		
Water Surface Slope (%)	0.99		

Cross-sectional Survey



Site ID: 16-R3M-14-19

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	59.26
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	5.56

FIBI Metric Values

Abundance per m²	0.51
Adj. No. of Benthic Species	0.00
% Tolerant	56.41
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	56.41

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	5
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	5
Diplectrona	2
Isopoda	3
Leuctra	17
Molanna	2
Naididae	1
Polypedilum	4
Prosimulium	1
Pycnopsyche	2
Rheocricotopus	1
Simulium	23
Stegopterna	43
Stygobromus	1
Synurella	1
Thienemanniella	1
Thienemannimyia	1

Fish Taxa

Eastern Mudminnow	22
Fallfish	17

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	10
Pool Variability	5
Sediment Deposition	16
Channel Flow Status	16
Channel Alteration	20
Channel Sinuosity	10
Bank Stability - Right Bank	6
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	4
Vegetative Protection - Left Bank	4
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	123
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	20.97	100.00
Shading	95	99.94
Epifaunal Substrate	5	47.74
Instream Habitat	4	43.94
Instream Woody Debris	10	86.10
Bank Stability	16.73	91.47

MPHI Habitat Score	78.20
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 16-R3M-15-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 134.78

Land Cover

	Acres	% Area
Developed Land	0.08	0.06
Forested Land	122.02	90.53
Open Land	12.67	9.40
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	1.86	1.38

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.96
Turbidity (NTU)	5.54
Temperature (°C)	12.2
pH (Standard Units)	5.1
Specific Conductivity (µS/cm)	32.4

Laboratory Measurements

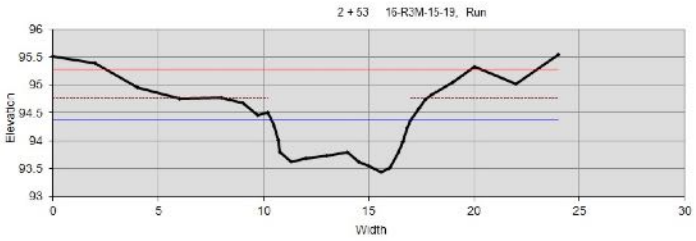
Total Phosphorus (mg/L)	<0.012	Chloride (mg/L)	2.133
Total Nitrogen (mg/L)	0.215	Magnesium (mg/L)	0.886
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	1.11
Total Ammonia N (mg/L)	0.013	Total Copper (µg/L)	1.882
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	14.229
Nitrate-N (mg/L)	<0.007	Total Lead (µg/L)	0.581
Total Kjehldal N (mg/L)	0.203	Turbidity (NTU)	4.8
Dissolved Organic C (mg/L)	6.548		
Total Organic C (mg/L)	7.145		
Hardness (mg eq. $CaCO_3$/L)	6.41		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.21	Sinuosity	1.47
Bankfull Width (ft)	6.6	D50 (mm)	7.60
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	20.0		
Entrenchment Ratio	3.0		
Width to Depth Ratio	10.5	**Rosgen Stream Type**	**E4**
Cross Sectional Area (ft²)	4.2		
Water Surface Slope (%)	0.59		

Cross-sectional Survey



Site ID: 16-R3M-15-19

Biological Assessments

BIBI Metric Values

Total Taxa	8
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	67.57
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	0.00

FIBI Metric Values

Abundance per m²	0.43
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	5
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ablabesmyia	1
Ceratopogoninae	13
Leuctra	25
Naididae	2
Rheocricotopus	1
Simulium	18
Stegopterna	50
Thienemannimyia	1

Fish Taxa

Eastern Mudminnow	38

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	13
Pool Variability	7
Sediment Deposition	12
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	9
Bank Stability - Right Bank	3
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	131
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.29	60.78
Shading	95	99.94
Epifaunal Substrate	5	53.31
Instream Habitat	5	58.25
Instream Woody Debris	15	100.00
Bank Stability	13.60	82.46

MPHI Habitat Score	75.79
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID 17-L1M-01-19

Revist of site R1-17-11A

Upstream View - 2019

Downstream View - 2019

Upstream View - 2007

Downstream View - 2007

Summary Results

	2019 Data	2007 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Severely Degraded
Water Quality Conditions	Elevated nitrogen	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 751.51

Land Cover	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Developed Land	531.22	536.76	70.69	68.28
Forested Land	193.86	222.48	25.80	28.30
Open Land	26.43	26.77	3.52	3.41
Agricultural Land	0.00	0.08	0.00	0.01

Impervious Surface	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Impervious Land	186.10	187.09	24.76	23.80

Site ID 17-L1M-01-19

Revist of site R1-17-11A

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2007 Spring
Dissolved Oxygen (mg/L)	17.41	8.46	11.45
Turbidity (NTU)	8.2	6.3	n/a
Temperature (°C)	5.7	17.2	8.12
pH (Standard Units)	7.1	6.41	n/a
Specific Conductivity (µS/cm)	221	178.5	231

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.011	Chloride (mg/L)	31.312
Total Nitrogen (mg/L)	1.638	Magnesium (mg/L)	3.842
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	12.38
Total Ammonia N (mg/L)	0.017	Total Copper (µg/L)	1.129
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	21.189
Nitrate-N (mg/L)	1.625	Total Lead (µg/L)	0.232
Total Kjehldal N (mg/L)	0.008	Turbidity (NTU)	6.3
Dissolved Organic C (mg/L)	3.726		
Total Organic C (mg/L)	3.820		
Hardness (mg eq. $CaCO_3$/L)	46.73		

Geomorphic Assessment

Rosgen Level II Classification Data

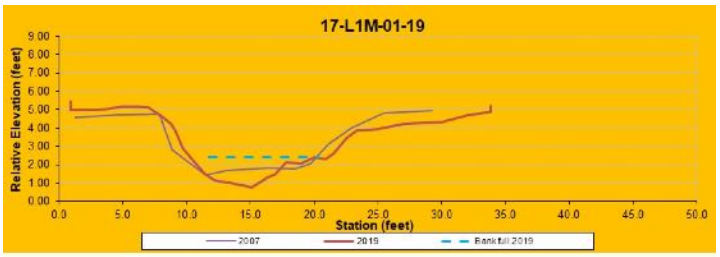
	2019	2007
Drainage Area (mi²)	1.17	
Bankfull Width (ft)	10.8	11.8
Mean Bankfull Depth (ft)	0.8	0.9
Floodprone Width (ft)	16.4	15.2
Entrenchment Ratio	1.5	1.3
Width to Depth Ratio	13.1	13.1
Cross Sectional Area (ft²)	8.8	10.7
Water Surface Slope (%)	0.270	0.230

	2019	2007
Sinuosity	1.45	1.20
D50 (mm)	1.40	0.23
Adjustments?	None	None

Rosgen Stream Type

2019	2007
B5c	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	7.87	42.39	8.00	43.08
Shading	75	73.32	15	15.33
Epifaunal Substrate	10	71.17	5	41.82
Instream Habitat	11	73.95	11	73.49
Instream Woody Debris	16	94.08	3	55.11
Bank Stability	6.13	55.38	8.00	63.25

	2019 Score	2007 Score
MPHI Habitat Score	68.38	48.68
MPHI Rating	Partially Degraded	Severely Degraded

Rapid Bioassessment Protocol

	2019 Score	2007 Score		2019 Score	2007 Score
Epifaunal Substrate/Available Cover	11	11	Bank Stability - Right Bank	7	6
Pool Substrate Characterization	10	8	Bank Stability - Left Bank	2	2
Pool Variability	8	6	Vegetative Protection - Right Bank	8	6
Sediment Deposition	3	7	Vegetative Protection - Left Bank	4	2
Channel Flow Status	10	17	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	17	Riparian Veg. Zone Width - Left Bank	10	2
Channel Sinuosity	10	9			

	2019 Score	2007 Score
RBP Habitat Score	113	103
RBP Rating	Partially Supporting	Partially Supporting

Site ID 17-L1M-01-19

Revist of site R1-17-11A

Biological Assessments

BIBI Metric Values	2019	2007
Total Taxa	6	18
EPT Taxa	0	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	0
% Climbers	0.00	2.86

FIBI Metric Values (2019 only)	
Abundance per m²	4.18
Adj. No. of Benthic Species	0.65
% Tolerant	73.53
% Gen., Omni., Invert.	90.39
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	51.76

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	5	1
% Climbers	1	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.57	1.57
BIBI Rating	Very Poor	Very Poor

FIBI Score	3.67
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Dusky Salamander

Fowler's Toad

Northern Green Frog

Pickerel Frog

Fish Taxa

Fish Taxa	Number
Blacknose Dace	264
Creek Chub	100
Eastern Mudminnow	1
Fathead Minnow	3
Least Brook Lamprey	49
Pumpkinseed	2
Rosyside Dace	83
White Sucker	8

Benthic Macroinvertebrate Taxa

2019	Number
Diamesa	1
Hydrobaenus	101
Macronychus	1
Orthocladius	6
Rheosmittia	1
Thienemannimyia group	1

Original Visit	Number
Nais	33
Enchytraeidae	3
Slavina	1
Tubificinae	3
Spirosperma	4
Ancyronyx	5
Ablabesmyia	1
Dicrotendipes	1
Hydrobaenus	43
Nanocladius	1
Paracladopelma	1
Polypedilum	1
Thienemannimyia	1
Tvetenia	1
Paratanytarsus	1
Tanytarsus	2
Cheumatopsyche	2
Crangonyx	1

Site ID 17-L1M-02-19

Revist of site R1-17-01

Upstream View - 2019

Downstream View - 2019

Upstream View - 2007

Downstream View - 2007

Summary Results

	2019 Data	2007 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 620.16

Land Cover	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Developed Land	463.62	472.89	74.76	73.83
Forested Land	72.65	101.91	11.71	15.91
Open Land	83.90	56.38	13.53	8.80
Agricultural Land	0.00	9.33	0.00	1.46

Impervious Surface	2019 Acres	2007 Acres	2019 % Area	2007 % Area
Impervious Land	231.84	284.56	37.38	44.43

Site ID 17-L1M-02-19

Revist of site R1-17-01

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2007 Spring
Dissolved Oxygen (mg/L)	8.94	3.8	12
Turbidity (NTU)	3.85	6.75	n/a
Temperature (°C)	19	23.4	10.02
pH (Standard Units)	7.6	6.66	n/a
Specific Conductivity (µS/cm)	414.3	209	477

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.019	Chloride (mg/L)	41.578
Total Nitrogen (mg/L)	0.534	Magnesium (mg/L)	7.732
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	35.39
Total Ammonia N (mg/L)	0.024	Total Copper (µg/L)	0.916
Nitrite-N (mg/L)	0.010	Total Zinc (µg/L)	2.599
Nitrate-N (mg/L)	0.199	Total Lead (µg/L)	0.052
Total Kjehldal N (mg/L)	0.325	Turbidity (NTU)	2.6
Dissolved Organic C (mg/L)	3.756		
Total Organic C (mg/L)	3.802		
Hardness (mg eq. $CaCO_3$/L)	120.21		

