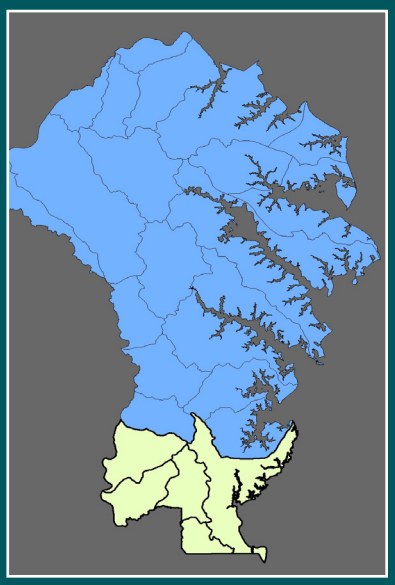

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2021

Anne Arundel County, Maryland
Department of Public Works
Bureau of Watershed Protection and Restoration

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2021

Round Three — Year Five

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Prepared for:

Anne Arundel County
Department of Public Works
Bureau of Watershed Protection and Restoration
Ecological Assessment and Evaluation Program

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Abstract

The Anne Arundel County Department of Public Works' Bureau of Watershed Protection and Restoration 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 2021 with sampling in five primary sampling units; Cabin Branch, Ferry Branch, Hall Creek, Herring Bay, and Lyons Creek. 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. Two of the five sampling units had mean BIBI values that resulted in 'Poor' biological condition ratings (Cabin Branch, Hall Creek), and three sampling units had a mean BIBI value that resulted in 'Fair' ratings (Ferry Branch, Herring Bay, Lyons Creek). One of the five sampling units had mean a FIBI value that resulted in 'Very Poor' biological condition rating (Herring Bay), two sampling units had a mean FIBI value that resulted in a 'Poor' rating (Cabin Branch, Hall Creek), and two sampling units had mean FIBI values that resulted in 'Fair' ratings (Ferry Branch, Lyons Creek). Three of the sampling units had mean physical habitat conditions rated as 'Partially Supporting' (Ferry, Herring, Lyons) and two rated as 'Non-Supporting' (Cabin Branch, Hall Creek) by the RBP method from spring sampling. Using the PHI summer sampling, three of the five sampling units had 'Partially Degraded' (Cabin Branch, Hall Creek, Lyons Creek) and two had 'Degraded' mean physical habitat conditions (Ferry Branch, Herring Bay).

There was some variability in geomorphic stream types throughout the sampling units surveyed in 2021. The largest portion of the sites were F type channels at 47.5%. Channel types E and G both were represented at approximately 15% of the sites. *In situ* water quality measurements were within COMAR standards for temperature and turbidity at all sites during both the spring and summer monitoring periods. 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 five sites spanning three of the five sampling units in the spring and at six sites spanning four of the five sampling units in the summer. For dissolved oxygen (DO), four of the sites in the summer had measured DO concentrations below the 5.0 mg/L standard. Nine of the sites in the spring and 10 sites in the summer had specific conductance values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data. All streams were within their designated criteria (Use I) for temperature in 2021 (i.e., ≤ 32 °C).

No spring grab sample parameters tested in 2021 exceeded EPA or COMAR standards for chloride, copper, lead, turbidity, or zinc for all five sampling units. All but one site in 2021 had ammonia concentrations the fell in the low (< 0.03 mg/L) or moderate (0.03-0.07 mg/L) categories. All nitrate concentrations fell in the low or moderate categories. Nitrite concentrations at 20 sites fell at or below the analytical detection limit of 0.028 mg/L. The detection limit for nitrite fell in the moderate category used by MBSS (i.e., 0.0025-

0.01 mg/L), so further categorization could not be made. Approximately 28% of the sites across four of the five sampling units had orthophosphate levels that fell in the high category (> 0.03 mg/L). Total nitrogen values fell in the low or moderate categories used by MBSS at all sites sampled. Over 75% of sites (N = 31) across the five sampling units had total phosphorus values that fell in the high category used by MBSS (i.e.,> 0.070 mg/L).

Mean PSU BIBI scores showed no significant difference when comparing results from Rounds One and Two to Round Three. Physical habitat comparisons between Round One and Three showed a significant decrease in the mean PHI score in the Ferry Branch. Cabin Branch and Ferry Branch showed significant decreases in mean RBP scores both between sampling Rounds One and Three, and between Rounds Two and Three. Hall Creek showed a significant decrease in RBP scores between sampling Rounds Two and Three, and Herring Bay showed a significant increase between sampling Rounds One and Three. No significant differences for PHI 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 Bureau of Watershed Protection and Restoration in 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 2021 mark the fifth 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 revisits of Round One and Round Two sites as well as several new sampling components to the Program. These additions to the Program were added prior to the beginning of and continued through the completion of Round Three. Eight sites are sampled in each PSU including four new randomly selected sites, two revisit sites selected from previously sampled Round One sites, and two revisit sites selected from previously sampled Round Two sites. Each of the Round Three sites are considered randomly selected sites as Round One and Round Two revisit sites were selected at random during those respective rounds. 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
2020	32	02-Stony Run 07-Upper Magothy	14-West River 20-Rock Branch	
2021	40	23-Cabin Branch 21-Ferry Branch	24- Hall Creek 15- Herring Bay	22- Lyons Creek

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 Three 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.

At every site, physicochemical parameters are measured *in situ* and water quality grab samples are collected for laboratory analysis 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 original Program design (Hill and Stribling, 2004) specified a stratified random sampling approach, stratified by stream order. Details of the current sampling program design, including the approach for the selection of sampling locations, can be found in Southerland et al. (2016). 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 2021, sites were randomly selected from each of the following five PSUs (with PSU code); Cabin Branch (23), Ferry Branch (21), Hall Creek (24), Herring Bay (15), and Lyons Creek (22). 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 2021. New for Round Three, in each PSU previously sampled sites from Rounds One and Two were randomly selected for resampling in this Round—two each from Round One and Round Two. 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.

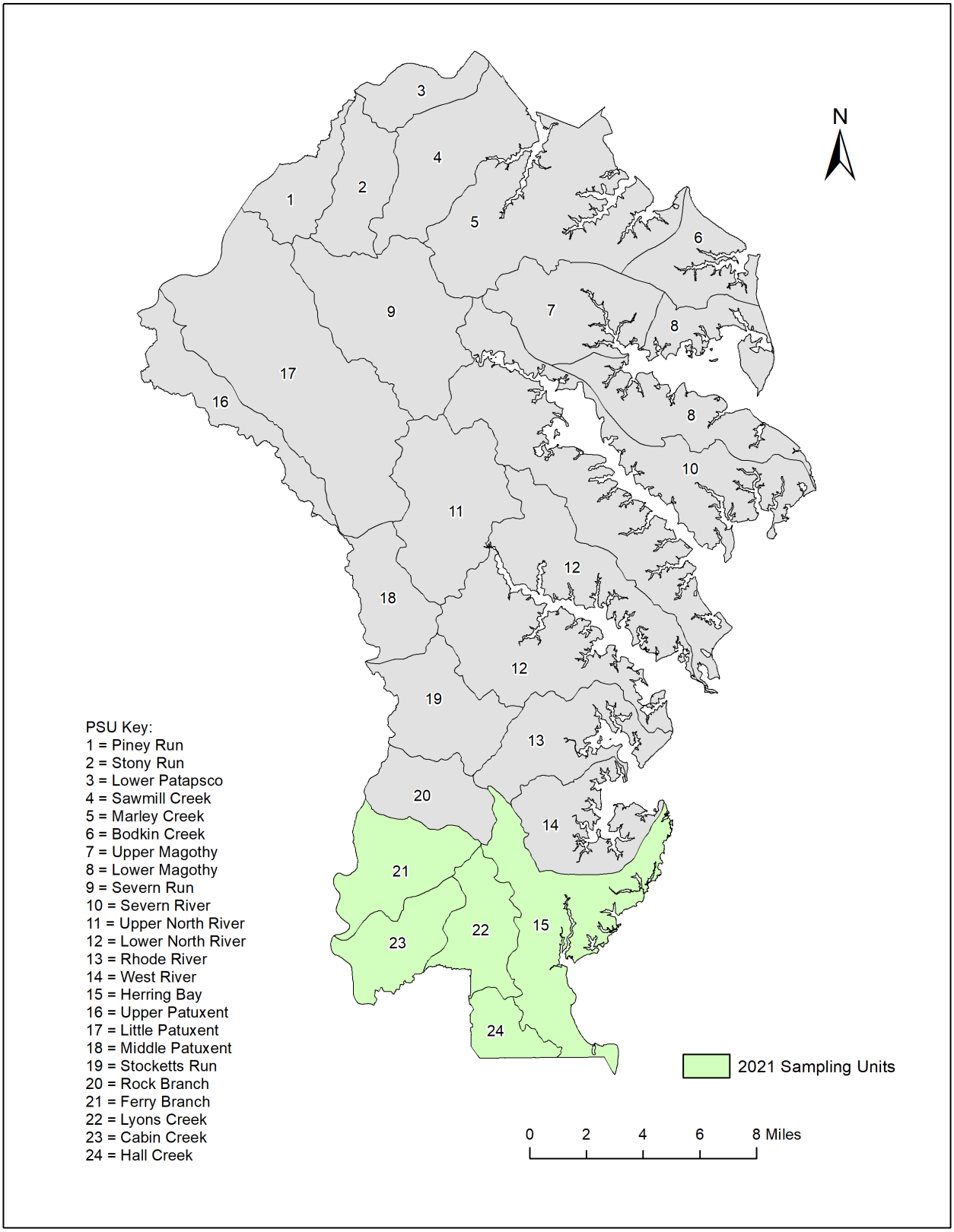

Figure 1 - 2021 Sampling Units

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 scores 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 that lack rootmats. 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 site 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. In general, samples were preserved on ice immediately after collection and all 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	0.38 NTU	APHA 2130B
Total Nitrogen	0.0738	APHA 4500-N C
Total Phosphorus	0.0123	APHA 4500-P H
Ammonia-N	0.0045	USGS (1993) NWQL I-2525
TKN (calculated)	NA	NA
Nitrate-Nitrogen	0.0043	APHA 4500-NO3 E
Nitrite-Nitrogen	0.0028	APHA 4500-NO2 B
Dissolved Organic Carbon	0.0815	APHA 5310 C
Orthophosphate	0.0038	APHA 4500-P G
Total Organic Carbon	0.0815	APHA 5310 C
Total Copper	0.039 µg/L	APHA 3125
Total Lead	0.013 µg/L	APHA 3125
Total Zinc	0.064 µg/L	APHA 3125
Chloride	0.031	APHA 4110B
Total Hardness	0.98	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 conductance, 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 System (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. If the site was a resample site from a prior Round, then an attempt was made to recover and remeasure the original cross-section. If the original cross-section was partially or completely lost, new monuments were installed. 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 file 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

FIBI 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. When an analyte value was reported to be at or below the MDL (method detection limit), the MDL value was used for all summary statistic calculations (i.e., mean and standard

deviation). 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 2021 were located on streams listed as Use Class I (Nontidal Warmwater) in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to the criteria 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 for Use I Streams

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

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.

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 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. It should be noted, however, that an effort is made to cite the cross section at a location in the

sampling reach that best represents typical physical conditions found within the reach, subject to the limitations discussed above.

- 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 84^{th} 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.

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

2.3.7 Land Use Analysis and Impervious Surface

Geospatial analysis was performed using Countywide GIS coverages in ArcGIS Pro (Version 2.9.0). Land use analysis was completed with the use of the County's 2017 Land Cover GIS layer. For the Hall Creek sampling unit, one site sampled in 2021 (24-R3M-08-21) had a drainage area that extended south into Calvert County. For that site, the High-Resolution Land Cover Dataset (2013/2014) developed by the Chesapeake Conservancy was used for the area extending outside of Anne Arundel County. Original land cover categories from both data sources were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 15). In addition, small sections of the Cabin Branch and Ferry Branch sampling units that fall near or within the Patuxent River do not contain a land cover designation in the County's 2017 Land Cover GIS layer. To complete the land use analysis for those two sampling units, these uncategorized sections were categorized as 'Open Space' after confirmation using aerial imagery. The County's 2017 impervious layer was used to assess imperviousness for 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 10.7.1. 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 majority 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, Mining, 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 2021 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 2021. 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)

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
Cabin Branch	69.77 ± 8.19 Partially Degraded	97.63 ± 10.08 Non-Supporting	2.82 ± 0.67 Poor	2.96 ± 1.30 Poor
Ferry Branch	61.11 ± 8.04 Degraded	104.13 ± 11.33 Partially Supporting	3.29 ± 0.55 Fair	3.79 ± 0.67 Fair
Hall Creek	66.86 ± 3.66 Partially Degraded	97.63 ± 9.02 Non-Supporting	2.18 ± 0.69 Poor	2.13 ± 0.59 Poor
Herring Bay	64.25 ± 6.65 Degraded	118.13 ± 12.33 Partially Supporting	3.00 ± 1.08 Fair	1.71 ± 0.55 Very Poor
Lyons Creek	67.47 ± 8.73 Partially Degraded	110.63 ± 13.86 Partially Supporting	3.14 ± 0.86 Fair	3.00 ± 1.18 Fair

3.1.1 Biological and Habitat Assessment Summary

Overall, the majority of BIBI scores throughout the sampling units were split between a rating of 'Fair' (17 of 40; 42.5%) and 'Poor' (11 of 40; 27.5%), with nearly a third of sites rated as 'Very Poor' (7 of 40; 17.5%) and 'Good' (5 of 40; 12.5%) (Figure 2). Three of the five sampling units assessed in 2021 had mean BIBI values that equate to 'Fair' biological condition ratings while two sampling units had a mean BIBI value rating in the 'Poor' category (Table 16).

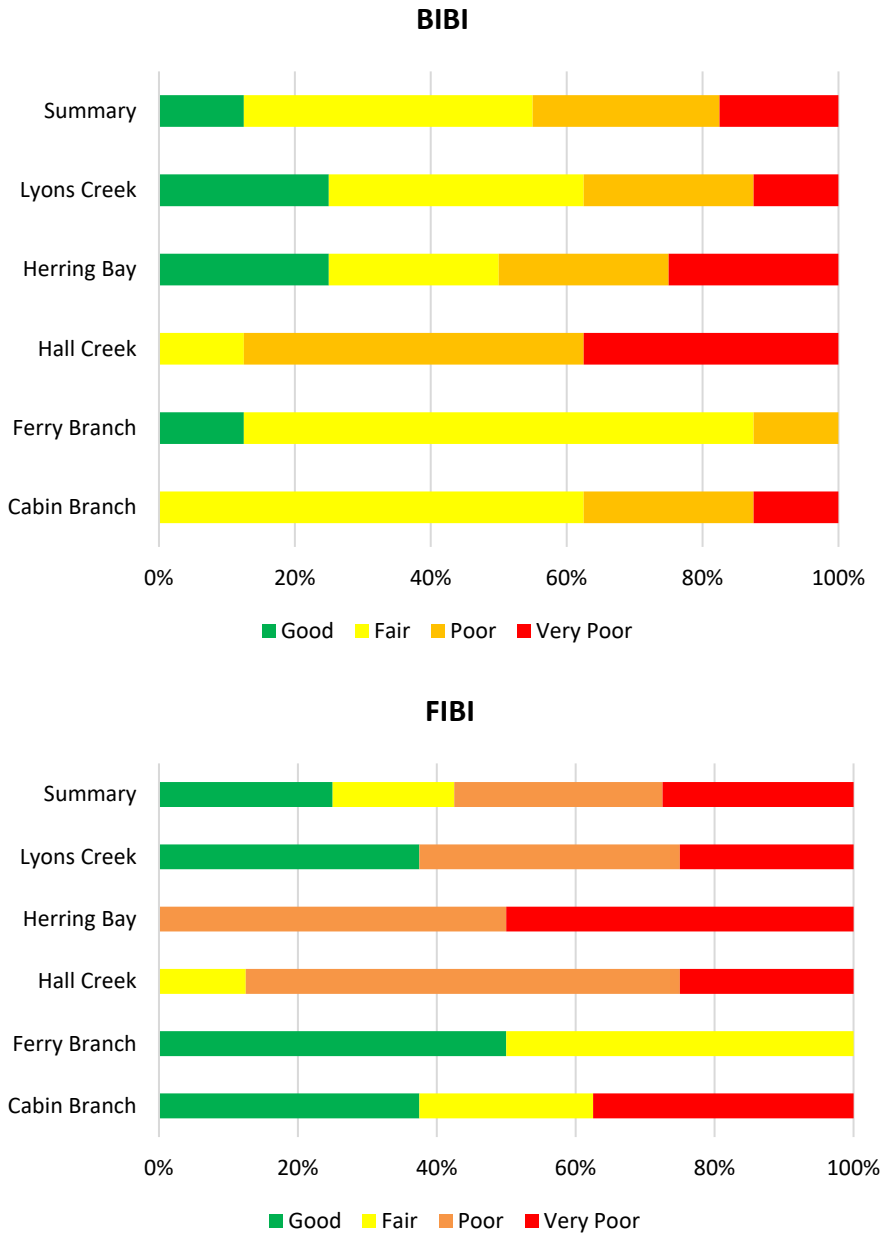

Figure 2 - Summary of biological conditions for sites assessed in 2021 (BIBI n=40, FIBI n=40)

The FIBI scores of sites sampled during 2021 were fairly evenly split between condition ratings of 'Good' (10 of 40; 25%), 'Fair' (7 of 40; 17.5%), 'Poor' (12 of 40; 30%) and 'Very Poor' (11 of 40; 27.5%) Figure 2. Two sampling units (Ferry Branch and Lyons Creek) had mean FIBI scores equating to a 'Fair' biological condition rating, two had mean FIBI ratings of 'Poor' (Cabin Branch and Hall Creek), and one had a mean FIBI rating of 'Very Poor' (Herring Bay; Table 16). Herring Bay was the sampling unit with the lowest mean FIBI score (1.71) equating to a 'Very Poor' condition rating. Ferry Branch had the highest mean FIBI rating of the sampling units from 2021, with a 3.79 mean equating to a 'Fair' biological condition rating.

Physical habitat conditions were assessed twice in 2021 by employing the RBP method during the spring season and the PHI method during the summer season. Spring physical habitat assessment results indicate that three of the five sampling units, as determined by the sampling unit mean, received ratings of 'Partially Supporting' and two sampling units received ratings of 'Non-Supporting' (RBP; Table 16). Half of the total sites sampled resulted in a RBP rating of 'Partially Supporting' (20 of 40; 50%) and another 37.5% of the sites (15 of 40) received a 'Non-Supporting' rating (Figure 3). Only five sites were rated as 'Supporting' (12.5%).

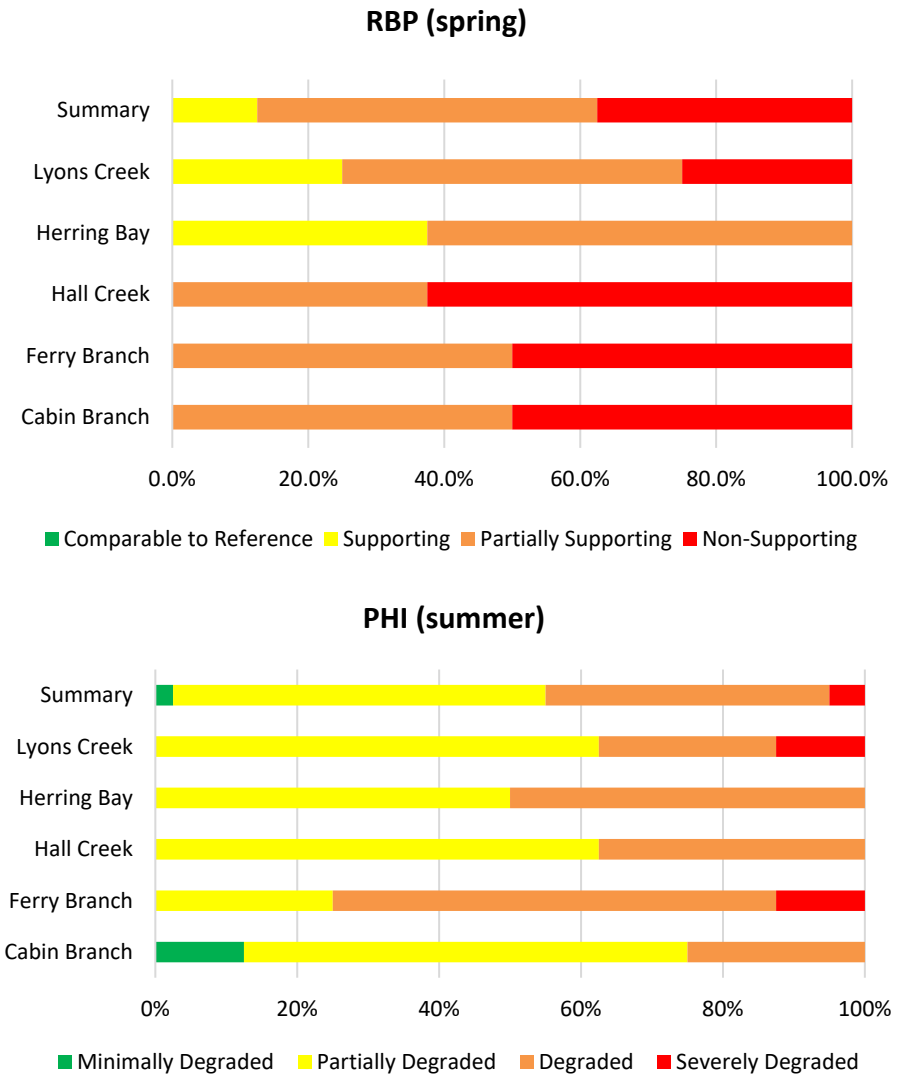

Figure 3- Summary of physical habitat conditions for sites assessed in 2021 (RBP n=40; PHI n=40)

Three of the five sampling units assessed during the summer season received a PHI rating of 'Partially Degraded' and two sampling units received a rating of 'Degraded', as determined by the sampling unit means (Table 16). Just over half of the total sites sampled resulted in a PHI rating of 'Partially Degraded' (21 of 40; 52.5%), while greater than one-third of the sites received 'Degraded' ratings (16 of 40; 40%).

One site (2.5%) received the highest possible rating of 'Minimally Degraded', while only two sites (5%) received a 'Severely Degraded' rating (Figure 3).

3.1.2 Water Quality Assessment Summary

In situ water quality measurements of instantaneous turbidity met COMAR standards for turbidity at all sites sampled during the spring and 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 five sites spanning three of the five sampling units in the spring and at six sites spanning all sampling units, except Herring Bay, in the summer. Sites that did not meet COMAR water quality standards sampled in the spring and summer had pH values that ranged from 6.05 to 6.35 SU and 6.00 to 6.48 SU, respectively. Low dissolved oxygen (DO) values, which were outside the acceptable range of values set forth by COMAR (i.e., ≥ 5 mg/L), were recorded at four sites spanning three of the five sampling units in the summer with values that ranged from 1.20 to 3.80 mg/L. 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). Furthermore, Morgan et al. (2012) identified a critical threshold of 469 µS/cm for fish within the Coastal Plain physiographic region. Specific conductance values that exceeded 247 µS/cm were recorded at nine sites spanning four of the five sampling units in the spring and at 10 sites spanning four sampling units in the summer. Specific conductance values exceeding the BIBI impairment threshold ranged from 250 to 350 µS/cm in the spring and 264 to 422 µS/cm in the summer. During both the spring and summer, specific conductance values for all sites fell below the critical threshold of 469 µS/cm for fish. All streams were within the Use I designated criterion for temperature in 2021 (i.e., ≤ 32 °C).

No spring grab sample parameters tested in 2021 exceeded EPA or COMAR standards for chloride, copper, lead, turbidity, or zinc for all five sampling units. Chloride values ranged from 7.14 to 50.50 mg/L; copper ranged from 0.209 to 0.921 µg/L; lead ranged from 0.071 to 1.012 µg/L; turbidity ranged from 2.6 to 37.7 NTU; and zinc ranged from 1.17 to 15.81 µg/L. Orthophosphate ranged from 0.0057 to 0.1567 mg/L. Nitrite values ranged from 0.0028 to 0.0117 mg/L, with 20 sites falling at or below the analytical detection limit of 0.0028 mg/L. The detection limit for Nitrite fell in the moderate category used by MBSS (i.e., 0.0025-0.01 mg/L), so further categorization to distinguish between low and moderate categories could not be made. Nitrate values at all 2021 sites fell in the low or moderate categories used by MBSS with average sampling unit values ranging from 0.499 to 1.604 mg/L. Ammonia values ranged from 0.0072 to 0.0781 mg/L with 75% of sites falling in the low category used my MBSS (< 0.03 mg/L). Total nitrogen values fell in the low or moderate categories used by MBSS at all sites sampled. Over 75% of sites (N = 31) across the five sampling units had total phosphorus values that fell in the high category used by MBSS (i.e.,> 0.070 mg/L), with values ranging from 0.0320 to 0.3098 mg/L. No state or national water quality standards exist for dissolved organic carbon (DOC), total organic carbon (TOC), calcium, magnesium, or hardness. Average values ranged from 2.3 to 3.1 mg/L for DOC, 2.4 to 3.2 mg/L for TOC, 11.06 to 17.19 mg/L for calcium, 2.181 to 3.010 mg/L for magnesium, and 39.4 to 52.2 mg/L for hardness, across all five sampling units.

3.1.3 Geomorphic Assessment Summary

There was some variability in stream types throughout the sampling units in 2021, however, almost half of the sites were entrenched F type channels (47.5%; Figure 4), which occurred for at least two sites in all sampling units. Across all sampling units, 17.5% of sites were classified as entrenched G type channels,

occurring in all sampling units except Ferry Branch. Moderately entrenched B type channels occurred at roughly 7.5% of sites, which occurred exclusively in the Cabin Branch and Hall Creek sampling units. Approximately 15% of sites were classified as slightly entrenched E type channels, occurring in the Herring Bay, Ferry Branch, and Lyons Creek sampling units. Slightly entrenched C type channels made up about 10% of sites, occurring only in the Herring Bay and Hall Creek sampling units. The remaining 2.5% of sites were classified as DA type channels, which were observed exclusively in the Ferry Branch sampling unit. None of the sites assessed in 2021 were considered D channel types or transitional between two classification types.

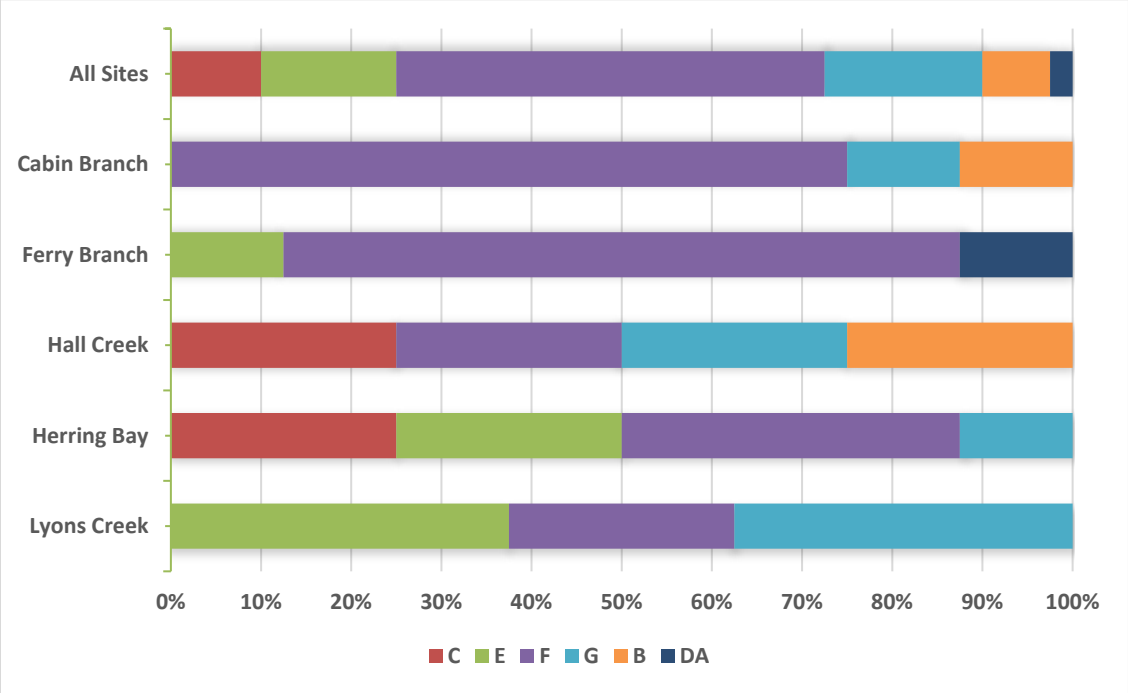

Figure 4 - Distribution of Rosgen stream types for sites assessed in 2021 (n=40)

The majority of the sites sampled in 2021 had channel substrate composed primarily of sand material (50%). Across all sites, silt/clay dominated streams comprised 15.0%, sand/silt/clay compromised 7.5%, gravel/sand compromised 15.0%, and gravel compromised 12.5%.

Stream slopes in the reaches assessed in 2021 were generally low (i.e., below 2%). The average slope of all reaches assessed was 0.53%. Individual site slopes ranged from 0.086% in the Herring Bay sampling unit to 1.6% in the Cabin Branch and Hall Creek sampling units. Average slope for the sampling units ranged from 0.35% in Herring Bay to 0.78% in Cabin Branch.

3.1.4 Land Use Analysis and Impervious Surface Summary

A summary of land use and impervious surface across each sampling unit assessed in 2021 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
Cabin Branch	6,443	2.0	18.4	42.6	24.3	14.8
Ferry Branch	8,038	3.8	25.4	41.7	21.5	11.4
Hall Creek	3,168	3.0	34.6	40.1	22.5	2.7
Herring Bay	14,595	4.7	30.5	50.1	10.3	9.0
Lyons Creek	6,154	3.2	27.1	34.7	33.8	4.3

At the sampling unit scale, all five sampling units had moderate development, with the Hall Creek sampling unit having the highest percentage of developed land at 34.6% of the total acreage, and the Cabin Branch sampling unit having the lowest percentage of developed land at 18.4% (Table 17). The Herring Bay, Lyons Creek and Ferry Branch sampling units had developed land compromising 30.5%, 27.1%, 25.4%, respectively. The Herring Bay sampling unit had the highest proportion of forested cover and the lowest proportion of agricultural land use, at 50.1% and 10.3%, respectively. In contrast, Lyons Creek had the highest proportion of agricultural land use and the lowest proportion of forested cover, at 33.8% and 34.7%, respectively. Forested cover comprised similar amounts of land in the Cabin Branch, Ferry Branch, and Hall Creek sampling units, at 42.6%, 41.7%, and 40.1%, respectively. Agricultural land uses comprised 24.3%, 22.5%, and 21.5% of Cabin Branch, Hall Creek, and Ferry Branch, respectively. Figure 5 shows land use for the entire County based on the County's 2017 Land Cover GIS layer. All five sampling units had extremely low percentages of impervious surface, ranging from 2.0% to 4.7%t. Cabin Branch had the lowest percentage of impervious surface at 2.0%, while Herring Bay had the highest percentage at 4.7%. Figure 6 shows impervious surface for the entire County based on the County's 2017 Impervious GIS layer.

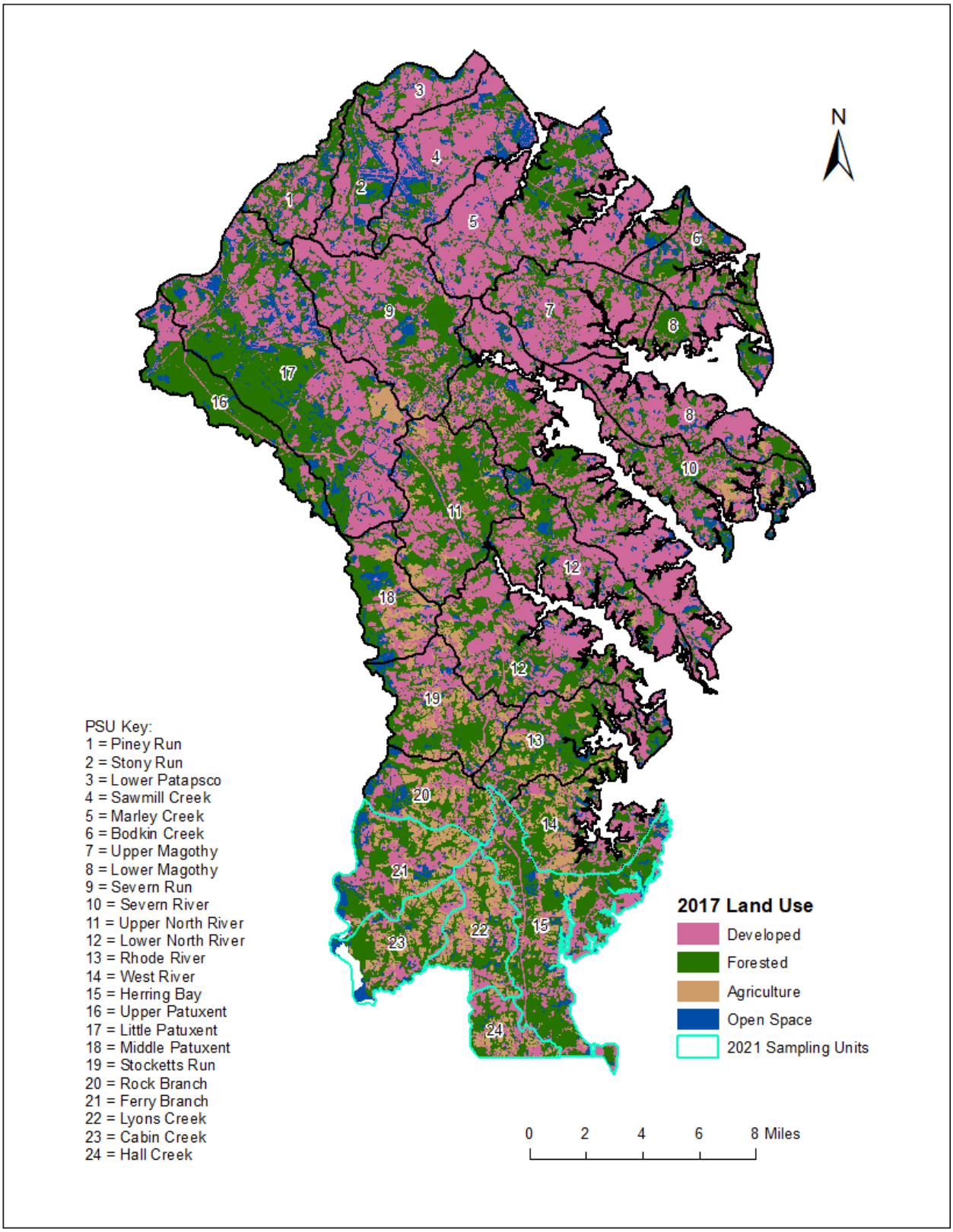

Figure 5 - Summarized land use in Anne Arundel County (2017)

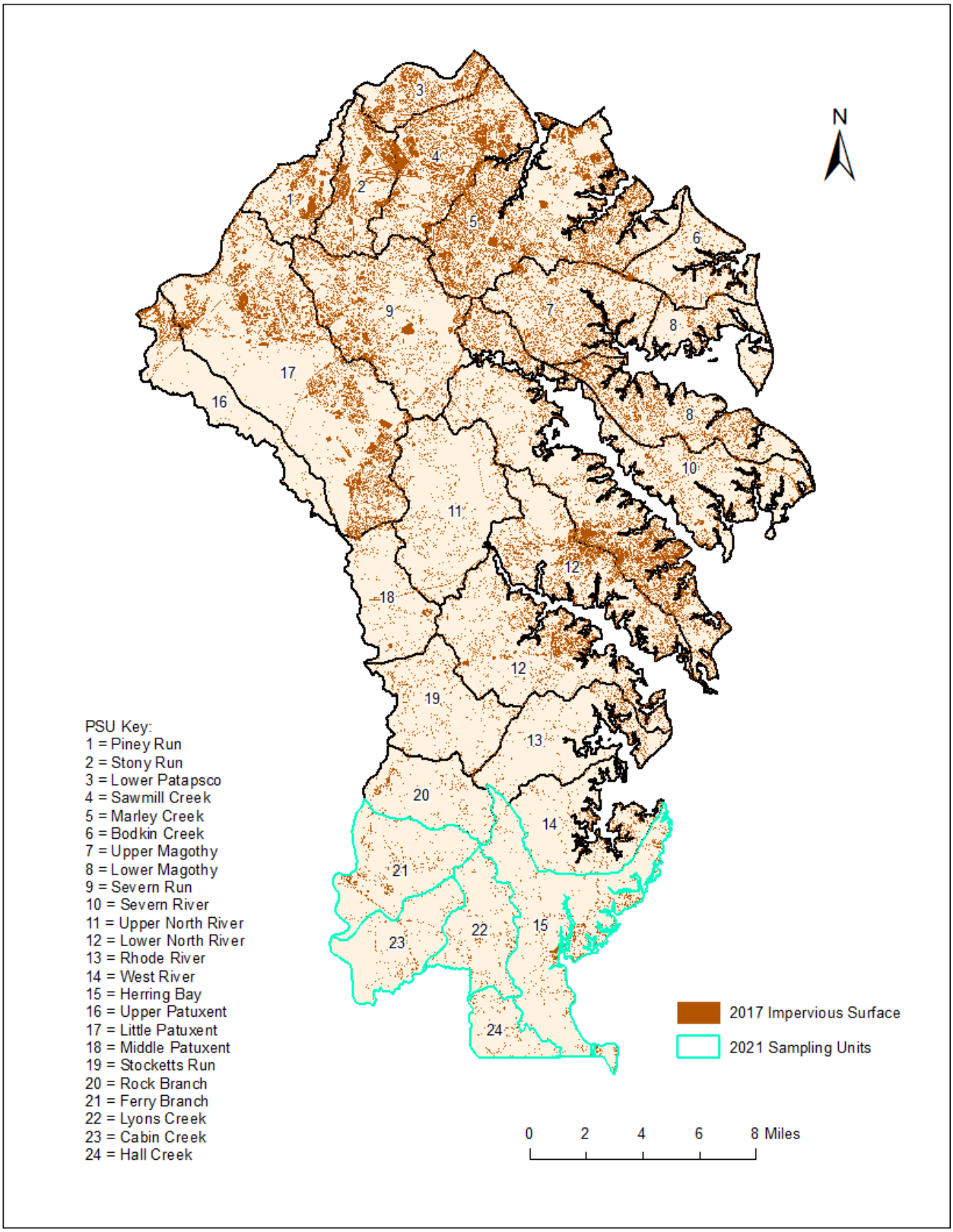

Figure 6 - Impervious surface in Anne Arundel County (2017)

4 Individual Sampling Unit Discussions

The following section summarizes the conditions within each of the five sampling units assessed during 2021. Site-specific data and assessment results can be found in Appendix D.