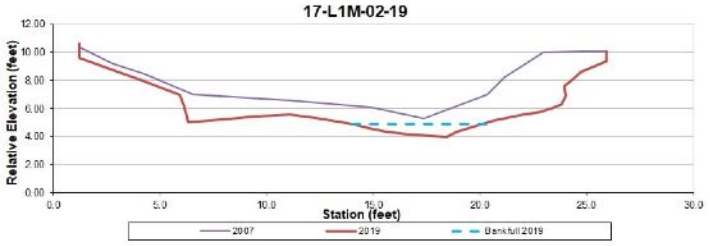
Geomorphic Assessment

Rosgen Level II Classification Data

	2019	2007		2019	2007
Drainage Area (mi²)	0.97		Sinuosity	1.37	1.13
Bankfull Width (ft)	15.8	16.7	D50 (mm)	0.74	0.44
Mean Bankfull Depth (ft)	0.7	1.8	Adjustments?	None	Sin
Floodprone Width (ft)	18.4	27.9			
Entrenchment Ratio	1.2	1.7			
Width to Depth Ratio	24.2	9.3			
Cross Sectional Area (ft²)	10.3	29.8			
Water Surface Slope (%)	0.800	1.330			

Rosgen Stream Type	
2019	2007
F5	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	11.88	63.95	13.00	70.01
Shading	60	58.94	90	91.34
Epifaunal Substrate	3	31.75	5	43.16
Instream Habitat	3	31.53	11	75.59
Instream Woody Debris	14	90.33	6	66.30
Bank Stability	2.53	35.59	8.00	63.25

	2019 Score	2007 Score
MPHI Habitat Score	52.01	68.27
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2007 Score		2019 Score	2007 Score
Epifaunal Substrate/Available Cover	12	11	Bank Stability - Right Bank	3	5
Pool Substrate Characterization	12	9	Bank Stability - Left Bank	2	2
Pool Variability	5	12	Vegetative Protection - Right Bank	8	5
Sediment Deposition	4	7	Vegetative Protection - Left Bank	8	3
Channel Flow Status	10	14	Riparian Veg. Zone Width - Right Bank	9	10
Channel Alteration	19	18	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	9			

	2019 Score	2007 Score
RBP Habitat Score	112	115
RBP Rating	Partially Supporting	Partially Supporting

Site ID 17-L1M-02-19

Revist of site R1-17-01

Biological Assessments

BIBI Metric Values	2019	2007
Total Taxa	13	16
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	1.82	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	3.64	1.90

FIBI Metric Values (2019 only)	
Abundance per m²	13.91
Adj. No. of Benthic Species	0.00
% Tolerant	1.45
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	98.55

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	3	3

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57	1.57
BIBI Rating	Very Poor	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Eastern Painted Turtle

Northern Green Frog

American Bullfrog

American Toad

Fish Taxa	Number
Bluegill	7
Eastern Mosquitofish	475

Benthic Macroinvertebrate Taxa

2019	Number
Chaetocladius	3
Cheumatopsyche	1
Cricotopus	2
Diamesa	38
Eukiefferiella	7
Helochares	1
Micropsectra	2
Naididae	22
Orthocladius	14
Physa	2
Psychodidae	1
Rheotanytarsus	1
Simulium	16

Original Visit	Number
Coenagrionidae	1
Dolichopeza	1
Enchytraeidae	14
Hydrobaenus	1
Lumbriculidae	1
Lymnaeidae	14
Nais	39
Nematoda	1
Neoporus	1
Orthocladius/Cricotopus	2
Physidae	23
Planariidae	1
Polypedilum	1
Prostoma	2
Rheotanytarsus	1
Tubificinae	2

Site ID 17-L2M-01-19

Revist of site R2-17-09

Upstream View - 2019

Downstream View - 2019

Upstream View - 2009

Downstream View - 2009

Summary Results

	2019 Data	2009 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 314.58

Land Cover	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Developed Land	114.14	96.72	36.28	31.22
Forested Land	190.63	202.72	60.60	65.45
Open Land	9.81	0.00	3.12	0.00
Agricultural Land	0.00	10.31	0.00	3.33

Impervious Surface	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Impervious Land	56.73	46.40	18.03	15.00

Site ID 17-L2M-01-19

Revist of site R2-17-09

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2009 Spring
Dissolved Oxygen (mg/L)	9.08	6.8	10.47
Turbidity (NTU)	11.7	22.4	n/a
Temperature (°C)	15.7	21.1	8.86
pH (Standard Units)	7.1	5.88	7.15
Specific Conductivity (µS/cm)	435.6	148	847

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.012	Chloride (mg/L)	104.415
Total Nitrogen (mg/L)	0.418	Magnesium (mg/L)	3.402
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	11.92
Total Ammonia N (mg/L)	0.018	Total Copper (µg/L)	2.107
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	21.038
Nitrate-N (mg/L)	0.249	Total Lead (µg/L)	0.428
Total Kjehldal N (mg/L)	0.164	Turbidity (NTU)	9.4
Dissolved Organic C (mg/L)	2.314		
Total Organic C (mg/L)	2.493		
Hardness (mg eq. $CaCO_3$/L)	43.77		

Geomorphic Assessment

Rosgen Level II Classification Data

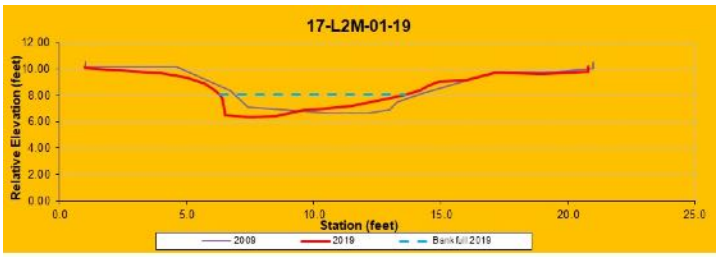
	2019	2009
Drainage Area (mi²)	0.49	
Bankfull Width (ft)	9.2	7.7
Mean Bankfull Depth (ft)	0.9	1.2
Floodprone Width (ft)	16.5	15.0
Entrenchment Ratio	1.8	1.9
Width to Depth Ratio	10.2	6.5
Cross Sectional Area (ft²)	8.3	9.1
Water Surface Slope (%)	0.012	0.460

	2019	2009
Sinuosity	1.42	1.40
D50 (mm)	0.84	0.47
Adjustments?	ER +0.2, Sin +0.1	Increased ER, Sin

Rosgen Stream Type

2019	2009
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	17.14	92.28	13.00	70.01
Shading	50	49.95	55	54.42
Epifaunal Substrate	4	41.98	7	59.51
Instream Habitat	7	60.67	15	100.00
Instream Woody Debris	9	83.23	16	100.00
Bank Stability	13.60	82.46	15.00	86.61

	2019 Score	2009 Score
MPHI Habitat Score	68.43	78.42
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2009 Score		2019 Score	2009 Score
Epifaunal Substrate/Available Cover	7	15	Bank Stability - Right Bank	2	7
Pool Substrate Characterization	13	8	Bank Stability - Left Bank	3	8
Pool Variability	14	9	Vegetative Protection - Right Bank	7	7
Sediment Deposition	7	7	Vegetative Protection - Left Bank	7	8
Channel Flow Status	17	10	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	14			

	2019 Score	2009 Score
RBP Habitat Score	127	133
RBP Rating	Supporting	Supporting

Site ID 17-L2M-01-19

Revist of site R2-17-09

Biological Assessments

BIBI Metric Values	2019	2009
Total Taxa	31	29
EPT Taxa	0	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	2.70	4.67
% Ephemeroptera	0.00	0.00
Scraper Taxa	3	0
% Climbers	9.91	13.08

FIBI Metric Values (2019 only)	
Abundance per m²	18.74
Adj. No. of Benthic Species	1.12
% Tolerant	93.14
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	32.71

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	5	1
% Climbers	5	5

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.71	2.43
BIBI Rating	Poor	Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

Eastern Cricket Frog

Northern Green Frog

Fish Taxa

Fish Taxa	Number
Blacknose Dace	21
Creek Chub	56
Eastern Mudminnow	122
Golden Shiner	204
Green Sunfish	243
Pumpkinseed	3
Rosyside Dace	51
Tessellated Darter	34
White Sucker	9

Benthic Macroinvertebrate Taxa

2019	Number
Ablabesmyia	33
Ancyronyx	1
Argia	1
Calopteryx	1
Ceratopogoninae	10
Chaetocladius	1
Diplocladius	2
Dubiraphia	2
Dytiscidae	1
Erioptera	1
Lumbriculidae	11
Lymnaeidae	1
Micropsectra	2
Microtendipes	1
Naididae	4
Nematoda	1
Orthocladius	1
Paraphaenocladius	1
Paratanytarsus	1
Phaenopsectra	3
Pilaria	2
Pisidium	3
Polypedilum	4
Potthastia	1
Prostoma	2
Rheotanytarsus	4
Sphaeriidae	1
Tanypodinae	1
Thienemannimyia	12
Tipula	1
Tipulidae	1

Original Visit	Number
Ablabesmyia	3
Ancyronyx	1
Aulodrilus	4
Corynoneura	4
Eukiefferiella	2
Ferrissia	2
Gomphidae	1
Hydrobaenus	1
Limnephilidae	1
Mideopsis	1
Mystacides	1
Nais	3
Nemata	1
Neoplasta	1
Neoporus	1
Paracladopelma	1
Parametriocnemus	19
Paratanytarsus	5
Physa	1
Polycentropus	4
Polypedilum	11
Prostoma	1
Rheotanytarsus	1
Stenochironomus	3
Tanypodinae	2
Thienemannimyia group	5
Tubificinae	1
Tvetenia	24
Xylotopus	2

Site ID 17-L2M-02-19

Revist of site R2-17-04

Upstream View - 2019

Downstream View - 2019

Upstream View - 2009

Downstream View - 2009

Summary Results

	2019 Data	2009 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 393.37

Land Cover	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Developed Land	331.00	336.03	84.14	80.20
Forested Land	58.42	81.37	14.85	19.42
Open Land	3.96	0.00	1.01	0.00
Agricultural Land	0.00	1.58	0.00	0.38

Impervious Surface	2019 Acres	2009 Acres	2019 % Area	2009 % Area
Impervious Land	114.54	130.50	29.12	31.20

Site ID 17-L2M-02-19

Revist of site R2-17-04

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2009 Spring
Dissolved Oxygen (mg/L)	11.67	6.02	12.79
Turbidity (NTU)	5.34	4.82	n/a
Temperature (°C)	9.5	22.5	11.83
pH (Standard Units)	7.5	6.93	7.3
Specific Conductivity (µS/cm)	246.1	285.1	535

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.016	Chloride (mg/L)	32.869
Total Nitrogen (mg/L)	1.452	Magnesium (mg/L)	4.117
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	15.58
Total Ammonia N (mg/L)	<0.003	Total Copper (µg/L)	1.185
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	21.548
Nitrate-N (mg/L)	1.384	Total Lead (µg/L)	0.277
Total Kjehldal N (mg/L)	0.063	Turbidity (NTU)	6.2
Dissolved Organic C (mg/L)	3.996		
Total Organic C (mg/L)	4.029		
Hardness (mg eq. $CaCO_3$/L)	55.86		