4.1 Cabin Branch

The Cabin Branch sampling unit is located along the most southwestern edge of the County and borders Prince George's County (Figure 1). Cabin Branch has a total drainage area of 6,443 acres and drains directly into the Patuxent River, which then drains into the Chesapeake Bay just north of the Naval Air Station Patuxent River. The eight sampling locations have drainage areas ranging from 35 to 2,278 acres (Figure 10).

4.1.1 Land Use

The dominant land use for the Cabin Branch sampling unit was forested land (43%), followed by agriculture (24%), developed land (18%), and open space (15%) (Table 17). The land use distribution within the sampling unit differed slightly when compared to the average land use among sites, which had higher average forest cover and agriculture, and lower developed land and open space. Forest was the most prevalent land cover type for six of the eight sites, while the remaining two sites had a larger proportion of agriculture (Figure 7). On average, land use among the eight sampling sites was comprised of 51% forested land, 30% agriculture, 16% developed land, and 2% open space. Impervious surfaces comprised 2% of the overall Cabin Branch sampling unit (Table 17), with individual sites ranging from less than 1% to 3% impervious surfaces.

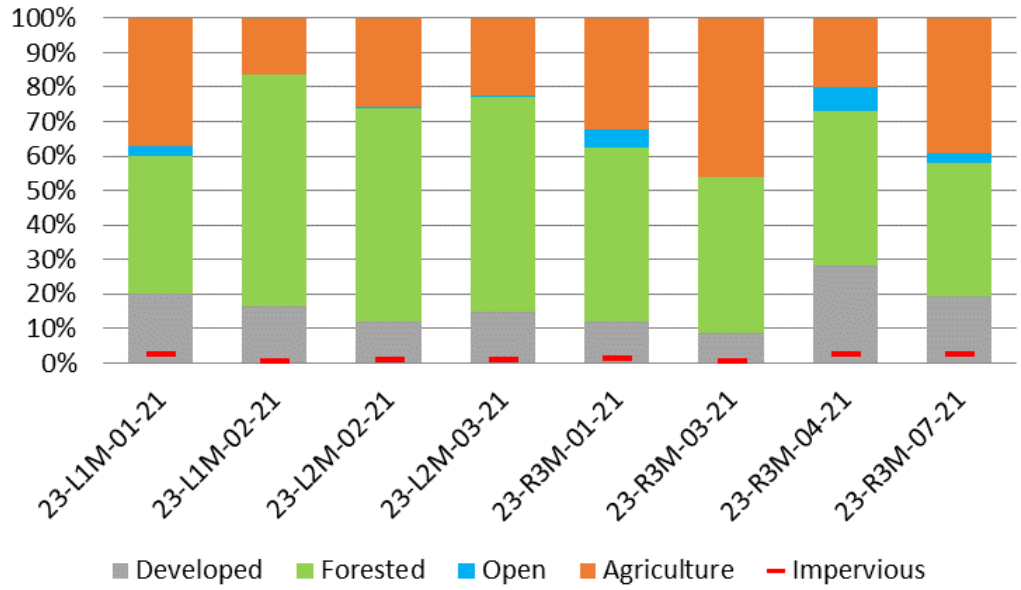

Figure 7 – Cabin Branch land use (n=8)

4.1.2 Physical Habitat

Physical habitat conditions were relatively consistent for sites in this sampling unit during the spring season. Based on the RBP scores, 50% of the Cabin Branch sites received a rating of 'Partially Supporting', and the remaining 50% were rated 'Non-Supporting' (Figure 8). The average RBP score for the Cabin Branch sampling unit was 97.63 ± 10.08, and the corresponding narrative rating was 'Non-Supporting'.

Individual site scores ranged from 83 ('Non-Supporting') to 111 ('Partially Supporting'). Cabin Branch had the lowest score (tied) for the spring RBP habitat assessment and the highest mean score for the summer PHI habitat assessment.

According to the PHI assessment (summer season), 62.5% of the Cabin Branch sites were rated as 'Partially Degraded', 25% were rated as 'Degraded', and the remaining 12.5% of sites were rated as 'Minimally Degraded' (Figure 8). The average PHI rating was 'Partially Degraded' with a score of 69.77 ± 8.19. Individual site scores ranged from 58.40 ('Degraded') to 81.99 ('Minimally Degraded'). Instream habitat and epifaunal substrate generally scored in the 'Suboptimal' and 'Marginal' categories. The scaled metric for number of rootwads and woody debris scored above 90% at five of the eight sites. Bank stability exceeded 70% at only one of the eight sites. Percent shading also scored above 75% at six of the eight sites.

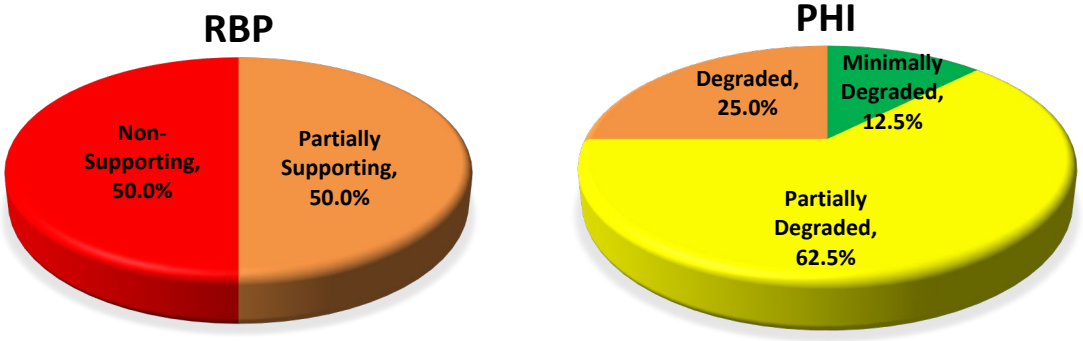

Figure 8 – Cabin Branch Physical Habitat Conditions (RBP n=8; PHI n=8)

4.1.3 Benthic Macroinvertebrates

Of the eight sites sampled in Cabin Branch, 62.5% of sites received a BIBI rating of 'Fair', 25% of the sites were rated as 'Poor', and the remaining 12.5% were rated as ' Very Poor' (Figure 9). The average BIBI score for the Cabin Branch sampling unit is 2.82 ± 0.67, with an average biological condition of 'Poor'. This sampling unit had the second lowest mean BIBI score but the second highest proportion of sites in the 'Fair' category. Individual BIBI scores ranged from 1.86 ('Very Poor') to 3.57 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

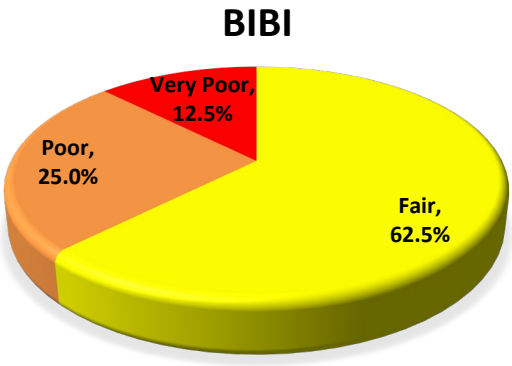

Figure 9 – Cabin Branch BIBI Conditions (n=8)

Site 23-L1M-02-21 received the lowest score in the Cabin Branch sampling unit of 1.86 with a 'Very Poor' narrative rating (Figure 10). The site had moderate taxa diversity (18 taxa), but completely lacked in Ephemeroptera sp., and scraper taxa. In contrast, site 23-L1M-01-21 received the highest BIBI score of 3.57, primarily due to, three EPT taxa, one scraper taxa, and 31.4% of the sampling consisting of climbers. Additionally, one Ephemeroptera taxa was present and the sample comprised of 21.9% intolerant taxa.

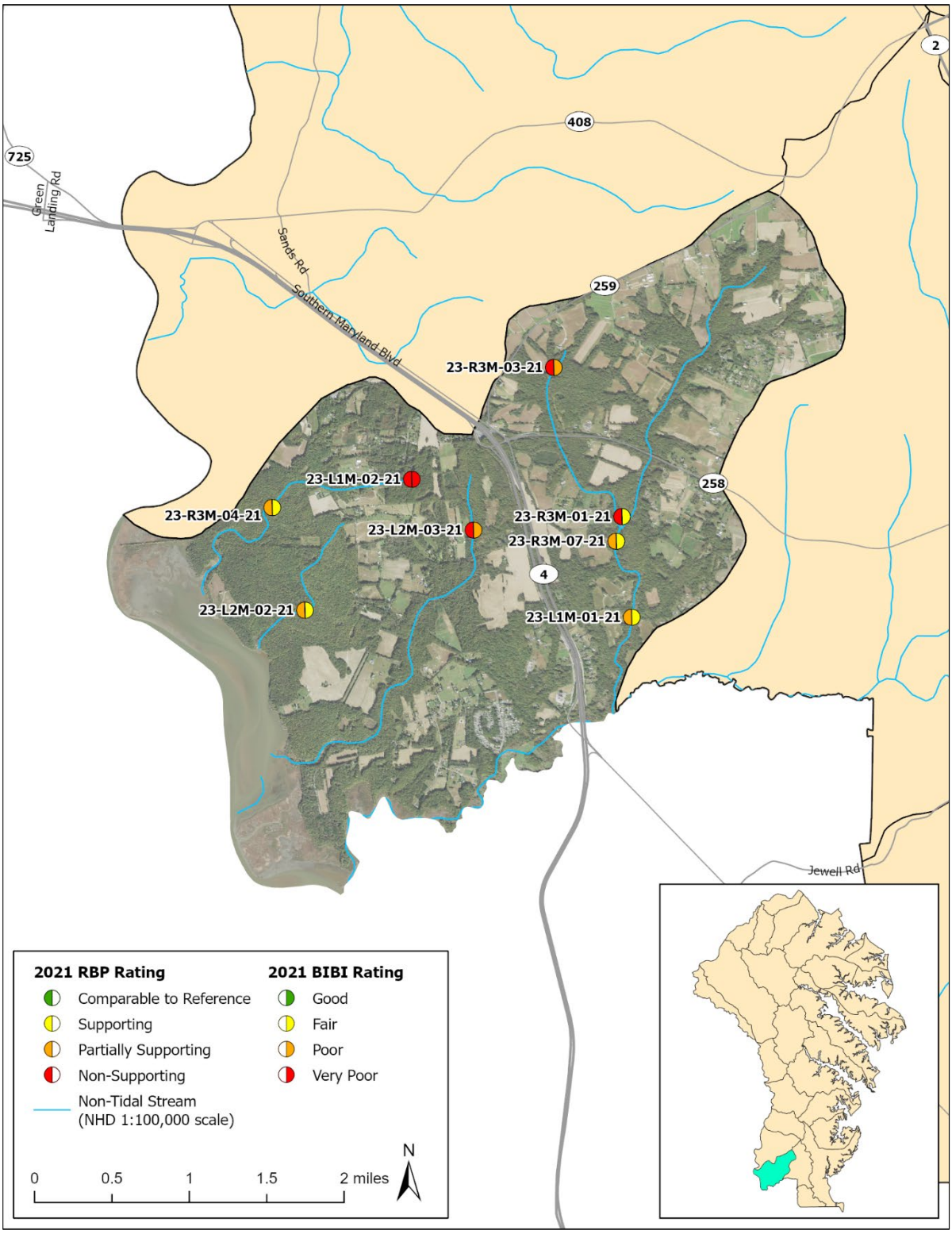

Figure 10 – Cabin Branch Sampling Sites (BIBI and RBP)

4.1.4 Fish

The Cabin Branch sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.96 ± 1.30. Three of the eight sites in this sampling unit received a biological condition rating of 'Good' (37.5%), 25% scored a biological condition rating of 'Fair', with the remaining 37.5% scoring in the 'Very Poor' category (Figure 11). Individual FIBI scores ranged from 1.00 ('Very Poor') to 4.33 ('Good'). Site-specific data and assessment results can be found in Appendix D.

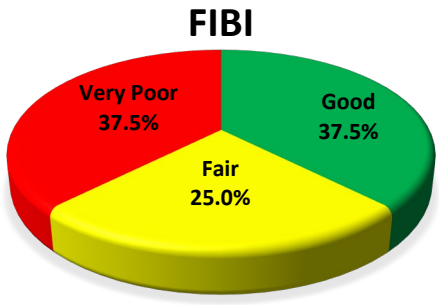

Figure 11 – Cabin Branch FIBI Conditions (n=8)

One site, 23-L1M-02-21, received the lowest FIBI score of Cabin Branch 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. In contrast, three of the eight sites received scores of 4.00 or better with ratings of 'Good'. Additionally, these sites all scored in the highest category for adjusted number of benthic species, percent tolerant species, and percent abundance of dominant taxon. These sites also had some of the highest observed levels of diversity in the sampling unit, with 7-13 species observed at each site.

Blacknose Dace (*Rhinichthys atratulus*) was the most widely distributed species in the sampling unit, present at seven sites, followed by American Eel (*Anguilla rostrata*), Green Sunfish (*Lepomis cyanellus*), and Tessellated Dater (*Etheostoma olmstedi*) which were each found at five sites. The least common species were Eastern Mosquitofish (*Gambusia holbrooki*), Eastern Mudminnow (*Umbra pygmaea*), Northern Snakehead (*Channa* spp.), Pumpkinseed (*Lepomis gibbosus*), and Satinfin Shiner (*Cyprinella analostana*) which were found at only a single site in this sampling unit. Eighteen species were observed in the sampling unit with three non-native species [Bluegill (*Lepomis macrochirus)*, Green Sunfish and Northern Snakehead]. Fifteen native species were also observed [American Eel, Blacknose Dace, Brown Bullhead (*Ameiurus nebulosus*), Creek Chub (*Semotilus atromaculatus*), Creek Chubsucker (*Erimyzon oblongus*), Eastern Mosquitofish, Eastern Mudminnow, Fallfish (*Semotilus corporalis*), Least Brook Lamprey (*Lampetra aepyptera*), Pumpkinseed, Rosyside Dace (*Clinostomus funduloides*), Satinfin Shiner, Tessellated Darter, White Sucker (*Catostomus commersonii*), and Yellow Bullhead (*Ameiurus natalis*)]. One round-bodied sucker (Creek Chubsucker) was present, along with two benthic fish species (Least Brook Lamprey and Tessellated Darter), and two species considered intolerant to pollution (Fallfish and Satinfin Shiner).

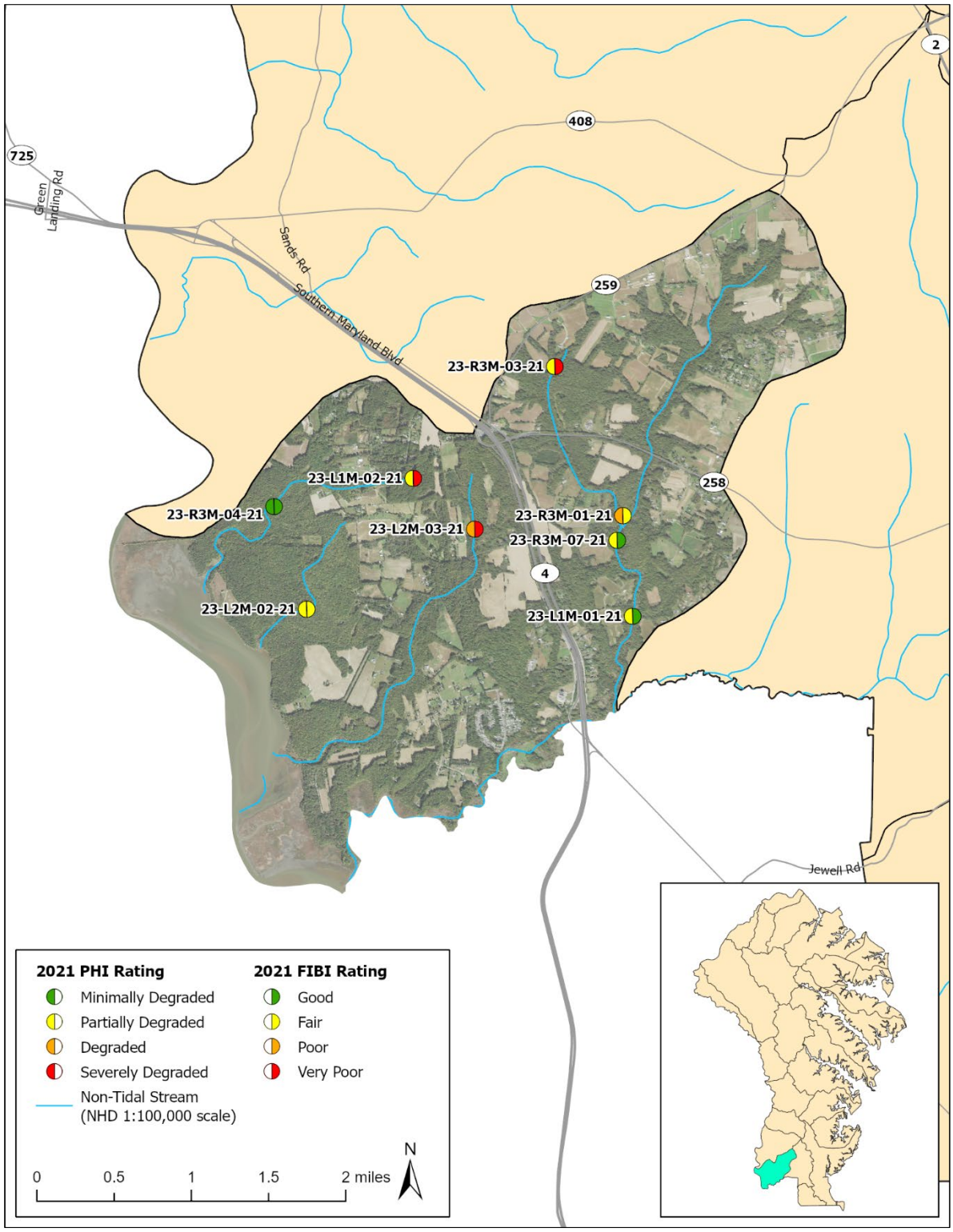

Figure 12 – Cabin Branch Sampling Sites (FIBI and PHI)

4.1.5 Water Quality

Average spring and summer *in situ* water quality values for the Cabin Branch sites are provided in Table 18. Seven of the eight sites sampled met COMAR standards for water quality in the spring. Site 23-R3M-03-21 fell below the COMAR standards for pH (i.e., 6.5-8.5 SU), with a value of 6.15 SU. Water temperature ranged from 9.80 to 17.70 °C; DO ranged from 9.42 to 13.14 mg/L; pH ranged from 6.15 to 6.81 SU; specific conductance ranged from 147.5 to 261.4 µS/cm; and turbidity ranged from 2.82 to 38.50 NTU.

In the summer, all eight Cabin Branch sites were sampleable with two sites not meeting COMAR standards for water quality. Site 23-L2M-03-21 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 6.0 SU and outside the COMAR range for DO (i.e., ≥ 5 mg/L) with a value of 2.73 mg/L. Site 23-R3M-04-21 measured outside the acceptable COMAR range for pH with a value of 6.31 SU. Summer water temperature ranged from 19.10 to 23.90 °C; DO ranged from 2.73 to 10.21 mg/L; pH ranged from 6.00 to 6.77 SU; specific conductance ranged from 170.9 to 209.4 µS/cm; and turbidity ranged from 5.84 to 35.60 NTU.

Table 18 - Average *in situ* water quality values – Cabin Branch

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	13.09 ± 2.55	10.92 ± 1.17	6.58 ± 0.20	196.2 ± 40.9	9.02 ± 12.13
Summer	21.73 ± 1.85	7.80 ± 2.18	6.53 ± 0.27	195.1 ± 13.1	15.14 ± 9.97

The average spring grab sample water quality values for the Cabin Branch sites are provided in Table 19. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. All Cabin Branch sites fell in the low to moderate MBSS categories for ammonia, total nitrogen, nitrate, and nitrite. Comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. Sites 23-L1M-01-21, 23-L1M-02-21, 23-L2M-03-21, 23-R3M-01-21, 23-R3M-03-21, and 23-R3M-07-21 had total phosphorus concentrations that fell in the high MBSS category (i.e., > 0.07 mg/L) with values ranging from 0.0743 to 0.3098 mg/L. The two remaining sites sampled in 2021 had total phosphorus concentrations that fell in the moderate category (i.e., 0.025-0.070 mg/L. Sites 23-L1M-01-21, 23-L1M-02-21, 23-L2M-03-21, 23-R3M-01-21, and 23-R3M-07-21 had orthophosphate levels in the high MBSS category (i.e., > 0.03 mg/L). All other orthophosphate values were in the low or moderate MBSS categories. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.455 to 3.827 mg/L; TOC ranged from 1.474 to 4.085 mg/L; magnesium ranged from 2.026 to 3.041 mg/L; calcium ranged from 6.78 to 15.25 mg/L; and hardness ranged from 27.55 to 47.16 mg/L.

Table 19 - Average grab samples water quality values – Cabin Branch

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)
14.11 ± 3.60	0.1102 ± 0.0866	1.3261 ± 0.6512	0.0370 ± 0.0266	0.0129 ± 0.0067	0.0036 ± 0.0014	1.2071 ± 0.7246	2.363 ± 0.883
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)
2.415 ± 0.981	2.527 ± 0.342	11.62 ± 2.84	39.43 ± 6.80	0.461 ± 0.212	10.9 ± 3.7	0.245 ± 0.316	8.7 ± 11.9

4.1.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of the sites assessed in the Cabin Branch sampling unit were entrenched F type channel (75%; Figure 13). Moderately entrenched B type channels and entrenched G type channels both represented 12.5% of the sites surveyed.

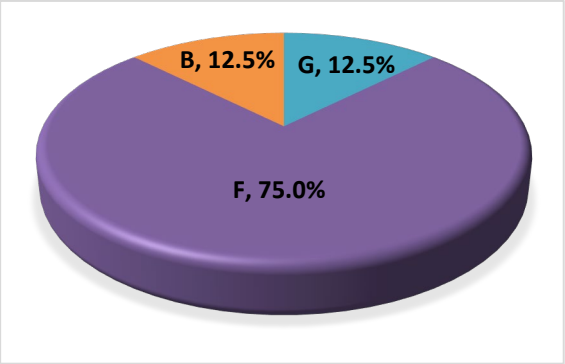

Figure 13 - Rosgen stream types observed in Cabin Branch (n=8)

The majority of the streams in this sampling unit had sand dominated substrate (75.0%), with the remainder of the sites being gravel dominated substrate (25.0%). The average D_{50} was 0.55 mm (coarse sand). Individual site slopes ranged from 0.23% to 1.60%, with an average slope of 0.78%.

4.2 Ferry Branch

The Ferry Branch sampling unit is located along the southwestern edge of the County near Prince George's County, drains directly to the Patuxent River, (Figure 1) and has a total drainage area of 8,038 acres. The eight sampling sites have drainage areas ranging from 182 to 2,324 acres.

4.2.1 Land Use

Land use in the Ferry Branch sampling unit was primarily comprised of forested land (42%), followed by developed land (25%), agriculture (21%), and open space (11%) (Table 17). The land use distribution within the sampling unit differed when compared to the average land use among sites, which had higher average development, and lower average forest cover, agriculture, and open space. Out of the eight sites in the sampling unit, four sites were dominated by forested land, three sites were dominated by developed land, and one site was dominated by agriculture. On average, the sites sampled in the Ferry Branch sampling unit were dominated by developed land (41%), followed by forested land (34%), agriculture (18%), and 6% open space (Figure 14). Impervious surfaces comprised 4% of Ferry Branch, with individual sites ranging from 3% to 6% impervious surfaces.

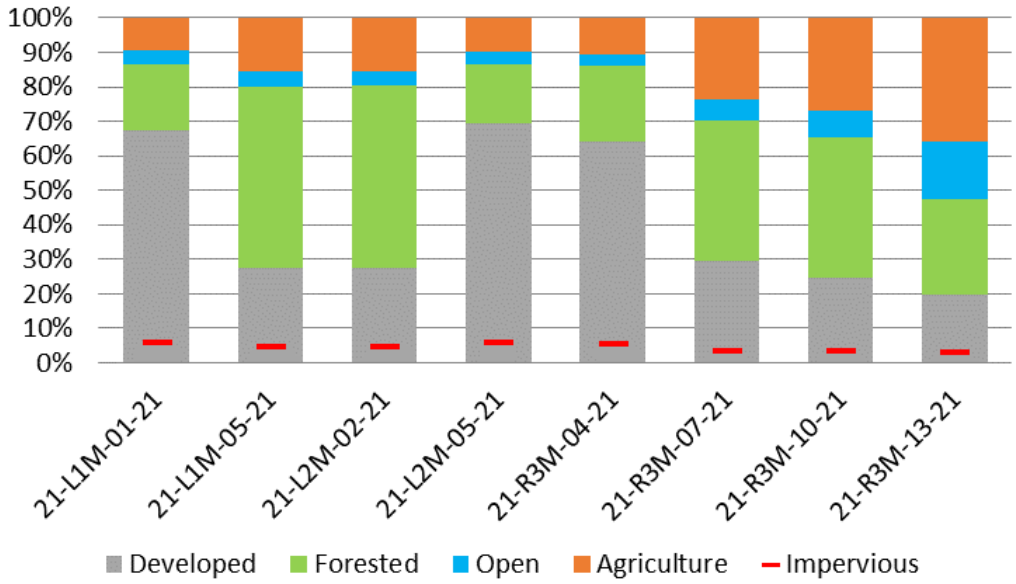

Figure 14 – Ferry Branch land use (n=8)

4.2.2 Physical Habitat

Physical habitat conditions during the spring season were generally impaired for this sampling unit. Based on the RBP scores, 50% of the Ferry Branch sites received a rating of 'Non-Supporting' and the remaining 50% received a rating of 'Partially Supporting' (Figure 15). The average RBP score for the Ferry Branch sampling unit was 104.13 ± 11.33 (Table 16), and the corresponding narrative rating was 'Partially Supporting'. Individual site scores ranged from 124 ('Partially Supporting') to 91 ('Non-Supporting').

According to the PHI (summer), 25% of the Ferry Branch sites were rated as 'Partially Degraded', 62.5% received a rating of 'Degraded', and the remaining 12.5% rated 'Severely Degraded' (Figure 15). The

average PHI rating was 'Degraded' with a score of 61.11 ± 8.04. Individual site scores ranged from 48.34 ('Severely Degraded') to 74.49 ('Partially Degraded'). Ferry Branch did not have any sites scoring in the highest 'Minimally Degraded' category. Instream habitat and epifaunal substrate generally scored in the 'Marginal' category; Ferry Branch had the lowest mean for PHI habitat assessment for the 2021 sampling year. Remoteness was mostly in the 'Marginal' category with one site in the 'Poor' category and two in the 'Suboptimal' category. The scaled metric for number of rootwads and woody debris scored above 85% at five of the eight sites. Bank stability exceeded 65% at only two sites. Percent shading metric scored above 70% at half of the sites. Embeddedness was high at the Ferry Branch sites, with all sites scoring 65% or more in 2021.

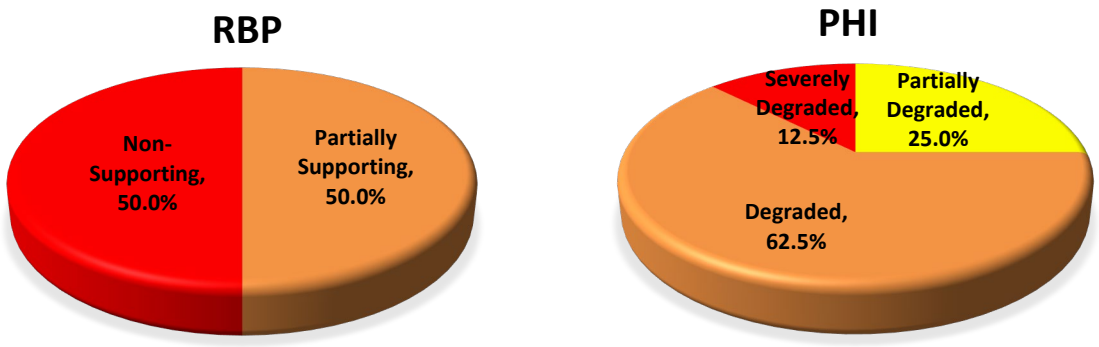

Figure 15 – Ferry Branch Physical Habitat Conditions (RBP n=8; PHI n=8)

4.2.3 Benthic Macroinvertebrates

Ferry Branch had the highest BIBI average out of the five sampling units in 2021. The Ferry Branch sampling unit received a BIBI narrative rating of 'Fair' with an average score of 3.29 ± 0.55 (Table 16). The majority of individual sites (75%) received a biological condition rating of 'Fair', 12.5% of the sites rated 'Good', and the remaining 12.5% received a 'Poor' rating (Figure 16). Individual BIBI scores ranged from 2.43 ('Poor') to 4.14 ('Good'). Site-specific data and assessment results can be found in Appendix D.

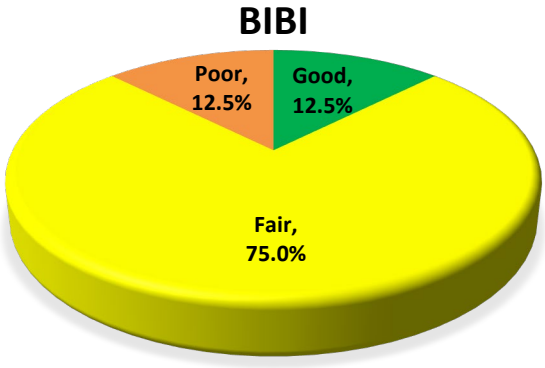

Figure 16 – Ferry Branch BIBI Conditions (n=8)

Site 21-R3M-13-21 received the lowest BIBI score of all Ferry Branch sites (2.43) with a narrative rating of 'Poor' (Figure 17). This site had only 10 total taxa, only one of which were in the EPT group. Additionally, very small percentages of intolerant taxa were observed at this site. In contrast, site 21-R3M-10-21 received the highest BIBI score (4.14; 'Good') in the Ferry Branch sampling unit. This site had seven EPT taxa, three Ephemeroptera taxa, and two scraper taxa from a total of 22 taxa present, with 19.4% of the sample consisting of climber taxa.

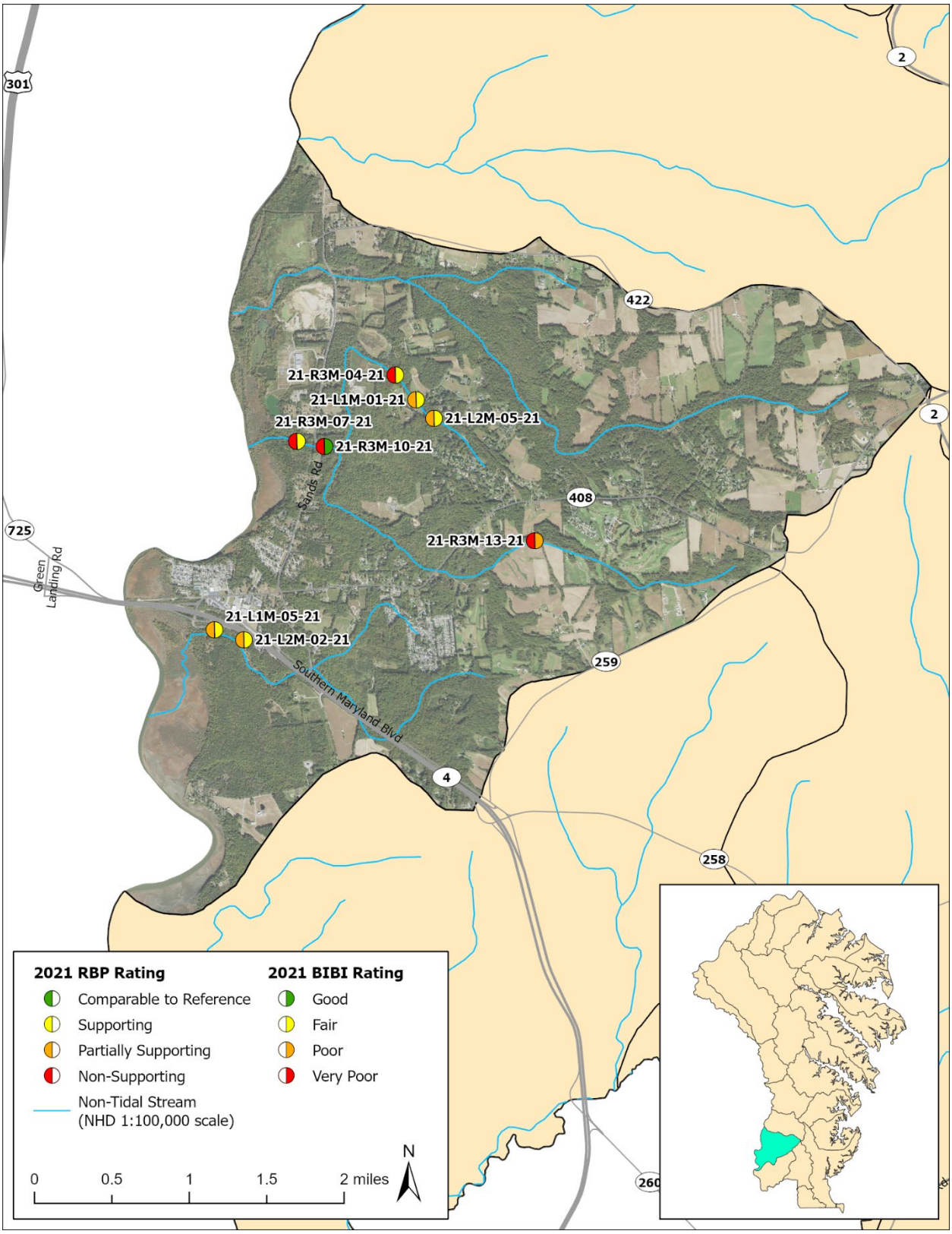

Figure 17 – Ferry Branch Sampling Sites (BIBI and RBP)

4.2.4 Fish

The Ferry Branch sampling unit received the highest FIBI score out of all five sampling units. Ferry Branch received a FIBI narrative rating of 'Fair' with an average score of 3.79 ± 0.67 (Table 16). Fifty percent of the individual sites sampled in this unit received a biological condition rating of 'Good', and 50% of sites were rated as 'Fair' (Figure 18). Individual FIBI scores ranged from 3.00 ('Fair') to 4.67 ('Good'). Site-specific data and assessment results can be found in Appendix D.

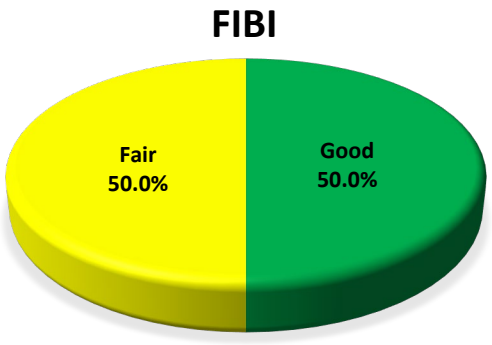

Figure 18 – Ferry Branch FIBI conditions (n=8)

Sites 21-L1M-01-21 and 21-L2M-05-21 received the lowest FIBIs score of all Ferry Branch sites (3.00) with narrative ratings of 'Fair.' These site scored in the lowest category (1) for both percent round bodied suckers, and percent abundance of dominant taxon. In contrast, sites 21-L1M-05-21 and 21-L2M-02-21 received the highest FIBI score (4.67; 'Good') of sites in the Ferry Branch sampling unit, and also of all sites sampled during 2021. Both sites scored in the highest category for abundance per square meter, adjusted number of benthic species, percent tolerant, and percent abundance of dominant taxa. Site 21-L1M-05-21 scored in the middle category for percent generalist, omnivores, and invertivores. This site also had the highest diversity in the sampling unit with 15 species observed. Site 21-L2M-02-21 scored in the middle category for abundance per square meter and percent round bodied suckers. The Ferry Branch sampling unit had the highest FIBI score mean of all units sampled in 2021.

American Eel, Blacknose Dace, and Least Brook Lamprey, were the most widely distributed species in the sampling unit, present at all eight sites, followed by Eastern Mudminnow, and Tessellated Darter which were found at seven sites. The least common species in this sampling unit, only present at one site, were Bluespotted Sunfish (*Enneacanthus gloriosus*), Brown Bullhead, White Sucker, and Yellow Bullhead. Nineteen species were observed in the sampling unit with two non-native species (Bluegill, and Green Sunfish), and seventeen native species [American Eel, Blacknose Dace, Bluespotted Sunfish, Brown Bullhead, Creek Chubsucker, Eastern Mosquitofish, Eastern Mudminnow, Fallfish, Least Brook Lamprey, Pumpkinseed, Rosyside Dace, Satinfin Shiner, Sea Lamprey (*Petromyzon marinus*), Swallowtail Shiner (*Notropis procne*), Tessellated Darter, White Sucker, and Yellow Bullhead]. One round-bodied sucker species (Creek Chubsucker) and two benthic fish (Tessellated Darter, and Least Brook Lamprey) were present in this sampling unit. Three species considered intolerant to pollution (Fallfish, Satinfin Shiner, and Sea Lamprey) were present in this sampling unit.

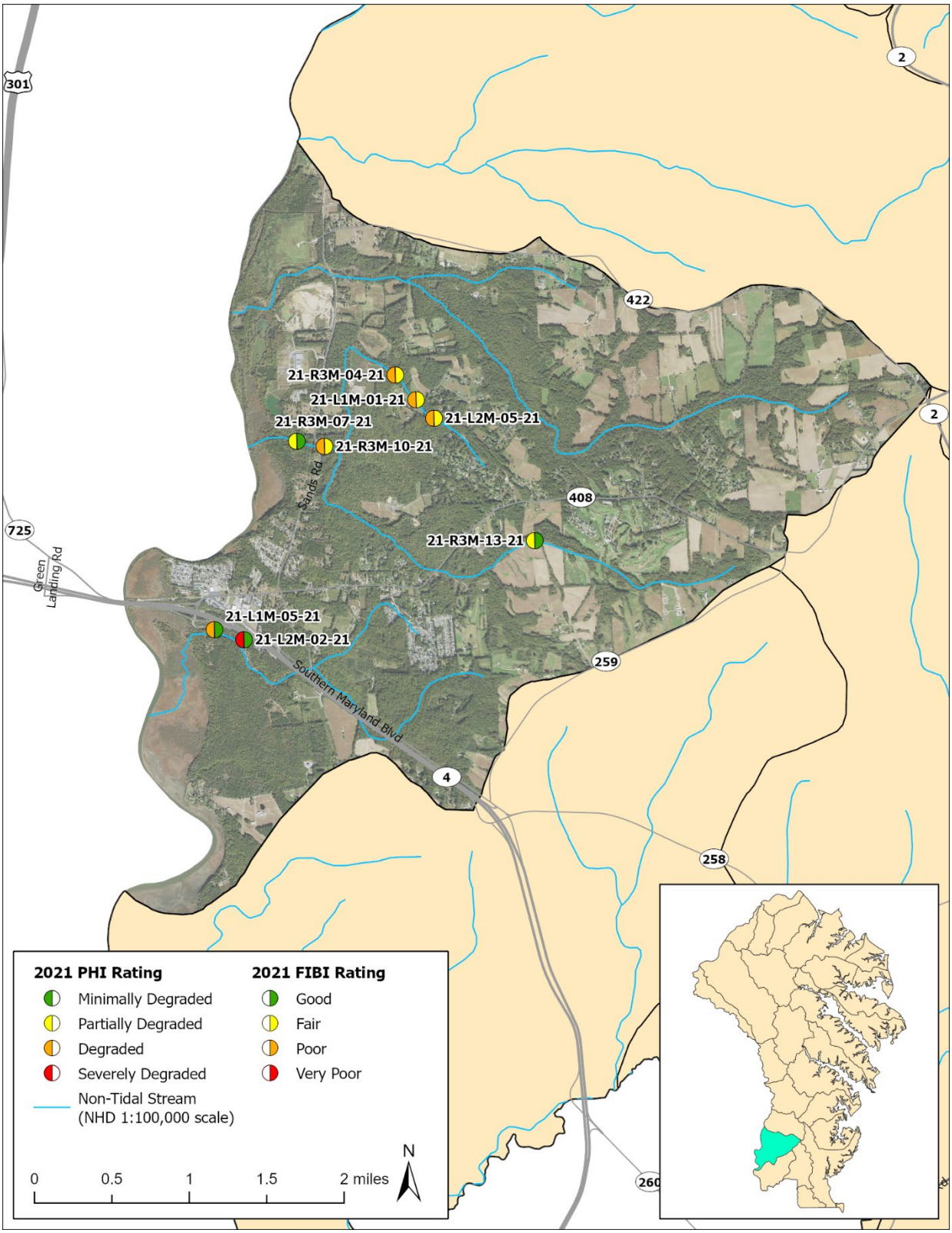

Figure 19 – Ferry Branch (FIBI and PHI)

4.2.5 Water Quality

Average spring and summer *in situ* water quality values for the Ferry Branch sites are provided in Table 20. Of the eight sites sampled, one site did not meet COMAR standards for water quality in the spring. The pH at site 21-L2M-05-21 was lower than the COMAR standard (i.e., 6.5-8.5 SU), with a value of 6.35 SU. In the spring, water temperature ranged from 6.00 to 17.10 °C; DO ranged from 10.40 to 13.96 mg/L; pH ranged from 6.35 to 6.89 SU; specific conductance ranged from 143.8 to 272.8 µS/cm; and turbidity ranged from 4.25 to 10.20 NTU.

In the summer, all eight Stony Run sites were sampleable. One site did not meet COMAR standards for water quality in the summer. Site 21-R3M-07-21 measured outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 6.48. In the summer, water temperature at Ferry Branch sites ranged from 21.50 to 27.60 °C; DO ranged from 5.46 to 8.26 mg/L; pH ranged from 6.48 to 7.09 SU; specific conductance ranged from 188.3 to 319.9 µS/cm; and turbidity ranged from 3.67 to 18.10 NTU.

Table 20 - Average *in situ* water quality values – Ferry Branch

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	12.13 ± 4.03	11.64 ± 1.36	6.68 ± 0.19	239.5 ± 42.3	6.48 ± 1.93
Summer	23.39 ± 2.02	7.08 ± 0.90	6.76 ± 0.22	253.8 ± 51.0	8.91 ± 5.25

Average spring grab sample water quality values for the Ferry Branch 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. All Ferry Branch sites fell in the low to moderate categories used by MBSS for ammonia, total nitrogen, nitrate, and nitrite. Comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. Sites 21-L1M-01-21, 21-L1M-05-21, 21-L2M-02-21, 21-L2M-05-21, 21-R3M-10-21, and 21-R3M-13-21 had total phosphorus concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L) with values ranging from 0.0826 to 0.1358 mg/L. The remaining two sites sampled in 2021 had total phosphorus concentrations that fell in the moderate category used by MBSS (i.e., 0.025-0.070 mg/L). Sites 21-L2M-05-21, 21-R3M-10-21, and 21-R3M-13-21 had orthophosphate levels in the high category used by MBSS (i.e., > 0.03 mg/L) with values of 0.0304, 0.0357, and 0.0526 mg/L, respectively. All other orthophosphate values were in the moderate category used by MBSS (i.e., 0.008-0.03 mg/L). No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.070 to 2.480 mg/L; TOC ranged from 2.134 to 2.798 mg/L; magnesium ranged from 2.557 to 3.866 mg/L; calcium ranged from 10.01 to 14.45 mg/L; and hardness ranged from 36.51 to 46.97 mg/L.

Table 21 - Average grab sample water quality values – Ferry Branch

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)
29.17 ± 8.30	0.0913 ± 0.027	1.2494 ± 0.3034	0.0269 ± 0.0129	0.0208 ± 0.0119	0.0039 ± 0.0020	1.1194 ± 0.3083	2.319 ± 0.124
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)
2.440 ± 0.211	3.010 ± 0.465	11.06 ± 1.48	40.01 ± 4.24	0.459 ± 0.078	9.2 ± 2.5	0.193 ± 0.060	6.04 ± 2.38

4.2.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results are presented in Appendix A. The majority of sites in the Ferry Branch sampling unit were entrenched F type channels (75.0%; Figure 20). Slightly entrenched E type channels and DA type channel both represented 12.5% of the sites surveyed.

All sites within the Ferry Branch sampling unit had stream bed substrate dominated by sand, gravel, or a mix of the two (25.0%, 12.5%, and 37.5% respectively). The average D_{50} within the Ferry Branch sampling unit was 0.75 mm (coarse sand). Streams in this sampling unit had an average slope of 0.49%, with individual slopes ranging from 0.25% to 0.82%.

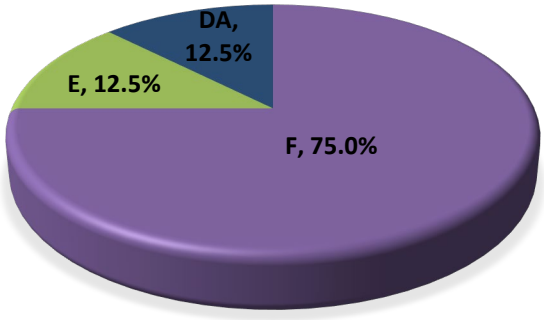

Figure 20 - Rosgen stream types observed in Ferry Branch (n=8)

4.3 Hall Creek

The Hall Creek sampling unit is located along the southern edge of the County in Friendship, Maryland. The sampling unit drains directly into the Patuxent River, which then drains into the Chesapeake Bay (Figure 1). The Hall Creek sampling unit has a total drainage area of 3,168 acres, the smallest of the 2021 sampling units. The eight sampling sites have drainage areas that range from 59 to 1,455 acres.

4.3.1 Land Use

The Hall Creek sampling unit was 40% forested land, followed by developed land (35%), agriculture (22%), and 3% open space (Table 17). The land use distribution within the sampling unit differed slightly when compared to the average land use among sites, which had higher average agriculture and developed land, and lower average forest cover. Developed land was the primary land use type at four sites, forested land was the primary land use type at three sites, and one site was primarily agriculture (Figure 21). On average, the eight sites in the Hall Creek sampling unit were comprised of 39% developed land, 34% forested land,

23% agriculture, and 3% open space. Impervious surfaces accounted for only 3% of the Hall Creek sampling unit, with individual sites ranging from 2% to 5% impervious surfaces.

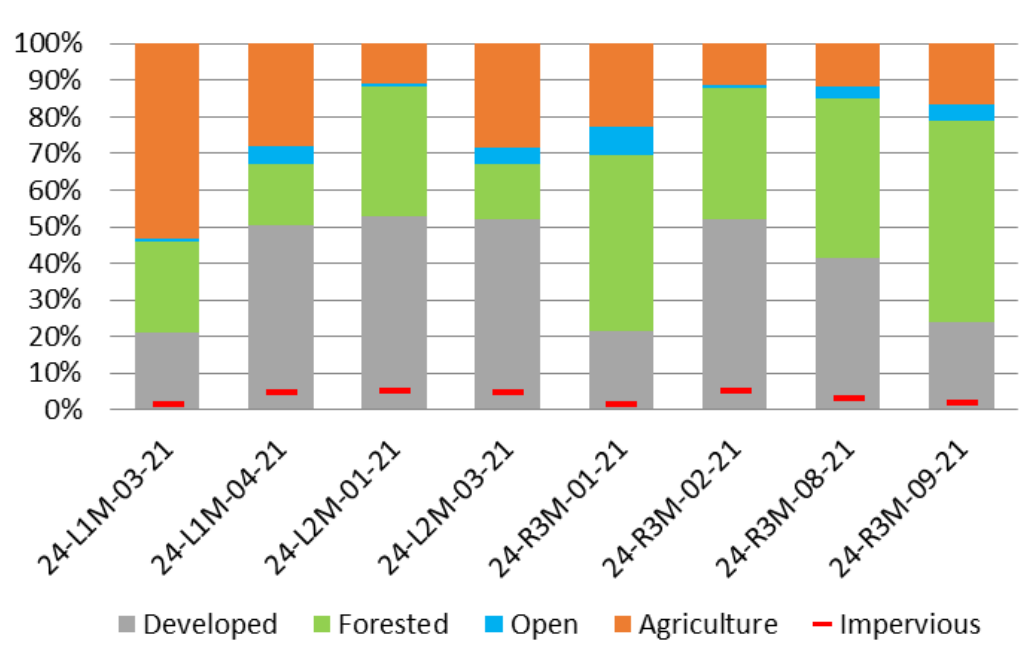

Figure 21 – Hall Creek land use (n=8)

4.3.2 Physical Habitat

Based on the RBP scores, 37.5% of the Hall Creek sites received a rating of 'Partially Supporting,' while 62.5% of sites were classified as 'Non-Supporting' (Figure 22). The average RBP score for the Hall Creek sampling unit was 97.63 ± 9.02, and the corresponding narrative rating was 'Non-Supporting.' Individual site scores ranged from 86 ('Non-Supporting') to 109 ('Partially Supporting'). This sampling unit had no sites rated as 'Comparable to Reference' in 2021.

According to the PHI (summer), 62.5% of the Hall Creek 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 66.86 ± 3.66. Individual site scores ranged from 60.32 ('Degraded') to 71.60 ('Partially Degraded'). The majority of sites sampled received 'Marginal' to 'Poor' scores for both instream habitat and epifaunal substrate. Bank stability scored in the 'Suboptimal' to 'Marginal' categories for most sites. Embeddedness scored 100% at six of the eight sites with the remaining two sites scoring at 60% and 80%.

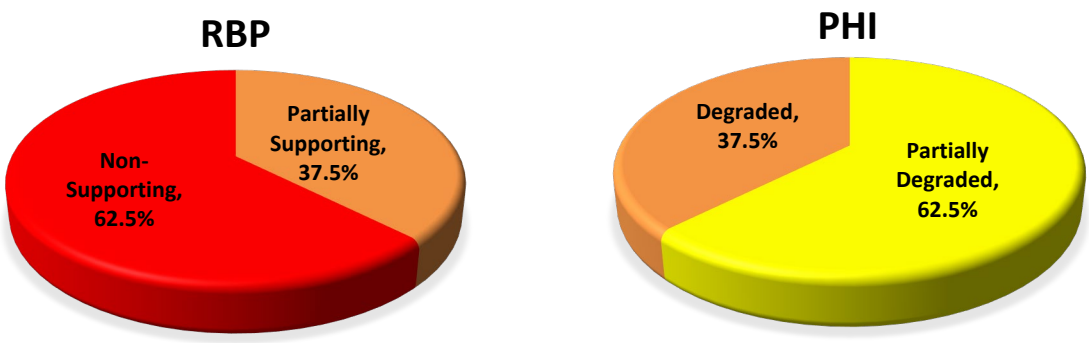

Figure 22 – Hall Creek Physical Habitat Conditions (RBP n=8; PHI n=8)

4.3.3 Benthic Macroinvertebrates

The average BIBI rating for the Hall Creek sampling unit is 'Poor' with an average BIBI score of 2.18 ± 0.69 (Table 16), the lowest mean BIBI of the five sampling units. Individual sites ranging from a low of 1.29 ('Very Poor') to 3.57 ('Fair'). Half of sites (50.0%) received a BIBI rating of 'Poor', 37.5% of the sites were rated as 'Very Poor', and the remaining 12.5% of sites were rated as 'Fair' (Figure 23). Site-specific data and assessment results can be found in Appendix D.

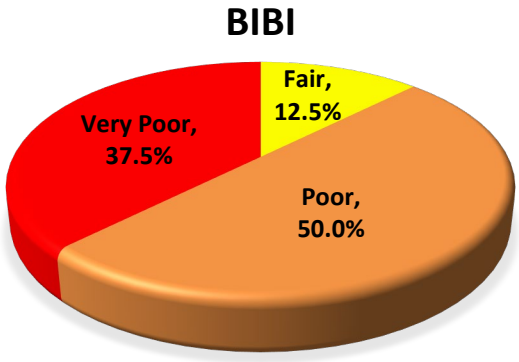

Figure 23 – Hall Creek BIBI Conditions (n=8)

Site 24-R3M-01-21 received the lowest BIBI score of all sites sampled during 2021 at 1.29 with a 'Very Poor' narrative rating (Figure 24). The site had a moderate taxa diversity (14 taxa), but completely lacked Ephemeroptera species; scraper and climber taxa were also absent from this site. Only 4.5% of intolerant organisms were present at this site. In contrast, site 24-R3M-08-21 received the highest BIBI score of Hall Creek sites (3.57), primarily due to four EPT taxa, two Ephemeroptera species, two scraper taxa, and 38.5% of the sample consisting of climbers. Only three sites in the Hall Creek sampling unit had Ephemeroptera taxa and only three had scraper taxa in the sample.

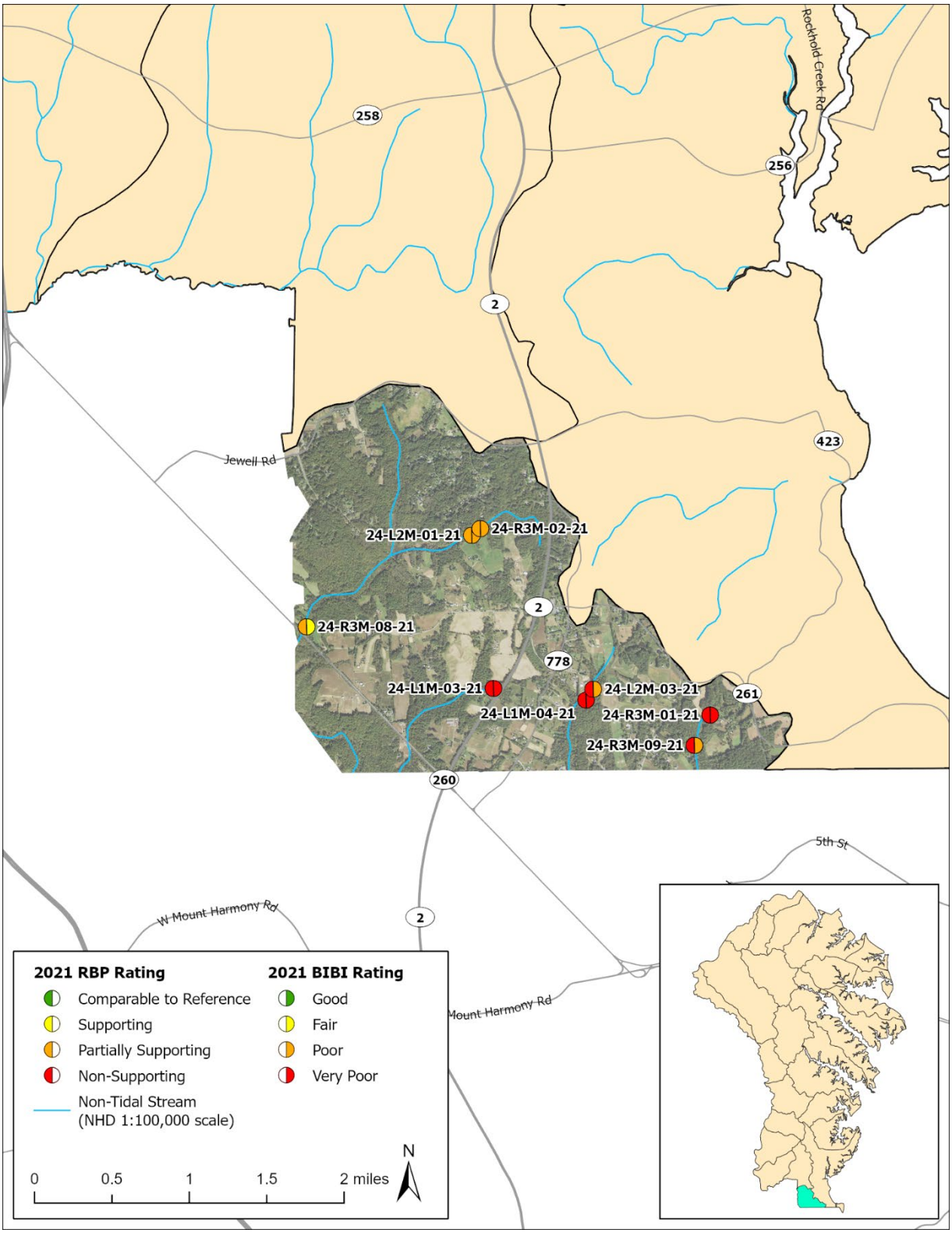

Figure 24 – Hall Creek Sampling Sites (BIBI and RBP)

4.3.4 Fish

The Hall Creek sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.13 ± 0.59 (Table 16). Of the sites in this sampling unit, 12.5% received a biological condition rating of 'Fair', while 62.5% received a rating of 'Poor', and 25.0% received a 'Very Poor' rating (Figure 25). Individual FIBI scores ranged from 1.33 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

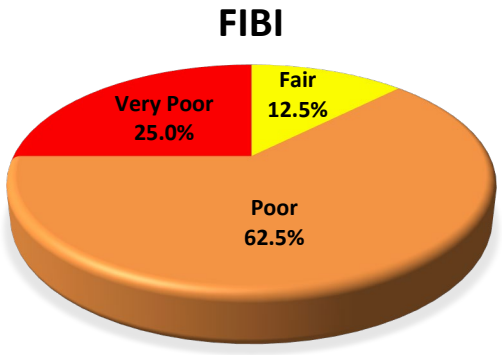

Figure 25 – Hall Creek FIBI Conditions (n=8)

Site 24-R3M-09-21 received the lowest FIBI scores of Hall 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. Site 24-R3M-08-21 received the highest FIBI score (3.33; 'Fair') in the Hall Creek sampling unit. This site scored in the highest category for adjusted number of benthic species, percent round bodied suckers, and percent abundance of dominant taxon; in the middle category for percent tolerant; and in the lowest category for abundance per square meter and percent generalist, omnivores, invertivores. This site also had the highest diversity in the sampling unit with fourteen species observed.

Blacknose Dace was the most widely distributed species in the Hall Creek sampling unit, present at each of the eight sites. Eastern Mudminnow, and Pumpkinseed were both found at four of the eight sites. The least common species in this sampling unit were Creek Chub, Creek Chubsucker, Fallfish, Warmouth (*Lepomis gulosus*), Yellow Bullhead, each found only at a single site. Fourteen species were observed in the sampling unit with two non-native species (Bluegill, and Green Sunfish), and twelve native species [American Eel, Blacknose Dace, Creek Chub, Creek Chubsucker, Eastern Mosquitofish, Eastern Mudminnow, Fallfish, Golden Shiner (*Notemigonus crysoleucas*), Pumpkinseed, Tessellated Darter, Warmouth, and Yellow Bullhead]. One round-bodied sucker species (Creek Chubsucker) was present, along with one benthic fish (Tessellated Darter) in this sampling unit. One species considered intolerant to pollution (Fallfish) was present.

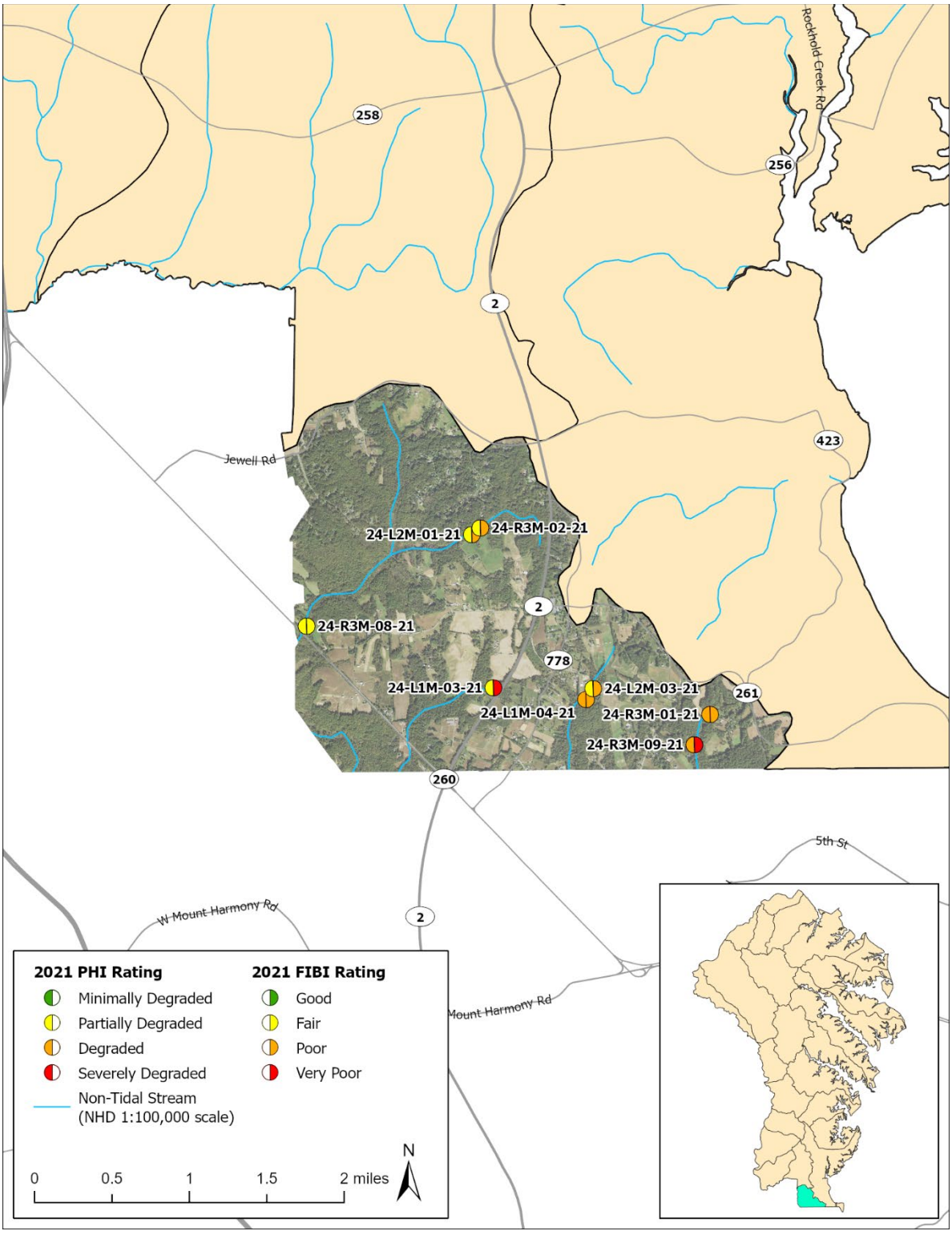

Figure 26 – Hall Creek Sampling Sites (FIBI and PHI)

4.3.5 Water Quality

Average spring and summer *in situ* water quality values for the Hall Creek sites are provided in Table 22. All eight sites sampled met COMAR standards for water quality in the spring. Water temperature ranged from 8.00 to 16.80 °C; DO ranged from 9.68 to 12.51 mg/L; pH ranged from 6.61 to 7.45 SU; specific conductance ranged from 129.0 to 239.0 µS/cm; and turbidity ranged from 5.60 to 14.80 NTU.

In the summer, all eight sites in the Hall Creek sampling unit were sampleable. Two sites did not meet COMAR standards for water quality. Site 24-R3M-09-21 measured outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) with a value 6.37 SU. Sites 24-R3M-01-21 and 24-R3M-09-21 had values lower than the acceptable COMAR standard (i.e., ≥ 5 mg/L) for DO, with measurements of 3.20 and 3.80, respectively. Water temperature ranged from 16.80 to 22.40 °C; DO ranged from 3.20 to 8.66 mg/L; pH ranged from 6.37 to 7.69 SU; specific conductance ranged from 178.0 to 422.0 µS/cm; and turbidity ranged from 5.10 to 21.20 NTU.

Table 22 - Average *in-situ* water quality values – Hall Creek

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	11.48 ± 3.05	11.25 ± 0.86	7.15 ± 0.29	182.4 ± 40.2	9.58 ± 2.95
Summer	20.50 ± 1.82	7.08 ± 2.22	7.21 ± 0.42	241.9 ± 86.6	13.33 ± 5.90

Average spring grab sample water quality values for the Hall Creek 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 Hall Creek sites fell in the low to moderate categories used by MBSS for total nitrogen, nitrate, and nitrite. Comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. One site, 24-L1M-03-21, had an ammonia concentration value that fell in the high category used by MBSS (> 0.07 mg/L) with a value of 0.0781. Sites 24-L1M-03-21, 24-L1M-04-21, 24-L2M-01-21, 24-L2M-03-21, 24-R3M-02-21, 24-R3M-08-21, and 24-R3M-09-21 had total phosphorus concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L), with values ranging from 0.0994 to 0.1320 mg/L. The remaining site sampled in 2021 had a total phosphorus concentration that fell in the moderate category (i.e., 0.025-0.070 mg/L). Sites 24-R3M-02-21 and 24-R3M-09-21 had orthophosphate levels in the high category used by MBSS (i.e., >0.03 mg/L) with values of 0.0340 and 0.0409 mg/L, respectively. All other orthophosphate values were in the low to 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 1.906 to 3.863 mg/L; TOC ranged from 1.956 to 4.160 mg/L; magnesium ranged from 1.793 to 2.907 mg/L; calcium ranged from 11.55 to 21.34 mg/L; and hardness ranged from 40.81 to 61.01 mg/L.

Table 23 - Average grab sample water quality values – Hall 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)
22.40 ± 8.56	0.1051 ± 0.0228	1.0257 ± 0.6865	0.0229 ± 0.0124	0.0405 ± 0.0218	0.0043 ± 0.0017	0.7732 ± 0.6578	2.986 ± 0.847
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)
3.078 ± 0.858	2.181 ± 0.349	17.19 ± 3.31	51.90 ± 7.27	0.473 ± 0.194	3.5 ± 1.2	0.302 ± 0.070	12.48 ± 2.01

4.3.6 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. There was an equal proportion of sites in the Hall Creek sampling unit that were classified as entrenched F and G type channels, moderately entrenched B type channels, and slightly entrenched C type channels (25.0% each; Figure 27).

All sites within the Hall Creek sampling unit had stream bed substrate dominated by sand, gravel, or a mix of the two (75.0%, 12.5%, and 12.5% respectively). The average D_{50} within the Hall Creek sampling unit was 0.38 mm (medium sand). Streams in this sampling unit had an average slope of 0.60%, with individual slopes ranging from 0.13% to 1.60%.

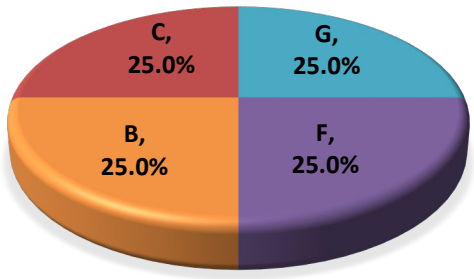

Figure 27- Rosgen stream types observed in Hall Creek (n=8)

4.4 Herring Bay

The Herring Bay sampling unit is located in the most southeastern portion of the County (Figure 1) near Deale, Maryland. The sampling unit drains directly into the Chesapeake Bay, just south of Shady Side, Maryland. The Herring Bay sampling unit has a total drainage area of 14,595 acres, the largest of the 2021 sampling units. The eight sites shown in Figure 31 have drainage areas ranging from 31 to 3,043 acres.

4.4.1 Land Use

Land use in the Herring Bay sampling unit was primarily comprised of forested land (50%), followed by developed land (30%), agriculture (10%) and 9% open space (Table 17). On average, sites in the Herring Bay sampling unit had a similar percentage of forested land (51%), slightly higher developed land (36%) and slightly lower agriculture (8%) and open space (5%) than the overall sampling unit (Figure 28). Forested land was the most dominant cover type for six sites and developed land was the most dominant cover type for the remaining two sites. Herring Bay had 5% impervious surfaces, and the individual sites ranged from 1% to 5% impervious surfaces.

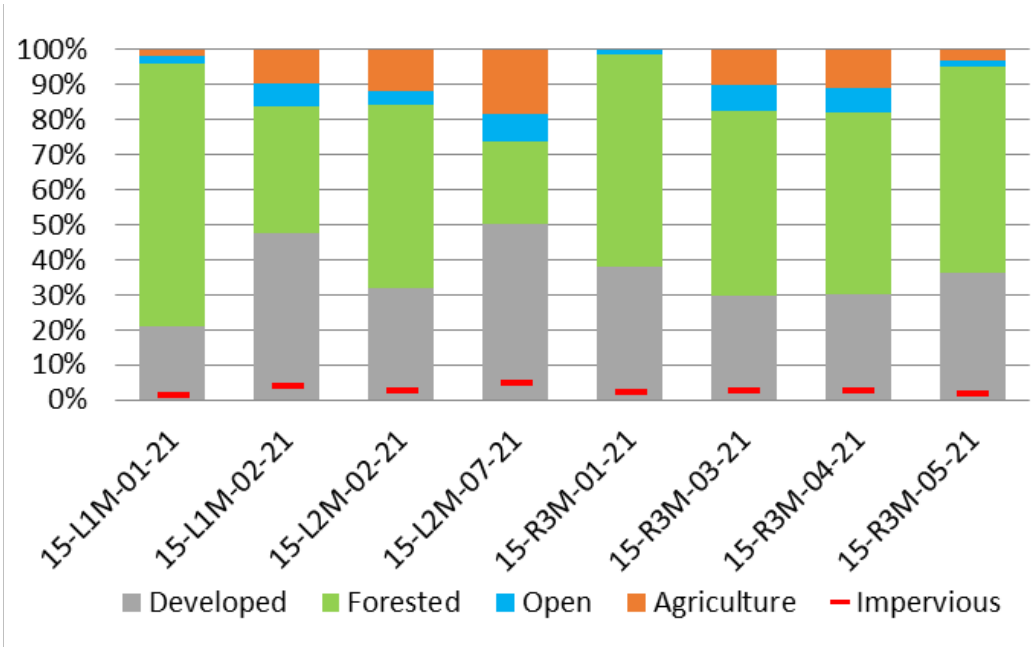

Figure 28 – Herring Bay land use (n=8)

4.4.2 Physical Habitat

Based on the RBP index assessed during the spring season, the majority of sites were rated 'Partially Supporting' (62.5%), and 37.5% were 'Supporting' (Figure 29). With an average RBP score of 118.13 ± 12.33 and a narrative rating of 'Partially Supporting'. RBP scores ranged from a minimum of 104 ('Partially Supporting') to a maximum of 134 ('Supporting').

The PHI (summer season) rated 50.0% of sites as 'Partially Degraded', and 50.0% of sites as 'Degraded' (Figure 29). The average PHI rating was 'Degraded' with a score of 64.25 ± 6.65 and was the second lowest mean PHI rating of the units sampled during 2021. Individual PHI scores ranged from 54.74 ('Degraded') to 76.11 ('Partially Degraded'). The majority of sites assessed received 'Marginal' to 'Poor' scores for

instream habitat, and epifaunal substrate. Bank stability was rated as 'Marginal' or 'Suboptimal' for most sites with one site rated as 'Optimal' and two sites rated as 'Poor'. Embeddedness was consistent at the Herring Bay sites, with all sites scoring 100%.

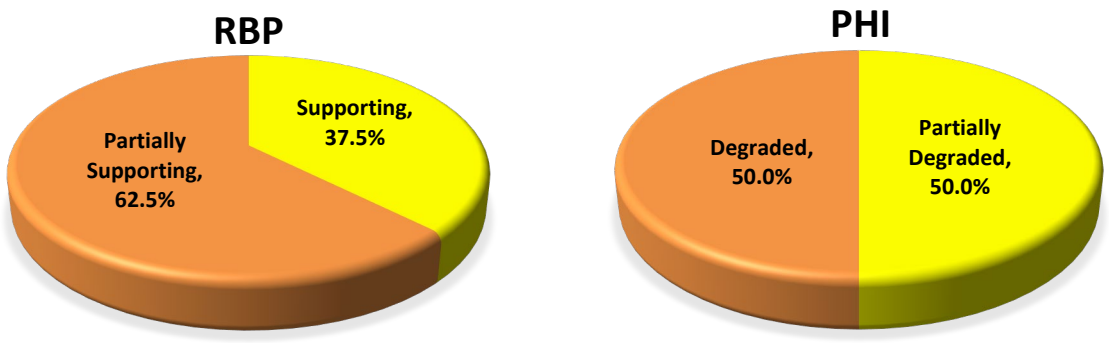

Figure 29 – Herring Bay Physical Habitat Conditions (RBP n=8; PHI n=8)

4.4.3 Benthic Macroinvertebrates

Among the Herring Bay sampling unit sites, a 25% split in all four categories occurred with two sites each receiving ratings of 'Good', 'Fair', 'Poor', and 'Very Poor' (Figure 30). The average BIBI score for the sampling unit was 3.00 ± 1.08, resulting in a 'Fair' biological condition rating (Table 16). Individual BIBI scores ranged from 1.57 ('Very Poor') to 4.43 ('Fair'). Herring Bay had two sites which scored the highest BIBI score observed during 2021, 4.43. Individual site data and assessment results can be found in Appendix D.

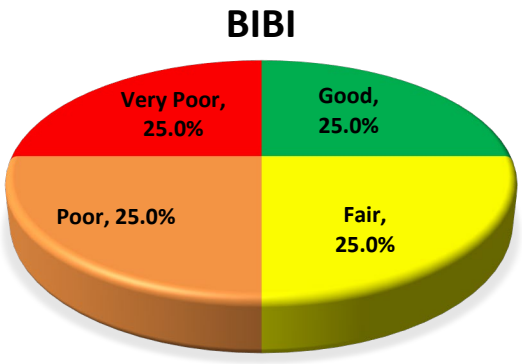

Figure 30 – Herring Bay BIBI Conditions (n=8)

Site 15-R3M-01-21 received the lowest BIBI score of 1.57 with a 'Very Poor' rating. Eleven taxa were present in this sample, none of which were Ephemeroptera or scraper taxa. In contrast, site 15-L2M-02-21 received the highest BIBI score for this sampling unit of 4.43, resulting in a 'Good' biological condition rating. This site had 27 total taxa, including seven EPT taxa, two Ephemeroptera taxon, and three scraper taxa. Ephemeroptera taxa were present at five of the eight sites sampled during 2021 in the Herring Bay sampling unit.