Geomorphic Assessment

Rosgen Level II Classification Data

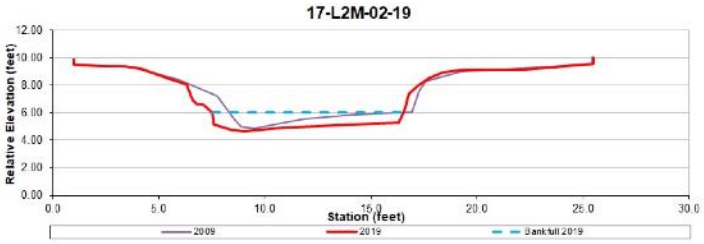
	2019	2009
Drainage Area (mi²)	0.61	
Bankfull Width (ft)	9.0	9.7
Mean Bankfull Depth (ft)	1.0	1.7
Floodprone Width (ft)	10.4	112.0
Entrenchment Ratio	1.1	11.5
Width to Depth Ratio	8.9	5.9
Cross Sectional Area (ft²)	9.2	16.1
Water Surface Slope (%)	0.490	0.370

	2019	2009
Sinuosity	1.27	1.30
D50 (mm)	8.00	2.60
Adjustments?	None	Increased Sin

Rosgen Stream Type

2019	2009
G4c	**E4**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	9.44	50.84	7.00	37.70
Shading	80	78.67	100	100.00
Epifaunal Substrate	8	63.76	3	34.30
Instream Habitat	9	69.48	9	68.83
Instream Woody Debris	15	98.45	9	79.98
Bank Stability	7.80	62.45	11.00	74.16

	2019 Score	2009 Score
MPHI Habitat Score	70.61	65.83
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2019 Score	2009 Score		2019 Score	2009 Score
Epifaunal Substrate/Available Cover	13	9	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	13	8	Bank Stability - Left Bank	2	5
Pool Variability	9	7	Vegetative Protection - Right Bank	7	6
Sediment Deposition	9	4	Vegetative Protection - Left Bank	7	5
Channel Flow Status	12	7	Riparian Veg. Zone Width - Right Bank	8	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	9	12			

	2019 Score	2009 Score
RBP Habitat Score	122	109
RBP Rating	Partially Supporting	Partially supporting

Site ID 17-L2M-02-19

Revist of site R2-17-04

Biological Assessments

BIBI Metric Values	2019	2009
Total Taxa	8	23
EPT Taxa	0	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	1
% Climbers	0.88	9.52

FIBI Metric Values (2019 only)	
Abundance per m²	3.75
Adj. No. of Benthic Species	0.95
% Tolerant	88.26
% Gen., Omni., Invert.	97.35
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	43.18

BIBI Metric Scores		
Total Taxa	1	5
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	5	3
% Climbers	1	5

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.57	2.43
BIBI Rating	Very Poor	Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American eel	1
Blacknose Dace	228
Creek Chub	222
Eastern Mudminnow	8
Least Brook Lamprey	14
Pumpkinseed	7
Rosyside Dace	47
White Sucker	1

Benthic Macroinvertebrate Taxa

2019	Number
Chaetocladius	1
Cricotopus	1
Diamesa	1
Eukiefferiella	1
Hydrobaenus	100
Naididae	1
Orthocladius	7
Physa	1

Original Visit	Number
Ancyronyx	2
Cheumatopsyche	5
Corynoneura	3
Crangonyx	1
Hydrobaenus	43
Limnodrilus	3
Menetus	1
Nais	5
Cricotopus/Orthocladius	2
Paracladopelma	2
Paratendipes	1
Phaenopsectra	1
Physa	3
Pisidium	2
Polypedilum	8
Stenelmis	1
Tanytarsus	1
Thienemanniella	1
Tipula	1
Torrenticola	1
Tubificinae	12
Tvetenia	4
Zavrelimyia	2

Site ID: 17-R3M-01-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Good
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 638.30

Land Cover	Acres	% Area
Developed Land	507.82	79.56
Forested Land	108.14	16.94
Open Land	22.34	3.50
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	179.95	28.19

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.37
Turbidity (NTU)	7.08
Temperature (°C)	7.3
pH (Standard Units)	7.49
Specific Conductivity (µS/cm)	230.3

Laboratory Measurements

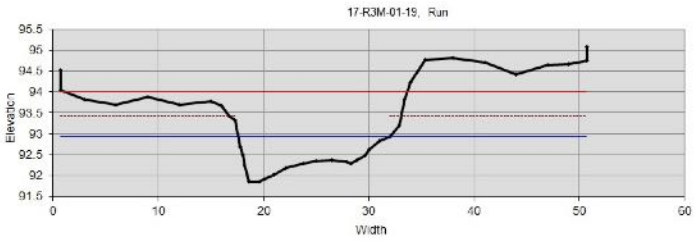
Total Phosphorus (mg/L)	<0.012	Chloride (mg/L)	33.601
Total Nitrogen (mg/L)	1.780	Magnesium (mg/L)	3.945
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	12.85
Total Ammonia N (mg/L)	0.018	Total Copper (µg/L)	1.130
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	20.353
Nitrate-N (mg/L)	1.752	Total Lead (µg/L)	0.238
Total Kjehldal N (mg/L)	0.023	Turbidity (NTU)	5.6
Dissolved Organic C (mg/L)	3.658		
Total Organic C (mg/L)	3.736		
Hardness (mg eq. $CaCO_3$/L)	48.33		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.00	Sinuosity	1.32
Bankfull Width (ft)	14.4	D50 (mm)	4.00
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	32.5		
Entrenchment Ratio	2.3		
Width to Depth Ratio	23.4	**Rosgen Stream Type**	**C4/5**
Cross Sectional Area (ft²)	8.8		
Water Surface Slope (%)	0.41		

Cross-sectional Survey



Site ID: 17-R3M-01-19

Biological Assessments

BIBI Metric Values

Total Taxa	9
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	1.69

FIBI Metric Values

Abundance per m²	3.15
Adj. No. of Benthic Species	0.71
% Tolerant	71.67
% Gen., Omni., Invert.	88.81
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	37.86

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Argia	2
Chaetocladius	1
Cheumatopsyche	1
Diamesa	2
Eukiefferiella	1
Hydrobaenus	105
Orthocladius	3
Rheotanytarsus	1
Saetheria	2

Fish Taxa

American Eel	1
Blacknose Dace	159
Creek Chub	124
Cyprinid Hybrid	1
Eastern Mudminnow	5
Fathead Minnow	2
Least Brook Lamprey	46
Pumpkinseed	3
Rosyside Dace	69
White Sucker	10

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	10
Pool Variability	9
Sediment Deposition	7
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	9
Bank Stability - Right Bank	5
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	111
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.26	60.65
Shading	85	84.56
Epifaunal Substrate	10	72.23
Instream Habitat	15	97.81
Instream Woody Debris	16	95.92
Bank Stability	14.20	84.26

MPHI Habitat Score	82.57
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Dusky Salamander

Northern Green Frog

American Bullfrog

Mussels

None Observed

Site ID: 17-R3M-02-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Severely Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 320.90

Land Cover

	Acres	% Area
Developed Land	141.12	43.98
Forested Land	124.50	38.80
Open Land	55.27	17.22
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	78.81	24.56

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.58
Turbidity (NTU)	23.6
Temperature (°C)	9
pH (Standard Units)	7.03
Specific Conductivity (µS/cm)	856

Laboratory Measurements

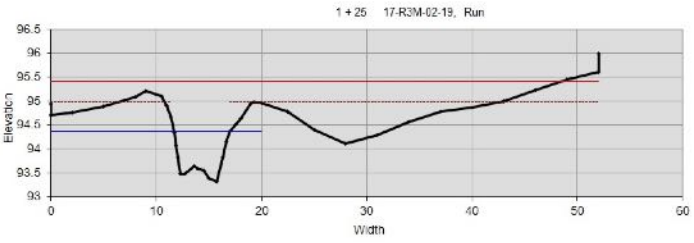
Total Phosphorus (mg/L)	0.033	Chloride (mg/L)	196.615
Total Nitrogen (mg/L)	0.458	Magnesium (mg/L)	5.662
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	25.29
Total Ammonia N (mg/L)	0.156	Total Copper (µg/L)	2.622
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	12.996
Nitrate-N (mg/L)	0.069	Total Lead (µg/L)	1.380
Total Kjehldal N (mg/L)	0.385	Turbidity (NTU)	25.5
Dissolved Organic C (mg/L)	3.207		
Total Organic C (mg/L)	3.500		
Hardness (mg eq. $CaCO_3$/L)	86.47		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.50	Sinuosity	1.21
Bankfull Width (ft)	5.3	D50 (mm)	0.44
Mean Bankfull Depth (ft)	0.7	Adjustments?	Sin +0.3
Floodprone Width (ft)	73.0		
Entrenchment Ratio	13.7		
Width to Depth Ratio	7.4	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	3.8		
Water Surface Slope (%)	0.22		

Cross-sectional Survey



Site ID: 17-R3M-02-19

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	1.79
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	1.79

FIBI Metric Values

Abundance per m²	9.90
Adj. No. of Benthic Species	0.00
% Tolerant	30.18
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	69.82

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Argia	1
Ceratopogoninae	14
Chaetocladius	1
Cheumatopsyche	6
Cricotopus/Orthocladius	25
Diamesa	2
Diplocladius	9
Eukiefferiella	1
Helobdella	1
Hydrobaenus	2
Ironoquia	1
Limnophyes	1
Lymnaeidae	1
Naididae	6
Nematoda	18
Orthocladius	16
Rheocricotopus	5
Stegopterna	2

Fish Taxa

Bluegill	3
Eastern Mosquitofish	118
Green Sunfish	47
Pumpkinseed	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	11
Pool Variability	8
Sediment Deposition	13
Channel Flow Status	15
Channel Alteration	18
Channel Sinuosity	8
Bank Stability - Right Bank	3
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	126
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	4.95	26.66
Shading	65	63.55
Epifaunal Substrate	1	24.42
Instream Habitat	2	32.72
Instream Woody Debris	2	62.29
Bank Stability	11.80	76.81

MPHI Habitat Score	47.74
MPHI Rating	Severely Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Pickerel Frog

Mussels

None Observed

Site ID: 17-R3M-04-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 155.55

Land Cover

	Acres	% Area
Developed Land	61.71	39.67
Forested Land	85.90	55.22
Open Land	7.94	5.11
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	20.58	13.23

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.6
Turbidity (NTU)	11.2
Temperature (°C)	13.6
pH (Standard Units)	7.23
Specific Conductivity (µS/cm)	488.4

Laboratory Measurements

Total Phosphorus (mg/L)	0.028	Chloride (mg/L)	95.371
Total Nitrogen (mg/L)	0.852	Magnesium (mg/L)	5.940
Orthophosphate (mg/L)	0.008	Calcium (mg/L)	21.87
Total Ammonia N (mg/L)	0.146	Total Copper (µg/L)	0.171
Nitrite-N (mg/L)	0.020	Total Zinc (µg/L)	13.700
Nitrate-N (mg/L)	0.417	Total Lead (µg/L)	0.137
Total Kjehldal N (mg/L)	0.416	Turbidity (NTU)	8.8
Dissolved Organic C (mg/L)	2.017		
Total Organic C (mg/L)	2.004		
Hardness (mg eq. $CaCO_3$/L)	79.07		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.24	Sinuosity	1.14
Bankfull Width (ft)	11.6	D50 (mm)	14.00
Mean Bankfull Depth (ft)	0.4	Adjustments?	Sin +0.1
Floodprone Width (ft)	12.7		
Entrenchment Ratio	1.1		
Width to Depth Ratio	27.0	**Rosgen Stream Type**	**F4**
Cross Sectional Area (ft²)	5.0		
Water Surface Slope (%)	1.1		

Cross-sectional Survey

Site ID: 17-R3M-04-19

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	1.85
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	18.52

FIBI Metric Values

Abundance per m²	0.14
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.64

BIBI Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	1.33
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	1
Chaetocladius	1
Cheumatopsyche	4
Cricotopus	1
Diamesa	1
Diplocladius	1
Eukiefferiella	6
Ferrissia	1
Hydrobaenus	1
Hydrosmittia	1
Limnophyes	8
Micropsectra	2
Naididae	32
Orthocladius	25
Polypedilum	17
Rheotanytarsus	1
Thienemanniella	1
Thienemanniyia	4

Fish Taxa

Blacknose Dace	4
Green Sunfish	7

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	7
Pool Variability	8
Sediment Deposition	7
Channel Flow Status	7
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	1
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	1
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	89
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.37	45.09
Shading	55	54.42
Epifaunal Substrate	1	29.14
Instream Habitat	3	45.68
Instream Woody Debris	11	97.12
Bank Stability	6.30	56.13

MPHI Habitat Score	54.60
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

Northern Green Frog

Gray Treefrog

Mussels

None Observed

Site ID: 17-R3M-06-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High conductivity; High lead; High copper; Elevated nutrients; High turbidity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 77.66

Land Cover

	Acres	% Area
Developed Land	12.49	16.08
Forested Land	54.63	70.35
Open Land	10.54	13.58
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	4.66	6.00

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.92
Turbidity (NTU)	242
Temperature (°C)	14
pH (Standard Units)	6.62
Specific Conductivity (µS/cm)	471.3

Laboratory Measurements

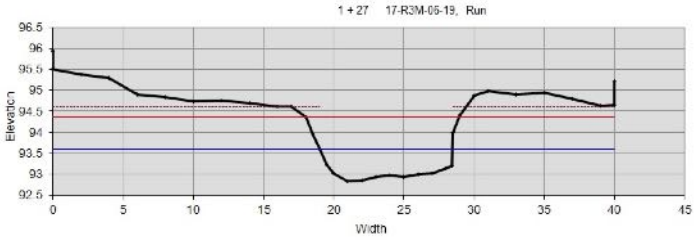
Total Phosphorus (mg/L)	0.190	Chloride (mg/L)	123.623
Total Nitrogen (mg/L)	1.378	Magnesium (mg/L)	4.820
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	21.07
Total Ammonia N (mg/L)	0.335	Total Copper (µg/L)	11.964
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	31.984
Nitrate-N (mg/L)	0.116	Total Lead (µg/L)	12.254
Total Kjehldal N (mg/L)	1.257	Turbidity (NTU)	431.0
Dissolved Organic C (mg/L)	8.077		
Total Organic C (mg/L)	17.075		
Hardness (mg eq. $CaCO_3$/L)	72.46		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.12	Sinuosity	1.20
Bankfull Width (ft)	9.4	D50 (mm)	0.31
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	11.0		
Entrenchment Ratio	1.2		
Width to Depth Ratio	15.8	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	5.7		
Water Surface Slope (%)	0.015		

Cross-sectional Survey



Site ID: 17-R3M-06-19

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	6.42
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	4.59

FIBI Metric Values

Abundance per m²	2.46
Adj. No. of Benthic Species	0.00
% Tolerant	92.88
% Gen., Omni., Invert.	99.69
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	87.62

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ablabesmyia	1
Anisoptera	1
Ceratopogoninae	3
Chaetocladius	3
Cheumatopsyche	1
Chironomus	49
Coenagrionidae	1
Corynoneura	1
Diplocladius	2
Dytiscidae	3
Ironoquia	1
Larsia	1
Limnophyes	12
Micropsectra	1
Naididae	1
Nematoda	2
Orthocladius	2
Parakiefferiella	4
Paratanytarsus	1
Peltodytes	1
Pseudorthocladius	1
Rheocricotopus	13
Synurella	2
Tanytarsus	2

Fish Taxa

Bluegill	16
Eastern Mosquitofish	23
Green Sunfish	283
Largemouth Bass	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	10
Pool Variability	8
Sediment Deposition	12
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	6
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	124
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.09	38.17
Shading	90	91.34
Epifaunal Substrate	5	56.90
Instream Habitat	5	63.89
Instream Woody Debris	14	100.00
Bank Stability	9.90	70.36

MPHI Habitat Score	70.11
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes virilis

Herpetofauna

Eastern Cricket Frog

Northern Green Frog

Gray Treefrog

Mussels

None Observed

Site ID 18-L1M-02-19

Revist of site R1-18-06

Upstream View - 2019

Downstream View - 2019

Upstream View - 2004

Downstream View - 2004

Summary Results

	2019 Data	2004 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Comparable to Reference
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 721.82

Land Cover	2019 Acres	2004 Acres	2019 % Area	2004 % Area
Developed Land	220.19	219.36	30.50	28.90
Forested Land	170.98	179.13	23.69	23.60
Open Land	45.59	53.13	6.32	7.00
Agricultural Land	285.07	306.65	39.49	40.40

Impervious Surface	2019 Acres	2004 Acres	2019 % Area	2004 % Area
Impervious Land	35.29	44.02	4.89	5.80

Site ID 18-L1M-02-19

Revist of site R1-18-06

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2004 Spring
Dissolved Oxygen (mg/L)	11.96	8.15	7.47
Turbidity (NTU)	6.3	2.9	5
Temperature (°C)	5.4	21.9	14.49
pH (Standard Units)	6.93	7.67	6.8
Specific Conductivity (µS/cm)	245	256	204.2

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.031	Chloride (mg/L)	30.039
Total Nitrogen (mg/L)	2.053	Magnesium (mg/L)	3.854
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	22.71
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	0.139
Nitrite-N (mg/L)	0.009	Total Zinc (µg/L)	8.913
Nitrate-N (mg/L)	2.007	Total Lead (µg/L)	0.058
Total Kjehldal N (mg/L)	0.038	Turbidity (NTU)	5.9
Dissolved Organic C (mg/L)	1.573		
Total Organic C (mg/L)	1.730		
Hardness (mg eq. $CaCO_3$/L)	72.58		

Geomorphic Assessment

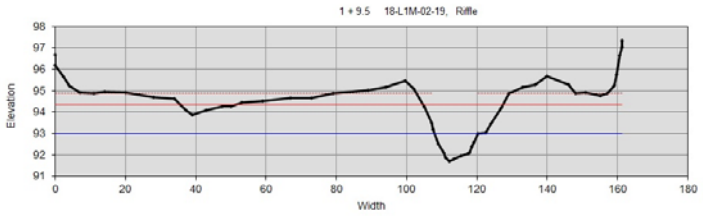
Rosgen Level II Classification Data

	2019	2004		2019	2004
Drainage Area (mi²)	1.13		Sinuosity	1.23	n/a
Bankfull Width (ft)	12.5	n/a	D50 (mm)	12.00	n/a
Mean Bankfull Depth (ft)	0.9	n/a	Adjustments?	None	
Floodprone Width (ft)	38.2	n/a			
Entrenchment Ratio	3.0	n/a			
Width to Depth Ratio	14.5	n/a			
Cross Sectional Area (ft²)	10.8	n/a			
Water Surface Slope (%)	0.750	n/a			

Rosgen Stream Type

2019	2004
C4	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	9.29	50.02	18.00	96.93
Shading	90	91.34	100	100.00
Epifaunal Substrate	10	71.43	16	100.00
Instream Habitat	10	68.81	16	100.00
Instream Woody Debris	16	94.53	3	55.50
Bank Stability	17.47	93.46	20.00	100.00

	2019 Score	2004 Score
MPHI Habitat Score	78.26	92.07
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2019 Score	2004 Score		2019 Score	2004 Score
Epifaunal Substrate/Available Cover	14	16	Bank Stability - Right Bank	6	10
Pool Substrate Characterization	15	17	Bank Stability - Left Bank	6	10
Pool Variability	10	12	Vegetative Protection - Right Bank	9	10
Sediment Deposition	11	15	Vegetative Protection - Left Bank	9	10
Channel Flow Status	14	19	Riparian Veg. Zone Width - Right Bank	9	4
Channel Alteration	19	20	Riparian Veg. Zone Width - Left Bank	4	9
Channel Sinuosity	11	8			

	2019 Score	2004 Score
RBP Habitat Score	137	160
RBP Rating	Supporting	Comparable to Reference

Site ID 18-L1M-02-19

Revist of site R1-18-06

Biological Assessments

BIBI Metric Values	2019	2004
Total Taxa	20	20
EPT Taxa	2	2
Ephemeroptera Taxa	1	0
% Intolerant to Urban	4.20	5.38
% Ephemeroptera	2.52	0.00
Scraper Taxa	1	1
% Climbers	17.65	20.43

FIBI Metric Values (2019 only)	
Abundance per m²	0.75
Adj. No. of Benthic Species	1.33
% Tolerant	98.26
% Gen., Omni., Invert.	99.13
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	61.74

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	3	3
Ephemeroptera Taxa	3	1
% Intolerant to Urban	1	1
% Ephemeroptera	3	1
Scraper Taxa	3	3
% Climbers	5	5

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.00	2.43
BIBI Rating	Fair	Poor

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Spring Peeper

Northern Green Frog

American Bullfrog

Fish Taxa	Number
Blacknose dace	71
Creek chub	9
Green sunfish	29
Least brook lamprey	1
Rosyside dace	1
Tessellated darter	4

Benthic Macroinvertebrate Taxa

2019	Number
Ablabesmyia	1
Acerpenna	3
Amphipoda	3
Calopteryx	1
Cricotopus/Orthocladius	41
Eukiefferiella	1
Gammarus	7
Hydrobaenus	11
Hydropsyche	5
Micropsectra	2
Orthocladius	2
Parametriocnemus	2
Paratanytarsus	4
Paratendipes	1
Polypedilum	16
Rheotanytarsus	10
Simulium	1
Sympotthastia	1
Tanytarsus	2
Thienemanniella	1
Thienemannimyia group	3
Tvetenia	1