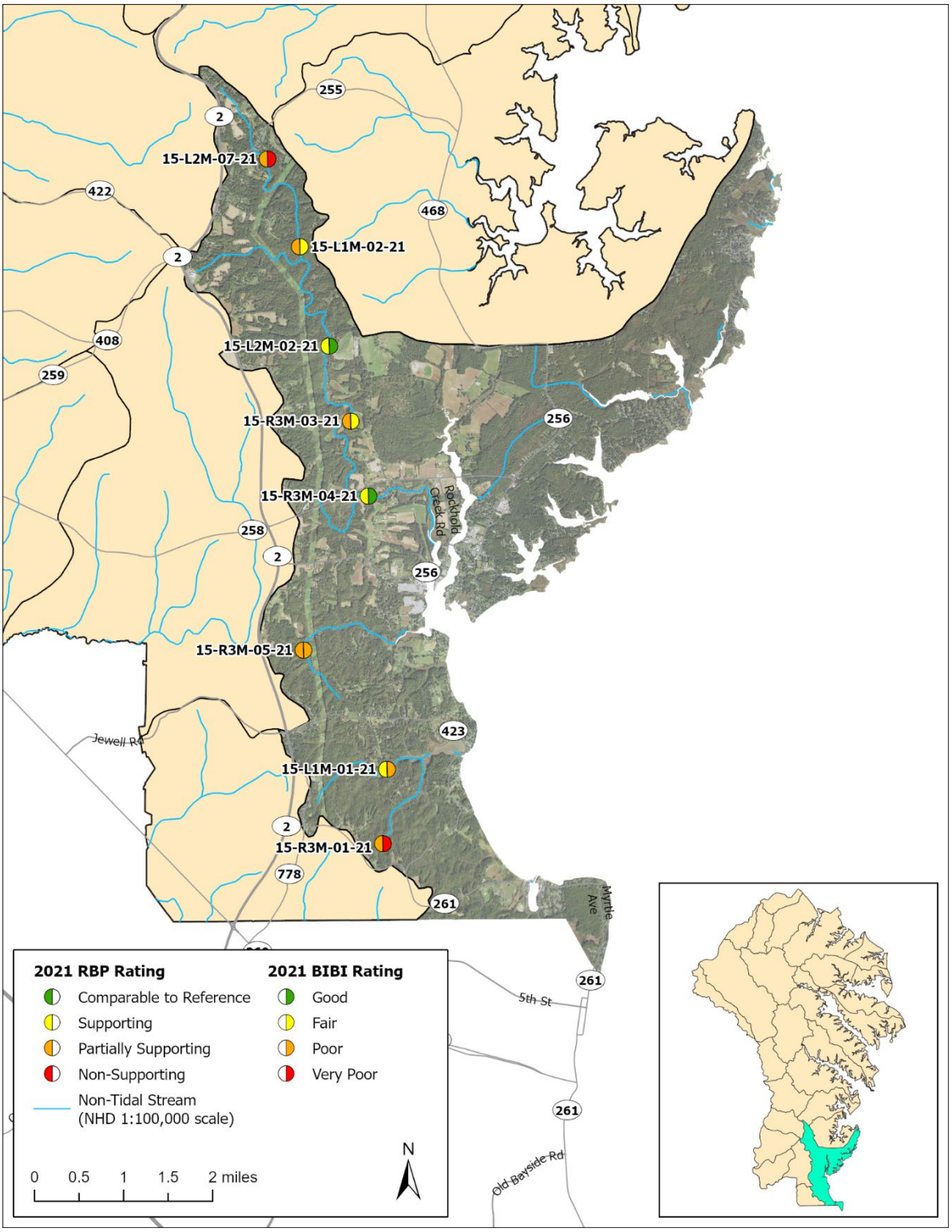

Figure 31 – Herring Bay Sampling Sites (BIBI and RBP)

4.4.4 Fish

The Herring Bay sampling unit received a FIBI narrative rating of 'Very Poor' with an average score of 1.71 ±0.55 (Table 16). A biological condition rating of 'Very Poor' was given to 50.0% of the sites, while the remaining 50.0% was rated as 'Poor' (Figure 32). Individual FIBI scores ranged from 1.00 ('Very Poor') to 2.33 ('Poor'). Site-specific data and assessment results can be found in Appendix D.

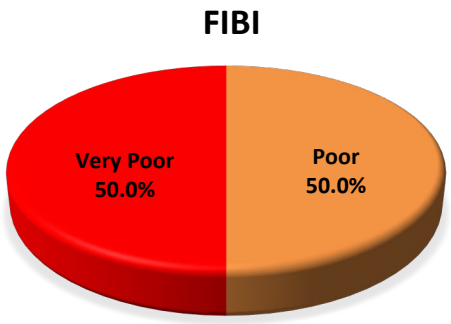

Figure 32 – Herring Bay FIBI Conditions (n=8)

Sites 15-L2M-07-21 and 15-R3M—03-21 both received the highest FIBI score (2.33; 'Poor') in the Herring Bay sampling unit. Both sites scored in the highest category (5) for percent abundance of dominant taxon while 15-R3M-03-21 also scored a (5) for percent tolerant organisms from the sample. The Herring Bay sampling unit had the lowest FIBI mean of all units sampled during the 2020 season (1.71; 'Very Poor'). Two sites, 15-R3M-01-21 and 15-R3M-05-21 received a FIBI score 1.00. The low FIBI score at site 15-R3M-01-21 was due to no fish being caught during sampling. MBSS scores sites as 1.00 where no fish were encountered during sampling even though there was water in the stream channel. Site 15-R3M-05-21 scored low in all metrics as only one single individual was captured.

Eastern Mosquitofish and Pumpkinseed were the most widely distributed species in the sampling unit, each present at six of the sites. Brown Bullhead was present at five of the eight sites. The least common species in this sampling unit were Black Crappie (*Pomoxis nigromaculatus*), Golden Shiner, Green Sunfish, Largemouth Bass (*Micropterus salmoides)* each found at only one site. Ten species were observed in the sampling unit with four non-native species (Black Crappie, Bluegill, Green Sunfish, and Largemouth Bass), and six native species (American Eel, Brown Bullhead, Eastern Mosquitofish, Eastern Mudminnow, Golden Shiner, and Pumpkinseed). No round-bodied suckers were present, and no benthic fish species were present. No species considered intolerant to urban stressors were found in this sampling unit.

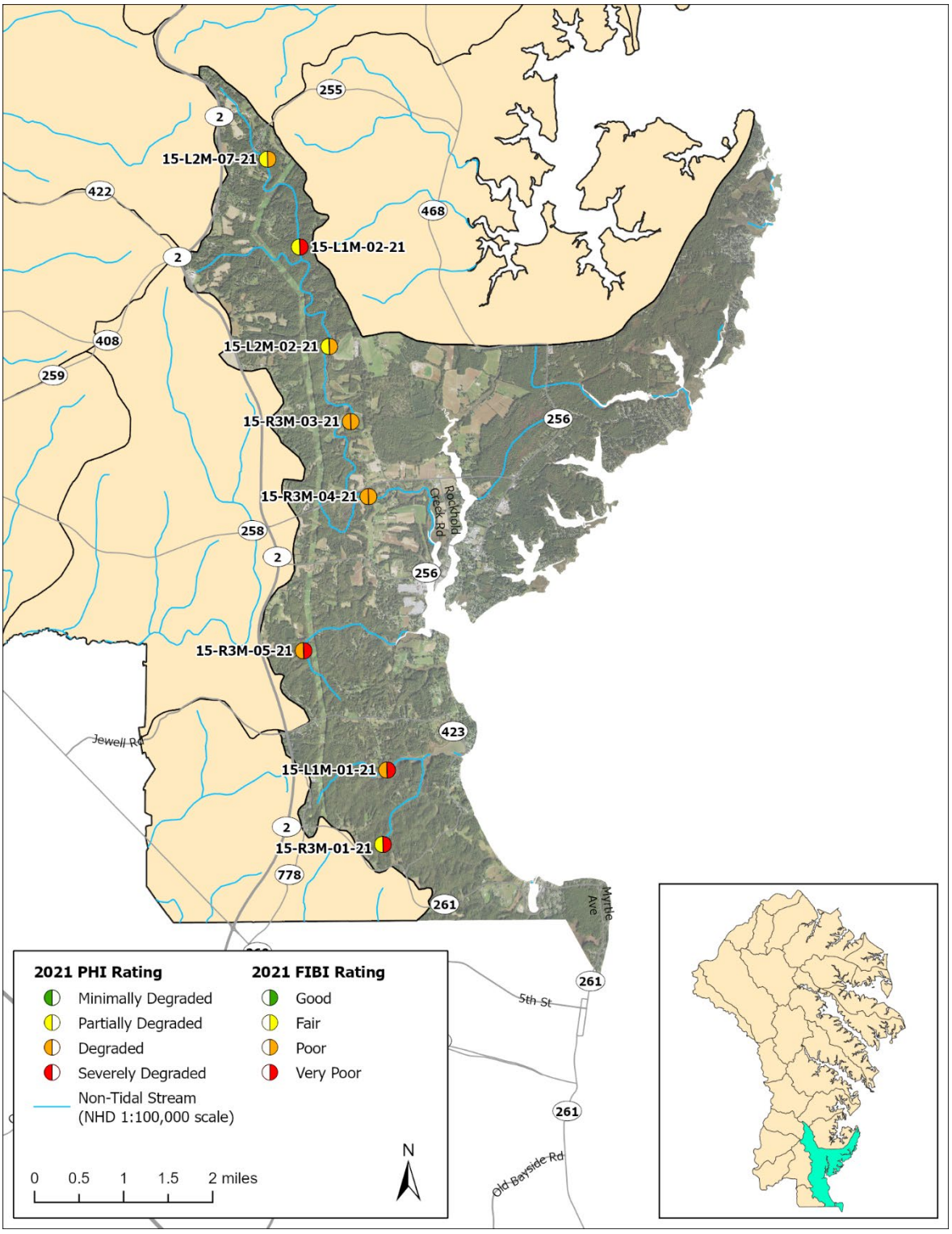

Figure 33 – Herring Bay Sampling Sites (FIBI and PHI)

4.4.5 Water Quality

Average spring and summer *in situ* water quality values for the Herring Bay sites are provided in Table 24. All eight sites sampled in the spring met COMAR standards for water quality. Spring water temperature ranged from 6.70 to 12.10 °C; DO ranged from 8.92 to 12.91 mg/L; pH ranged from 6.69 to 7.40 SU; specific conductance ranged from 138.0 to 350.0 µS/cm; and turbidity ranged from 3.40 to 19.90 NTU.

In the summer, all eight Herring Bay sites were sampleable. One site did not meet COMAR standards for water quality during the summer. Site 15-L1M-01-21 measured below the acceptable COMAR range for DO (i.e., ≥ 5 mg/L), with a value of 1.20 mg/L. In the summer, water temperature ranged from 14.60 to 27.10 °C; DO ranged from 1.20 to 9.42 mg/L; pH ranged from 6.28 to 7.32 SU; specific conductance ranged from 157.0 to 304.0 µS/cm; and turbidity ranged from 3.80 to 43.50 NTU.

Table 24 - Average *in-situ* water quality values – Herring Bay

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	9.08 ± 2.16	11.20 ± 1.31	6.94 ± 0.24	198.6 ± 69.3	10.09 ± 5.82
Summer	20.35 ± 4.15	7.18 ± 2.57	6.94 ± 0.35	218.5 ± 50.5	19.20 ± 12.11

Average spring grab sample water quality values for the Herring Bay sites are provided in Table 25. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. All Herring Bay sites fell in the low to moderate categories used by MBSS for ammonia, total nitrogen, nitrate, and nitrite. Comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. All eight sites sampled in 2021 had total phosphorus concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L) with values ranging from 0.0729 to 0.2207 mg/L. One site, 15-R3M-01-21, had orthophosphate levels in the high category used by MBSS (i.e., > 0.03 mg/L) with a value of 0.1567 mg/L. All other orthophosphate values were in the moderate category used by MBSS (i.e., 0.008-0.03 mg/L). No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.220 to 3.937 mg/L; TOC ranged from 2.209 to 4.005 mg/L; magnesium ranged from 2.095 to 5.790 mg/L; calcium ranged from 12.66 to 24.59 mg/L; and hardness ranged from 40.24 to 85.24 mg/L.

Table 25 - Average grab sample water quality values – Herring Bay

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)
25.83 ± 12.95	0.1368 ± 0.0560	0.7162 ± 0.3772	0.0351 ± 0.0495	0.0233 ± 0.0133	0.0037 ± 0.0012	0.4994 ± 0.3815	3.080 ± 0.655
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)
3.176 ± 0.671	2.943 ± 1.185	16.05 ± 3.97	52.19 ± 14.36	0.449 ± 0.121	5.4 ± 2.5	0.260 ± 0.157	12.24 ± 7.48

4.4.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of the sites assessed in the Herring Bay sampling unit were entrenched F type channels (37.5%; Figure 34). Slightly entrenched C and E type channels both represented 25.0% of the sites and a single entrenched G type channel represented the remaining 12.5% of the sites surveyed.

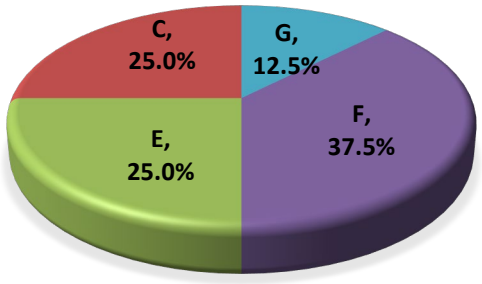

Figure 34 - Rosgen stream types observed in Herring Bay (n=8)

All sites within the Herring Bay sampling unit had stream bed substrate dominated by sand, silt/clay, or a mix of the two (37.5%, 50.0%, and 12.5% respectively). The average D_{50} within the Herring Bay sampling unit was 0.07 mm (very fine sand). Streams in this sampling unit had an average slope of 0.35%, with individual slopes ranging from 0.09% to 1.50%.

4.5 Lyons Creek

The Lyons Creek sampling unit is located in the southern portion of the County (Figure 1) near Tracy's Landing, Maryland. The sampling unit drains into the Patuxent River just south of Jug Bay Wetlands Sanctuary, which drains directly into the Chesapeake Bay. The Lyons Creek sampling unit has a total drainage area of 6,154 acres, with the eight sites shown in Figure 38 having drainage areas ranging from 92 to 3,786 acres.

4.5.1 Land Use

Land use in the Lyons Creek sampling unit was primarily comprised of forested land (35%), followed by agriculture (34%), developed land (27%), and 4% open space (Table 17). On average, sites had more agriculture (40%), a similar percentage of developed land (26%) and open space (4%), and less forested land (30%) than the overall sampling unit (Figure 35). Agriculture was the most dominant land use for six sites and forested land was the most dominant land use for the remaining two sites. Lyons Creek had 3% impervious surfaces, and the individual sites ranged from 2% to 4% impervious surfaces.

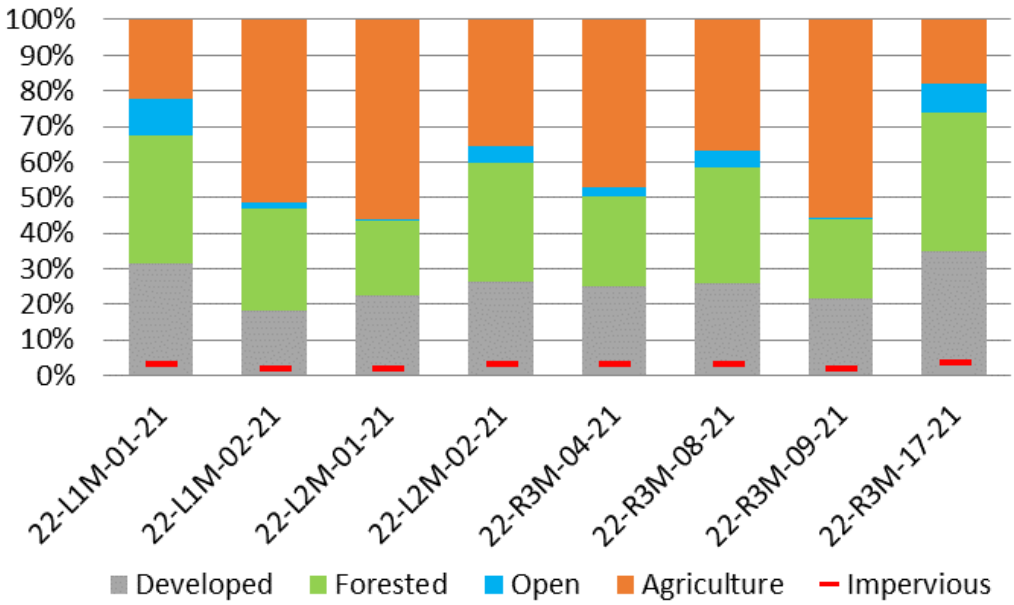

Figure 35 – Lyons Creek land use (n=8)

4.5.2 Physical Habitat

Based on the RBP index assessed during the spring season, the majority of sites were rated as 'Partially Supporting' (50.0%), 25.0% were rated as 'Supporting', and 25.0% were 'Non-Supporting' (Figure 29). With an average RBP score of 110.63 ± 13.86 and a narrative rating of 'Partially Supporting'. RBP scores ranged from a minimum of 93 ('Non-Supporting') to a maximum of 129 ('Supporting').

The PHI (summer season) rated 62.5% of sites as 'Partially Degraded', 25.0% of sites as 'Degraded', and 12.5% as 'Severely Degraded' (Figure 29). The average PHI rating was 'Partially Degraded' with a score of 67.47 ± 8.73. Individual PHI scores ranged from 50.67 ('Severely Degraded') to 77.49 ('Partially Degraded'). The majority of sites assessed received 'Marginal' to 'Poor' scores for instream habitat, epifaunal

substrate with three sites receiving 'Suboptimal' scores. Bank stability was rated as 'Marginal' or 'Poor' for most sites. Six of the eight sites had embeddedness scores of 80% or more, with two sites scoring 10% and 0%.

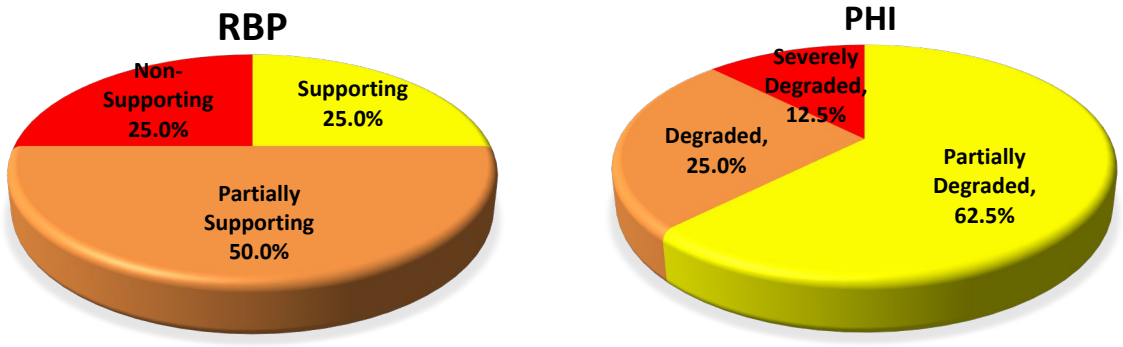

Figure 36 – Lyons Creek Physical Habitat Conditions (RBP n=8; PHI n=8)

4.5.3 Benthic Macroinvertebrates

Among the Lyons Creek sampling unit sites, 37.5% of the sites received 'Fair' BIBI ratings, 25.0% were rated as 'Good', 25.0% were rated as 'Poor', and the remaining 12.5% of sites received a 'Very Poor' rating (Figure 30). The average BIBI score for the sampling unit was 3.14 ± 0.86, resulting in a 'Fair' biological condition rating (Table 16). Individual BIBI scores ranged from 1.86 ('Very Poor') to 4.43 ('Fair'). Individual site data and assessment results can be found in Appendix D.

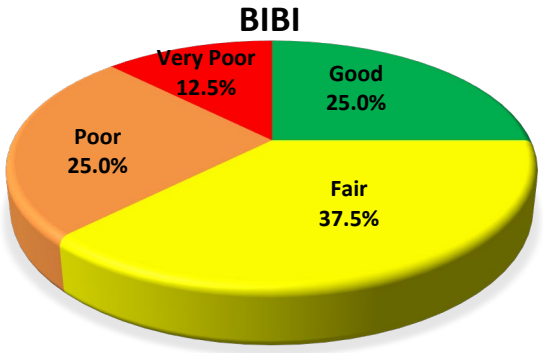

Figure 37 – Lyons Creek BIBI Conditions (n=8)

Site 22-R3M-17-21 received the lowest BIBI score of 1.86 with a 'Very Poor' rating. Thirteen taxa were present in this sample, none of which were Ephemeroptera or scraper taxa. In contrast, site 22-L2m-02-21 received the highest BIBI score for this sampling unit of 4.43, resulting in a 'Good' biological condition rating. This site had 19 total taxa, including six EPT taxa, two Ephemeroptera taxon, five scraper taxa, and 14.3% climber taxa. Ephemeroptera taxa were present at five of the eight sites sampled during 2021 in the Lyons Creek sampling unit, with percentages ranging from 0.84% to 37.5%.

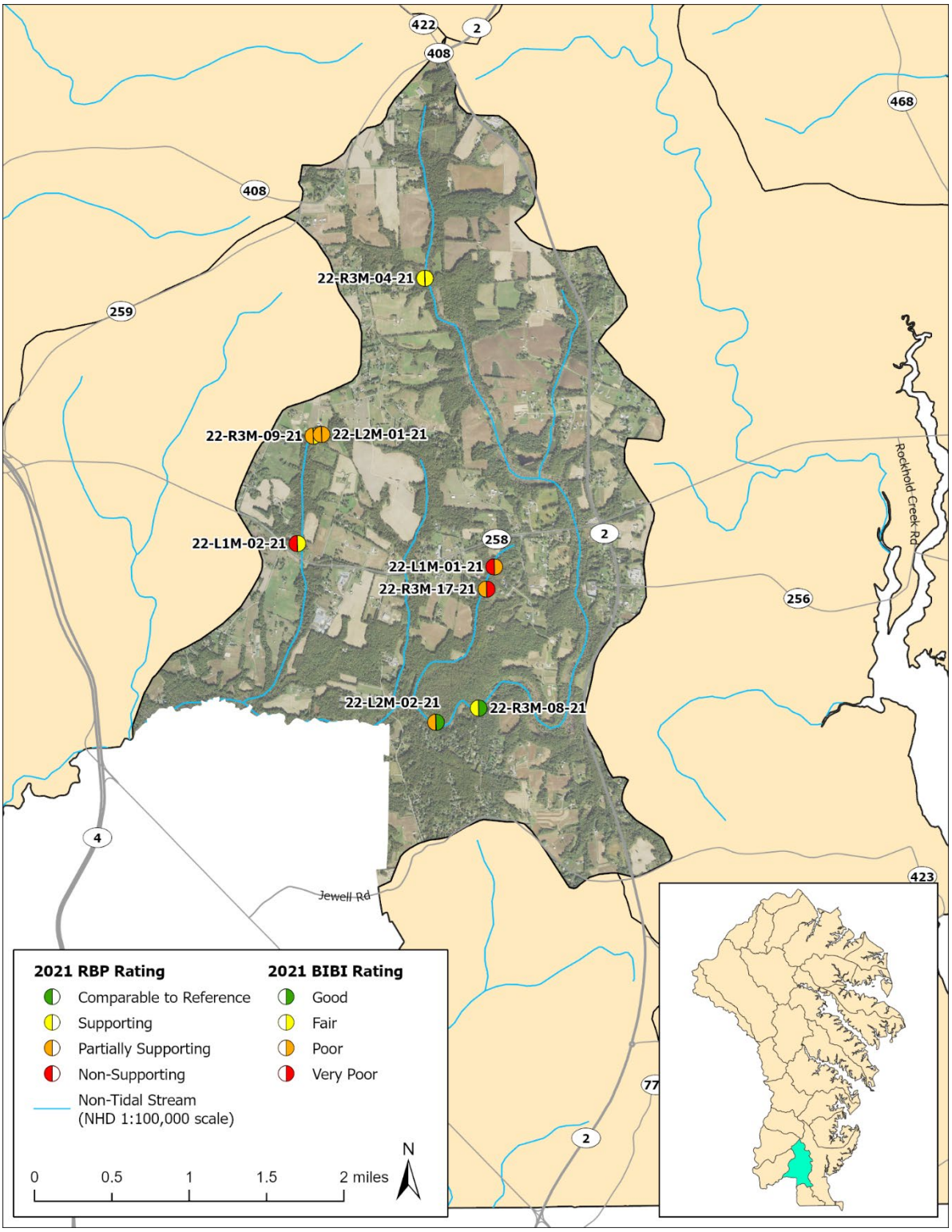

Figure 38 – Lyons Creek Sampling Sites (BIBI and RBP)

4.5.4 Fish

The Lyons Creek sampling unit received a FIBI narrative rating of 'Fair' with an average score of 3.00 ± 1.18 (Table 16). A biological condition rating of 'Good' was given to 37.5% of the sites, another 37.5% of the sites were rated as 'Poor', while the remaining 25.0% was rated as 'Very Poor' (Figure 39). Individual FIBI scores ranged from 1.67 ('Very Poor') to 4.67 ('Good'). Site-specific data and assessment results can be found in Appendix D.

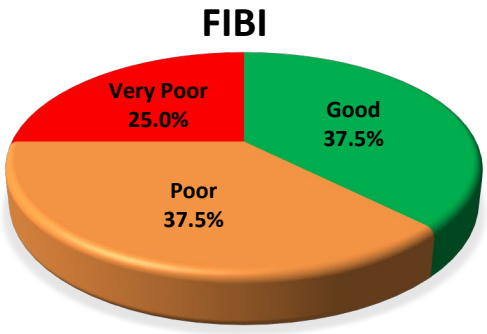

Figure 39 – Lyons Creek FIBI Conditions (n=8)

Site 22-R3M-08-21 received the highest FIBI score (4.67; 'Good') in the Lyons Creek sampling unit. This site scored in the highest category (5) all categories except percent generalist, omnivores, invertivores where it scored a (3). The Lyons Creek sampling unit had the second highest FIBI mean of all units sampled during the 2021 season (3.00; 'Fair'). Sites 22-L1M-01-21 and 22-L2M-01-21 both received the lowest FIBI score (1.67; 'Very Poor') in this sampling unit. Both sites scored in the lowest category (1) for all categories except abundance per square meter where each scored a (5).

Blacknose Dace was the most widely distributed species in the sampling unit, present at seven of the sites. Green Sunfish was the next most common species, observed at five of the eight sites. The least common species in this sampling unit were Golden Shiner, Northern Snakehead, Rosyside Dace, Satinfin Shiner, and White Sucker each found at only one site. Nineteen species were observed in the sampling unit including three non-native species (Bluegill, Green Sunfish, and Northern Snakehead). Sixteen native species [American Eel, Blacknose Dace, Brown Bullhead, Creek Chubsucker, Eastern Mosquitofish, Eastern Mudminnow, Fallfish, Golden Shiner, Least Brook Lamprey, Redfin Pickerel (*Esox americanus*), Rosyside Dace, Satinfin Shiner, Swallowtail Shiner, Tessellated Darter, White Sucker, and Yellow Bullhead] were observed in the sampling unit. One round-bodied sucker species (Creek Chubsucker) was present, and two benthic fish species (Least Brook Lamprey, and Tessellated Darter) were present. Two species considered intolerant to urban stressors (Fallfish, and Satinfin Shiner) were found in this sampling unit.

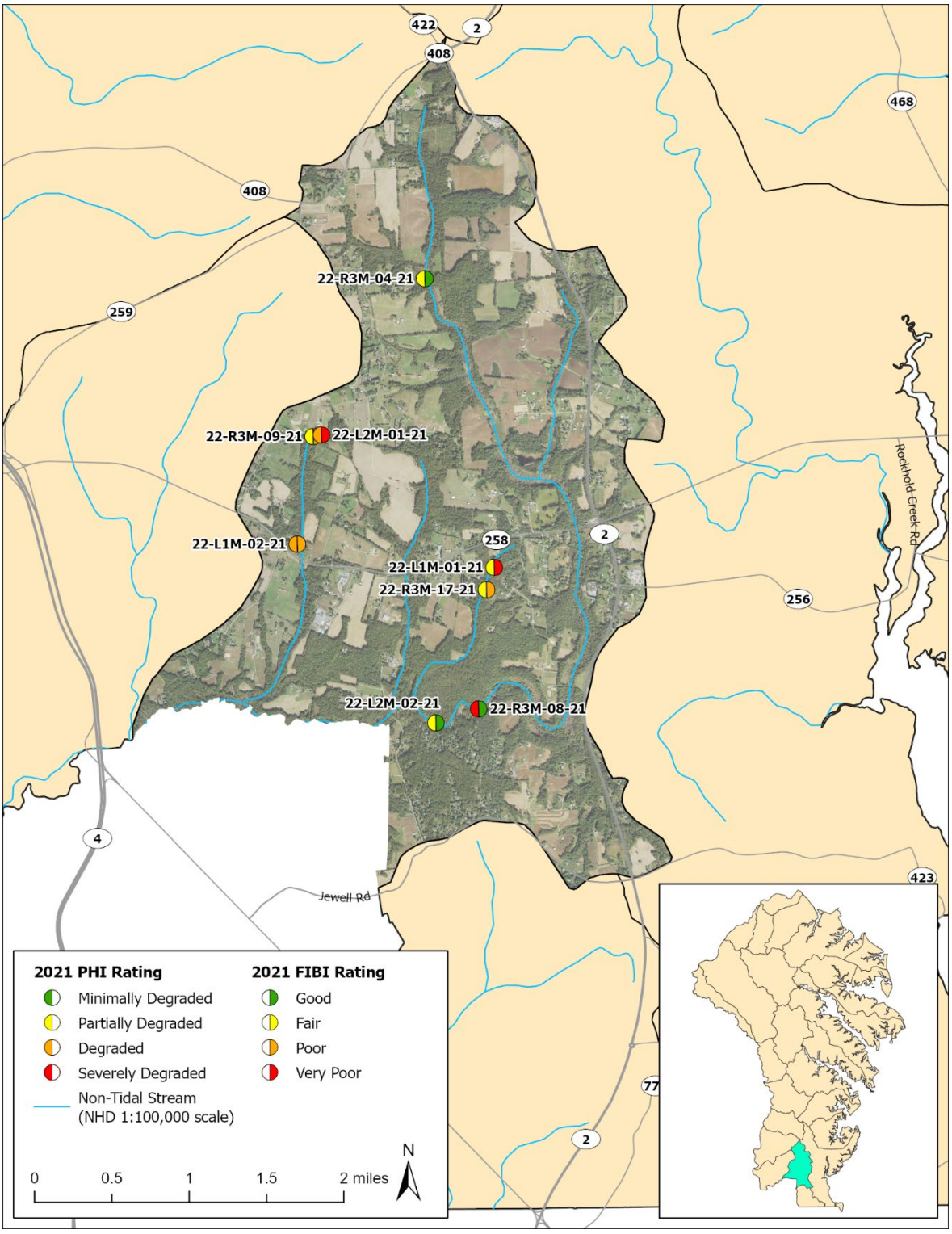

Figure 40 – Lyons Creek Sampling Sites (FIBI and PHI)

4.5.5 Water Quality

Average spring and summer *in situ* water quality values for the Lyons Creek sites are provided in Table 26. Five of the eight sites sampled in the spring met COMAR standards for water quality. The pH at sites 22-L1M-01-21, 22-L2M-01-21, and 22-R3M-09-21 was lower than the COMAR standard (i.e., 6.5-8.5 SU), with values of 6.05, 6.16, and 6.25 SU, respectively. All other parameters sampled met COMAR standards for water quality for all Lyons Creek sites. Spring water temperature ranged from 5.80 to 13.30 °C; DO ranged from 10.60 to 12.93 mg/L; pH ranged from 6.05 to 7.11 SU; specific conductance ranged from 139.0 to 342.5 µS/cm; and turbidity ranged from 3.10 to 12.30 NTU.

In the summer, all eight Lyons Creek sites were sampleable. Two sites did not meet COMAR standards for water quality during the summer. Sites 22-L2M-02-21 and 22-R3M-09-21 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with values of 6.38 and 6.34 SU, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 17.50 to 25.00 °C; DO ranged from 6.50 to 10.51 mg/L; pH ranged from 6.34 to 7.38 SU; specific conductance ranged from 149.0 to 264.6 µS/cm; and turbidity ranged from 7.82 to 27.1 NTU.

Table 26 - Average *in-situ* water quality values – Lyons Creek

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	10.16 ± 2.59	11.51 ± 0.75	6.63 ± 0.42	209.0 ± 73.9	6.72 ± 3.61
Summer	20.70 ± 2.63	8.08 ± 1.27	6.78 ± 0.38	212.9 ± 35.1	13.62 ± 6.02

The average spring grab sample water quality values for the Lyons Creek 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, lead, and turbidity. All Lyons Creek sites fell in the low to moderate categories used by MBSS for ammonia, total nitrogen, orthophosphate, and nitrate. Sites 22-L1M-01-21, 22-L2M-01-21, 22-L2M-02-21, and 22-R3M-08-21 had total phosphorus concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L) with values of 0.0705, 0.0751, 0.1561, and 0.0965 mg/L, respectively. The remaining four sites fell in the moderate category for total phosphorus used by MBSS (i.e., 0.025-0.070 mg/L). Site 22-R3M-08-21 had a nitrite concentration that fell in the high category used by MBSS (i.e., >0.01 mg/L) with a value of 0.0117 mg/L. All other nitrite values fell in the moderate category, or lower. Comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.078 to 5.090 mg/L; TOC ranged from 1.156 to 5.339 mg/L; magnesium ranged from 2.267 to 2.924 mg/L; calcium ranged from 13.16 to 16.94 mg/L; and hardness ranged from 42.67 to 52.75 mg/L.

Table 27 - Average grab sample water quality values – Lyons 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)
23.39 ± 9.58	0.0790 ± 0.0342	1.7409 ± 1.2746	0.0121 ± 0.0033	0.0230 ± 0.0113	0.0050 ± 0.0033	1.6036 ± 1.3520	2.294 ± 1.502
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)
2.427 ± 1.651	2.586 ± 0.231	15.66 ± 1.11	49.75 ± 3.13	0.413 ± 0.154	9.0 ± 4.5	0.183 ± 0.072	7.76 ± 4.00

4.5.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of the sites assessed in the Lyons Creek sampling unit were entrenched G type channel and slightly entrenched E type channels (both 37.5%; Figure 41). Entrenched F type channel represented the remaining 25.0% of the sites surveyed.

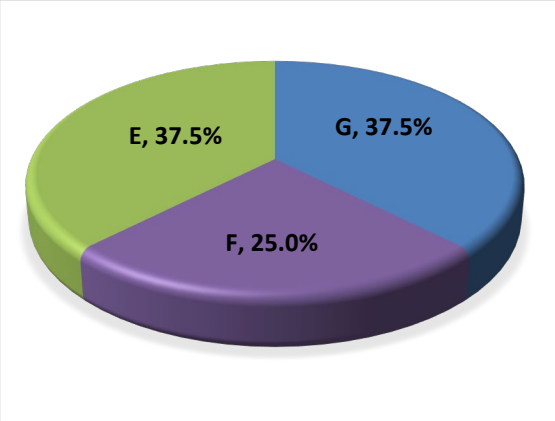

Figure 41 - Rosgen stream types observed in Hall Creek (n=8)

The majority of the streams in this sampling unit had sand or a mix of sand and gravel dominated substrates (37.5% and 25.0%, respectively). Gravel, mixtures of silt/clay, and sand/silt/clay substrates each dominated 12.5% of the sites surveyed. The average D_{50} was 0.25 mm (fine sand). Individual site slopes ranged from 0.20% to 0.81%, with an average slope of 0.49%.

5 Round Comparisons for Repeated Sites

In Round Three, a subset of sites from Rounds 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 Cabin Branch and Hall Creek sampling units, became finer in the Ferry Branch sampling unit, and remained similar in the Herring Bay and Lyons Creek sampling units based on the average D_{50} values. Substrate size increased from medium sand to very coarse sand in the Cabin Branch sampling unit and from very fine sand to medium sand in the Hall Creek sampling unit. Substrate size decreased from very coarse sand to coarse sand in the Ferry Branch sampling unit. Substrate size remained fine sand in the Herring Bay sampling unit and coarse sand

in the Lyons Creek sampling unit. Trends in BIBI scores at revisit sites also varied by sampling unit. On average, BIBI scores remained the similar in Cabin Branch and Hall Creek, improved in Ferry Branch and Lyons Creek, and declined in Herring Bay. No consistent trend between BIBI scores and substrate or cross-sectional area was apparent for the 2021 sampling units.

Cabin Branch

Cross-section overlays at Cabin Branch sites indicate varying magnitudes of change since the initial assessments in Rounds One and Two. Site 23-L1M-01-21 was re-established due to missing cross-section pins and no overlay was conducted. Two of the three remaining sites experienced a decrease in cross-sectional area (Table 28). For sites 23-L1M-02-21 and 23-L2M-03-21, cross-sectional area decreased notably, likely due to the channels downcutting and shifting causing subsequent erosion and creating different bankfull features observed during previous rounds and Round Three site visits. Site 23-L1M-02-21 maintained a similar bed elevation, but experienced erosion along the toe of slope and banks likely leading to new field indicators. Site 23-L2M-03-21 experienced channel downcutting in addition to significant bank erosion that also likely created new bankfull indicators leading to a reduction in bankfull area. At both sites, the bankfull features identified in Round Three did not match those identified in previous rounds. Since there were poor indicators at both sites, the features used in the 2021 comparison were chosen in the field to relate closely with the regional curve. At site 23-L2M-02-21, the D_{50} value increased notably in Round Three. Site 23-L1M-02-21 changed stream classification since the initial Round Two assessment, from a G5c to a F5 channel type due to slight widening of the channel. Site 23-L2M-03-21 changed from a transitional channel to a G channel. This was due to downcutting and slight widening of the overall channel. Site 23-L2M-02-21 remained a F channel type.

Average BIBI scores at Cabin Branch revisit sites declined slightly in Round Three compared to previous rounds but generally remained in the 'Poor' category (Table 28). All revisit sites experienced a decrease in BIBI scores or remained the same, with the exception of site 23-L1M-01-21, where the BIBI score improved in Round Three ('Poor' rating to a 'Fair' rating). Round Two revisit site 23-L2M-02-21 experienced a large decrease in BIBI score compared to all of the revisit sites sampled in 2021, decreasing from 'Good' to 'Fair'. No trends were evident between changes in BIBI score and changes in cross-sectional area.