Original Visit	Number
Sphaeriidae	2
Naididae	3
Crangonyx	45
Gammarus	1
Caecidotea	5
Isotomidae	3
Macronychus	1
Chironomidae	1
Hydrobaenus	10
Larsia	1
Orthocladius	25
Polypedilum	18
Potthastia	2
Psectrocladius	5
Tanytarsus	1
Thienemannimyia	3
Empididae	2
Hemerodromia	1
Simulium	1
Hexatoma	1
Nigronia	7
Boyeria	2
Calopteryx	3
Cheumatopsyche	2
Pycnopsyche	2
Polycentropus	1

Site ID 18-L1M-03-19

Revist of site R1-18-12A

Upstream View - 2019

Downstream View - 2019

Upstream View - 2004

Downstream View - 2004

Summary Results

	2019 Data	2004 Data
Benthic Macroinvertebrate Community	Very Poor	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 657.25

Land Cover	2019 Acres	2004 Acres	2019 % Area	2004 % Area
Developed Land	198.97	181.45	30.27	28.60
Forested Land	153.02	153.53	23.28	24.20
Open Land	42.60	37.43	6.48	5.90
Agricultural Land	262.66	261.39	39.96	41.20

Impervious Surface	2019 Acres	2004 Acres	2019 % Area	2004 % Area
Impervious Land	32.16	37.43	4.89	5.90

Site ID 18-L1M-03-19

Revist of site R1-18-12A

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2004 Spring
Dissolved Oxygen (mg/L)	12.73	8.45	8.57
Turbidity (NTU)	3.1	4.2	3
Temperature (°C)	9.1	19.7	13.14
pH (Standard Units)	7.23	6.27	7.3
Specific Conductivity (µS/cm)	231	246	204.8

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.038	Chloride (mg/L)	30.319
Total Nitrogen (mg/L)	2.170	Magnesium (mg/L)	3.692
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	22.34
Total Ammonia N (mg/L)	0.016	Total Copper (µg/L)	0.151
Nitrite-N (mg/L)	0.010	Total Zinc (µg/L)	7.377
Nitrate-N (mg/L)	2.123	Total Lead (µg/L)	0.064
Total Kjehldal N (mg/L)	0.037	Turbidity (NTU)	6.6
Dissolved Organic C (mg/L)	1.562		
Total Organic C (mg/L)	1.746		
Hardness (mg eq. $CaCO_3$/L)	70.99		

Geomorphic Assessment

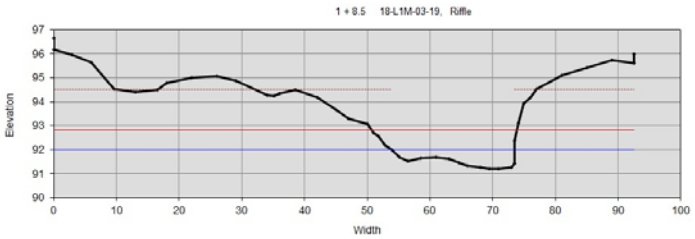
Rosgen Level II Classification Data

	2019	2004		2019	2004
Drainage Area (mi²)	1.03		Sinuosity	1.37	n/a
Bankfull Width (ft)	19.5	n/a	D50 (mm)	7.70	n/a
Mean Bankfull Depth (ft)	0.5	n/a	Adjustments?	None	
Floodprone Width (ft)	23.2	n/a			
Entrenchment Ratio	1.2	n/a			
Width to Depth Ratio	36.4	n/a			
Cross Sectional Area (ft²)	10.5	n/a			
Water Surface Slope (%)	0.420	n/a			

Rosgen Stream Type

2019	2004
F4	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	7.57	40.76	12.00	64.62
Shading	75	73.32	80	78.67
Epifaunal Substrate	9	66.23	18	100.00
Instream Habitat	12	80.87	16	100.00
Instream Woody Debris	10	77.84	5	63.45
Bank Stability	13.00	80.63	14.00	83.67

	2019 Score	2004 Score
MPHI Habitat Score	69.94	81.74
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2019 Score	2004 Score		2019 Score	2004 Score
Epifaunal Substrate/Available Cover	12	18	Bank Stability - Right Bank	6	6
Pool Substrate Characterization	15	12	Bank Stability - Left Bank	5	8
Pool Variability	10	11	Vegetative Protection - Right Bank	9	9
Sediment Deposition	10	12	Vegetative Protection - Left Bank	9	8
Channel Flow Status	11	8	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	14			

	2019 Score	2004 Score
RBP Habitat Score	134	146
RBP Rating	Supporting	Supporting

Site ID 18-L1M-03-19

Revist of site R1-18-12A

Biological Assessments

BIBI Metric Values	2019	2004
Total Taxa	12	18
EPT Taxa	1	5
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	4.12
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	2
% Climbers	4.72	19.59

FIBI Metric Values (2019 only)	
Abundance per m²	0.98
Adj. No. of Benthic Species	1.40
% Tolerant	98.68
% Gen., Omni., Invert.	99.12
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	78.85

BIBI Metric Scores		
Total Taxa	1	3
EPT Taxa	1	5
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	5
% Climbers	3	5

FIBI Metric Scores (2019 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57	3.00
BIBI Rating	Very Poor	Fair

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Fauna (2019 only)

Crayfish

Procambarus clarkii

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Pickerel Frog

Fish Taxa	Number
American eel	1
Blacknose dace	179
Bluegill	1
Creek chub	22
Green sunfish	15
Least brook lamprey	2
Tessellated darter	7

Benthic Macroinvertebrate Taxa

2019	Number
Brillia	3
Caloptervx	1
Cheumatopsyche	2
Cricotopus/Orthocladius	77
Diamesa	3
Eukiefferiella	2
Hydrobaenus	7
Orthocladius	3
Polypedilum	4
Rheotanytarsus	2
Sphaeriidae	1
Zavrelimyia	1

Original Visit	Number
Naididae	4
Tubificidae	1
Crangonyx	50
Gammarus	2
Caecidotea	12
Collembola	1
Anchytarsus	1
Bezzia/Palpomyia	1
Chironomidae	1
Chironomidae	3
Brillia	4
Orthocladius	13
Parametriocnemus	4
Polypedilum	16
Sympotthastia	4
Tanytarsus	3
Simulium	6
Tipula	1
Caloptervx	3
Cheumatopsyche	2
Limnephilidae	1
Pycnopsyche	3
Lype	1
Neophylax	1

Site ID 18-L2M-01-19

Revist of site R2-18-09

Upstream View - 2019

Downstream View - 2019

Upstream View - 2010

Downstream View - 2010

Summary Results

	2019 Data	2010 Data
Benthic Macroinvertebrate Community	Poor	Good
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Low pH; Elevated phosphorus	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 298.58

Land Cover	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Developed Land	18.96	18.30	6.35	6.20
Forested Land	142.26	136.90	47.65	46.80
Open Land	43.09	95.80	14.43	32.70
Agricultural Land	94.27	41.60	31.57	14.20

Impervious Surface	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Impervious Land	3.64	3.80	1.22	1.30

Site ID 18-L2M-01-19

Revist of site R2-18-09

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2010 Spring
Dissolved Oxygen (mg/L)	10.29	8.65	9.82
Turbidity (NTU)	16.8	0	4.54
Temperature (°C)	15.6	19.9	14.2
pH (Standard Units)	6.28	6.78	7.37
Specific Conductivity (µS/cm)	56	76	54.6

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.031	Chloride (mg/L)	2.895
Total Nitrogen (mg/L)	0.770	Magnesium (mg/L)	1.377
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	3.82
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	0.243
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	10.150
Nitrate-N (mg/L)	0.747	Total Lead (µg/L)	0.235
Total Kjehldal N (mg/L)	0.018	Turbidity (NTU)	8.7
Dissolved Organic C (mg/L)	1.233		
Total Organic C (mg/L)	1.375		
Hardness (mg eq. $CaCO_3$/L)	15.20		

Geomorphic Assessment

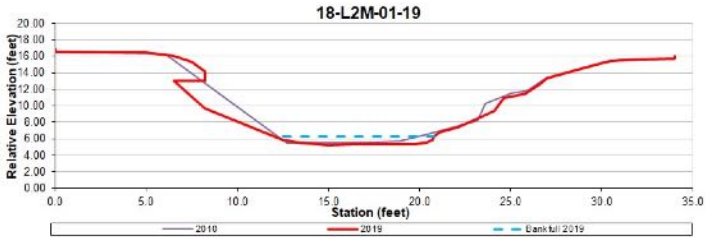
Rosgen Level II Classification Data

	2019	2010		2019	2010
Drainage Area (mi²)	0.47		Sinuosity	2.02	1.70
Bankfull Width (ft)	8.8	8.1	D50 (mm)	0.50	1.80
Mean Bankfull Depth (ft)	0.8	0.8	Adjustments?	None	None
Floodprone Width (ft)	8.8	10.5			
Entrenchment Ratio	1.0	1.3			
Width to Depth Ratio	10.4	10.1			
Cross Sectional Area (ft²)	7.4	6.5			
Water Surface Slope (%)	1.400	0.440			

Rosgen Stream Type

2019	2010
G5/4c	**G4/5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	10.98	59.13	16.00	86.16
Shading	95	99.94	95	99.94
Epifaunal Substrate	6	53.94	14	100.00
Instream Habitat	7	61.20	13	94.70
Instream Woody Debris	29	100.00	12	92.93
Bank Stability	3.77	43.40	8.00	63.25

	2019 Score	2010 Score
MPHI Habitat Score	69.60	89.50
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2019 Score	2010 Score		2019 Score	2010 Score
Epifaunal Substrate/Available Cover	14	14	Bank Stability - Right Bank	2	3
Pool Substrate Characterization	9	12	Bank Stability - Left Bank	4	5
Pool Variability	8	14	Vegetative Protection - Right Bank	9	5
Sediment Deposition	10	13	Vegetative Protection - Left Bank	9	7
Channel Flow Status	14	15	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	2	18			

	2019 Score	2010 Score
RBP Habitat Score	121	146
RBP Rating	Partially Supporting	Supporting

Site ID 18-L2M-01-19

Revist of site R2-18-09

Biological Assessments

BIBI Metric Values	2019	2010
Total Taxa	18	34
EPT Taxa	2	10
Ephemeroptera Taxa	0	2
% Intolerant to Urban	2.13	39.80
% Ephemeroptera	0.00	1.70
Scraper Taxa	1	3
% Climbers	7.45	5.90

FIBI Metric Values (2019 only)	
Abundance per m²	0.34
Adj. No. of Benthic Species	0.00
% Tolerant	98.04
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	96.08

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	3	5
Ephemeroptera Taxa	1	5
% Intolerant to Urban	1	5
% Ephemeroptera	1	3
Scraper Taxa	3	5
% Climbers	3	3

FIBI Metric Scores (2019 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14	4.43
BIBI Rating	Poor	Good

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Northern Two-lined Salamander

Northern Red Salamander

Wood Frog

Fish Taxa

Fish Taxa	Number
American eel	1
Blacknose dace	49
Green Sunfish	1

Benthic Macroinvertebrate Taxa

2019	Number
Anchytarsus	1
Brillia	7
Chaetocladius	18
Cricotopus/Orthocladius	3
Diamesa	2
Diplocladius	2
Diploperla	1
Eukiefferiella	27
Haploperla	1
Hydrobaenus	2
Nematoda	1
Orthocladius	12
Parametriocnemus	1
Polypedilum	7
Simulium	6
Tipula	1
Tvetenia	1
Zavrelimyia	1

Original Visit	Number
Acerpenna	1
Amphinemura	12
Anchytarsus	25
Calopteryx	1
Ceratopogonidae	1
Cricotopus	1
Diplectrona	6
Dixella	2
Eccoptura	2
Enchytraeidae	1
Haploperla	5
Helichus	3
Heptageniidae	1
Heterotrissocladius	2
Hydropsychidae	1
Lepidostoma	1
Leuctridae	1
Molophilus	1
Nigronia	1
Orthocladiinae	1
Orthocladius	3
Oulimnius	2
Parametriocnemus	1
Parametriocnemus	3
Polycentropus	12
Polypedilum	4
Pseudolimnophila	1
Pycnopsyche	3
Rheocricotopus	3
Rheotanytarsus	1
Simuliidae	1
Tanytarsus	1
Thienemannimyia	3
Tipula	4
Trichoptera	1
Tubificidae	1
Turbellaria	1
Zavrelimyia	4

Site ID 18-L2M-02-19

Revist of site R2-18-03

Upstream View - 2019

Downstream View - 2019

Upstream View - 2010

Downstream View - 2010

Summary Results

	2019 Data	2010 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	Within acceptable ranges	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 734.16

Land Cover	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Developed Land	230.50	224.40	31.40	24.80
Forested Land	272.31	356.00	37.09	39.30
Open Land	134.13	169.90	18.27	18.80
Agricultural Land	97.23	155.70	13.24	17.20

Impervious Surface	2019 Acres	2010 Acres	2019 % Area	2010 % Area
Impervious Land	37.69	59.59	5.13	6.60

Site ID 18-L2M-02-19

Revist of site R2-18-03

Water Chemistry

In Situ Measurements

	2019 Spring	2019 Summer	2010 Spring
Dissolved Oxygen (mg/L)	12.56	8.54	10.36
Turbidity (NTU)	1.7	11.1	4.97
Temperature (°C)	5.7	20	16.57
pH (Standard Units)	7.64	6.87	6.8
Specific Conductivity (µS/cm)	123	98	113.5

Laboratory Measurements (collected 2019 only)

Total Phosphorus (mg/L)	0.016	Chloride (mg/L)	21.828
Total Nitrogen (mg/L)	0.318	Magnesium (mg/L)	2.529
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	5.87
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	0.170
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	10.393
Nitrate-N (mg/L)	0.308	Total Lead (µg/L)	0.057
Total Kjehldal N (mg/L)	0.005	Turbidity (NTU)	3.1
Dissolved Organic C (mg/L)	0.939		
Total Organic C (mg/L)	1.016		
Hardness (mg eq. $CaCO_3$/L)	25.07		

Geomorphic Assessment

Rosgen Level II Classification Data

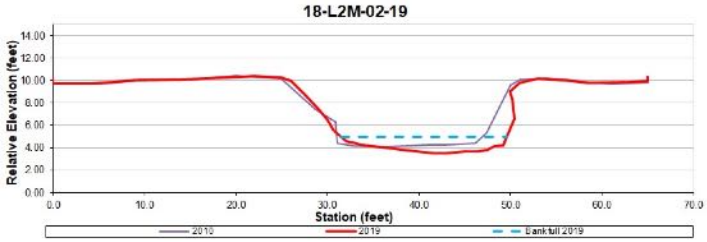
	2019	2010
Drainage Area (mi²)	1.15	
Bankfull Width (ft)	17.4	16.4
Mean Bankfull Depth (ft)	0.7	1.1
Floodprone Width (ft)	19.4	17.8
Entrenchment Ratio	1.1	1.1
Width to Depth Ratio	24.2	15.3
Cross Sectional Area (ft²)	12.5	17.6
Water Surface Slope (%)	0.520	0.560

	2019	2010
Sinuosity	1.20	1.10
D50 (mm)	1.80	0.12
Adjustments?	None	None

Rosgen Stream Type

2019	2010
F4/5	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2019 Summer Value	2019 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	6.75	36.34	8.00	43.08
Shading	80	78.67	90	91.34
Epifaunal Substrate	7	53.89	10	69.95
Instream Habitat	8	57.54	11	72.04
Instream Woody Debris	19	100.00	13	83.08
Bank Stability	6.53	57.16	7.00	59.16

	2019 Score	2010 Score
MPHI Habitat Score	63.93	69.78
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2019 Score	2010 Score		2019 Score	2010 Score
Epifaunal Substrate/Available Cover	11	10	Bank Stability - Right Bank	4	3
Pool Substrate Characterization	11	8	Bank Stability - Left Bank	3	4
Pool Variability	9	8	Vegetative Protection - Right Bank	9	5
Sediment Deposition	9	7	Vegetative Protection - Left Bank	8	6
Channel Flow Status	8	13	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	15	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	11			

	2019 Score	2010 Score
RBP Habitat Score	119	110
RBP Rating	Partially Supporting	Partially Supporting

Site ID 18-L2M-02-19

Revist of site R2-18-03

Biological Assessments

BIBI Metric Values	2019	2010
Total Taxa	29	32
EPT Taxa	3	10
Ephemeroptera Taxa	1	1
% Intolerant to Urban	14.02	36.90
% Ephemeroptera	6.54	1.90
Scraper Taxa	1	1
% Climbers	10.28	5.80

FIBI Metric Values (2019 only)	
Abundance per m²	0.58
Adj. No. of Benthic Species	0.66
% Tolerant	68.10
% Gen., Omni., Invert.	71.55
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	62.07

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	5
Ephemeroptera Taxa	3	3
% Intolerant to Urban	3	5
% Ephemeroptera	3	3
Scraper Taxa	3	3
% Climbers	5	3

FIBI Metric Scores (2019 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.57	3.86
BIBI Rating	Fair	Fair

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2019 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Red Salamander

Wood Frog

Northern Green Frog

Fish Taxa	Number
American eel	3
Blacknose dace	72
Creek chub	7
Fallfish	1
Least brook lamprey	33

Benthic Macroinvertebrate Taxa

2019	Number
Acerpenna	7
Anchytarsus	4
Calopteryx	1
Chaetocladius	1
Chloroperlidae	2
Corynoneura	1
Cricotopus/Orthocladius	25
Diamesa	11
Diplocladius	2
Dolichopodidae	1
Enchytraeidae	1
Eukiefferiella	2
Georthocladius	4
Haploperla	3
Hemerodromia	2
Hexatoma	1
Hydrobaenus	4
Ironoquia	1
Limnephilidae	1
Neoplasta	1
Nigronia	1
Parametriocnemus	3
Polypedilum	8
Pseudorthocladius	1
Rheocricotopus	2
Rheotanytarsus	11
Synurella	1
Thienemannimyia group	2
Tipula	2
Tvetenia	1

Original Visit	Number
Acerpenna	2
Amphinemura	16
Anchytarsus	14
Caecidotea	3
Chironomidae	1
Chironomini	2
Chloroperlidae	1
Cryptochironomus	1
Curculionidae	1
Diamesa	1
Diplectrona	1
Eccoptura	1
Enchytraeidae	2
Haploperla	4
Hexatoma	2
Hydrobaenus	1
Hydropsyche	1
Leuctra	2
Lumbricina	2
Micropsectra	3
Natarsia	10
Nigronia	1
Orthocladiinae	2
Orthocladiinae	1
Orthocladius	4
Paracladopelma	1
Paramerina	1
Polycentropus	2
Polypedilum	2
Pycnopsyche	4
Simuliidae	1
Stenochironomus	1
Tanytarsus	1
Thienemannimyia	1
Tipula	1
Tubificidae	9

Site ID: 18-R3M-01-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 299.47

Land Cover

	Acres	% Area
Developed Land	18.96	6.33
Forested Land	143.04	47.76
Open Land	43.20	14.43
Agricultural Land	94.27	31.48

Impervious Surface

	Acres	% Area
Impervious Land	3.64	1.22

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.6
Turbidity (NTU)	3.1
Temperature (°C)	13
pH (Standard Units)	6.32
Specific Conductivity (µS/cm)	54

Laboratory Measurements

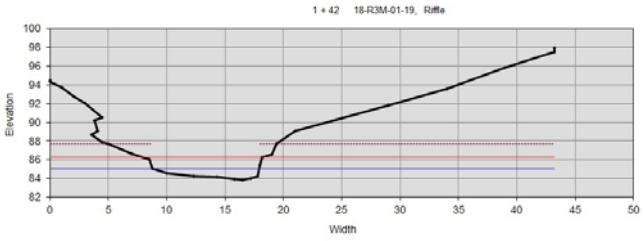
Total Phosphorus (mg/L)	0.022	Chloride (mg/L)	3.104
Total Nitrogen (mg/L)	0.756	Magnesium (mg/L)	1.359
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	3.79
Total Ammonia N (mg/L)	<0.008	Total Copper (µg/L)	0.123
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	9.589
Nitrate-N (mg/L)	0.711	Total Lead (µg/L)	0.067
Total Kjehldal N (mg/L)	0.039	Turbidity (NTU)	3.7
Dissolved Organic C (mg/L)	1.193		
Total Organic C (mg/L)	1.267		
Hardness (mg eq. $CaCO_3$/L)	15.05		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.47	Sinuosity	1.37
Bankfull Width (ft)	9.1	D50 (mm)	4.00
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	10.3		
Entrenchment Ratio	1.1		
Width to Depth Ratio	11.8	**Rosgen Stream Type**	**G4/5c**
Cross Sectional Area (ft²)	7.0		
Water Surface Slope (%)	0.97		

Cross-sectional Survey



Site ID: 18-R3M-01-19

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	5
Ephemeroptera Taxa	0
% Intolerant to Urban	4.67
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	1.87

FIBI Metric Values

Abundance per m²	0.58
Adj. No. of Benthic Species	1.17
% Tolerant	93.24
% Gen., Omni., Invert.	94.59
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	93.24

BIBI Metric Scores

Total Taxa	3
EPT Taxa	5
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	3

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphinemura	1
Capniidae	1
Chaetocladius	13
Diplocladius	1
Diploperla	1
Eukiefferiella	61
Haploperla	2
Leuctra	1
Limnophyes	1
Orthocladius	15
Parametriocnemus	1
Polypedilum	2
Simulium	3
Tvetenia	4

Fish Taxa

American eel	1
Blacknose dace	69
Least brook lamprey	4

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	14
Pool Substrate Characterization	10
Pool Variability	8
Sediment Deposition	11
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	125
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.44	50.84
Shading	95	99.94
Epifaunal Substrate	6	53.92
Instream Habitat	5	50.08
Instream Woody Debris	26	100.00
Bank Stability	0.00	0.00

MPHI Habitat Score	59.13
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Northern Black Racer

Northern Red Salamander

Northern Dusky Salamander

Pickerel Frog

Mussels

None Observed

Site ID: 18-R3M-02-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres): 353.43