Ferry Branch

No geomorphic assessments were performed in Ferry Branch during Round One (Table 28). Therefore, cross-section overlays were only completed for sites 21-L2M-02-21 and 21-L2M-05-21 within the Ferry Branch sampling unit. The Round Two revisited sites had similar D_{50} values in Round Three, with substrate size at site 21-L2M-05-21 decreasing slightly from very fine gravel to very coarse sand. Site 21-L2M-02-21 remained a DA channel type and 21-L2M-05-21 remained an F channel type. Bankfull area for site 21-L2M-02-21 nearly doubled in size from Round Two to Round Three. The channel has downcut approximately 1.0' while retaining similar bankfull field indicators. Site 21-L2M-05-21 experienced increased bed and bank erosion, but likely formed new field indicators, leading to a reduction in bankfull area.

The BIBI scores in Ferry Branch generally remained in the 'Fair' category from Round Two to Round Three (Table 28). The BIBI score at site 21-L1M-05-21 experienced the largest increase out of all the revisit sites sampled in 2021, improving from 'Poor' to 'Fair'. A relationship between BIBI score and cross-sectional

area could not be determined due to the Round One sampling sites lacking geomorphic assessments. BIBI scores for all other Ferry Branch revisit sites remained in the 'Fair' category across sampling rounds.

Hall Creek

Changes in cross-sectional area in the Hall Creek revisit sites varied in direction and magnitude. Cross-section pins could not be located at 24-L1M-04-21, so no cross-section overlay was conducted for that site. On average, cross-sectional area increased by 37.5% from Rounds One and Two to Round Three (Table 28). Cross-sectional area increased at two of revisit sites and decreased by 15% at 24-L2M-03-21. In Round Three, sites 24-L1M-03-21 and 24-L2M-03-21 both transitioned from a G to B channel type, with 24-L1M-03-21 eroding on the left bank and 24-L2M-03-21 losing material on both banks. Channel enlargement at both sites resulted in width to depth ratios in the range describing a B channel. Additionally, both sites have developed some terraces in the bottom of the channel, further evidence that downcutting has ended and widening is ongoing at these sites. The cross-sectional area at site 24-L2M-01-21 increased substantially due to a slight shift in the channel to the right and subsequent fill occurring in the channel and both banks leading to less entrenchment and causing a transition from a G to C channel type. All D_{50} values in Round Three were in the medium sand substrate classification type, which is slightly coarser than in previous rounds.

BIBI scores at Hall Creek revisit sites were similar in Round Three compared to previous rounds and remained in the 'Very Poor' to 'Poor' categories (Table 28). All revisit sites experienced a slight decrease in BIBI scores, with the exception of site 24-L2M-03-21, where the BIBI score improved in Round Three ('Very Poor' rating to a 'Poor' rating). No trends were evident between changes in BIBI score and changes in cross-sectional area as changes in BIBI score were subtle.

Herring Bay

Cross-section overlays at Herring Bay indicate varying magnitudes of changes since the initial assessments in previous rounds. The previous round cross-section pins could not be located at 15-L1M-01-21, so no cross-section overlay was conducted for that site. On average, cross-sectional area decreased by 5.3% from Round One and Two to Round Three (Table 28). Cross-sectional area decreased at two of revisit sites and increased by 28.5% at 15-L2M-02-21, where notable left bank erosion had occurred since 2005. Site 15-L1M-02-21 transitioned from a G to an F channel type due to a higher width-depth ratio caused by downcutting. Site 15-L2M-07-21 also transitioned from a G to an F channel type; however, this change was caused by aggradation in the channel resulting in a higher width-depth ratio. Site 15-L2M-02-21 remained a C channel type in Round Three. In Round Three, revisit sites had a substrate D_{50} that ranged from very fine sand to medium sand. Site 15-L1M-02-21 changed from silt/clay to very fine sand, site 15-L1M-02-21 changed from medium sand to fine sand, site 15-L2M-02-21 changed from very fine sand to medium sand, and site 15-L2M-07-21 remained as very fine sand.

Herring Bay revisit site BIBI scores declined from previous rounds to Round Three, declining, on average, from the 'Fair' to the 'Poor' category (Table 28). All revisit sites experienced a decrease in BIBI score or remained the same, with the exception of site 15-L1M-01-21, where the BIBI score improved in Round Three ('Very Poor' rating to a 'Poor' rating). Round Two revisit site 15-L2M-07-21 experienced the largest decrease in BIBI score of all the revisit sites sampled in 2021, decreasing from 'Fair' to 'Very Poor'. The decrease in cross-sectional area coincided with a decrease in BIBI scores for Herring Bay sites.

Lyons Creek

Changes in cross-sectional area in the Lyons Creek revisit sites varied in direction and magnitude. Due to limited property access, site 22-L1M-02-21 was shifted upstream from its original location in Round 1. Therefore, the site was re-established and no overlay was conducted The cross-sectional area increased by 159.9% from Round One to Round Three at site 22-L1M-01-21 (Table 28). Cross-sectional area also increased at both Round Two revisit sites, with site 22-L2M-01-21 increasing by 141.5% due to downcutting and a substantial channel shift to the right, causing subsequent erosion. Cross-sectional area at site 22-L2M-02-21 increased by 16.3%, likely due to increased bank erosion occurring on both banks. The channel type at site 22-L1M-01-21 transitioned from an F to G channel type due to a decrease in width-depth ratio. Both Round Two revisit sites did not change channel types in Round Three. Site 22-L2M-02-21 substrate type coarsened from very fine sand to very fine gravel in Round Three. All other D_{50} values in Round Three ranged from the very fine sand to medium sand substrate classification types.

BIBI scores at Lyons Creek revisit sites improved in Round Three compared to previous rounds and increased, on average, from the 'Poor' to 'Fair' category (Table 28). All revisit sites experienced an increase in BIBI scores, with the exception of site 22-L1M-01-21, where the BIBI score remained the same ('Poor'). Site 22-L2M-02-21 BIBI score increased substantially in Round Three from 'Fair' to 'Good'. No trends were evident between changes in BIBI score and changes in cross-sectional area due to the varying trends in cross-sectional area for the Lyons Creek sampling unit. 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.

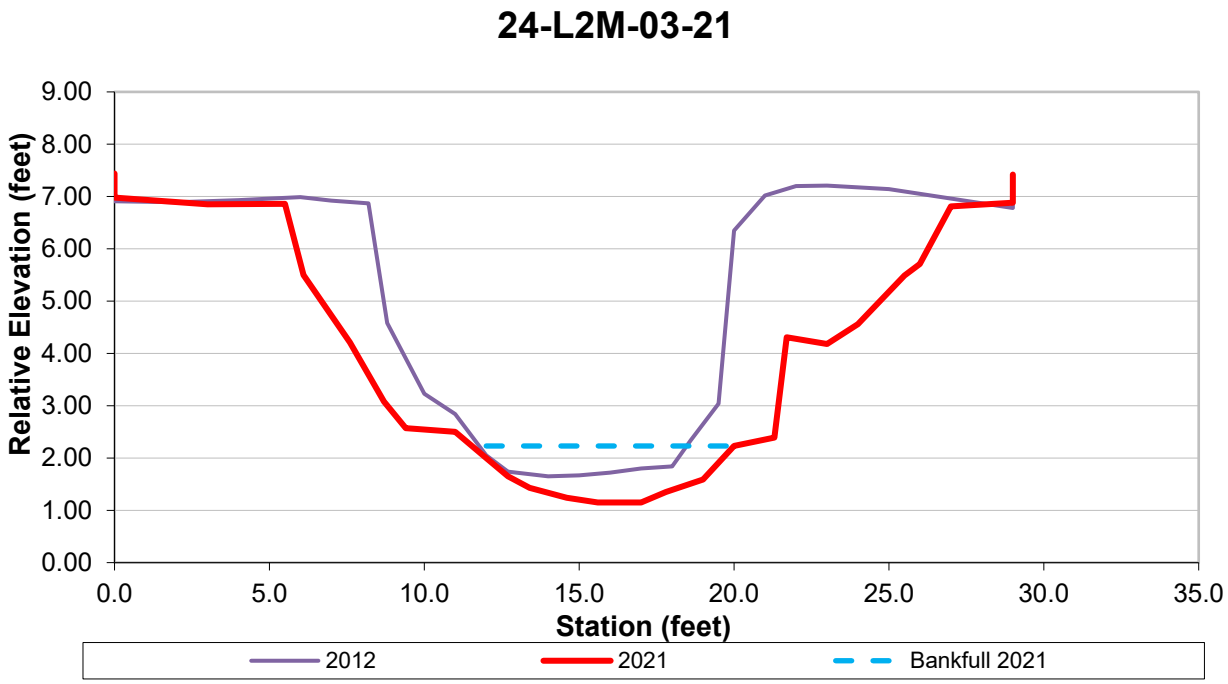

Figure 42- Representative cross-section overlay in the Hall Creek sampling unit

Table 28 - Comparison of Round One and Round Two (2004 - 2013) with Round Three (2021) geomorphological and biological data

PSU	2021 Site Name	Year First Sampled	Cross-Sectional Area (ft^2)			D50 Substrate Classification (Size in mm)		Rosgen Classification		BIBI Narrative Ranking (Score)	
			R1/R2	R3	%Δ	R1/R2	R3	R1/R2	R3	R1/R2	R3
Cabin Branch	23-L1M-01-21	2008	58.2	26.5	---[2]	medium sand (0.36)	medium sand (0.3)	E5	F5	Poor (2.43)	Fair (3.57)
	23-L1M-02-21	2008	8.8	1.0	-88.6	medium sand (0.25)	fine sand (0.23)	G5c	F5	Very Poor (1.86)	Very Poor (1.86)
	23-L2M-02-21	2013	6.4	8.1	26.5	medium sand (0.4)	fine gravel (6)	F4/5	F4	Good (4.43)	Fair (3.29)
	23-L2M-03-21	2013	2.1	1.3	-38.0	very fine sand (0.08)	very fine sand (0.08)	Transitional	G5c	Poor (2.71)	Poor (2.14)
	Cabin Branch Average		18.9	9.2	-33.4	medium sand (0.27)	very coarse sand (1.65)	---	---	Poor (2.86)	Poor (2.72)
Ferry Branch	21-L1M-01-21	2004	---	5.4	---[1]	---	coarse sand (0.67)	---	F5	Fair (3.00)	Fair (3.00)
	21-L1M-05-21	2004	---	15.6	---[1]	---	fine sand (0.2)	---	E5/6	Poor (2.14)	Fair (3.86)
	21-L2M-02-21	2010	7.5	14.8	96.8	very fine sand (0.06)	very fine sand (0.06)	DA5	DA6	Fair (3.00)	Fair (3.57)
	21-L2M-05-21	2010	8.2	4.8	-41.2	very fine gravel (2.1)	very coarse sand (1.4)	F4/6	F5/4	Fair (3.00)	Fair (3.00)
	Ferry Branch Average		7.9	10.1	27.8	very coarse sand (1.08)	coarse sand (0.58)	---	---	Poor (2.79)	Fair (3.36)
Hall Creek	24-L1M-03-21	2006	2.7	2.9	6.9	very fine sand (0.08)	medium sand (0.35)	G5c	B5c	Poor (2.71)	Very Poor (1.86)
	24-L1M-04-21	2006	5.0	8.4	---[2]	very fine sand (0.07)	medium sand (0.42)	G5c	G5c	Very Poor (1.86)	Very Poor (1.57)
	24-L2M-01-21	2012	5.8	12.8	120.8	fine sand (0.16)	medium sand (0.33)	G5c	C5	Poor (2.71)	Poor (2.43)
	24-L2M-03-21	2012	7.6	6.5	-15.0	fine sand (0.15)	medium sand (0.47)	G5c	B5c	Very Poor (1.57)	Poor (2.14)
	Hall Creek Average		5.3	7.6	37.5	very fine sand (0.11)	medium sand (0.39)	---	---	Poor (2.21)	Poor (2.00)
Herring Bay	15-L1M-01-21	2005	8.6	10.5	---[2]	silt/clay (0.03)	very fine sand (0.062)	E6	C6	Very Poor (1.86)	Poor (2.43)
	15-L1M-02-21	2005	13.3	11.8	-11.1	medium sand (0.41)	fine sand (0.18)	G5c	F5	Fair (3.86)	Fair (3.00)
	15-L2M-02-21	2010	17.0	21.8	28.5	very fine sand (0.07)	medium sand (0.35)	C5/6c-	C5c-	Good (4.43)	Good (4.43)
	15-L2M-07-21	2010	9.6	6.4	-33.3	very fine sand (0.09)	very fine sand (0.081)	G5c	F5/6	Fair (3.00)	Very Poor (1.86)
	Herring Bay Average		12.1	12.7	-5.3	fine sand (0.15)	fine sand (0.168)	---	---	Fair (3.29)	Poor (2.93)
Lyons Creek	22-L1M-01-21	2005	4.5	11.7	159.9	medium sand (0.43)	medium sand (0.26)	F5	G5c	Poor (2.43)	Poor (2.43)
	22-L1M-02-21[3]	2005	8.5	4.2	---[3]	very fine gravel (2.67)	fine sand (0.23)	G4c	F5/4	Poor (2.43)	Fair (3.00)
	22-L2M-01-21	2013	3.6	8.7	141.5	fine sand (0.21)	very fine sand (0.11)	G4/5c	G5c	Poor (2.14)	Poor (2.71)
	22-L2M-02-21	2013	33.4	38.8	16.3	very fine sand (0.12)	very fine gravel (2)	E5	E4	Fair (3.00)	Good (4.43)
	Lyons Creek Average		12.5	15.9	105.9	coarse sand (0.86)	coarse sand (0.65)	---	---	Poor (2.50)	Fair (3.14)

[11]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 round; [3]Site 22-L1M-02-21 was shifted upstream in R3, therefore, direct comparisons were not made with R1; 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)

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 four PSUs assessed in 2021. Refer to Figure 43 for box plots comparing mean BIBI, RBP, and PHI results from Rounds One, Two and Three in the Cabin Branch, Ferry Branch, Hall Creek, Cabin Branch, and Hall Creek 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.

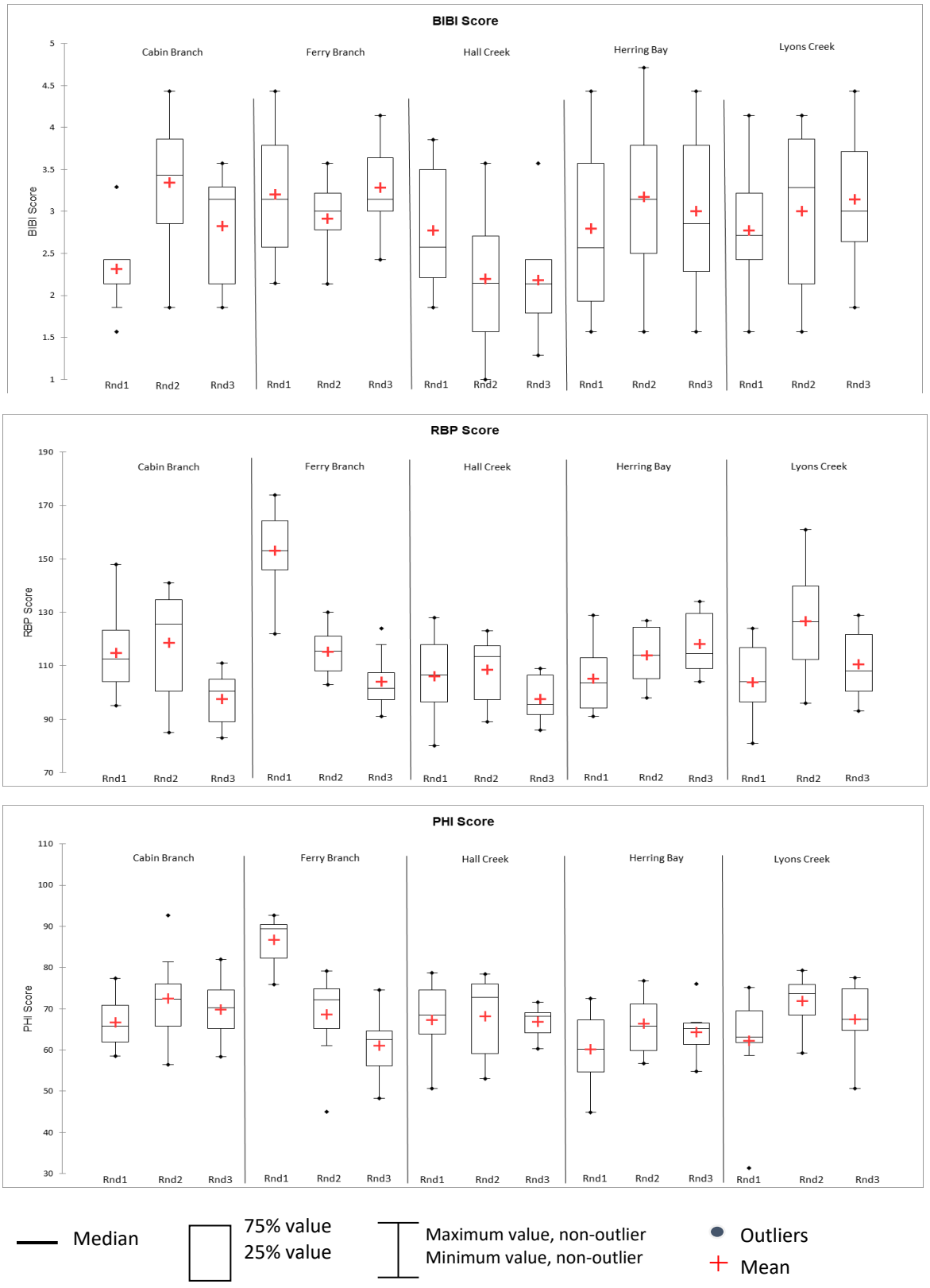

Figure 43 - Box plots comparing mean BIBI, RBP and PHI scores between Rounds One, Two and Three

6.1 Biological Conditions

Comparisons of mean BIBI scores by PSU between Round Two and Round Three are presented in Table 29, and between Round One and Round Three in Table 30. None of the PSUs sampled during 2021 showed significant changes in mean BIBI scores between sampling Rounds Two and Three or Rounds One and Three.

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			
Cabin Branch	2.82	0.24	3.34	0.25	1.20	-0.16	No
Ferry Branch	3.29	0.19	2.91	0.15	0.11	-0.85	No
Hall Creek	2.18	0.24	2.20	0.25	0.71	-0.67	No
Herring Bay	3.00	0.38	3.17	0.32	1.14	-0.80	No
Lyons Creek	3.14	0.31	3.00	0.31	0.71	-1.00	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			
Cabin Branch	2.82	0.24	2.31	0.16	0.05	-1.07	No
Ferry Branch	3.29	0.19	3.20	0.26	0.54	-0.72	No
Hall Creek	2.18	0.24	2.77	0.24	1.26	-0.07	No
Herring Bay	3.00	0.38	2.80	0.34	0.80	-1.20	No
Lyons Creek	3.14	0.31	2.77	0.25	0.40	-1.14	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. Comparisons between Round Two and Three showed significant decreases in the mean RBP habitat condition in three PSUs. Cabin Branch decreased from 118.60 ±6.43 in Round Two to 97.63 ±3.57 in Round Three, Ferry Branch decreased from 115.30 ±2.84 in Round Two to 104.13 ±4.01 in Round Three, and Hall Creek decreased with the mean RBP scores of 108.50 ±3.82 in Round Two to 97.63 ±3.19 in Round Three. The comparisons between Round One and Round Three showed a significant change in three PSUs as well. Mean RBP score decreased in Cabin Branch, (114.90 ±5.07 in Round One to 97.63 ±3.57 in Round Three), and Ferry Branch (153.00 ±4.78 in Round One to 104.13 ±4.01 in Round Three), and increased in Herring Bay (105.20 ±4.08 in Round One to 118.13 ±4.36 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			
Cabin Branch	97.63	3.57	118.60	6.43	35.38	6.57	Yes (Decrease)
Ferry Branch	104.13	4.01	115.30	2.84	20.80	1.55	Yes (Decrease)
Hall Creek	97.63	3.19	108.50	3.82	20.62	1.13	Yes (Decrease)
Herring Bay	118.13	4.36	113.80	3.49	6.62	-15.27	No
Lyons Creek	110.63	4.90	126.70	6.80	32.51	-0.36	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			
Cabin Branch	97.63	3.57	114.90	5.07	29.43	5.12	Yes (Decrease)
Ferry Branch	104.13	4.01	153.00	4.78	61.10	36.65	Yes (Decrease)
Hall Creek	97.63	3.19	106.00	5.10	20.17	-3.42	No
Herring Bay	118.13	4.36	105.20	4.08	-1.22	-24.63	Yes (Increase)
Lyons Creek	110.63	4.90	103.90	4.78	6.69	-20.14	No

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. There were no significant changes between Round Two and Round Three for physical habitat conditions. Only one PSU, Ferry Branch, showed significant changes in PHI habitat conditions between sampling Rounds One and Three. The mean PHI score in Ferry Branch decreased from 86.72 ±1.77 in Round One to 61.11 ±2.84 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			
Cabin Branch	69.77	2.89	72.41	3.20	11.10	-5.81	No
Ferry Branch	61.11	2.84	68.63	3.19	15.89	-0.85	No
Hall Creek	66.86	1.30	68.17	3.20	8.09	-5.46	No
Herring Bay	64.25	2.35	66.34	2.30	8.54	-4.36	No
Lyons Creek	67.47	3.09	71.85	1.92	11.50	-2.74	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			
Cabin Branch	69.77	2.89	66.62	2.26	4.04	-10.35	No
Ferry Branch	61.11	2.84	86.72	1.77	32.17	19.05	Yes (Decrease)
Hall Creek	66.86	1.30	67.27	2.87	6.59	-5.77	No
Herring Bay	64.25	2.35	60.17	2.98	3.35	-11.51	No
Lyons Creek	67.47	3.09	62.31	3.81	4.45	-14.78	No

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 2021 assessment indicate impaired biological conditions in three of the five sampling units. Two of the five sampling units (Cabin Branch and Hall Creek) had mean BIBI scores in the 'Poor' category, and the remaining three sampling units (Ferry Branch, Herring Bay, and Lyons Creek) had a mean BIBI of 'Fair'. Two of the five had mean FIBI scores in the 'Poor' category, one sampling unit (Herring Bay) had a mean FIBI of 'Very Poor', and two sampling units (Ferry Branch and Lyons Creek) had mean FIBI of 'Fair'.

No significant changes in mean BIBI scores were observed between Round One and Round Three or between Round Two and Round Three (Table 30).

There were no discernable trends in PHI habitat data at four of the five sampling units. Ferry Branch showed a statistically significant decrease in mean PHI scores between Round One and Round Three but no change between Round Two and Round Three. Both Cabin Branch and Ferry Branch showed a statistically significant decrease in mean RBP scores between Round One and Round Three, as well as between Round Two and Round Three. Hall Creek showed a significant decrease in mean RBP scores between Rounds Two and Three. Herring Bay showed a significant increase in mean RBP scores between Round One and Round Three. Lyons Creek showed no significant trends in mean PHI or RBP scores between either Round Three and Round Two, or Round Three and Round One.

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 Three 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 (62.5%); nearly one-in-five of sites in those two categories (16%) resulted in biological conditions that were lower than the habitat category may suggest is possible (Table 35) which is lower than the 25% observed in 2020 data. Similar to the RBP method, results from the PHI method showed the great majority of sites with a 'Partially Degraded' or 'Degraded' rating (92.5%), with nearly half (48.6%) of those sites in those two categories with 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				
Supporting	15-L2M-02-21 15-R3M-04-21 22-R3M-08-21	22-R3M-04-21 23-R3M-01-21	15-L1M-01-21	
Partially Supporting	**22-L2M-02-21**	15-L1M-02-21 15-R3M-03-21 21-L1M-01-21 21-L1M-05-21 21-L2M-02-21 21-L2M-05-21 22-R3M-09-21 23-L1M-01-21 23-L2M-02-21 23-R3M-04-21 23-R3M-07-21 24-R3M-08-21	15-R3M-05-21 22-L2M-01-21 24-L2M-01-21 24-R3M-02-21	15-L2M-07-21 15-R3M-01-21 22-R3M-17-21
Non-Supporting	**21-R3M-10-21**	**21-R3M-04-21** **21-R3M-07-21** **22-L1M-02-21**	21-R3M-13-21 22-L1M-01-21 23-L2M-03-21 23-R3M-03-21 24-L2M-03-21 24-R3M-09-21	23-L1M-02-21 24-L1M-03-21 24-L1M-04-21 24-R3M-01-21

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	23-R3M-04-21			
Partially Degraded	21-R3M-07-21 21-R3M-13-21 22-L2M-02-21 22-R3M-04-21 23-L1M-01-21 23-R3M-07-21	23-L2M-02-21 24-R3M-08-21	15-L2M-02-21 15-L2M-07-21 22-R3M-09-21 22-R3M-17-21 24-L2M-01-21 24-L2M-03-21 24-R3M-02-21	**15-L1M-02-21** **15-R3M-01-21** **22-L1M-01-21** **23-L1M-02-21** **23-R3M-03-21** **24-L1M-03-21**
Degraded	**21-L1M-05-21**	21-L1M-01-21 21-L2M-05-21 21-R3M-04-21 21-R3M-10-21 23-R3M-01-21	15-R3M-03-21 15-R3M-04-21 22-L1M-02-21 24-L1M-04-21 24-R3M-01-21	15-L1M-01-21 15-R3M-05-21 22-L2M-01-21 23-L2M-03-21 24-R3M-09-21
Severely Degraded	**21-L2M-02-21** **22-R3M-08-21**			

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

Although physical habitat conditions show impairment in all five watersheds, habitat impairment 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 Three 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, water quality stressors are likely strong contributors to impaired biological conditions. The five sampling units visited in 2021 have low levels of impervious surfaces, with impervious surface coverage ranging from 2% to 4.7%, and the patterns of water quality stressors affection biological conditions is not as strong as the northern part of the County. Elevated specific conductance values were observed at 9 of 40 sites in the spring and 10 of 40 sites in the summer which exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data (Morgan et al, 2007; Morgan et al, 2012). The expected pattern of increased imperviousness leading to increased specific conductance measurements was not evident in 2017 data but was observed with 2018, 2019, and 2020 spring and summer data and again in 2021 data. There was a significant positive trends in springtime (R^2=0.166; p=0.009) and summer (R^2=0.137; p=0.019) specific conductance and impervious surfaces for the sites sampled in 2021. The PSU with the second largest amount of imperviousness, Ferry Branch (3.8%) had the highest mean specific conductance of the spring (239.5 µS/cm) and summer (253.8 µS/cm) 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), Ferry Branch had the highest mean BIBI and FIBI scores during 2021. Cabin Branch had the lowest

amount of impervious surface (2.0%) and lowest mean specific conductance (195.1 µS/cm) during the summer. The PSU with the second lowest amount of imperviousness, Hall Creek (3.0%), had the lowest mean specific conductance measurement in the spring (182.4 µS/cm). There were no trends between spring specific conductance and BIBI score, or between summer specific conductance and FIBI scores. The lack of significant trends in data from 2021 sites is likely due to the small amount of impervious surfaces in the drainage areas contributing to these sites. Impervious surface percentages for 2021 sites ranged from a low of 0.6% to a maximum of 6.1%. A larger analysis of the complete Round Three dataset from all sampling units within the County will 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 2021 sites, drainage area has a significant positive effect on BIBI score (R^2=0.567; p<0.0001) with increased drainage area. With the addition of fish data in Round Three, similar correlation can be investigated for the drainage area effect on the FIBI in Anne Arundel County. Similar to results from 2017 through 2020, data from 2021 sampling shows a significant correlation between increasing drainage area and FIBI score (R^2=0.248; p=0.001). 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 Maryland Coastal Plain (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.

Comparisons of bankfull width values show the trendline for B (R^2 = 0.99) channels as the closest to matching the MCP curve and the least variable (Figure 44). The trendline for F (R^2 = 0.86) channels contained little variability as well, with data points scattered above the MCP curve indicating wider channels than predicted. This was likely due to not having adequate bankfull indicators in the incised channels and therefore relying on the regional curve. The trendlines for G (R^2 = 0.30) and C (R^2 = 0.55) channels fell slightly above the MCP curve indicating wider channels than predicted by the regional curve. The trendline for E (R^2 = 0.55) type channels was slightly below the MCP curve, indicating narrower

channels than predicted by the regional curve. The single DA channel surveyed in 2021 fell 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 B type channels (R^2 = 0.98) closely matching the MCP curve (Figure 45). For F (R^2 = 0.87) channel types, points were scattered mostly below the curve, which suggests the large variance in width/depth ratios as the sites were well above the mean width MCP curve. The G (R^2 = 0.33) and E (R^2 = 0.59) type channels fell above the MCP curve, suggesting greater depths than the MCP curve would predict. As with bankfull width, the channel types follow the expected mean bankfull depth relationship (Rosgen, 1996).

Comparisons of bankfull cross-sectional area values show the trendlines for all stream types closely match the MCP curve (Figure 46). The trendlines for F (R^2 = 0.94), B (R^2 = 0.99), and E (R^2 = 0.82) channels were least variable. Very few channel cross-sectional areas, including some F and E channel types, fell below the MCP curve. Somewhat unexpectedly, G 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 2021 were below one square mile drainage areas and are therefore much smaller than sites used to develop 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 2021 (n=26), six sites (23.1%) received a 'Very Poor' biological rating, 7 sites (26.9%) received a 'Poor' rating, 12 sites (46.2%) received a 'Fair' rating, and 1 site (3.8%) received a 'Good' rating. Of the sites classified as B and C type channels in 2021 (n=7), 5 sites (71.4%) received a 'Very Poor' or 'Poor' rating, indicating degraded benthic macroinvertebrate communities regardless of channel type. All E and DA channel types (n=7) scored in the 'Fair' or 'Good' categories. Overall, most of sites in 2021 (n=40) scored as 'Fair' (42.5%; 30% F and G channel types) and five sites (12.5%) scored as 'Good'.

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 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 2021 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. Additional analysis will be conducted at the conclusion of Round Three to investigate countywide trends.

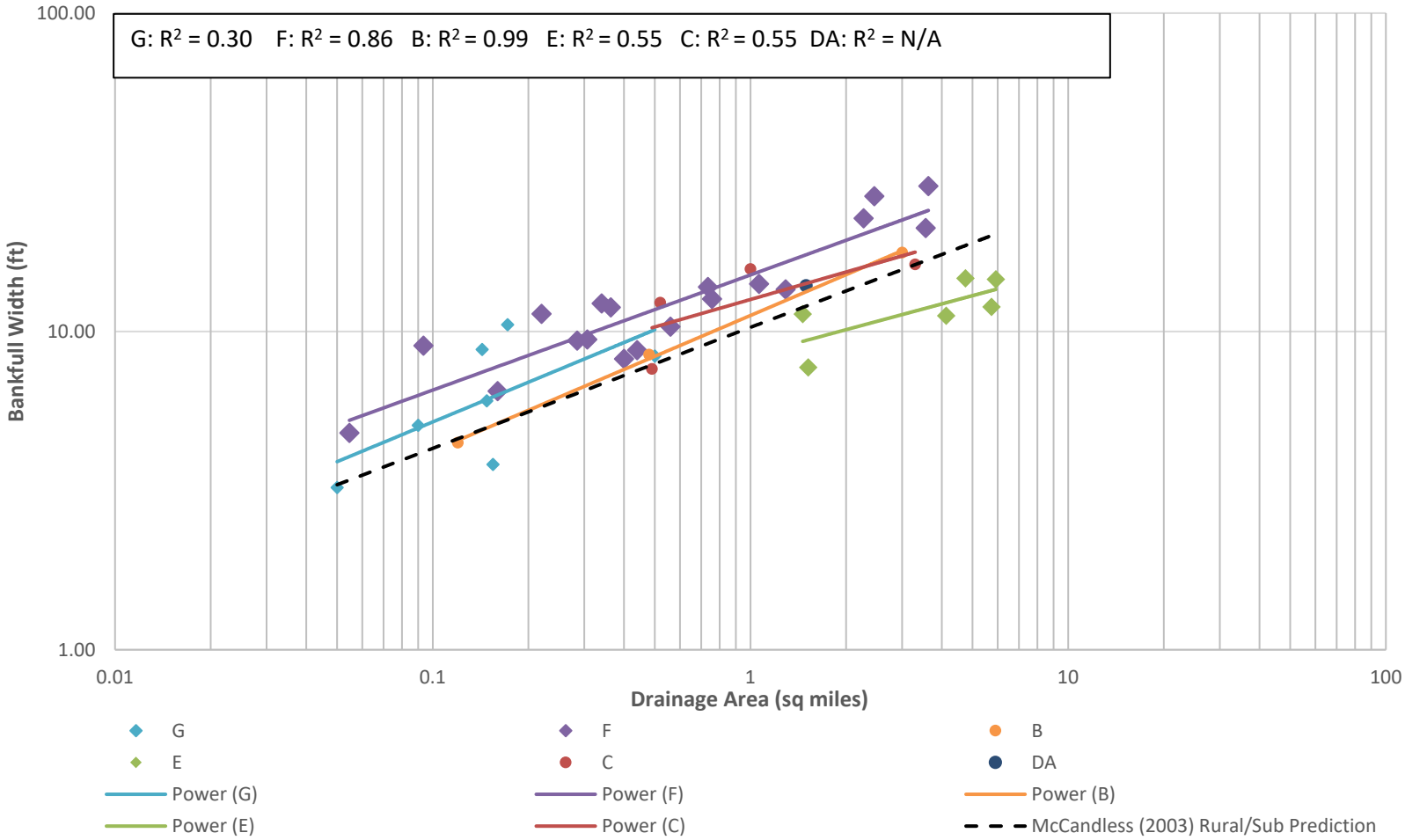

Figure 44- Comparison of bankfull width - Drainage area relationship between field data and regional curve data

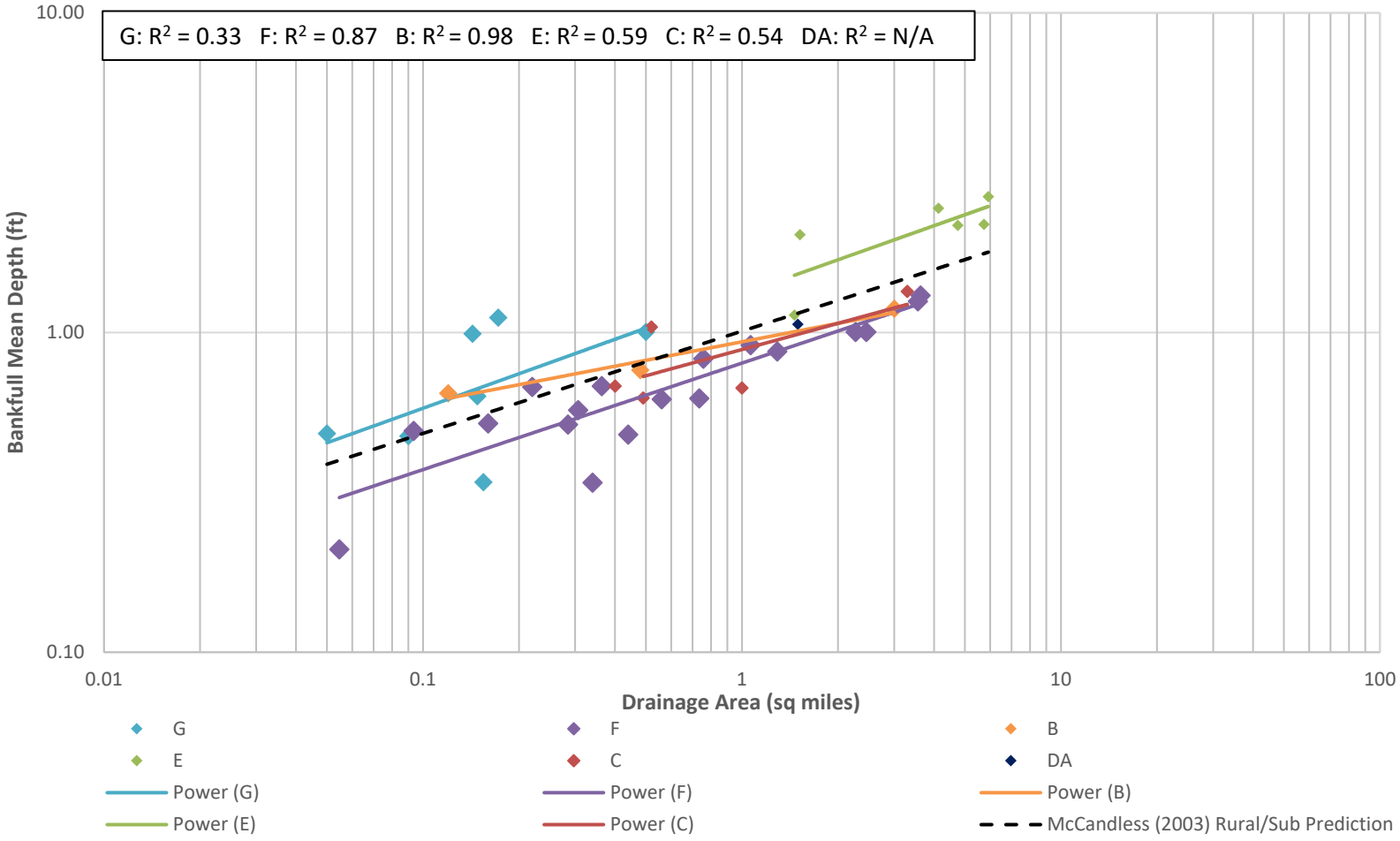

Figure 45 - Comparison of mean bankfull depth - Drainage area relationship between field data and regional curve data

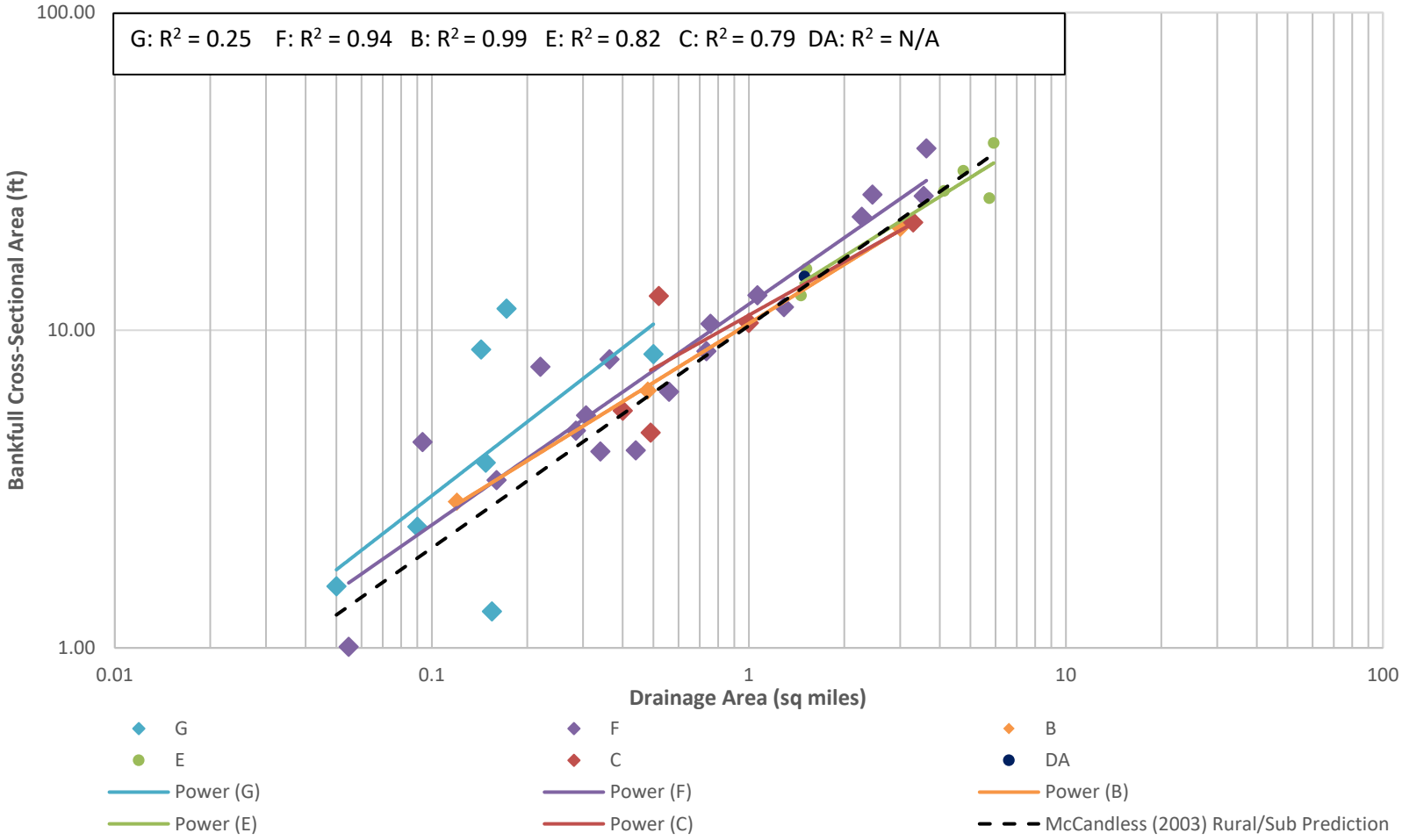

Figure 46 - Comparison of the bankfull cross-sectional area - Drainage area relationship between field data and regional curve data

7.3 Water Quality Conditions

In situ water quality measurements were within COMAR standards for temperature and turbidity at all sites during both the spring and summer monitoring periods. 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 five sites spanning three of the five sampling units in the spring and at six sites spanning four of the five sampling units in the summer. Although these values did not meet COMAR standards, the low pH values generally fell just below the criteria and all values that did not meet COMAR standards ranged from 6.0 to 6.5 SU. Low pH values were likely the result of soils within the 2021 sampling units being generally strongly to very strongly acidic (NRCS, 2021).