Land Cover	Acres	% Area
Developed Land	117.16	33.15
Forested Land	129.79	36.72
Open Land	4.60	1.30
Agricultural Land	101.89	28.83

Impervious Surface	Acres	% Area
Impervious Land	14.90	4.22

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.88
Turbidity (NTU)	2.9
Temperature (°C)	7.3
pH (Standard Units)	7.18
Specific Conductivity (µS/cm)	174

Laboratory Measurements

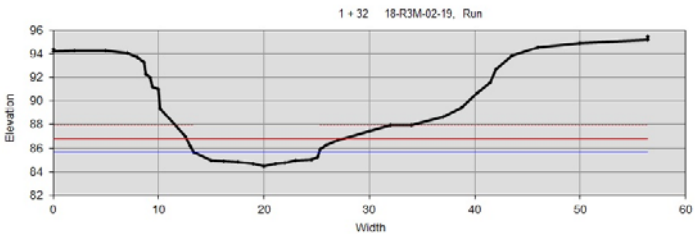
Total Phosphorus (mg/L)	0.020	Chloride (mg/L)	25.260
Total Nitrogen (mg/L)	0.957	Magnesium (mg/L)	3.439
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	10.36
Total Ammonia N (mg/L)	<0.008	Total Copper (µg/L)	0.092
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	13.734
Nitrate-N (mg/L)	1.018	Total Lead (µg/L)	0.065
Total Kjehldal N (mg/L)	<0.022	Turbidity (NTU)	4.9
Dissolved Organic C (mg/L)	0.836		
Total Organic C (mg/L)	0.814		
Hardness (mg eq. $CaCO_3$/L)	40.03		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.55	Sinuosity	1.21
Bankfull Width (ft)	11.9	D50 (mm)	1.60
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	14.8		
Entrenchment Ratio	1.2		
Width to Depth Ratio	16.0	**Rosgen Stream Type**	**F4/5**
Cross Sectional Area (ft²)	8.9		
Water Surface Slope (%)	0.91		

Cross-sectional Survey



Site ID: 18-R3M-02-19

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	22.81
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	8.77

FIBI Metric Values

Abundance per m²	0.67
Adj. No. of Benthic Species	1.02
% Tolerant	97.14
% Gen., Omni., Invert.	99.05
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	96.19

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphinemura	2
Anchytarsus	5
Ceratopogoninae	2
Chaetocladius	7
Chloroperlidae	21
Corynoneura	1
Diamesa	23
Eukiefferiella	1
Haploperla	3
Orthocladius	15
Parametriocnemus	12
Polypedilum	9
Pycnopsyche	1
Rheotanytarsus	4
Thienemanniella	1
Thienemannimyia group	1
Tipula	4
Tvetenia	2

Fish Taxa

American eel	1
Blacknose dace	101
Fallfish	1
Least brook lamprey	1
White sucker	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	10
Pool Variability	7
Sediment Deposition	7
Channel Flow Status	13
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	5
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	4
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	109
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.52	35.14
Shading	95	99.94
Epifaunal Substrate	6	52.84
Instream Habitat	5	48.38
Instream Woody Debris	3	64.16
Bank Stability	3.47	41.63

MPHI Habitat Score	57.01
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Eastern Red-backed Salamander

Northern Two-lined Salamander

Northern Green Frog

Mussels

None Observed

Site ID: 18-R3M-03-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Fair
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; Elevated phosphorus

Land Use/Land Cover Analysis

Total Drainage Area (acres) 306.46

Land Cover

	Acres	% Area
Developed Land	102.08	33.31
Forested Land	100.74	32.87
Open Land	82.31	26.86
Agricultural Land	21.32	6.96

Impervious Surface

	Acres	% Area
Impervious Land	14.58	4.76

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.19
Turbidity (NTU)	3.8
Temperature (°C)	13.7
pH (Standard Units)	6.28
Specific Conductivity (µS/cm)	94

Laboratory Measurements

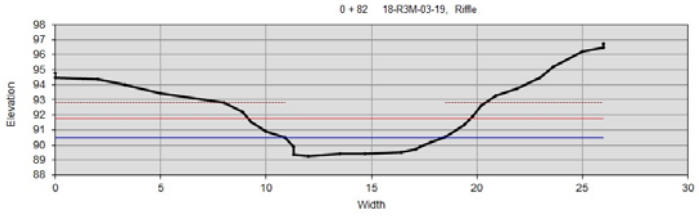
Total Phosphorus (mg/L)	0.028	Chloride (mg/L)	18.500
Total Nitrogen (mg/L)	0.380	Magnesium (mg/L)	1.785
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	4.68
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	0.258
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	8.296
Nitrate-N (mg/L)	0.246	Total Lead (µg/L)	0.144
Total Kjehldal N (mg/L)	0.129	Turbidity (NTU)	4.1
Dissolved Organic C (mg/L)	2.130		
Total Organic C (mg/L)	2.263		
Hardness (mg eq. $CaCO_3$/L)	19.03		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.48	Sinuosity	1.63
Bankfull Width (ft)	7.5	D50 (mm)	5.70
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	10.5		
Entrenchment Ratio	1.4		
Width to Depth Ratio	8.3	**Rosgen Stream Type**	**G4/5**
Cross Sectional Area (ft²)	6.7		
Water Surface Slope (%)	0.53		

Cross-sectional Survey



Site ID: 18-R3M-03-19

Biological Assessments

BIBI Metric Values

Total Taxa	25
EPT Taxa	5
Ephemeroptera Taxa	1
% Intolerant to Urban	17.92
% Ephemeroptera	1.89
Scraper Taxa	2
% Climbers	16.04

FIBI Metric Values

Abundance per m²	1.90
Adj. No. of Benthic Species	1.15
% Tolerant	77.27
% Gen., Omni., Invert.	77.27
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	61.16

BIBI Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	3
% Intolerant to Urban	3
% Ephemeroptera	3
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	4.14
BIBI Rating	Good

FIBI Score	3.67
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Acerpenna	2
Amphinemura	4
Anchytarsus	1
Brillia	5
Capniidae	3
Chaetocladius	3
Corynoneura	1
Diplocladius	9
Eukiefferiella	1
Hemerodromia	4
Leuctra	12
Lype	1
Microtendipes	1
Nigronia	1
Orthocladius	24
Parametriocnemus	1
Polypedilum	16
Rheocricotopus	4
Rheotanytarsus	4
Simulium	5
Sphaeriidae	1
Stenelmis	1
Thienemannimyia group	2

Fish Taxa

Blacknose dace	148
Creek Chub	36
Eastern Mudminnow	3
Least brook lamprey	55

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	10
Pool Variability	10
Sediment Deposition	10
Channel Flow Status	10
Channel Alteration	10
Channel Sinuosity	9
Bank Stability - Right Bank	5
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	6
Riparian Veg. Zone Width - Right Bank	6
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	108
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.76	41.78
Shading	75	73.32
Epifaunal Substrate	11	82.82
Instream Habitat	11	83.13
Instream Woody Debris	16	100.00
Bank Stability	9.23	67.95

MPHI Habitat Score	74.83
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Red Salamander

Northern Two-lined Salamander

Northern Green Frog

Wood Frog

Mussels

None Observed

Site ID: 18-R3M-04-19

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Fair
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 216.54

Land Cover

	Acres	% Area
Developed Land	97.96	45.24
Forested Land	85.81	39.63
Open Land	11.45	5.29
Agricultural Land	21.32	9.85

Impervious Surface

	Acres	% Area
Impervious Land	12.43	5.74

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.32
Turbidity (NTU)	6.1
Temperature (°C)	12.2
pH (Standard Units)	6.24
Specific Conductivity (µS/cm)	143

Laboratory Measurements

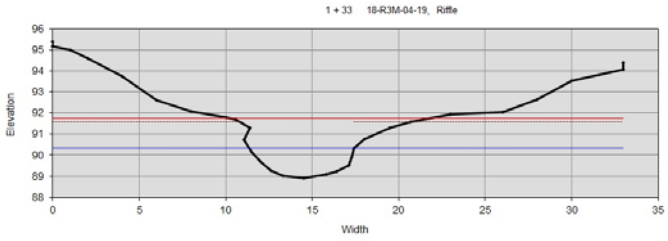
Total Phosphorus (mg/L)	0.024	Chloride (mg/L)	24.798
Total Nitrogen (mg/L)	0.372	Magnesium (mg/L)	2.508
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	6.88
Total Ammonia N (mg/L)	0.026	Total Copper (µg/L)	1.568
Nitrite-N (mg/L)	<0.005	Total Zinc (µg/L)	4.610
Nitrate-N (mg/L)	0.323	Total Lead (µg/L)	0.248
Total Kjehldal N (mg/L)	0.044	Turbidity (NTU)	14.8
Dissolved Organic C (mg/L)	1.229		
Total Organic C (mg/L)	1.712		
Hardness (mg eq. $CaCO_3$/L)	27.50		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.34	Sinuosity	1.59
Bankfull Width (ft)	6.1	D50 (mm)	0.42
Mean Bankfull Depth (ft)	1.1	Adjustments?	ER +0.2
Floodprone Width (ft)	11.5		
Entrenchment Ratio	1.9		
Width to Depth Ratio	5.6	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	6.5		
Water Surface Slope (%)	0.45		

Cross-sectional Survey



Site ID: 18-R3M-04-19

Biological Assessments

BIBI Metric Values

Total Taxa	30
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	14.68
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	4.59

FIBI Metric Values

Abundance per m²	2.21
Adj. No. of Benthic Species	1.62
% Tolerant	77.01
% Gen., Omni., Invert.	77.01
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	76.44

BIBI Metric Scores

Total Taxa	5
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Anchytarsus	1
Brillia	5
Caecidotea	3
Ceratopogoninae	1
Chaetocladius	2
Chironomus	2
Corynoneura	3
Cricotopus/Orthocladius	1
Dicranota	7
Diplocladius	40
Isopoda	1
Limnophyes	1
Lype	1
Naididae	2
Natarsia	3
Odontomesa	1
Parametriocnemus	2
Paratendipes	1
Phaenopsectra	1
Polypedilum	5
Prostoma	2
Rheocricotopus	5
Sphaeriidae	1
Stilocladius	4
Synurella	5
Tabanidae	1
Thienemanniella	3
Thienemannimyia group	4
Tipula	1

Fish Taxa

Blacknose dace	133
Creek Chub	1
Least brook lamprey	40

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	8
Pool Variability	7
Sediment Deposition	7
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	9
Bank Stability - Right Bank	4
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	8
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	115
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.20	65.72
Shading	85	84.56
Epifaunal Substrate	6	56.03
Instream Habitat	7	64.49
Instream Woody Debris	16	100.00
Bank Stability	7.97	63.12

MPHI Habitat Score	72.32
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-lined Salamander