In the spring, none of the sites sampled had DO values below the COMAR criterion of 5 mg/L. In the summer, DO values below the acceptable COMAR standard were recorded at four sites spanning three of the five sampling units. 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). Furthermore, Morgan et al. (2012) identified a critical threshold of 469 µS/cm for fish within the Coastal Plain physiographic region. Specific conductance values that exceeded 247 µS/cm were recorded at over 22% of the sites sampled in the spring, spanning four of the five sampling units. Approximately 25% of sites sampled in the summer, located in all sampling units except Cabin Branch, had specific conductance values that exceeded the BIBI impairment threshold. However, during both the spring and summer, specific conductance values for all sites fell below the critical threshold of 469 µS/cm for fish. Despite elevated specific conductance levels at sites sampled in 2021, there was no significant trend between specific conductance and BIBI or FIBI.

All 2021 sites met COMAR or EPA standards for chloride, copper, zinc, lead, and turbidity based on grab samples. For total nitrogen and nitrate, all 2021 sites fell in the low or moderate categories used by MBSS, suggesting low to moderate anthropogenic stress based on these parameters. Over 77% of sites sampled in 2021 fell in the high category used by MBSS for total phosphorus (i.e., > 0.07 mg/L). Over 27% of sites sampled in 2021 fell in the high category used by MBSS for orthophosphate (i.e., > 0.03 mg/L), with Lyons Creek being the only exception with no orthophosphate readings in the high category. One site in Hall Creek fell in the high category for ammonia (i.e., > 0.07 mg/L), with all other sites falling in the low or moderate categories. Ammonia concentrations were generally elevated in Hall Creek, relative to the other 2021 sampling units. Because pH levels were generally acidic or neutral in all sampling units, un-ionized ammonia was not found in high concentrations at any sampling unit other than Hall Creek. The un-ionized form of ammonia is fraction of this parameter largely toxic to aquatic biota. Point source discharge and nutrient enrichment are both common sources of elevated ammonia in surface waters (USEPA, 2000). One site in the Lyons Creek sampling unit fell in the high category used by MBSS for nitrite concentration (i.e., >0.01 mg/L), while all other sites fell in the low or moderate categories. Additional comparisons of nitrite levels with categories used by MBSS were limited due to 2021 analytical detection limits. 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 2021.

The relationship between specific conductance and chloride concentration varied by sampling unit in 2021 (Figure 47). There was a positive correlation in the Hall Creek, Herring Bay, and Lyons Creek sampling units, with a strong relationship being observed for Hall Creek ($R^2 = 0.9808$) and Herring Bay ($R^2 = 0.9396$). In the Cabin Branch and Ferry Branch sampling units, the relationship between specific conductance and chloride concentration was weak ($R^2 < 0.1$). This weak relationship may be due to low specific conductance

overall in those two sampling units. In Ferry Branch, specific conductance values ranged from 143 to 273 µS/cm; however, chloride levels remained low overall relative to the other 2021 sampling units. Similarly, specific conductance ranged from 147 to 262 µS/cm for Cabin Branch. The relationship in Ferry Branch was also affected by site 21-L2M-02-21, which had relatively high chloride concentration (37.32 mg/L) relative to specific conductance (143.8 µS/cm). 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).

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.

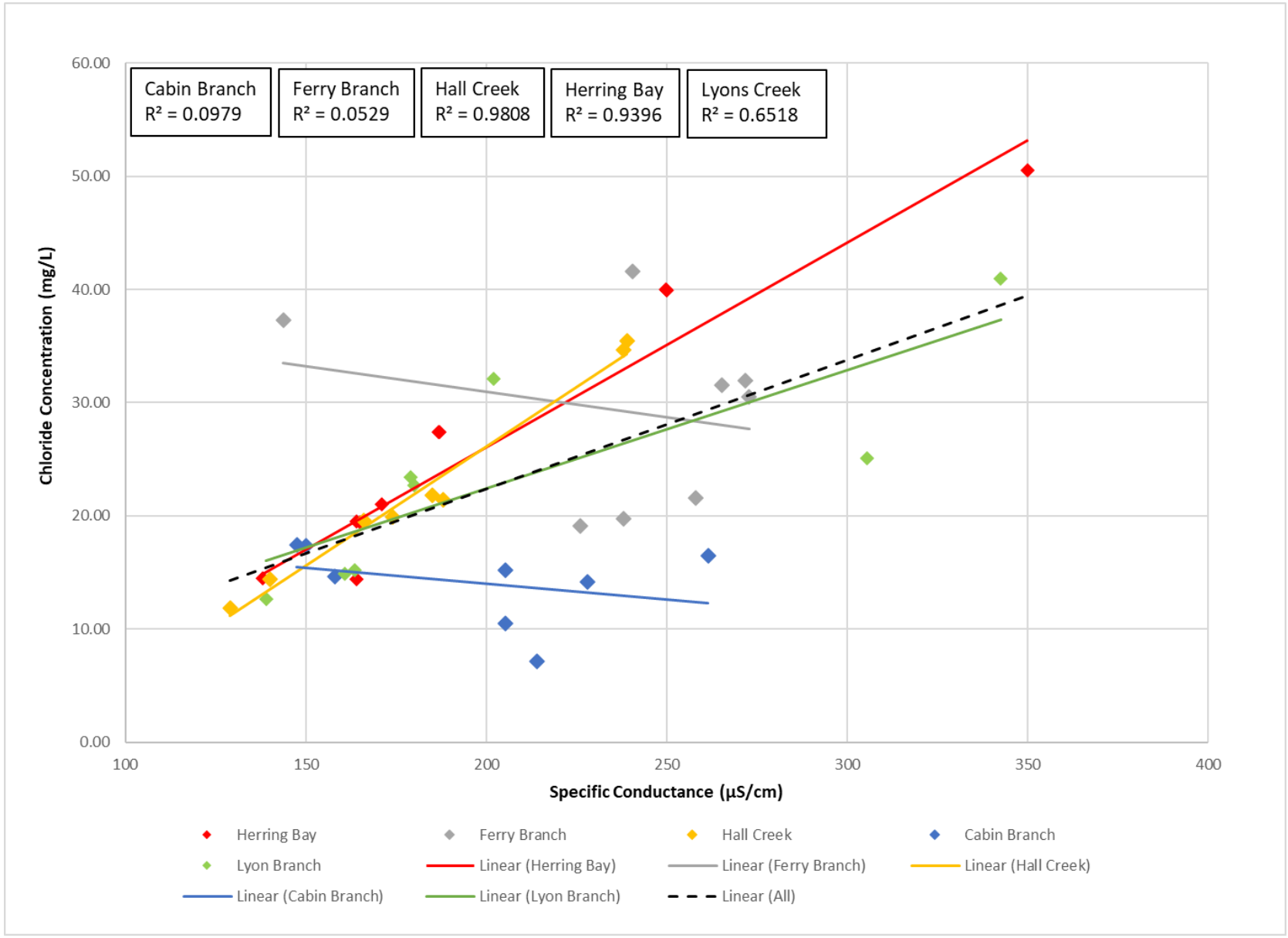

Figure 47 – Relationship between specific conductance and chloride concentration for each PSU

Best Management Practices

Stormwater Management

These five sampling units are relatively lightly developed (18% - 35% developed land use) but still may 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. Upgrading existing BMPs and installing new BMPs would have the dual benefit of improving runoff conditions affecting habitat and potentially gaining the County credit towards MS4 and TMDL targets.

Agricultural Lands

While the five sampling units from 2021 contained less developed land, PSU mean and individual BIBI scores still show signs of impairment. These subwatersheds contain a larger portion of agricultural lands (10% - 34%) and are likely 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 and appropriate agricultural agencies like the County's Soil Conservation District to improve existing agricultural BMPs and/or initiate new BMPs, wherever practical and feasible, in these five 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	Adjustments	Comments
15-L1M-01-21	1.00	15.7	0.7	300.0	19.1	23.4	10.5	0.38	1.1	0.062	C6	SIN +0.1	Revisit site. Unable to locate origional cross-section pins. Stream has significantly changed SINce initial survey based on previous cross-sectional data and site photos. One main pilot channel with extensive floodplain wetlands and frequent out of bank flows. Stream splits at approx. sta. 0+98. Virtually no bank tops. Valley width is roughly 400 LF. Entire floodplain is saturated with wetlands throughout. Canopy appears to be opening up due to dying trees likely from too much saturation. A secondary tributary not connected to the study reach can be found in the left floodplain approximately 100 LF from study reach left tob of bank. Stream seems to have significantly moved from initial survey. Lots of wood scattered throughout floodplain and in channel. Bed material is dominatenly silt/clay full of leaves. Scour pools created from downed logs.
15-L1M-02-21	1.29	13.6	0.9	16.4	1.2	15.6	11.8	0.29	1.3	0.18	F5	None	Revisit site. Previous years cross-section is located upstream of the study reach. Tape was extended upstream to include a profile shot at the cross-section. Cross-section pins were located and shot. Sand bed stream throughout. Downstream riffle was entirely made of clay. Stream is incised. Deposition was noted along mid banks but not along the floodplain. A tributary enters the sight from the right floodplain at the middle of the project reach. Stream banks are actively eroding and average 5+ feet in vertical height. Floodplain is forested with mature trees and minimal invasives. The stream is located along the right vally wall after the tributary confluence. A wetland is located in the left floodplain. The previous survey places sta. 0 at the approximate mid point of the 2021 geomorph survey based on biomonitoring site photos.
15-L2M-02-21	3.30	16.3	1.3	50.0	3.1	12.1	21.8	0.086	1.1	0.35	C5c-	SIN +0.1	C5C-, Minor adjustment for SINuosity. Only found REP from original survey, established new LEP. Low gradient channel, access to floodplain, minor erosion on some banks but mostly in good condition. Sand plain bed.
15-L2M-07-21	0.56	10.4	0.6	10.4	1.0	16.8	6.4	0.12	1.1	0.081	F5/6	SIN +0.1	Revisit site. Sand bed dominant F channel type with steep eroding banks. Algae is present through the pool and glide located between 50 - 75 meters. Vernal pool located within left floodplain that drains into stream at aproximately station 0+00. Bank pins were located from R2. Floodplain vegetation by cross-section has changed significantly from R2 survey. Upstream extent of the study reach containes an extensive pool which required a profile shot to be taken in a pool. Pool extends well above the profile tie-out location. Forested floodplain on both sides. Deposition noted along left top of bank.
15-R3M-01-21	0.05	3.2	0.5	4.2	1.3	6.7	1.6	1.5	1.2	0.18	G5c	None	Incised channel, little to no floodplain access, sand bed, mostly riffle.
15-R3M-03-21	4.13	11.2	2.4	400.0	35.7	4.6	27.4	0.11	1.1	0.062	E6	SIN +0.4	E6 with low SINuosity. Few defined bed features. Actively eroding banks, no good indicators. REP placed close to top of bank and flush to avoid mowing. Downcut to clay with fine sand on edges of channel from banks. Little sediment deposition on floodplain, does not seem to access often.
15-R3M-04-21	4.75	14.7	2.2	50.0	3.4	6.8	31.8	0.13	1.2	0.062	E6	SIN +0.3	E6 with low SINuosity. Backwatered by mainstem - no real bed features. Few good indicators, banks actively eroding/slumping. Downcut to clay in channel with fine sediment from banks on edges of channel. Accesses floodplain based on sediment deposition on floodplain.
15-R3M-05-21	0.40	8.2	0.7	9.7	1.2	12.1	5.6	0.2	1.1	0.062	F6	SIN +0.1	Stream classified as an F6 channel type. Width to depth ratio was 12.4. Stream is disconnected from floodplain. No evidence of deposition along top of banks. Banks are undercut with active erosioin occurring. Streambed is a mixture of silt/ clay and sand. Minimal substrate was located within the riffle cross sections. Floodplain is forested with minimal invasives present. Bankfull indicators were poor so bankfull was gaged uSINg regional curve.
21-L1M-01-21	0.31	9.4	0.6	12.5	1.3	16.5	5.4	0.57	1.1	0.67	F5	SIN +0.1	R1 revisit, no Ferry Branch PSU R1 geomorph. Site along edge of horse pasture. Left bank used by horses, no left pin installed. Stream incised. Very straight channel.
21-L1M-05-21	1.52	7.7	2.0	172.0	22.3	3.8	15.6	0.46	1.1	0.2	E5/6	SIN +0.4	Lots of sediment deposited in floodplain. Incised but not entrenched. Raw clay banks. Wide access to floodplain along river left, constrained on right bank by service road. Bimodal distribution of sand & silt/clay substrates.
21-L2M-02-21	1.50	13.9	1.1	178.0	12.8	13.1	14.8	0.82	1.2	0.062	DA6	None	Few bedform features. Two channels at XS, left channel standing pools. Wide floodplain. Incised with clay banks. Stream splits near st 217.
21-L2M-05-21	0.28	9.4	0.5	11.9	1.3	18.2	4.8	0.55	2.2	1.4	F5/4	None	Relocated R2 XS and resurveyed. Incised stream. Streambed scoured down to clay layer. Downstream half on left descending bank with high eroded banks, approximately 10' high.
21-R3M-04-21	0.34	12.3	0.3	14.2	1.2	36.1	4.2	0.47	1.6	2.8	F4/5	None	Relocated R2 xs and resurveyed. Tree had fallen on right pin. Stream incised and entrenched.
21-R3M-07-21	3.63	28.6	1.3	38.4	1.3	21.9	37.4	0.31	1.3	0.81	F5	None	Lots of sand deposition high on the banks and on the floodplain. Raw. Eroded banks on meander bends. Incised and entrenched stream.
21-R3M-10-21	2.45	26.6	1.0	28.9	1.1	26.5	26.7	0.48	1.2	5.4	F4	None	Site is mostly one long riffle, very little bedform diversity. Stream is incised and entrenched. Large gravel bars. Sand deposition on banks and floodplain surfaces.
21-R3M-13-21	1.06	14.1	0.9	18.5	1.3	15.4	12.9	0.25	1.5	0.45	F5/4	None	Lots of sand deposition. Site between two crop fields in narrow band of forest. Vertical eroded banks. Incised and entrenched stream. Silty covering over most substrate particles. Large amount of woody debris on banks.
22-L1M-01-21	0.17	10.5	1.1	13.6	1.3	9.4	11.7	0.56	1.1	0.26	G5c	SIN +0.1	Relocated R1 pins. Left pin did not have a cap, did not reinstall, would have pounded pin down below surface. XS now located in a pool.
22-L1M-02-21	0.44	8.7	0.5	9.3	1.1	18.2	4.2	0.81	1.1	0.23	F5/4	SIN +0.1	F5/4 with low SINuosity. Downcut to hard clay with sand and gravel throughout likely from bank erosion. Right bank pushed against valley wall. Little to no floodplain access.
22-L2M-01-21	0.14	8.8	1.0	10.9	1.2	8.9	8.7	0.6	1.1	0.11	G5c	SIN +0.1	Located both R2 pins, resurveyed R2 cross-section. Incised stream, minimal buffer adjacent to crop field.
22-L2M-02-21	5.92	14.6	2.7	50.0	3.4	5.5	38.8	0.2	1.1	2	E4	SIN +0.4	E4 with low SINuosity. Limited floodplain access, some sand deposition on floodplain. Mostly pool with a few riffles.
22-R3M-04-21	1.46	11.3	1.1	50.0	4.4	10.0	12.9	0.27	1.1	0.35	E5	SIN +0.4	E channel with low SINuosity, slightly downcut but accesses floodplain. Low bankfull benches. Flat, not many bed features.
22-R3M-08-21	5.74	11.9	2.2	500.0	41.8	5.5	26.0	0.39	1.5	0.073	E5/6	None	Stream regularly reaches wide, wetland-like floodplain. Banks actively eroding in places. Bed scoured down to clay layer. Tight meanders throughout site. Bimodal distribution of sand and silt/clay substrates.
22-R3M-09-21	0.15	6.1	0.6	7.7	1.3	9.6	3.8	0.8	1.1	1.2	G5/4c	SIN +0.1	Incised, straight channel adjacent to crops with minimal buffer on right descending bank. Several small debris jams on rootwads thoughout reach.
22-R3M-17-21	0.22	11.4	0.7	13.1	1.2	16.8	7.7	0.3	1.1	0.062	F6	SIN +0.1	F6 with low SINusoity. Downcut to hard clay bottom. Very minimal floodplain access, high eroded banks.
23-L1M-01-21	3.56	21.1	1.3	30.3	1.4	16.9	26.5	0.25	1.4	0.3	F5	ER -0.1	Road culvert at 75m, upper part of site in very deep scour pool. Incised stream, large sand bars throughout. Eroded banks throughout reach.
23-L1M-02-21	0.05	4.8	0.2	6.1	1.3	22.9	1.0	1.3	1.1	0.23	F5	SIN +0.1	Relocated both R1 pins. Left pin misSINg cap, reinstalled cap before surveying. Do not believe elevation changed. Stream has scoured down to clay layer.
23-L2M-02-21	0.36	11.9	0.7	14.6	1.2	17.5	8.1	0.55	1.3	6	F4	None	Located and resurveyed existing pins. Incised and entrenched stream.
23-L2M-03-21	0.15	3.8	0.3	4.9	1.3	11.2	1.3	0.84	1.1	0.077	G5c	SIN +0.1	Stream runs underground (under sycamore tree root) from sta 52 to 74. Very soft sand/silt bottom, SINk into stream bed with each stop. Stream is incised and entrenched.
23-R3M-01-21	0.76	12.7	0.8	16.2	1.3	15.3	10.5	0.99	1.1	8.6	F4	SIN +0.1	Headcut at St 6, incised and entrenched stream. Very straight channel. Short distance upstream from confluence with mainstem Cabin Branch.
23-R3M-03-21	0.09	9.0	0.5	10.1	1.1	18.3	4.4	1.6	1.2	1.4	F5	None	Eroded meander bends. Downed tree cauSINg debris jam. Incised stream channel down to clay layer in places. Sizeable tributary enters near downstream end of site. Cross-section upstream of the trib.
23-R3M-04-21	0.73	13.8	0.6	15.3	1.1	22.2	8.6	0.47	1.2	0.81	F5	None	Incised and entrenched stream. Wide floodplain and the stream accesses the floodplain in places despite being incised. Erosion at each meander bend. Large sand and gravel bars throughout.
23-R3M-07-21	3.01	17.7	1.2	26.5	1.5	14.9	21.0	0.23	1.6	0.21	B5c	None	Incised channel but with sand deposited on the floodplain. Floodprone calculated as contained inside channel. Very soft stream bottom. Debris jam at st 170, high water appears to get around debris jam with minimal backwater. Stream with tight meanders.

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 and held valid MBSS certifications. Due to precautions in place due to the COVID-19 pandemic, no Spring or Summer Index Period training was held by MBSS in 2021. Field staff holding valid certifications at the end of 2019 had those certifications extended by MBSS through 2021. 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 2021, 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. Only one metric, Total Number of Taxa, exceeded the MQO for mRPD. The BIBI was within the acceptable range for all MQOs in the QC dataset.

Total Number of Taxa also exceeded the MQO for CV, but passed for RMSE. This suggests that the relatively low mean number of total taxa in the QC data set skewed the CV value upward and just barely exceeded the MQO of 20.0.

Two metrics, Percent Ephemeroptera and Percent Climbers, exceeded the MQOs for RMSE. High RMSE for Percent Ephemeroptera is largely due to only two sample pairs having Ephemeroptera present while the remaining sample pairs all had 0.0%, which skewed the value upward. Once RMSE was normalized by the mean of all values, the resulting CV was well below the stated MQO. A similar result was observed for Percent Climbers, which had just two outlier

sample pairs that skewed the RMSE upward. Once normalized by the sample mean, the resulting CV was well below the stated MQO.

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), patchy distributions of the organisms, 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
21-R3M-07-21	18	3	1	9.4	5.7	2	26.4	3.29	Fair
21-R3M-07-21-QC	24	5	1	13.4	7.1	3	21.4	4.14	Good
21-R3S-26-21	22	0	0	0.9	0.0	1	0.9	2.14	Poor
21-R3S-26-21-QC	20	1	0	0.0	0.0	1	1.8	1.86	Very Poor
24-R3M-08-21	14	4	2	2.8	2.8	2	38.5	3.57	Fair
24-R3M-08-21-QC	20	4	2	7.6	3.4	1	38.1	3.29	Fair
24-R3S-10-21	8	1	0	0.0	0.0	0	54.1	1.57	Very Poor
24-R3S-10-21-QC	12	1	0	0.9	0.0	0	29.2	1.57	Very Poor
15-L2M-07-21	15	2	0	2.6	0.0	0	5.2	1.86	Very Poor
15-L2M-07-21-QC	15	2	0	5.7	0.0	0	5.7	1.86	Very Poor
15-R3S-13-21	20	2	0	5.9	0.0	0	27.1	2.14	Poor
15-R3S-13-21-QC	16	0	0	4.2	0.0	0	12.7	1.86	Very Poor
22-R3M-17-21	17	1	0	4.6	0.0	1	2.8	1.86	Very Poor
22-R3M-17-21-QC	13	1	0	1.8	0.0	0	3.6	1.29	Very Poor
22-R3S-01-21	11	0	0	0.0	0.0	1	9.3	1.86	Very Poor
22-R3S-01-21-QC	9	0	0	0.0	0.0	0	4.6	1.29	Very Poor
Median RPD	**26.8**	0.0	0.0	60.3	0.0	20.0	22.9	14.0	-
RMSE	3.6	0.9	0.00	2.4	**0.98**	0.6	**8.1**	0.35	-
CV	**21.8**	42.8	0.0	52.1	73.4	84.5	51.3	15.2	-

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, 10% (9 of 90 samples) underwent quality control procedures for sorting, fulfilling the ten percent requirement. Average percent sorting efficiency was 97.9% (n=9). 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 (15-R3S-04-21, 15-L1M-01-21, 15-R3M-01-21, 21-R3S-26-21-QC, 23-R3S-01-21, 23-R3M-01-21, 24-R3S-03-21, 24-R3M-08-21, 24-R3M-08-21-QC) were randomly selected for QC identification and enumeration by an independent lab. Initial identification was performed by EcoAnalysts[1]. Re-identification of the randomly selected samples was completed by Ellen Friedman of ESFriedman Lab, 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 6 through Table 13. 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.

Only one sample exceeded the threshold for PTD. Sample 24-R3S-03-21 had very few individual disagreements; however, a single disagreement among 15 specimens in the Simuliidae family yielded a PTD of 17.0%, just above the allowable threshold of 15.0%. The primary taxonomist identified 13 individuals as *Simulium* and the remaining 2 as *Prosimulium,* while the secondary taxonomist identified all 15 individuals as *Stegopterna*. Thus, a single disagreement involving a relatively large number of individuals skewed the PTD upward for this sample. Aside from this one outlier sample, PTD was well within the acceptable range for the eight other samples. The average PTD was 6.6% with a range between 2.5% and 17.0%. The average PDE for all samples was 1.0% with a range between 0.0% and 4.5%.

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 10 QC samples, two from each PSU, were collected during the spring index period according to methods detailed in the County QAPP. Of the 10 QC samples collected, eight (8) were duplicate water quality grab sample pairs and two (2) were field blank samples. To

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

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 2021, there were no parameters that exceeded 20% mRPD (median RPD). Therefore, 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 collected at two of the 10 QC sites during 2021. Results of individual parameter values for both field blank samples are presented in Table 4. At site 21-R3S-26-21-QC, five individual parameters had values slightly above the method detection limit, which include Total Nitrogen, Kjeldahl Nitrogen, DOC, TOC, and turbidity. At site 24-R3S-10-21-QC, values for Total Nitrogen, Kjeldahl Nitrogen, DOC, TOC, and copper fell slightly above the method detection limit, with all other parameter values falling below.

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	Total Kjehldal Nitrogen	Dissolved Organic Carbon
23-R3M-01-21	17.45	0.1207	1.4902	0.0669	0.0081	0.0041	1.359	0.1272	1.574
23-R3M-01-21-QC	17.52	0.1236	1.5057	0.0722	0.0080	0.0039	1.373	0.1290	1.592
23-R3S-01-21	15.02	0.0148	0.1200	0.0058	0.0059	BDL	0.0109	0.1102	1.381
23-R3S-01-21-QC	15.84	0.0161	0.1091	BDL	0.0059	BDL	0.0122	0.0975	1.377
21-R3M-07-21	19.74	0.0582	1.0520	0.0229	0.0116	BDL	0.9425	0.1073	2.308
21-R3M-07-21-QC	19.12	0.0642	1.0565	0.0258	0.0115	0.0030	0.9284	0.1251	2.388
24-R3M-08-21	19.88	0.1097	0.6266	0.0134	0.0663	0.0060	0.4216	0.1990	3.046
24-R3M-08-21-QC	19.94	0.0897	0.7033	0.0159	0.0669	0.0061	0.4223	0.2749	3.134
15-R3S-13-21	91.39	0.2671	0.4270	0.1785	0.0225	BDL	0.2294	0.1970	2.009
15-R3S-13-21-QC	98.48	0.3288	0.5259	0.1903	0.0195	BDL	0.2431	0.2812	1.880
15-L2M-07-21	39.93	0.0729	1.1677	0.0080	0.0382	0.0050	0.8912	0.2715	2.687
15-L2M-07-21-QC	40.46	0.0805	1.1242	0.0095	0.0359	0.0057	0.8824	0.2361	2.646
22-R3M-17-21	32.14	0.0632	0.5586	0.0136	0.0164	BDL	0.4727	0.0858	1.524
22-R3M-17-21-QC	32.69	0.0771	0.5714	0.0125	0.0227	BDL	0.4757	0.0951	1.676
22-R3S-01-21	26.45	0.1062	1.9705	0.0265	0.0340	0.0041	1.793	0.1737	2.023
22-R3S-01-21-QC	25.47	0.1058	2.0254	0.0299	0.0356	0.0051	1.839	0.1814	2.032
Median RPD	1.7	9.8	2.7	10.2	1.2	5.0	12.2	1.3	1.6

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)
23-R3M-01-21	1.623	2.378	12.23	40.33	0.266	6.52	0.071	3.56
23-R3M-01-21-QC	1.726	2.368	12.24	40.31	0.262	6.78	0.079	3.57
23-R3S-01-21	1.489	2.403	5.740	24.23	0.379	13.0	0.202	3.73
23-R3S-01-21-QC	1.402	2.511	6.107	25.59	0.356	13.6	0.213	2.78
21-R3M-07-21	2.414	2.838	10.33	37.48	0.509	7.89	0.136	3.64
21-R3M-07-21-QC	2.241	2.800	10.26	37.15	0.605	7.49	0.136	4.06
24-R3M-08-21	3.156	2.169	17.37	52.30	0.370	1.94	0.273	15.4
24-R3M-08-21-QC	3.277	2.128	16.86	50.86	0.404	2.63	0.299	15.4
15-R3S-13-21	1.857	4.339	38.44	113.85	0.582	6.38	0.326	10.0
15-R3S-13-21-QC	2.004	4.704	33.68	103.47	0.802	10.2	0.683	23.3
15-L2M-07-21	2.680	2.918	18.07	57.14	0.514	7.09	0.229	10.8
15-L2M-07-21-QC	2.666	2.877	18.13	57.12	0.688	7.47	0.354	9.66
22-R3M-17-21	1.560	2.524	16.19	50.82	0.248	9.67	0.093	4.37
22-R3M-17-21-QC	1.817	2.395	16.36	50.71	0.310	10.2	0.124	6.13
22-R3S-01-21	2.110	1.857	19.76	56.99	0.541	2.59	0.261	8.81
22-R3S-01-21-QC	2.332	1.913	20.43	58.89	0.491	2.60	0.204	8.01
Median RPD	6.2	1.9	1.0	0.9	9.7	5.2	10.7	10.9

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	21-R3S-26-21-QC	24-R3S-10-21-QC	Parameter	21-R3S-26-21-QC	24-R3S-10-21-QC
Chloride	BDL	BDL	Kjeldahl Nitrogen	0.1237	0.1364
Total Phosphorus	BDL	BDL	Magnesium	BDL	BDL
Total Nitrogen	0.1256	0.1375	Calcium	BDL	BDL
Orthophosphate	BDL	BDL	Hardness	BDL	BDL
Total Ammonia Nitrogen	BDL	BDL	Total Copper (µg/L)	BDL	0.121
Nitrite-N	BDL	BDL	Total Zinc (µg/L)	BDL	BDL
Nitrate-N	BDL	BDL	Total Lead (µg/L)	BDL	BDL
Dissolved Organic Carbon	0.2934	0.3355	Turbidity (NTU)	0.65	0.58
Total Organic Carbon	0.3663	0.3179			

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 5. While several individual metrics had exceeded measures for mRPD and CV, the overall BIBI was within acceptable limits for all measures of precision. 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 also within the desired 90% confidence interval for the BIBI (0.57), well below the MQO of ≤0.96.

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 where 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 MQOs were met during the 2021 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	2021 Results
Field Sampling	Precision	mRPD (BIBI)	<20	14.0
		RMSE (BIBI)	<0.6	0.35
Laboratory Sorting/Subsampling	Bias	PSE	>90	97.9
Taxonomic Identification	Precision	PDE	<5	1.0
		PTD	<15	6.6
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	0.57

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

Table 6 - Taxonomic Identification and Enumeration Results: 15-R3S-04-21

Order	Family	Tribe	Final ID	15-R3S-04-21		
				Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae		Sphaeriidae	1		1
			PISIDIIDAE		1	-
Haplotaxida	Enchytraeidae		Enchytraeidae	1	1	1
Diptera	Chironomidae		Chaetocladius	1	1	1
	Chironomidae		Eukiefferiella	4	4	4
	Chironomidae		Orthocladius	16	15	15
			Orthocladinae sp.		2	-
	Chironomidae		Parametriocnemus	12	11	11
	Chironomidae		Rheocricotopus	13	13	13
	Psychodidae		Psychodidae	1		1
			Pericomaini		1	-
	Tabanidae		Chrysops	1		1
			TABANIDAE		1	-
	Tipulidae		Dicranota	2	2	2
Trichoptera	Limnephilidae		Ironoquia	1	1	1
Amphipoda	not identified		Amphipoda	34		-
	Crangonyctidae		Crangonyctidae	16		-
			Synurella sp.		49	49
Isopoda	Asellidae		Caecidotea	11	10	10
			Total	114	112	110
			PDE			0.88
			PTD			3.51

Table 7 - Taxonomic Identification and Enumeration Results: 15-L1M-01-21

Order	Family	Tribe	Final ID	15-L1M-01-21 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae		Sphaeriidae	12		11
			PISIDIIDAE		11	-
Lumbriculida	Lumbriculidae		Lumbriculidae	5	5	5
Basommatophora	Physidae		Physidae	1		1
			Physa/Physella sp.		1	-
Diptera	Chironomidae		Corynoneura	5	5	5
	Chironomidae		Diplocladius	4	4	4
	Chironomidae		Heterotrissocladius	1	1	1
	Chironomidae		Hydrobaenus	1	1	1
	Chironomidae		Mesocricotopus	2		2
			Orthocladinae sp.		3	-
	Chironomidae		Orthocladius	37	36	36
	Chironomidae		Parametriocnemus	4	4	4
	Chironomidae	Chironomini	Polypedilum	9	9	9
	Chironomidae		Rheocricotopus	2	2	2
	Chironomidae	Tanytarsini	Tanytarsus	1		0
			Micropsectra sp.		1	0
	Chironomidae		Thienemanniella	7	7	7
	Chironomidae	Pentaneurini	Zavrelimyia	1	1	1
Plecoptera	not identified		Plecoptera	1		-
			PERLODIDAE		2	-
	Nemouridae		Nemouridae	7	7	7
	Perlodidae		Isoperla	1	1	1
Trichoptera	Phryganeidae		Ptilostomis	1	1	1
Amphipoda	not identified		Amphipoda	15	13	13
	Crangonyctidae		Synurella	1	1	1
			Gammarus	3	4	3
Isopoda			Caecidotea	2	2	2
NEMATODA			NEMATODA		1	0

Order	Family	Tribe	Final ID	15-L1M-01-21 Taxonomist 1	Taxonomist 2	# of agreements
			Total	123	123	117
			PDE			0.00
			PTD			4.88

Table 8 - Taxonomic Identification and Enumeration Results: 15-R3M-01-21

Order	Family	Tribe	Final ID	15-R3M-01-21 Taxonomist 1	Taxonomist 2	# of agreements
Diptera	Chironomidae		Chaetocladius	1	1	1
	Chironomidae	Diamesini	Diamesa	7	7	7
	Chironomidae		Orthocladius	11	7	7
	Chironomidae		Parametriocnemus	7	5	5
	Chironomidae		Thienemanniella	1	0	0
			Ceratopogon/Culiodes	0	1	0
	Dixidae		Dixa	2	2	2
Plecoptera	Nemouridae		Nemouridae	2		2
			Ostrocerca sp.		2	
	Nemouridae		Amphinemura	2	2	2
Trichoptera	Limnephilidae	Stenophylacini	Pycnopsyche	1	0	0
			Ironoquia sp.	0	1	0
	Philopotamidae		Philopotamidae	1		1
			Wormaldia sp.		1	
Amphipoda	not identified		Amphipoda	15		8
	Gammaridae		Gammarus	74	82	74
Isopoda	Asellidae		Caecidotea	4	5	4
	not identified		Turbellaria	1		1
	not identified		Girardia sp.		2	
			Total	129	118	114
			PDE			4.45
			PTD			11.63

Table 9 - Taxonomic Identification and Enumeration Results: 21-R3S-26-21-QC

Order	Family	Tribe	Final ID	21-R3S-26-21-QC Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae		Enchytraeidae	1	1	1
	Naididae		Naididae	11	10	10
Lumbriculida	Lumbriculidae		Lumbriculidae	2	2	2
Hoplonemertea	Tetrastemmatidae		Prostoma	1	1	1
Basommatophora	Lymnaeidae		Lymnaeidae	1	1	1
Diptera	Chironomidae		Chaetocladius	8	8	8
	Chironomidae	Chironomini	Chironomus	2	2	2
	Chironomidae	Diamesini	Diamesa	1	1	1
	Chironomidae		Diplocladius	26	26	26
	Chironomidae		Eukiefferiella	9	7	7
	Chironomidae		Limnophyes	17	17	17
	Chironomidae		Orthocladius	23	20	20
			Orthocladinae sp.	0	5	0
	Chironomidae		Parametriocnemus	2	2	2
	Chironomidae	Chironomini	Polypedilum	1	1	1
	Chironomidae		Thienemannimyia group	1	1	1
	Ephydridae		Ephydridae	1	1	1
	Simuliidae	Simuliini	Simulium	20	20	20
Trichoptera	Limnephilidae		Ironoquia	1	1	1
Amphipoda	not identified		Amphipoda	1	-	1
			Crangonyctidae	-	1	-
	Crangonyctidae		Stygobromus	1	1	1
			Turbellaria	1	-	1
			Girardia sp.	-	1	-
			Total	131	130	125
			PDE			0.38
			PTD			3.85

Table 10 - Taxonomic Identification and Enumeration Results: 23-R3S-01-21

Order	Family	Tribe	Final ID	23-R3S-01-21 Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae		Enchytraeidae	1	0	0
			LUMBRICULIDAE	0	1	0
	Naididae		Naididae	8	8	8
Diptera	Chironomidae		Corynoneura	3	3	3
	Chironomidae		Diplocladius	17	17	17
	Chironomidae		Orthocladius	2	1	1
			Orthocladinae		1	1
	Chironomidae		Parametriocnemus	3	3	3
	Chironomidae	Chironomini	Polypedilum	3	3	3
	Chironomidae		Pseudorthocladius	1	1	1
	Chironomidae		Rheocricotopus	2	2	2
	Chironomidae		Thienemanniella	18	18	18
	Simuliidae	Simuliini	Simulium	45	37	37
			Stegopterna sp.	0	8	0
	Tipulidae		Tipula	2	2	2
Plecoptera	Nemouridae		Amphinemura	1	3	1
Trichoptera	Hydropsychidae		Diplectrona	6	6	6
	Limnephilidae		Limnephilidae	3	3	3
	Philopotamidae		Philopotamidae	1	1	1
			Total	116	118	107
			PDE			0.85
			PTD			9.32

Table 11 - Taxonomic Identification and Enumeration Results: 23-R3M-01-21

Order	Family	Tribe	Final ID	23-R3M-01-21 Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Naididae	0	Naididae	1	1	1
Diptera	Chironomidae	0	Cricotopus	2	0	0
	Chironomidae	Diamesini	Diamesa	7	7	7
	Chironomidae	0	Diplocladius	2	1	1
	Chironomidae	0	Eukiefferiella	1	1	1
	Chironomidae	0	Hydrobaenus	59	57	57
			Orthocladinae sp.	-	4	2
	Chironomidae	0	Orthocladius	15	15	15
	Chironomidae	0	Parametriocnemus	2	2	2
	Chironomidae	Chironomini	Polypedilum	13	12	12
			Chironomini	-	1	1
	Chironomidae	Tanytarsini	Rheotanytarsus	2	2	2
	Empididae	0	Neoplasta	1	1	1
	Simuliidae	Simuliini	Simulium	3	3	3
Ephemeroptera	Baetidae	0	Acerpenna	6	6	6
Plecoptera	Nemouridae	0	Amphinemura	2	2	2
			CAPNIIDAE	0	1	0
Trichoptera	Limnephilidae	0	Limnephilidae	1	1	1
Isopoda	Asellidae	0	Caecidotea	2	2	2
			Total	119	119	116
			PDE			0.00
			PTD			2.52

Table 12 - Taxonomic Identification and Enumeration Results: 24-R3S-03-21

Order	Family	Tribe	Final ID	24-R3S-03-21 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae		Sphaeriidae	3	-	3
			Musculium sp.	-	3	-
Haplotaxida	Naididae		Naididae	3	3	3
Diptera	Chironomidae		Corynoneura	1	1	1
	Chironomidae	Diamesini	Diamesa	1	1	1
	Chironomidae		Diplocladius	23	23	23
	Chironomidae		Hydrobaenus	3	3	3
	Chironomidae	Chironomini	Microtendipes	1	1	1
	Chironomidae		Orthocladius	22	20	20
			Orthocladinae sp.	-	2	2
	Chironomidae		Parametriocnemus	18	18	18
	Chironomidae	Chironomini	Polypedilum	5	5	5
	Chironomidae		Rheocricotopus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	3	1	1
			Micropsectra sp.	0	2	0
	Chironomidae		Thienemanniella	1	1	1
	Chironomidae		Thienemannimyia Grp	2	2	2
	Simuliidae	Prosimuliini	Prosimulium	2	0	0
	Simuliidae	Simuliini	Simulium	13	0	0
			Stegopterna sp.	0	15	0
	Tipulidae		Pseudolimnophila	1	1	1
			DIPTERA	0	1	0
Ephemeroptera	Heptageniidae		Maccaffertium	1	1	1
Amphipoda	Gammaridae		Gammarus	7	6	6
Nematoda			NEMATODA	0	1	0
			Total	111	112	93
			PDE			0.45
			PTD			16.96

Table 13 - Taxonomic Identification and Enumeration Results: 24-R3M-08-21

Order	Family	Tribe	Final ID	24-R3M-08-21		
				Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Naididae		Naididae	2	2	2
Diptera	Chironomidae	Chironomini	Cryptochironomus	1	1	1
	Chironomidae		Hydrobaenus	3	2	2
	Chironomidae		Orthocladius	32	32	32
	Chironomidae		Parametriocnemus	1	1	1
	Chironomidae	Chironomini	Polypedilum	46	46	46
	Chironomidae		Rheocricotopus	2	2	2
	Chironomidae	Tanytarsini	Tanytarsus	1	1	1
	Simuliidae	Simuliini	Simulium	23	20	20
			Stegopterna sp.	0	4	0
	Tipulidae		Tipula	2	0	0
Ephemeroptera	Baetidae		Baetidae	1	1	1
	Baetidae		Acerpenna	1	1	1
	Heptageniidae		Maccaffertium	1	1	1
Trichoptera	Hydropsychidae		Cheumatopsyche	3	3	3
	Limnephilidae		Ironoquia	2	2	2
			Total	121	119	115
			PDE			0.83
			PTD			3.36

Table 14 - Taxonomic Identification and Enumeration Results: 24-R3M-08-21-QC

Order	Family	Tribe	Final ID	24-R3M-08-21-QC		
				Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Naididae		Naididae	1	1	1
Diptera	Chironomidae		Chaetocladius	2	2	2
	Chironomidae	Chironomini	Cryptochironomus	2	2	2
	Chironomidae		Diplocladius	1	1	1

Order	Family	Tribe	Final ID	24-R3M-08-21-QC Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae		Eukiefferiella	1	1	1
	Chironomidae		Orthocladius	17	17	17
	Chironomidae		Parametriocnemus	4	4	4
	Chironomidae	Chironomini	Polypedilum	43	39	39
			Chironomini		3	3
	Chironomidae		Rheocricotopus	4	4	4
	Chironomidae	Tanytarsini	Rheotanytarsus	2	2	2
	Chironomidae	Tanytarsini	Tanytarsus	2	1	1
			Tanytarsini		1	
	Chironomidae		Thienemanniella	1	1	1
	Chironomidae		Thienemannimyia Grp	4	4	4
	Simuliidae	Simuliini	Simulium	19	15	15
			Prosimulium sp.	0	4	0
Ephemeroptera	Baetidae		Baetidae	1	2	1
	Heptageniidae		Maccaffertium	3	3	3
Plecoptera	not identified		Plecoptera	1	0	1
			Taeniopteryx sp.	0	1	0
	Nemouridae		Amphinemura	3	3	3
Trichoptera	Hydropsychidae		Cheumatopsyche	5	5	5
Amphipoda	Gammaridae		Gammarus	1	1	1
Isopoda	Asellidae		Caecidotea	1	1	1
			Total	118	118	112
			PDE			0.00
			PTD			5.08

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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	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2	1014	23.47%	39	97.5%
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	519	12.01%	35	87.5%
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	359	8.31%	34	85.0%
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	286	6.62%	26	65.0%
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2	249	5.76%	21	52.5%
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	184	4.26%	28	70.0%
Amphipoda	not identified	not identified	Amphipoda	0	sp	6	154	3.56%	18	45.0%
Ephemeroptera	Baetidae	Acerpenna	Acerpenna	Collector	sw, cn	2.6	111	2.57%	19	47.5%
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	105	2.43%	28	70.0%
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	89	2.06%	22	55.0%
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	88	2.04%	15	37.5%
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	75	1.74%	18	45.0%
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	71	1.64%	21	52.5%
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7	65	1.50%	11	27.5%
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	65	1.50%	15	37.5%
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	63	1.46%	19	47.5%
Ephemeroptera	Heptageniidae	Maccaffertium	Maccaffertium	Scraper	cn	3	44	1.02%	7	17.5%
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3	42	0.97%	13	32.5%
Diptera	Simuliidae	Prosimulium	Prosimulium	Filterer	cn	2.4	39	0.90%	2	5.0%
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	39	0.90%	16	40.0%
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	39	0.90%	15	37.5%
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	37	0.86%	12	30.0%
Ephemeroptera	Baetidae	Plauditus	Plauditus	0	0	na	35	0.81%	4	10.0%
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	32	0.74%	15	37.5%
Diptera	Chironomidae	Diamesa	Diamesa	Collector	sp	8.5	29	0.67%	10	25.0%
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	29	0.67%	19	47.5%
Plecoptera	Chloroperlidae	Haploperla	Haploperla	Predator	cn	1.6	25	0.58%	2	5.0%
Veneroida	Pisidiidae	not identified	Sphaeriidae	Filterer	bu	6.5	25	0.58%	7	17.5%
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	24	0.56%	8	20.0%
Plecoptera	Nemouridae	not identified	Nemouridae	Shredder	sp, cn	2.9	22	0.51%	7	17.5%
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	21	0.49%	9	22.5%
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7	20	0.46%	8	20.0%
Ephemeroptera	Baetidae	not identified	Baetidae	Collector	sw, cn	2.3	16	0.37%	4	10.0%
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	14	0.32%	9	22.5%
Plecoptera	Perlodidae	Isoperla	Isoperla	Predator	cn, sp	2.4	14	0.32%	4	10.0%
Amphipoda	Crangonyctidae	Synurella	Synurella	0	0	0.4	14	0.32%	5	12.5%
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	12	0.28%	8	20.0%
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	12	0.28%	5	12.5%

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	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	10	0.23%	4	10.0%
Diptera	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	10	0.23%	4	10.0%
Diptera	Chironomidae	not identified	Orthocladiinae	Collector	0	7.6	9	0.21%	6	15.0%
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	9	0.21%	7	17.5%
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	9	0.21%	7	17.5%
Diptera	Ceratopogonidae	not identified	Ceratopogoninae	0	0	na	8	0.19%	6	15.0%
Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	Collector	bu	6.6	8	0.19%	2	5.0%
Diptera	Empididae	Neoplasta	Neoplasta	Predator	0	na	8	0.19%	6	15.0%
Diptera	Chironomidae	Saetheria	Saetheria	Collector	bu	6.6	8	0.19%	1	2.5%
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	8	0.19%	6	15.0%
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	7	0.16%	3	7.5%
not identified	not identified	not identified	Turbellaria	Predator	sp	4	7	0.16%	5	12.5%
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	6	0.14%	2	5.0%
Ephemeroptera	Heptageniidae	not identified	Heptageniidae	Scraper	cn	2.6	6	0.14%	3	7.5%
Trichoptera	Hydropsychidae	not identified	Hydropsychidae	Filterer	cn	5.7	5	0.12%	2	5.0%
0	0	not identified	Nematoda	0	0	na	5	0.12%	3	7.5%
Trichoptera	Uenoidae	Neophylax	Neophylax	Scraper	cn	2.7	5	0.12%	2	5.0%
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	4	0.09%	3	7.5%
Plecoptera	Chloroperlidae	not identified	Chloroperlidae	Predator	cn	1.6	4	0.09%	2	5.0%
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9	4	0.09%	4	10.0%
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9	4	0.09%	3	7.5%
Lepidoptera	not identified	not identified	Lepidoptera	0	0	6.7	4	0.09%	2	5.0%
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	4	0.09%	3	7.5%
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	3	0.07%	3	7.5%
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	3	0.07%	1	2.5%
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	3	0.07%	3	7.5%
Plecoptera	Leuctridae	not identified	Leuctridae	Shredder	sp, cn	0.8	3	0.07%	2	5.0%
Ostracoda	not identified	not identified	Ostracoda	Collector	0	8	3	0.07%	2	5.0%
Diptera	Chironomidae	Paracladopelma	Paracladopelma	Collector	sp	6.6	3	0.07%	3	7.5%
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1	3	0.07%	3	7.5%
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	3	0.07%	1	2.5%
Diptera	Tipulidae	Pseudolimnophila	Pseudolimnophila	Predator	bu	2.8	3	0.07%	2	5.0%
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	2	0.05%	2	5.0%
Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	Predator	bu	2.4	2	0.05%	2	5.0%
Diptera	Dixidae	Dixa	Dixa	Predator	sw, cb	5.8	2	0.05%	1	2.5%
Diptera	Empididae	not identified	Empididae	Predator	sp, bu	7.5	2	0.05%	2	5.0%
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	2	0.05%	2	5.0%
Diptera	Chironomidae	Mesocricotopus	Mesocricotopus	0	0	6.6	2	0.05%	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	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	2	0.05%	1	2.5%
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	2	0.05%	2	5.0%
Plecoptera	Perlidae	Perlesta	Perlesta	Predator	cn	1.6	2	0.05%	2	5.0%
Basommatophora	Physidae	not identified	Physidae	Scraper	cb	7	2	0.05%	1	2.5%
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.01	2	0.05%	2	5.0%
Diptera	Chironomidae	Pseudorthocladius	Pseudorthocladius	Collector	sp	6	2	0.05%	2	5.0%
Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	Shredder	cb	4.3	2	0.05%	2	5.0%
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	2	0.05%	2	5.0%
Diptera	Chironomidae	not identified	Tanypodinae	Predator	0	7.5	2	0.05%	2	5.0%
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	2	0.05%	2	5.0%
Ephemeroptera	Baetidae	Baetis	Baetis	Collector	sw, cb, cn	3.9	1	0.02%	1	2.5%
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3	1	0.02%	1	2.5%
Decapoda	Cambaridae	not identified	Cambaridae	Shredder	sp	2.8	1	0.02%	1	2.5%
Diptera	Chironomidae	Chironomini	Chironomini	0	0	5.9	1	0.02%	1	2.5%
Collembola	not identified	not identified	Collembola	0	0	6	1	0.02%	1	2.5%
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1	1	0.02%	1	2.5%
Veneroida	Corbiculidae	Corbicula	Corbicula	Filterer	bu	6	1	0.02%	1	2.5%
Ephemeroptera	Ephemerellidae	Ephemerella	Ephemerella	Collector	cn, sw	2.3	1	0.02%	1	2.5%
Diptera	Chironomidae	Heterotrissocladius	Heterotrissocladius	Collector	sp, bu	2	1	0.02%	1	2.5%
Diptera	Tipulidae	Hexatoma	Hexatoma	Predator	bu, sp	1.5	1	0.02%	1	2.5%
Trichoptera	Hydroptilidae	not identified	Hydroptilidae	0	0	4	1	0.02%	1	2.5%
Trichoptera	Leptoceridae	not identified	Leptoceridae	Collector	0	4.1	1	0.02%	1	2.5%
Ephemeroptera	Leptophlebiidae	not identified	Leptophlebiidae	Collector	sw, cn	1.7	1	0.02%	1	2.5%
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6	1	0.02%	1	2.5%
Coleoptera	Hydrophilidae	Paracymus	Paracymus	0	bu	na	1	0.02%	1	2.5%
Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	Collector	sp	4	1	0.02%	1	2.5%
Plecoptera	Perlidae	not identified	Perlidae	Predator	cn	2.2	1	0.02%	1	2.5%
Plecoptera	Perlodidae	not identified	Perlodidae	Predator	cn	2.2	1	0.02%	1	2.5%
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7	1	0.02%	1	2.5%
Trichoptera	Philopotamidae	not identified	Philopotamidae	Filterer	cn	2.6	1	0.02%	1	2.5%
Diptera	Tipulidae	Pilaria	Pilaria	Predator	bu	4.8	1	0.02%	1	2.5%
Plecoptera	not identified	not identified	Plecoptera	0	0	2.4	1	0.02%	1	2.5%
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1	1	0.02%	1	2.5%
Diptera	Psychodidae	not identified	Psychodidae	0	0	4	1	0.02%	1	2.5%
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	1	0.02%	1	2.5%
Diptera	Chironomidae	Rheosmittia	Rheosmittia	0	0	6.6	1	0.02%	1	2.5%
Amphipoda	Crangonyctidae	Stygobromus	Stygobromus	Collector	0	4	1	0.02%	1	2.5%
Diptera	Chironomidae	Tribelos	Tribelos	Collector	bu	7	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

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	2948	43.6%	30	75.0%
Eastern Mudminnow	*Umbra pygmaea*	T	IV	N	NOTYPE	831	12.3%	20	50.0%
Tessellated Darter	*Etheostoma olmstedi*	T	IV	N	B	498	7.4%	19	47.5%
Green Sunfish	*Lepomis cyanellus*	T	GE	N	NOTYPE	399	5.9%	20	50.0%
Fallfish	*Semotilus corporalis*	I	GE	Y	NOTYPE	373	5.5%	11	27.5%
Eastern Mosquitofish	*Gambusia holbrooki*	NOTYPE	IV	N	NOTYPE	275	4.1%	18	45.0%
American Eel	*Anguilla rostrata*	NOTYPE	GE	N	NOTYPE	234	3.5%	24	60.0%
Creek Chubsucker	*Erimyzon oblongus*	NOTYPE	IV	N	R	182	2.7%	12	30.0%
Least Brook Lamprey	*Lampetra aepyptera*	NOTYPE	FF	N	B	154	2.3%	14	35.0%
Pumpkinseed	*Lepomis gibbosus*	T	IV	N	NOTYPE	136	2.0%	14	35.0%
Rosyside Dace	*Clinostomus funduloides*	NOTYPE	IV	Y	NOTYPE	129	1.9%	8	20.0%
Creek Chub	*Semotilus atromaculatus*	T	GE	Y	NOTYPE	119	1.8%	4	10.0%
Satinfin Shiner	*Cyprinella analostana*	I	IV	N	NOTYPE	96	1.4%	7	17.5%
Swallowtail Shiner	*Notropis procne*	NOTYPE	IV	Y	NOTYPE	94	1.4%	5	12.5%
Brown Bullhead	*Ameiurus nebulosus*	T	OM	N	NOTYPE	89	1.3%	10	25.0%
Yellow Bullhead	*Ameiurus natalis*	NOTYPE	OM	N	NOTYPE	55	0.8%	7	17.5%
White Sucker	*Catostomus commersonii*	T	OM	Y	NOTYPE	34	0.5%	5	12.5%
Bluegill	*Lepomis macrochirus*	T	IV	N	NOTYPE	33	0.5%	11	27.5%
Golden Shiner	*Notemigonus crysoleucas*	T	OM	N	NOTYPE	29	0.4%	5	12.5%
Redfin Pickerel	*Esox americanus*	T	TP	N	NOTYPE	22	0.3%	3	7.5%
Sea Lamprey	*Petromyzon marinus*	I	FF	N	NOTYPE	14	0.2%	2	5.0%
Northern Snakehead	*Channa sp.*	NOTYPE	TP	N	NOTYPE	3	0.0%	2	5.0%
Black Crappie	*Pomoxis nigromaculatus*	NOTYPE	GE	N	NOTYPE	2	0.0%	1	2.5%
Bluespotted Sunfish	*Enneacanthus gloriosus*	NOTYPE	IV	N	NOTYPE	2	0.0%	1	2.5%
Largemouth Bass	*Mictopterus salmoides*	T	TP	N	NOTYPE	2	0.0%	1	2.5%
Warmouth	*Lepomis gulosus*	NOTYPE	GE	N	NOTYPE	2	0.0%	1	2.5%

Crayfish

Common Name	Scientific Name	Total Number of Sites	% of Sites
Spinycheek Crayfish	*Orconectes limosus*	5	13%
Devil Crawfish	*Cambarus diogenes*	3	8%
Red Swamp Crawfish	*Procambarus clarkii*	2	5%
White River Crawfish	*Procambarus acutus*	1	3%
n/a	*Procambarus acutus/zonangulus*	1	3%

Herpetofauna

Common Name	Scientific Name	Total Number of Sites	% of Sites
Northern Green Frog	*Lithobates clamitans*	36	90%
Northern Two-lined Salamander	*Eurycea bislineata*	25	63%
Eastern Cricket Frog	*Acris crepitans*	15	38%
Pickerel Frog	*Lithobates palustris*	14	35%
Northern Spring Peeper	*Pseudacris crucifer*	12	30%
Wood Frog	*Lithobates sylvaticus*	7	18%
Eastern Box Turtle	*Terrapene carolina*	5	13%
American Bullfrog	*Lithobates catesbeianus*	4	10%
Northern Water Snake	*Nerodia sipedon sipedon*	4	10%
Southern Leopard Frog	*Lithobates sphenocephala*	4	10%
Eastern American Toad	*Anaxyrus americanus*	3	8%
Common Five-lined Skink	*Plestiodon fasciatus*	3	8%
Cope’s Gray Treefrog	*Hyla chrysoscelis*	1	3%
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	1	3%
Fowler’s Toad	*Anaxyrus fowleri*	1	3%
Gray Treefrog	*Hyla versicolor*	1	3%
Red -spotted Newt	*Notophthalmus viridescens viridescens*	1	3%
Snapping Turtle	*Chelydra serpentina*	1	3%

Non-native Riparian Plants

Common Name	Scientific Name	Total Number of Sites	% of Sites
Japanese stiltgrass	*Microstegium vimineum*	38	95%
Multiflora rose	*Rosa multiflora*	28	70%
Japanese honeysuckle	*Lonicera japonica*	17	43%
Mile-a-Minute	*Persicaria perfoliata*	10	25%
Indian strawberry	*Duchesnea indica*	6	15%
Oriental bittersweet	*Celastrus orbiculatus*	6	15%
Japanese barberry	*Berberis thunbergii*	5	13%
Ground ivy	*Glechoma hederacea*	5	13%
Garlic mustard	*Alliaria petiolata*	3	8%
Reed Canary Grass	*Phalaris arundinacea*	3	8%
Wineberry	*Rubus phoenicolasius*	3	8%
Beefsteak plant	*Perilla frutescens var. crispa*	2	5%
Phragmites	*Phragmites australis*	2	5%
English ivy	*Hedera helix*	1	3%

Freshwater Mussels/Corbicula

Common Name	Scientific Name	Total Number of Sites	% of Sites
Asiatic clam	*Corbicula sp.*	2	5%
Eastern Elliptio	*Elliptio complanata*	1	3%

Appendix D: Individual Site Summaries

Site ID 15-L1M-01-21

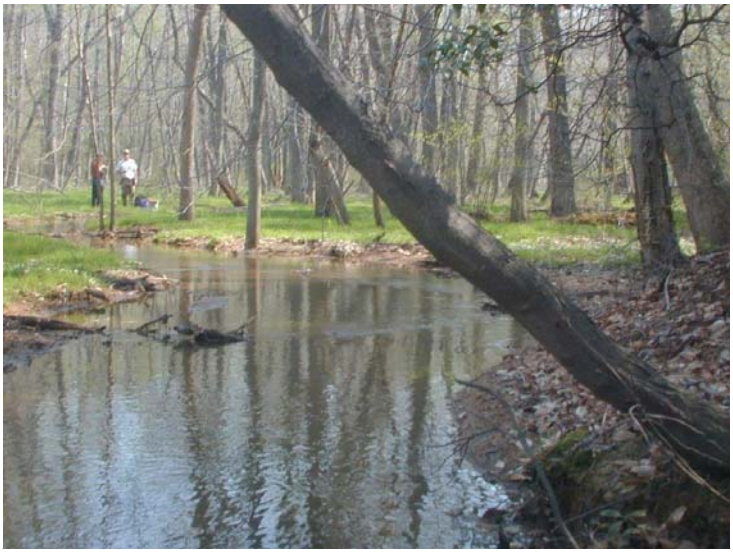
Revist of site R1-15-01

Upstream View - 2021

Downstream View - 2021

Upstream View - 2005

Downstream View - 2005



Summary Results

	2021 Data	2005 Data
Benthic Macroinvertebrate Community	Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 639.72

Land Cover	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Developed Land	134.21	153.67	20.98	22.00
Forested Land	480.87	516.89	75.17	74.00
Open Land	13.16	17.46	2.06	2.50
Agricultural Land	11.48	10.48	1.80	1.50

Impervious Surface	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Impervious Land	7.64	27.94	1.19	2.50

Site ID 15-L1M-01-21

Revist of site R1-15-01

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2005 Spring
Dissolved Oxygen (mg/L)	12.91	1.2	11.27
Turbidity (NTU)	6.1	43.5	24.3
Temperature (°C)	8.5	18.4	14.59
pH (Standard Units)	6.91	6.85	6.81
Specific Conductivity (µS/cm)	138	207	155

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.079	Chloride (mg/L)	14.460
Total Nitrogen (mg/L)	0.225	Magnesium (mg/L)	2.095
Orthophosphate (mg/L)	0.021	Calcium (mg/L)	12.66
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.315
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	1.169
Nitrate-N (mg/L)	0.032	Total Lead (µg/L)	0.092
Total Kjehldal N (mg/L)	0.191	Turbidity (NTU)	4.5
Dissolved Organic C (mg/L)	3.937		
Total Organic C (mg/L)	3.954		
Hardness (mg eq. $CaCO_3$/L)	40.24		

Geomorphic Assessment

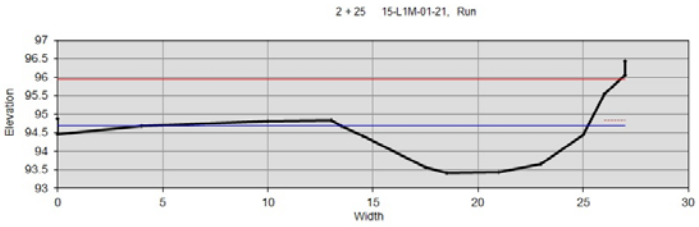
Rosgen Level II Classification Data

	2021	2005		2021	2005
Drainage Area (mi²)	1.00		Sinuosity	1.05	1.10
Bankfull Width (ft)	15.7	7.6	D50 (mm)	0.06	0.03
Mean Bankfull Depth (ft)	0.7	1.1	Adjustments?	SIN +0.1	None
Floodprone Width (ft)	300.0	200.0			
Entrenchment Ratio	19.1	26.2			
Width to Depth Ratio	23.4	6.8			
Cross Sectional Area (ft²)	10.5	8.6			
Water Surface Slope (%)	0.380	0.300			

Rosgen Stream Type

2021	2005
C6	**E6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	11.21	60.38	n/a	64.46
Shading	15	15.33	70	68.32
Epifaunal Substrate	3	31.55	3	30.98
Instream Habitat	3	31.21	6	46.96
Instream Woody Debris	14	89.98	25	100.00
Bank Stability	20.00	100.00	n/a	98.32

	2021 Score	2005 Score
MPHI Habitat Score	54.74	68.17
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2005 Score		2021 Score	2005 Score
Epifaunal Substrate/Available Cover	10	3	Bank Stability - Right Bank	10	10
Pool Substrate Characterization	9	8	Bank Stability - Left Bank	10	9
Pool Variability	10	5	Vegetative Protection - Right Bank	4	9
Sediment Deposition	15	10	Vegetative Protection - Left Bank	4	9
Channel Flow Status	16	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	9			

	2021 Score	2005 Score
RBP Habitat Score	134	129
RBP Rating	Supporting	Supporting

Site ID 15-L1M-01-21

Revist of site R1-15-01

Biological Assessments

BIBI Metric Values	2021	2005
Total Taxa	20	12
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	10.53	21.43
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	7.89	2.04

FIBI Metric Values (2021 only)	
Abundance per m²	0.38
Adj. No. of Benthic Species	0.00
% Tolerant	96.77
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	96.77

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

FIBI Metric Scores (2021 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43	1.86
BIBI Rating	Poor	Very Poor

FIBI Score	1.33
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Mussels

None Observed

Herpetofauna

Red Spotted Newt

Northern Green Frog

Northern Cricket Frog

Fish Taxa	Number
Eastern Mosquitofish	1
Eastern Mudminnow	30

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	14
Caecidotea	2
Corynoneura	5
Diplocladius	4
Gammarus	3
Heterotrissocladius	1
Hydrobaenus	1
Isoperla	1
Lumbriculidae	5
Mesocricotopus	2
Nemouridae	6
Orthocladius	35
Parametriocnemus	4
Plecoptera	1
Polypedilum	7
Ptilostomis	1
Rheocricotopus	2
Sphaeriidae	12
Synurella	1
Tanytarsus	1
Thienemanniella	5
Zavrelimyia	1

Original Visit	Number
Agabus	1
Amphinemura	16
Caecidotea	2
Cricotopus/Orthocladius	59
Gammarus	1
Ironoquia	1
Isoperla	1
Oligochaeta	9
Pisidium	2
Polypedilum	2
Rheocricotopus	2
Synurella	2

Site ID 15-L1M-02-21

Revist of site R1-15-12A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2005

Downstream View - 2005

Summary Results

	2021 Data	2005 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 824.58

Land Cover	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Developed Land	391.03	244.63	47.42	30.40
Forested Land	301.31	420.86	36.54	52.30
Open Land	53.64	70.81	6.50	8.80
Agricultural Land	78.60	67.59	9.53	8.40

Impervious Surface	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Impervious Land	31.29	32.19	3.79	5.90

Site ID 15-L1M-02-21

Revist of site R1-15-12A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2005 Spring
Dissolved Oxygen (mg/L)	11.41	8.66	12.07
Turbidity (NTU)	8.8	16.6	24.4
Temperature (°C)	6.7	16.7	17.54
pH (Standard Units)	6.84	6.73	6.78
Specific Conductivity (µS/cm)	187	211	182

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.107	Chloride (mg/L)	27.381
Total Nitrogen (mg/L)	0.660	Magnesium (mg/L)	2.505
Orthophosphate (mg/L)	0.019	Calcium (mg/L)	14.25
Total Ammonia N (mg/L)	0.015	Total Copper (µg/L)	0.374
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	7.844
Nitrate-N (mg/L)	0.458	Total Lead (µg/L)	0.240
Total Kjehldal N (mg/L)	0.199	Turbidity (NTU)	10.4
Dissolved Organic C (mg/L)	2.514		
Total Organic C (mg/L)	2.773		
Hardness (mg eq. $CaCO_3$/L)	45.90		

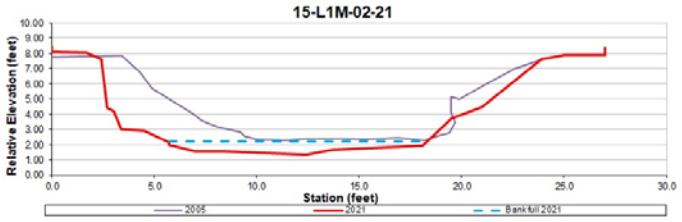
Geomorphic Assessment

Rosgen Level II Classification Data

	2021	2005		2021	2005
Drainage Area (mi²)	1.29		Sinuosity	1.33	1.12
Bankfull Width (ft)	13.6	12.4	D50 (mm)	0.18	0.41
Mean Bankfull Depth (ft)	0.9	1.1	Adjustments?	None	Sin
Floodprone Width (ft)	16.4	14.0			
Entrenchment Ratio	1.2	1.1			
Width to Depth Ratio	15.6	11.6			
Cross Sectional Area (ft²)	11.8	13.3			
Water Surface Slope (%)	0.290	0.300			

Rosgen Stream Type	
2021	2005
F5	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	12.77	68.77	n/a	71.68
Shading	90	91.34	65	63.55
Epifaunal Substrate	6	47.32	4	35.86
Instream Habitat	7	50.81	3	28.86
Instream Woody Debris	12	81.19	1	48.93
Bank Stability	7.20	60.00	n/a	77.46

	2021 Score	2005 Score
MPHI Habitat Score	66.57	54.39
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2005 Score		2021 Score	2005 Score
Epifaunal Substrate/Available Cover	10	4	Bank Stability - Right Bank	2	3
Pool Substrate Characterization	10	6	Bank Stability - Left Bank	2	3
Pool Variability	10	7	Vegetative Protection - Right Bank	5	3
Sediment Deposition	8	13	Vegetative Protection - Left Bank	5	3
Channel Flow Status	13	12	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	11			

	2021 Score	2005 Score
RBP Habitat Score	111	104
RBP Rating	Partially Supporting	Partially Supporting

Site ID 15-L1M-02-21

Revist of site R1-15-12A

Biological Assessments

BIBI Metric Values	2021	2005
Total Taxa	20	16
EPT Taxa	4	6
Ephemeroptera Taxa	1	2
% Intolerant to Urban	3.39	5.00
% Ephemeroptera	2.54	9.00
Scraper Taxa	2	3
% Climbers	5.93	8.00

FIBI Metric Values (2021 only)	
Abundance per m²	0.36
Adj. No. of Benthic Species	0.00
% Tolerant	71.43
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	53.06

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

FIBI Metric Scores (2021 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.00	3.86
BIBI Rating	Fair	Fair

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

Procambarus sp.