Mussels

None Observed

Appendix E: Water Quality Data

KCI - Anne Arundel County Project - Spring 2019

Site ID	Date Collected	Time Collected	Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Orthophosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)	Total Kjehldal Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg equivalent CaCO3/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)	Comments
04-L1M-01-19	04/18/19	9:00	29.14	0.0775	1.216	0.0134	0.1287	0.0148	0.6024	0.5992	7.3178	7.6109	4.32	34.4	103.7	1.03	6.00	0.505	9.3	
04-L1M-02-19	03/18/19	12:00	45.65	0.0212	1.722	< 0.0032	0.0377	< 0.0052	1.470	0.2463	4.4867	4.7096	2.54	11.2	38.37	1.52	19.9	0.840	6.8	
04-L1M-02-19-QC	03/18/19	13:00	< 0.0121	< 0.0102	< 0.0774	< 0.0032	< 0.0084	< 0.0052	0.0144	0.0578	0.1751	0.1553	< 0.033	< 0.094	0.37	< 0.039	< 0.064	< 0.013	0.3	
04-L2M-02-19	03/18/19	9:00	103.4	0.0189	1.645	< 0.0032	0.0287	< 0.0052	1.470	0.1693	2.2934	2.4996	3.30	14.0	48.63	1.25	24.4	0.858	6.3	
04-L2M-03-19	03/25/19	11:05	74.47	0.0215	0.8105	0.0035	0.0507	0.0058	0.6674	0.1373	3.1555	3.2111	4.54	22.0	73.62	1.12	14.2	0.564	5.4	
04-R3M-06-19	03/14/19	14:00	28.25	0.0231	2.083	< 0.0032	0.0376	< 0.0052	1.868	0.2106	4.1517	4.4801	2.62	11.3	38.94	1.91	23.2	1.36	9.9	
04-R3M-08-19	03/26/19	11:00	77.88	0.0353	0.7424	0.0039	0.1670	0.0059	0.4512	0.2853	3.6175	3.9008	5.09	23.9	80.72	1.26	12.3	0.704	15.5	
04-R3M-12-19	03/26/19	13:00	27.51	0.0146	2.061	< 0.0032	0.0346	< 0.0052	2.021	0.0351	4.6264	4.8584	2.72	10.9	38.53	1.79	24.3	0.786	7.0	
04-R3M-14-19	03/25/19	8:39	75.16	0.0178	0.8132	0.0034	0.0629	0.0063	0.6760	0.1309	3.0754	3.1540	4.36	21.0	70.44	1.05	15.0	0.441	5.0	
12-L1M-02-19	04/10/19	13:00	4.712	0.0212	0.6281	< 0.0032	0.0227	< 0.0052	0.5435	0.0794	1.4882	1.7172	3.01	8.49	33.57	0.230	11.8	0.118	8.5	
12-L1M-03-19	04/11/19	13:00	29.96	0.0285	0.5501	< 0.0032	0.0325	0.0060	0.3205	0.2236	2.6779	2.7517	3.82	7.99	35.67	0.312	5.50	0.120	13.3	
12-L2M-01-19	04/24/19	12:00	91.38	0.0940	0.6787	< 0.0032	0.1199	0.0099	0.5630	0.1058	0.8050	1.0896	5.44	12.1	52.52	0.085	21.0	0.020	23.4	
12-L2M-02-19	03/13/19	9:00	48.76	0.0625	1.017	0.0073	0.0316	< 0.0052	0.9601	0.0521	1.2366	1.2983	2.95	14.0	47.20	0.339	19.0	0.189	5.9	
12-R3M-01-19	03/27/19	12:00	35.36	0.0442	1.130	< 0.0032	0.1031	< 0.0052	1.072	0.0531	0.9377	1.0851	3.85	10.7	42.55	0.186	17.4	0.118	12.4	
12-R3M-03-19	03/28/19	8:30	40.06	0.0835	1.050	0.0066	0.0386	0.0057	0.9923	0.0515	1.3677	1.3921	3.49	17.3	57.49	0.213	22.0	0.129	8.2	
12-R3M-05-19	03/13/19	13:00	24.29	0.0722	1.841	< 0.0032	0.0676	< 0.0052	1.804	0.0315	0.8176	0.9533	3.34	12.1	44.06	0.300	23.7	0.238	15.2	
12-R3M-05-19-QC	03/13/19	13:00	24.64	0.0694	1.852	0.0034	0.0678	< 0.0052	1.831	0.0154	0.8451	0.9075	3.34	12.1	43.93	0.277	23.3	0.199	14.8	
12-R3M-07-19	04/03/19	12:30	37.00	0.0557	0.7204	0.0108	0.0287	< 0.0052	0.5958	0.1194	2.1622	2.2605	4.06	12.2	47.22	0.294	15.4	0.110	5.7	
16-L1M-01-19	03/28/19	10:00	45.18	< 0.0102	0.2057	< 0.0032	0.0092	< 0.0052	0.0618	0.1387	3.7695	3.8825	3.36	14.4	49.88	1.18	6.36	0.405	7.3	
16-L1M-02-19	03/13/19	13:15	1.732	< 0.0102	0.1286	< 0.0032	0.0109	< 0.0052	0.0097	0.1137	3.8935	3.9402	0.934	0.819	5.89	1.55	20.8	0.350	3.3	
16-L2M-01-19	03/12/19	12:30	1.844	< 0.0102	0.1568	< 0.0032	< 0.0084	< 0.0052	< 0.0071	0.1445	5.0173	5.1422	0.689	0.854	4.97	1.11	17.5	0.385	1.9	
16-L2M-01-19-QC	03/12/19	10:30	1.884	< 0.0102	0.1622	< 0.0032	0.0085	< 0.0052	< 0.0071	0.1499	5.1172	5.2055	0.693	0.804	4.86	1.09	17.1	0.410	2.5	
16-L2M-02-19	03/27/19	13:40	1.714	< 0.0102	0.1368	< 0.0032	0.0191	< 0.0052	0.0165	0.1151	4.3575	4.4798	0.831	0.882	5.62	1.64	19.8	0.455	3.9	
16-R3M-02-19	03/13/19	10:00	5.803	< 0.0102	0.1224	< 0.0032	< 0.0084	< 0.0052	0.0408	0.0764	2.3498	2.4907	1.08	1.06	7.09	0.722	22.0	0.211	4.2	
16-R3M-09-19	04/03/19	10:45	1.947	< 0.0102	0.1952	< 0.0032	0.0194	< 0.0052	0.0261	0.1639	5.0662	5.2339	0.987	0.982	6.52	1.51	18.6	0.536	3.1	
16-R3M-14-19	04/11/19	10:15	1.932	0.0183	0.3046	< 0.0032	0.0632	< 0.0052	0.0205	0.2789	6.7838	8.0088	0.982	0.868	6.21	3.16	19.7	1.06	10.6	
16-R3M-15-19	04/11/19	12:30	2.133	< 0.0102	0.2153	0.0035	0.0126	< 0.0052	< 0.0071	0.2030	6.5480	7.1448	0.886	1.11	6.41	1.88	14.2	0.581	4.8	
17-L1M-01-19	04/01/19	9:00	31.31	0.0109	1.638	< 0.0032	0.0166	< 0.0052	1.625	0.0084	3.7263	3.8199	3.84	12.4	46.73	1.13	21.2	0.232	6.3	
17-L1M-02-19	04/08/19	15:00	41.58	0.0194	0.5340	< 0.0032	0.0244	0.0101	0.1986	0.3253	3.7561	3.8019	7.73	35.4	120.2	0.916	2.60	0.052	2.6	
17-L2M-01-19	04/08/19	12:00	104.4	0.0115	0.4182	< 0.0032	0.0181	< 0.0052	0.2488	0.1642	2.3142	2.4931	3.40	11.9	43.77	2.11	21.0	0.428	9.4	
17-L2M-02-19	04/01/19	13:45	32.87	0.0157	1.452	< 0.0032	< 0.0084	< 0.0052	1.384	0.0626	3.9956	4.0287	4.12	15.6	55.86	1.19	21.5	0.277	6.2	
17-R3M-01-19	04/01/19	10:45	33.60	< 0.0102	1.780	< 0.0032	0.0177	< 0.0052	1.752	0.0231	3.6582	3.7355	3.95	12.9	48.33	1.13	20.4	0.238	5.6	
17-R3M-01-19-QC	04/01/19	12:00	35.10	0.0117	1.819	< 0.0032	0.0105	< 0.0052	1.815	-0.0012	3.7752	3.8834	3.99	13.2	49.35	1.17	19.8	0.224	4.5	
17-R3M-02-19	04/02/19	12:45	196.6	0.0326	0.4584	< 0.0032	0.1556	< 0.0052	0.0687	0.3845	3.2069	3.5003	5.66	25.3	86.47	2.62	13.0	1.38	25.5	
17-R3M-04-19	04/18/19	11:00	95.37	0.0280	0.8522	0.0084	0.1462	0.0199	0.4166	0.4157	2.0166	2.0038	5.94	21.9	79.07	0.171	13.7	0.137	8.8	
17-R3M-06-19	04/22/19	10:00	123.6	0.1903	1.378	0.0046	0.3350	< 0.0052	0.1157	1.2567	8.0773	17.0750	4.82	21.1	72.46	12.0	32.0	12.3	431	
18-L1M-02-19	03/19/19	9:00	30.04	0.0305	2.053	0.0050	0.0111	0.0088	2.007	0.0375	1.5734	1.7303	3.85	22.7	72.58	0.139	8.91	0.058	5.9	
18-L1M-02-19-QC	03/19/19	11:00	30.23	0.0313	2.077	0.0047	0.0100	0.0088	2.049	0.0192	1.5269	1.6515	3.87	23.0	73.25	0.132	7.93	0.049	6.0	
18-L1M-03-19	03/19/19	13:00	30.32	0.0377	2.170	0.0038	0.0157	0.0095	2.123	0.0371	1.5621	1.7464	3.69	22.3	70.99	0.151	7.38	0.064	6.6	
18-L2M-01-19	04/18/19	13:00	2.895	0.0314	0.7703	0.0048	0.0109	< 0.0052	0.7470	0.0181	1.2333	1.3747	1.38	3.82	15.20	0.243	10.2	0.235	8.7	
18-L2M-02-19	04/02/19	9:00	21.83	0.0161	0.3176	< 0.0032	0.0110	< 0.0052	0.3076	0.0048	0.9390	1.0157	2.53	5.87	25.07	0.170	10.4	0.057	3.1	
18-R3M-01-19	04/18/19	11:30	3.104	0.0220	0.7555	0.0051	< 0.0084	< 0.0052	0.7113	0.0390	1.1926	1.2666	1.36	3.79	15.05	0.123	9.59	0.067	3.7	
18-R3M-02-19	04/03/19	9:20	25.26	0.0197	0.9568	0.0045	< 0.0084	< 0.0052	1.018	-0.0666	0.8361	0.8140	3.44	10.4	40.03	0.092	13.7	0.065	4.9	
18-R3M-03-19	04/16/19	14:00	18.50	0.0284	0.3802	0.0051	0.0112	< 0.0052	0.2456	0.1294	2.1303	2.2629	1.79	4.68	19.03	0.258	8.30	0.144	4.1	
18-R3M-04-19	04/18/19	8:30	24.80	0.0243	0.3715	< 0.0032	0.0257	< 0.0052	0.3226	0.0437	1.2292	1.7119	2.51	6.88	27.50	1.57	4.61	0.248	14.8	