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Two-Lined Salamander

Fish Taxa	Number
American Eel	10
Bluegill	8
Brown Bullhead	1
Eastern Mosquitofish	4
Pumpkinseed	26

Benthic Macroinvertebrate Taxa

2021	Number
Cheumatopsyche	8
Cryptochironomus	1
Diplocladius	8
Gammarus	1
Hydrobaenus	22
Hydropsyche	1
Ironoquia	1
Limnephilidae	2
Maccaffertium	3
Naididae	2
Orthocladius	43
Parametriocnemus	11
Polypedilum	4
Prosimulium	1
Psychodidae	1
Rheocricotopus	2
Sphaeriidae	1
Stenochironomus	1
Tanytarsus	1
Thienemanniella	2
Thienemannimyia Gr.	2

Original Visit	Number
Caecidotea	1
Calopteryx	1
Cheumatopsyche	1
Cricotopus/Orthocladius	51
Diamesa	1
Dicranota	1
Gammarus	22
Helichus	1
Ironoquia	1
Isoperla	1
Lype	1
Oligochaeta	1
Orthocladiinae	1
Plauditus	2
Polypedilum	7
Stenonema	7

Site ID 15-L2M-02-21

Revist of site R2-15-10

Upstream View - 2021

Downstream View - 2021

Upstream View - 2010

Downstream View - 2010

Summary Results

	2021 Data	2010 Data
Benthic Macroinvertebrate Community	Good	Good
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2108.86

Land Cover	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Developed Land	670.93	503.00	31.81	23.70
Forested Land	1104.18	1292.40	52.36	61.00
Open Land	85.72	106.90	4.06	5.00
Agricultural Land	248.03	216.90	11.76	10.20

Impervious Surface	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Impervious Land	59.83	77.63	2.84	3.70

Site ID 15-L2M-02-21

Revist of site R2-15-10

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2010 Spring
Dissolved Oxygen (mg/L)	11.12	7.04	10.65
Turbidity (NTU)	10.5	10.6	29.9
Temperature (°C)	7	23.1	10.9
pH (Standard Units)	6.76	6.28	7.61
Specific Conductivity (µS/cm)	171	176	141.3

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.118	Chloride (mg/L)	20.990
Total Nitrogen (mg/L)	0.938	Magnesium (mg/L)	2.529
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	13.53
Total Ammonia N (mg/L)	0.045	Total Copper (µg/L)	0.394
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	8.306
Nitrate-N (mg/L)	0.763	Total Lead (µg/L)	0.220
Total Kjehldal N (mg/L)	0.172	Turbidity (NTU)	11.8
Dissolved Organic C (mg/L)	2.648		
Total Organic C (mg/L)	2.807		
Hardness (mg eq. $CaCO_3$/L)	44.20		

Geomorphic Assessment

Rosgen Level II Classification Data

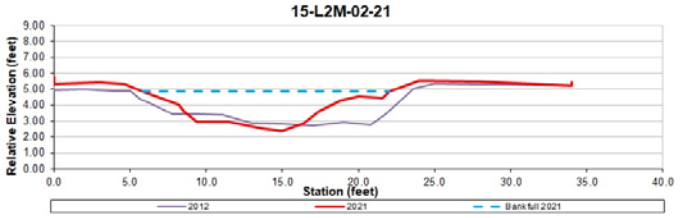
	2021	2010
Drainage Area (mi²)	3.30	
Bankfull Width (ft)	16.3	16.4
Mean Bankfull Depth (ft)	1.3	1.0
Floodprone Width (ft)	50.0	150.0
Entrenchment Ratio	3.1	9.1
Width to Depth Ratio	12.1	15.9
Cross Sectional Area (ft²)	21.8	17.0
Water Surface Slope (%)	0.086	0.036

	2021	2010
Sinuosity	1.08	1.10
D50 (mm)	0.35	0.07
Adjustments?	SIN +0.1	None

Rosgen Stream Type

2021	2010
C5c-	**C5/6c-**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	8.13	43.76	6.00	32.31
Shading	50	49.95	85	84.56
Epifaunal Substrate	11	70.25	11	70.22
Instream Habitat	13	74.49	10	57.79
Instream Woody Debris	16	82.39	12	70.50
Bank Stability	12.33	78.53	15.00	86.61

	2021 Score	2010 Score
MPHI Habitat Score	66.56	67.00
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2010 Score		2021 Score	2010 Score
Epifaunal Substrate/Available Cover	13	11	Bank Stability - Right Bank	6	7
Pool Substrate Characterization	14	7	Bank Stability - Left Bank	6	8
Pool Variability	16	4	Vegetative Protection - Right Bank	4	7
Sediment Deposition	11	10	Vegetative Protection - Left Bank	4	7
Channel Flow Status	14	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	6			

	2021 Score	2010 Score
RBP Habitat Score	134	125
RBP Rating	Supporting	Partially Supporting

Site ID 15-L2M-02-21

Revist of site R2-15-10

Biological Assessments

BIBI Metric Values	2021	2010
Total Taxa	27	23
EPT Taxa	7	5
Ephemeroptera Taxa	2	2
% Intolerant to Urban	23.42	38.10
% Ephemeroptera	4.50	31.40
Scraper Taxa	3	1
% Climbers	16.22	3.80

FIBI Metric Values (2021 only)	
Abundance per m²	0.32
Adj. No. of Benthic Species	0.00
% Tolerant	39.66
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	48.28

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

FIBI Metric Scores (2021 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	4.43	4.43
BIBI Rating	Good	Good

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

Cambarus diogenes

Procambarus clarkii

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American eel	7
Bluegill	2
Brown Bullhead	8
Eastern Mosquitofish	28
Eastern Mudminnow	4
Golden Shiner	1
Pumpkinseed	8

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	2
Amphipoda	2
Ancyronyx	1
Caecidotea	2
Ceratopogoninae	2
Cheumatopsyche	1
Chrysops	1
Corynoneura	1
Cryptochironomus	1
Diplectrona	6
Diplocladius	1
Gammarus	1
Heptageniidae	1
Hydrobaenus	4
Ironoquia	2
Isoperla	7
Maccaffertium	2
Naididae	2
Nemouridae	4
Orthocladius	17
Parametriocnemus	8
Perlodidae	1
Pilaria	1
Polypedilum	13
Rheotanytarsus	16
Simulium	4
Tanytarsus	5
Thienemanniella	1
Thienemannimyia Gr.	1
Zavrelimyia	1

Original Visit	Number
Amphinemura	21
Amphipoda	6
Anopheles	1
Baetis	23
Caecidotea	6
Calopteryx	1
Cambaridae	2
Chironomini	1
Conchapelopia	1
Crangonyx	8
Gammarus	4
Hydroporini	1
Ironoquia	4
Maccaffertium	10
Nanocladius	1
Orthocladius	3
Parametriocnemus	1
Perlodidae	1
Pisidium	1
Polypedilum	3
Pseudorthocladius	1
Rheotanytarsus	1
Stygobromus	1
Tipula	1
Tubificidae	2

Site ID 15-L2M-07-21

Revist of site R2-15-02

Upstream View - 2021

Downstream View - 2021

Upstream View - 2010

Downstream View - 2010

Summary Results

	2021 Data	2010 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	Degraded
Water Quality Conditions	High Conductivity; Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 355.93

Land Cover	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Developed Land	178.97	130.80	50.28	37.00
Forested Land	83.54	124.80	23.47	35.30
Open Land	28.04	34.90	7.88	9.90
Agricultural Land	65.39	63.00	18.37	17.80

Impervious Surface	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Impervious Land	17.88	26.99	5.02	7.60

Site ID 15-L2M-07-21

Revist of site R2-15-02

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2010 Spring
Dissolved Oxygen (mg/L)	12.42	7.84	9.97
Turbidity (NTU)	5.9	14.7	17.1
Temperature (°C)	10.6	17.9	14.43
pH (Standard Units)	6.86	7.1	7.08
Specific Conductivity (µS/cm)	250	284	190.9

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.073	Chloride (mg/L)	39.933
Total Nitrogen (mg/L)	1.168	Magnesium (mg/L)	2.918
Orthophosphate (mg/L)	0.008	Calcium (mg/L)	18.07
Total Ammonia N (mg/L)	0.038	Total Copper (µg/L)	0.514
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	7.086
Nitrate-N (mg/L)	0.891	Total Lead (µg/L)	0.229
Total Kjehldal N (mg/L)	0.272	Turbidity (NTU)	10.8
Dissolved Organic C (mg/L)	2.687		
Total Organic C (mg/L)	2.680		
Hardness (mg eq. $CaCO_3$/L)	57.14		

Geomorphic Assessment

Rosgen Level II Classification Data

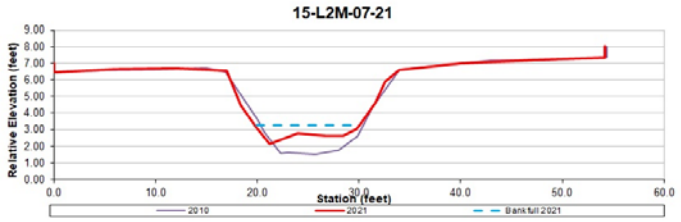
	2021	2010
Drainage Area (mi²)	0.56	
Bankfull Width (ft)	10.4	9.4
Mean Bankfull Depth (ft)	0.6	1.0
Floodprone Width (ft)	10.4	11.9
Entrenchment Ratio	1.0	1.3
Width to Depth Ratio	16.8	9.2
Cross Sectional Area (ft²)	6.4	9.6
Water Surface Slope (%)	0.120	0.097

	2021	2010
Sinuosity	1.07	1.10
D50 (mm)	0.08	0.07
Adjustments?	SIN +0.1	None

Rosgen Stream Type

2021	2010
F5/6	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	6.61	35.62	6.00	32.31
Shading	85	84.56	90	91.34
Epifaunal Substrate	6	52.80	4	41.22
Instream Habitat	8	64.95	4	42.83
Instream Woody Debris	9	81.83	6	73.03
Bank Stability	12.80	80.00	10.00	70.71

	2021 Score	2010 Score
MPHI Habitat Score	66.63	58.57
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2010 Score		2021 Score	2010 Score
Epifaunal Substrate/Available Cover	7	4	Bank Stability - Right Bank	2	5
Pool Substrate Characterization	9	4	Bank Stability - Left Bank	4	5
Pool Variability	13	4	Vegetative Protection - Right Bank	6	4
Sediment Deposition	6	10	Vegetative Protection - Left Bank	6	4
Channel Flow Status	14	17	Riparian Veg. Zone Width - Right Bank	8	9
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	6	9			

	2021 Score	2010 Score
RBP Habitat Score	110	105
RBP Rating	Partially Supporting	Partially Supporting

Site ID 15-L2M-07-21

Revist of site R2-15-02

Biological Assessments

BIBI Metric Values	2021	2010
Total Taxa	15	27
EPT Taxa	2	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	2.61	21.10
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	5.22	9.20

FIBI Metric Values (2021 only)	
Abundance per m²	0.64
Adj. No. of Benthic Species	0.00
% Tolerant	97.17
% Gen., Omni., Invert.	98.11
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	33.02

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

FIBI Metric Scores (2021 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	1.86	3.00
BIBI Rating	Very Poor	Fair

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peeper

Fish Taxa	Number
Black Crappie	2
Bluegill	2
Brown Bullhead	64
Eastern Mosquitofish	1
Largemouth Bass	2
Pumpkinseed	35

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	3
Caecidotea	2
Cheumatopsyche	1
Cricotopus	1
Diplocladius	3
Empididae	1
Limnephilidae	1
Naididae	5
Orthocladius	68
Parakiefferiella	1
Parametriocnemus	7
Pisidium	3
Polypedilum	5
Rheocricotopus	4
Simulium	9
Tanypodinae	1

Original Visit	Number
Amphinemura	3
Caecidotea	16
Ceratopogonidae	1
Conchapelopia	1
Corduliidae	1
Corynoneura	1
Crangonyx	33
Dicrotendipes	1
Diplocladius	3
Hydroporini	1
Ironoquia	3
Lumbricina	1
Lype	1
Naididae	1
Nigronia	1
Ormosia	1
Orthocladius	2
Parametriocnemus	5
Pisidium	8
Polypedilum	10
Procladius	1
Pseudolimnophila	1
Simuliidae	1
Thienemannimyia	2
Tipula	1
Tubificidae	8
Zavrelimyia	1

Site ID: 15-R3M-01-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 31.03

Land Cover	Acres	% Area
Developed Land	11.74	37.85
Forested Land	18.87	60.83
Open Land	0.41	1.32
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	0.71	2.27

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.92
Turbidity (NTU)	3.4
Temperature (°C)	9.5
pH (Standard Units)	6.69
Specific Conductivity (µS/cm)	350

Laboratory Measurements

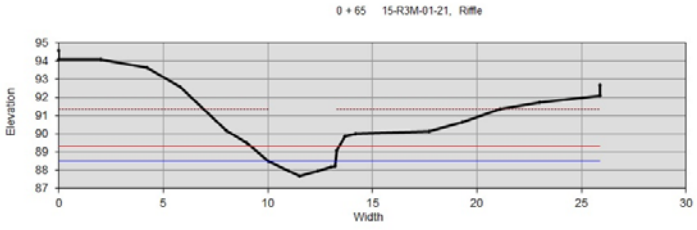
Total Phosphorus (mg/L)	0.188	Chloride (mg/L)	50.503
Total Nitrogen (mg/L)	1.243	Magnesium (mg/L)	5.790
Orthophosphate (mg/L)	0.157	Calcium (mg/L)	24.59
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.430
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	4.073
Nitrate-N (mg/L)	1.077	Total Lead (µg/L)	0.144
Total Kjehldal N (mg/L)	0.167	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	2.220		
Total Organic C (mg/L)	2.209		
Hardness (mg eq. $CaCO_3$/L)	85.24		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.05	Sinuosity	1.21
Bankfull Width (ft)	3.2	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	4.2		
Entrenchment Ratio	1.3		
Width to Depth Ratio	6.7	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	1.6		
Water Surface Slope (%)	1.5		

Cross-sectional Survey



Site ID: 15-R3M-01-21

Biological Assessments

BIBI Metric Values

Total Taxa	11
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	6.54
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	1.87

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

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

Amphinemura	2
Amphipoda	13
Caecidotea	2
Chaetocladius	1
Diamesa	5
Dixa	2
Gammarus	60
Nemouridae	2
Orthocladius	10
Parametriocnemus	7
Philopotamidae	1
Thienemanniella	1
Turbellaria	1

Fish Taxa

NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	9
Pool Substrate Characterization	10
Pool Variability	5
Sediment Deposition	11
Channel Flow Status	12
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	7
Bank Stability - Left Bank	7
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	118
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.34	66.47
Shading	95	99.94
Epifaunal Substrate	5	62.88
Instream Habitat	2	56.64
Instream Woody Debris	10	100.00
Bank Stability	10.00	70.71

MPHI Habitat Score	76.11
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Eastern Box Turtle

Mussels

None Observed

Site ID: 15-R3M-03-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2642.52

Land Cover	Acres	% Area
Developed Land	791.01	29.93
Forested Land	1385.73	52.44
Open Land	196.24	7.43
Agricultural Land	269.54	10.20

Impervious Surface	Acres	% Area
Impervious Land	71.27	2.70

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.97
Turbidity (NTU)	19.9
Temperature (°C)	12.1
pH (Standard Units)	7.18
Specific Conductivity (µS/cm)	164

Laboratory Measurements

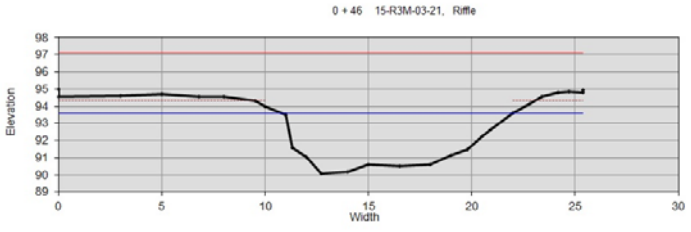
Total Phosphorus (mg/L)	0.221	Chloride (mg/L)	19.496
Total Nitrogen (mg/L)	0.623	Magnesium (mg/L)	2.777
Orthophosphate (mg/L)	0.023	Calcium (mg/L)	13.73
Total Ammonia N (mg/L)	0.020	Total Copper (µg/L)	0.624
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	5.998
Nitrate-N (mg/L)	0.381	Total Lead (µg/L)	0.515
Total Kjehldal N (mg/L)	0.237	Turbidity (NTU)	24.5
Dissolved Organic C (mg/L)	3.579		
Total Organic C (mg/L)	3.788		
Hardness (mg eq. $CaCO_3$/L)	45.72		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	4.13	Sinuosity	1.06
Bankfull Width (ft)	11.2	D50 (mm)	0.06
Mean Bankfull Depth (ft)	2.4	Adjustments?	SIN +0.4
Floodprone Width (ft)	400.0		
Entrenchment Ratio	35.7		
Width to Depth Ratio	4.6	**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)	27.4		
Water Surface Slope (%)	0.11		

Cross-sectional Survey



Site ID: 15-R3M-03-21

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	4
Ephemeroptera Taxa	2
% Intolerant to Urban	16.36
% Ephemeroptera	16.36
Scraper Taxa	1
% Climbers	4.55

FIBI Metric Values

Abundance per m²	0.27
Adj. No. of Benthic Species	0.00
% Tolerant	57.14
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	34.29

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.57
BIBI Rating	Fair

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	18
Baetidae	6
Caecidotea	3
Cheumatopsyche	4
Cryptochironomus	1
Diplocladius	1
Gammarus	5
Maccaffertium	8
Orthocladius	35
Parametriocnemus	1
Perlesta	1
Plauditus	4
Polypedilum	4
Rheocricotopus	1
Rheotanytarsus	4
Simuliidae	1
Simulium	6
Sphaeriidae	1
Stenochironomus	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia Gr.	3

Fish Taxa

American Eel	3
Brown Bullhead	3
Eastern Mosquitofish	12
Eastern Mudminnow	6
Green Sunfish	1
Pumpkinseed	10

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	14
Pool Variability	16
Sediment Deposition	13
Channel Flow Status	15
Channel Alteration	19
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	2
Vegetative Protection - Left Bank	2
Riparian Veg. Zone Width - Right Bank	2
Riparian Veg. Zone Width - Left Bank	5

RBP Habitat Score	106
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.95	42.78
Shading	70	68.32
Epifaunal Substrate	8	51.35
Instream Habitat	10	55.53
Instream Woody Debris	13	70.96
Bank Stability	5.00	50.00

MPHI Habitat Score	56.49
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 15-R3M-04-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3042.74

Land Cover

	Acres	% Area
Developed Land	921.31	30.28
Forested Land	1576.33	51.81
Open Land	209.57	6.89
Agricultural Land	335.52	11.03

Impervious Surface

	Acres	% Area
Impervious Land	79.07	2.60

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.9
Turbidity (NTU)	17.7
Temperature (°C)	11.4
pH (Standard Units)	7.4
Specific Conductivity (µS/cm)	165

Laboratory Measurements

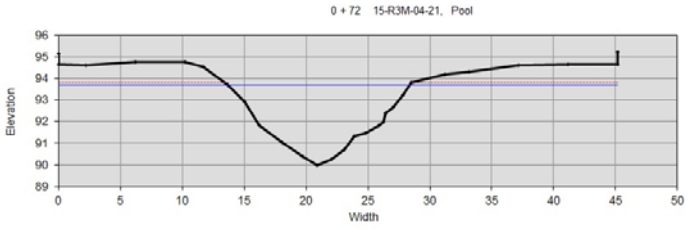
Total Phosphorus (mg/L)	0.193	Chloride (mg/L)	19.473
Total Nitrogen (mg/L)	0.602	Magnesium (mg/L)	2.752
Orthophosphate (mg/L)	0.022	Calcium (mg/L)	13.92
Total Ammonia N (mg/L)	0.026	Total Copper (µg/L)	0.611
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	5.963
Nitrate-N (mg/L)	0.346	Total Lead (µg/L)	0.487
Total Kjehldal N (mg/L)	0.251	Turbidity (NTU)	22.2
Dissolved Organic C (mg/L)	3.860		
Total Organic C (mg/L)	4.005		
Hardness (mg eq. $CaCO_3$/L)	46.09		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	4.75	Sinuosity	1.17
Bankfull Width (ft)	14.7	D50 (mm)	0.06
Mean Bankfull Depth (ft)	2.2	Adjustments?	SIN +0.3
Floodprone Width (ft)	50.0		
Entrenchment Ratio	3.4		
Width to Depth Ratio	6.8	**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)	31.8		
Water Surface Slope (%)	0.13		

Cross-sectional Survey



Site ID: 15-R3M-04-21

Biological Assessments

BIBI Metric Values

Total Taxa	20
EPT Taxa	4
Ephemeroptera Taxa	2
% Intolerant to Urban	31.25
% Ephemeroptera	23.21
Scraper Taxa	2
% Climbers	9.82

FIBI Metric Values

Abundance per m²	0.69
Adj. No. of Benthic Species	0.00
% Tolerant	85.88
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	56.47

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	4.43
BIBI Rating	Good

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	20
Brillia	2
Caecidotea	6
Cambaridae	1
Cheumatopsyche	6
Gammarus	14
Hemerodromia	1
Heptageniidae	4
Isoperla	3
Maccaffertium	19
Orthocladiinae	1
Orthocladius	11
Parakiefferiella	1
Parametriocnemus	1
Plauditus	3
Polypedilum	10
Potthastia	1
Rheotanytarsus	1
Simulium	2
Stenelmis	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia Gr.	2

Fish Taxa

American Eel	2
Brown Bullhead	5
Eastern Mosquitofish	10
Eastern Mudminnow	48
Pumpkinseed	20

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	11
Pool Variability	16
Sediment Deposition	13
Channel Flow Status	18
Channel Alteration	20
Channel Sinuosity	7
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	9

RBP Habitat Score	128
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.91	47.97
Shading	85	84.56
Epifaunal Substrate	8	50.44
Instream Habitat	9	48.54
Instream Woody Debris	22	95.99
Bank Stability	5.00	50.00

MPHI Habitat Score	62.92
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Procambarus acutus acutus

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 15-R3M-05-21

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	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 258.58

Land Cover	Acres	% Area
Developed Land	94.15	36.41
Forested Land	151.60	58.63
Open Land	4.39	1.70
Agricultural Land	8.44	3.26

Impervious Surface	Acres	% Area
Impervious Land	5.01	1.94

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.98
Turbidity (NTU)	8.4
Temperature (°C)	6.8
pH (Standard Units)	6.84
Specific Conductivity (µS/cm)	164

Laboratory Measurements

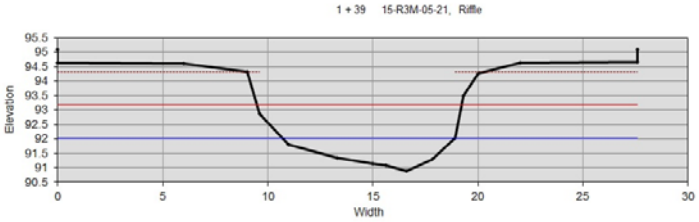
Total Phosphorus (mg/L)	0.116	Chloride (mg/L)	14.386
Total Nitrogen (mg/L)	0.271	Magnesium (mg/L)	2.180
Orthophosphate (mg/L)	0.021	Calcium (mg/L)	17.63
Total Ammonia N (mg/L)	0.027	Total Copper (µg/L)	0.331
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	2.863
Nitrate-N (mg/L)	0.047	Total Lead (µg/L)	0.156
Total Kjehldal N (mg/L)	0.224	Turbidity (NTU)	9.8
Dissolved Organic C (mg/L)	3.196		
Total Organic C (mg/L)	3.191		
Hardness (mg eq. $CaCO_3$/L)	53.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.40	Sinuosity	1.10
Bankfull Width (ft)	8.2	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.7	Adjustments?	SIN +0.1
Floodprone Width (ft)	9.7		
Entrenchment Ratio	1.2		
Width to Depth Ratio	12.1	**Rosgen Stream Type**	**F6**
Cross Sectional Area (ft²)	5.6		
Water Surface Slope (%)	0.2		

Cross-sectional Survey



Site ID: 15-R3M-05-21

Biological Assessments

BIBI Metric Values

Total Taxa	14
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	11.93
% Ephemeroptera	0.92
Scraper Taxa	0
% Climbers	5.50

FIBI Metric Values

Abundance per m²	0.02
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	3
EPT Taxa	3
Ephemeroptera Taxa	3
% Intolerant to Urban	3
% Ephemeroptera	3
Scraper Taxa	1
% Climbers	3

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	2.71
BIBI Rating	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Acerpenna	1
Caecidotea	1
Diplocladius	10
Eukiefferiella	1
Limnephilidae	6
Naididae	2
Nemouridae	5
Orthocladius	28
Parametriocnemus	23
Simulium	22
Sphaeriidae	2
Synurella	6
Tipula	1
Tribelos	1

Fish Taxa

Pumpkinseed	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	7
Pool Variability	5
Sediment Deposition	8
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	6
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	104
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.56	62.26
Shading	85	84.56
Epifaunal Substrate	4	43.26
Instream Habitat	6	57.13
Instream Woody Debris	3	67.70
Bank Stability	9.50	68.92

MPHI Habitat Score	63.97
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Green Frog

Southern Leopard Frog

Northern Two-lined Salamander

Pickerel Frog

Mussels

None Observed

Site ID 21-L1M-01-21

Revist of site R1-21-05

Upstream View - 2021

Downstream View - 2021

Upstream View - 2004

Downstream View - 2004

Summary Results

	2021 Data	2004 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Degraded	Minimally Degraded
Water Quality Conditions	High Conductivity; Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 196.24

Land Cover	2021 Acres	2004 Acres	2021 % Area	2004 % Area
Developed Land	131.91	110.34	67.22	55.40
Forested Land	38.21	53.97	19.47	27.10
Open Land	7.59	19.52	3.87	9.80
Agricultural Land	18.53	14.94	9.44	7.50

Impervious Surface	2021 Acres	2004 Acres	2021 % Area	2004 % Area
Impervious Land	11.55	7.97	5.89	10.70

Site ID 21-L1M-01-21

Revist of site R1-21-05

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2004 Spring
Dissolved Oxygen (mg/L)	10.51	6.29	8.2
Turbidity (NTU)	6.58	6.89	5.8
Temperature (°C)	15.3	22.8	16.07
pH (Standard Units)	6.5	6.52	7
Specific Conductivity (µS/cm)	265.3	208	174.7

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.083	Chloride (mg/L)	31.522
Total Nitrogen (mg/L)	1.082	Magnesium (mg/L)	2.830
Orthophosphate (mg/L)	0.022	Calcium (mg/L)	10.15
Total Ammonia N (mg/L)	0.013	Total Copper (µg/L)	0.383
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	11.206
Nitrate-N (mg/L)	0.933	Total Lead (µg/L)	0.204
Total Kjehldal N (mg/L)	0.147	Turbidity (NTU)	5.8
Dissolved Organic C (mg/L)	2.070		
Total Organic C (mg/L)	2.134		
Hardness (mg eq. $CaCO_3$/L)	37.00		

Geomorphic Assessment

Rosgen Level II Classification Data

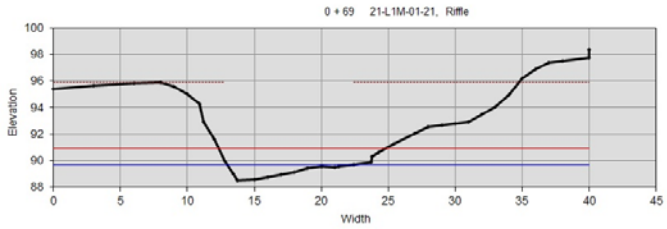
	2021	2004
Drainage Area (mi²)	0.31	
Bankfull Width (ft)	9.4	n/a
Mean Bankfull Depth (ft)	0.6	n/a
Floodprone Width (ft)	12.5	n/a
Entrenchment Ratio	1.3	n/a
Width to Depth Ratio	16.5	n/a
Cross Sectional Area (ft²)	5.4	n/a
Water Surface Slope (%)	0.570	n/a

	2021	2004
Sinuosity	1.06	n/a
D50 (mm)	0.67	n/a
Adjustments?	SIN +0.1	

Rosgen Stream Type

2021	2004
F5	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	6.57	35.38	11.00	59.24
Shading	95	99.94	95	99.94
Epifaunal Substrate	4	45.06	16	100.00
Instream Habitat	4	48.85	14	100.00
Instream Woody Debris	11	94.49	7	82.48
Bank Stability	7.33	60.55	19.00	97.47

	2021 Score	2004 Score
MPHI Habitat Score	64.04	89.85
MPHI Rating	Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2021 Score	2004 Score		2021 Score	2004 Score
Epifaunal Substrate/Available Cover	5	14	Bank Stability - Right Bank	4	9
Pool Substrate Characterization	11	16	Bank Stability - Left Bank	2	9
Pool Variability	4	10	Vegetative Protection - Right Bank	8	9
Sediment Deposition	9	13	Vegetative Protection - Left Bank	8	9
Channel Flow Status	9	15	Riparian Veg. Zone Width - Right Bank	10	4
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	7	10
Channel Sinuosity	7	7			

	2021 Score	2004 Score
RBP Habitat Score	104	145
RBP Rating	Partially Supporting	Supporting

Site ID 21-L1M-01-21

Revist of site R1-21-05

Biological Assessments

BIBI Metric Values	2021	2004
Total Taxa	18	19
EPT Taxa	4	4
Ephemeroptera Taxa	1	0
% Intolerant to Urban	4.90	20.00
% Ephemeroptera	0.98	0.00
Scraper Taxa	1	2
% Climbers	14.71	25.00

FIBI Metric Values (2021 only)	
Abundance per m²	4.61
Adj. No. of Benthic Species	3.67
% Tolerant	95.95
% Gen., Omni., Invert.	98.84
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	94.22

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00	3.00
BIBI Rating	Fair	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American Eel	10
Blacknose Dace	326
Eastern Mudminnow	5
Least Brook Lamprey	4
Tessellated Darter	1

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	1
Amphinemura	2
Chaetocladius	9
Chrysops	1
Diplectrona	1
Diplocladius	2
Eukiefferiella	2
Gammarus	7
Hydrobaenus	17
Ironoquia	1
Naididae	2
Orthocladiinae	2
Orthocladius	28
Parametriocnemus	3
Polypedilum	14
Rheotanytarsus	1
Simulium	4
Tanytarsus	1
Tvetenia	4

Original Visit	Number
Amphinemura	13
Caecidotea	2
Calopteryx	2
Chironomidae	1
Crangonyx	22
Cyclopoida	1
Dicranota	10
Diplectrona	2
Eukiefferiella	7
Hoperius	1
Hydrobaenus	2
Hydroporus	3
Ironoquia	4
Limnephilidae	1
Nigronia	1
Paratanytarsus	1
Polypedilum	17
Simulium	1
Thienemannimyia	7
Tipula	1
Tubificidae	1

Site ID 21-L1M-05-21

Revist of site R1-21-10

Upstream View - 2021

Downstream View - 2021

Upstream View - 2004

Downstream View - 2004

Summary Results

	2021 Data	2004 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Comparable
MPHI Habitat Condition	Degraded	Minimally Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 973.06

Land Cover	2021 Acres	2004 Acres	2021 % Area	2004 % Area
Developed Land	265.80	267.81	27.32	23.80
Forested Land	514.03	659.40	52.83	58.60
Open Land	43.46	41.63	4.47	3.70
Agricultural Land	149.76	154.16	15.39	13.70

Impervious Surface	2021 Acres	2004 Acres	2021 % Area	2004 % Area
Impervious Land	43.65	45.01	4.49	10.30

Site ID 21-L1M-05-21

Revist of site R1-21-10

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2004 Spring
Dissolved Oxygen (mg/L)	13.96	7.22	7.79
Turbidity (NTU)	8.19	8.43	35.3
Temperature (°C)	6	21.9	13.87
pH (Standard Units)	6.77	6.83	7.1
Specific Conductivity (µS/cm)	240.4	319.9	226.3

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.107	Chloride (mg/L)	41.562
Total Nitrogen (mg/L)	1.428	Magnesium (mg/L)	3.866
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	11.76
Total Ammonia N (mg/L)	0.044	Total Copper (µg/L)	0.455
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	11.006
Nitrate-N (mg/L)	1.283	Total Lead (µg/L)	0.247
Total Kjehldal N (mg/L)	0.140	Turbidity (NTU)	9.0
Dissolved Organic C (mg/L)	2.249		
Total Organic C (mg/L)	2.428		
Hardness (mg eq. $CaCO_3$/L)	45.28		

Geomorphic Assessment

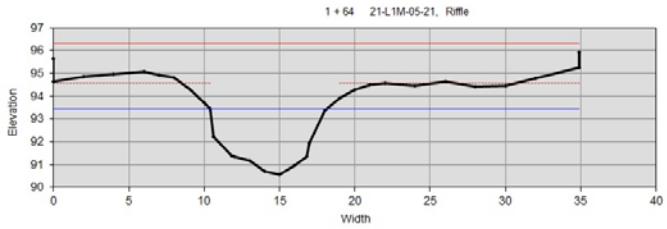
Rosgen Level II Classification Data

	2021	2004		2021	2004
Drainage Area (mi²)	1.52		Sinuosity	1.14	n/a
Bankfull Width (ft)	7.7	n/a	D50 (mm)	0.20	n/a
Mean Bankfull Depth (ft)	2.0	n/a	Adjustments?	SIN +0.4	
Floodprone Width (ft)	172.0	n/a			
Entrenchment Ratio	22.3	n/a			
Width to Depth Ratio	3.8	n/a			
Cross Sectional Area (ft²)	15.6	n/a			
Water Surface Slope (%)	0.460	n/a			

Rosgen Stream Type

2021	2004
E5/6	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	6.70	36.10	5.00	26.93
Shading	50	49.95	100	100.00
Epifaunal Substrate	6	46.24	12	80.15
Instream Habitat	10	65.76	15	92.01
Instream Woody Debris	6	61.57	17	92.46
Bank Stability	8.00	63.25	18.00	94.87

	2021 Score	2004 Score
MPHI Habitat Score	53.81	81.07
MPHI Rating	Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2021 Score	2004 Score		2021 Score	2004 Score
Epifaunal Substrate/Available Cover	7	13	Bank Stability - Right Bank	1	10
Pool Substrate Characterization	13	14	Bank Stability - Left Bank	1	8
Pool Variability	12	11	Vegetative Protection - Right Bank	3	10
Sediment Deposition	14	18	Vegetative Protection - Left Bank	3	9
Channel Flow Status	18	19	Riparian Veg. Zone Width - Right Bank	9	4
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	7			

	2021 Score	2004 Score
RBP Habitat Score	118	153
RBP Rating	Partially Supporting	Comparable

Site ID 21-L1M-05-21

Revist of site R1-21-10

Biological Assessments

BIBI Metric Values	2021	2004
Total Taxa	21	17
EPT Taxa	2	2
Ephemeroptera Taxa	1	0
% Intolerant to Urban	13.16	4.50
% Ephemeroptera	13.16	0.00
Scraper Taxa	3	1
% Climbers	17.54	3.60

FIBI Metric Values (2021 only)	
Abundance per m²	2.26
Adj. No. of Benthic Species	1.16
% Tolerant	36.49
% Gen., Omni., Invert.	98.99
% Round-bodied Suckers	3.38
% Abund. Dominant Taxon	30.74

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	5
% Abund. Dominant Taxon	5

BIBI Score	3.86	2.14
BIBI Rating	Fair	Poor

FIBI Score	4.67
FIBI Rating	Good

Supplemental Fauna (2021 only)

Crayfish

Orconectes limosis

Mussels

Corbicula sp.

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	27
Blacknose Dace	27
Bluegill	4
Brown Bullhead	4
Creek Chubsucker	10
Eastern Mosquitofish	91
Eastern Mudminnow	9
Fallfish	2
Green Sunfish	9
Least Brook Lamprey	3
Pumpkinseed	4
Satinfin Shiner	31
Swallowtail Shiner	22
Tessellated Darter	51
Yellow Bullhead	2

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	15
Ceratopogoninae	1
Cricotopus	4
Cryptochironomus	1
Dubiraphia	3
Hydrobaenus	14
Hydropsyche	5
Macronychus	1
Naididae	2
Nanocladius	1
Neoplasta	1
Orthocladius	24
Parametriocnemus	9
Polypedilum	14
Rheocricotopus	1
Rheosmittia	1
Rheotanytarsus	8
Simulium	2
Tanytarsus	3
Thienemannimyia Gr.	3
Turbellaria	1

Original Visit	Number
Brillia	1
Caecidotea	49
Calopteryx	1
Cheumatopsyche	3
Chironomidae	3
Crangonyx	5
Ironoquia	4
Lumbriculidae	1
Naididae	3
Orthocladiinae	4
Orthocladius	2
Oulimnius	1
Parametriocnemus	1
Paratanytarsus	21
Polypedilum	3
Rheotanytarsus	1
Simulium	2
Thienemannimyia	5
Tubificidae	1

Site ID 21-L2M-02-21

Revist of site R2-21-06

Upstream View - 2021

Downstream View - 2021

Upstream View - 2010

Downstream View - 2010

Summary Results

	2021 Data	2010 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Severely Degraded	Severely Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 958.70

Land Cover	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Developed Land	262.44	255.80	27.37	27.40
Forested Land	507.86	513.20	52.97	54.90
Open Land	38.63	36.20	4.03	3.90
Agricultural Land	149.76	129.20	15.62	13.80

Impervious Surface	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Impervious Land	43.62	81.86	4.55	8.80

Site ID 21-L2M-02-21

Revist of site R2-21-06

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2010 Spring
Dissolved Oxygen (mg/L)	13.44	8.26	11
Turbidity (NTU)	10.2	8.27	8.47
Temperature (°C)	6.6	27.6	12.67
pH (Standard Units)	6.83	7.09	7.45
Specific Conductivity (µS/cm)	143.8	288.1	186.9

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.136	Chloride (mg/L)	37.321
Total Nitrogen (mg/L)	1.458	Magnesium (mg/L)	3.584
Orthophosphate (mg/L)	0.024	Calcium (mg/L)	11.06
Total Ammonia N (mg/L)	0.033	Total Copper (µg/L)	0.562
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	9.493
Nitrate-N (mg/L)	1.258	Total Lead (µg/L)	0.276
Total Kjehldal N (mg/L)	0.195	Turbidity (NTU)	10.4
Dissolved Organic C (mg/L)	2.370		
Total Organic C (mg/L)	2.798		
Hardness (mg eq. $CaCO_3$/L)	42.38		

Geomorphic Assessment

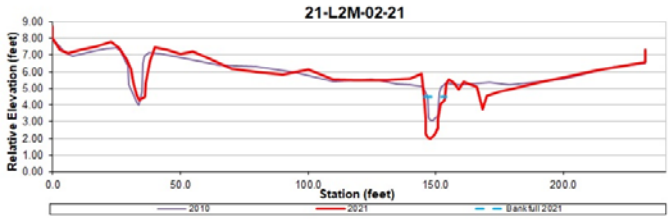
Rosgen Level II Classification Data

	2021	2010		2021	2010
Drainage Area (mi²)	1.50		Sinuosity	1.21	1.10
Bankfull Width (ft)	13.9	8.5	D50 (mm)	0.06	0.06
Mean Bankfull Depth (ft)	1.1	0.9	Adjustments?	None	None
Floodprone Width (ft)	178.0	156.3			
Entrenchment Ratio	12.8	18.3			
Width to Depth Ratio	13.1	9.7			
Cross Sectional Area (ft²)	14.8	7.5			
Water Surface Slope (%)	0.820	0.420			

Rosgen Stream Type

2021	2010
DA6	**DA5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	3.89	20.96	5.00	26.93
Shading	20	21.22	5	0.00
Epifaunal Substrate	11	75.39	7	52.32
Instream Habitat	8	54.81	7	49.53
Instream Woody Debris	8	67.65	9	70.90
Bank Stability	5.00	50.00	10.00	70.71

	2021 Score	2010 Score
MPHI Habitat Score	48.34	45.06
MPHI Rating	Severely Degraded	Severely Degraded

Rapid Bioassessment Protocol

	2021 Score	2010 Score		2021 Score	2010 Score
Epifaunal Substrate/Available Cover	11	7	Bank Stability - Right Bank	1	5
Pool Substrate Characterization	13	4	Bank Stability - Left Bank	1	5
Pool Variability	15	5	Vegetative Protection - Right Bank	2	7
Sediment Deposition	13	18	Vegetative Protection - Left Bank	2	7
Channel Flow Status	18	20	Riparian Veg. Zone Width - Right Bank	10	5
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	8			

	2021 Score	2010 Score
RBP Habitat Score	124	121
RBP Rating	Partially Supporting	Partially Supporting

Site ID 21-L2M-02-21

Revist of site R2-21-06

Biological Assessments

BIBI Metric Values	2021	2010
Total Taxa	18	21
EPT Taxa	4	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	10.17	41.70
% Ephemeroptera	10.17	0.90
Scraper Taxa	2	2
% Climbers	38.14	0.90

FIBI Metric Values (2021 only)	
Abundance per m²	0.77
Adj. No. of Benthic Species	1.17
% Tolerant	47.32
% Gen., Omni., Invert.	89.29
% Round-bodied Suckers	0.89
% Abund. Dominant Taxon	26.79

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	3
% Abund. Dominant Taxon	5

BIBI Score	3.57	3.00
BIBI Rating	Fair	Fair

FIBI Score	4.67
FIBI Rating	Good

Supplemental Fauna (2021 only)

Crayfish

Orconectes limosis

Mussels

Corbicula sp.

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	27
Blacknose Dace	12
Bluegill	1
Creek Chubsucker	1
Eastern Mosquitofish	6
Eastern Mudminnow	4
Green Sunfish	5
Least Brook Lamprey	12
Pumpkinseed	1
Satinfin Shiner	13
Tessellated Darter	30

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	12
Cheumatopsyche	9
Corbicula	1
Hemerodromia	2
Hydrobaenus	3
Hydropsyche	6
Leptoceridae	1
Neoplasta	2
Orthocladius	5
Ostracoda	1
Parametriocnemus	3
Polypedilum	45
Rheotanytarsus	19
Stenelmis	1
Thienemanniella Gr.	3
Tipula	3
Tipulidae	1
Tvetenia	1

Original Visit	Number
Ablabesmyia	1
Baetidae	1
Brillia	1
Caecidotea	46
Calopteryx	1
Chaetocladius	1
Chironomidae	1
Conchapelopia	1
Cricotopus	18
Dubiraphia	3
Heterotrissocladius	1
Lumbriculidae	1
Macronychus	1
Naididae	4
Odontomesa	1
Orthocladius	25
Parachaetocladius	1
Rheocricotopus	1
Simuliidae	1
Thienemanniella	1
Tubificidae	2
Tvetenia	2

Site ID 21-L2M-05-21

Revist of site R2-21-04

Upstream View - 2021

Downstream View - 2021

Upstream View - 2010

Downstream View - 2010

Summary Results

	2021 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	Degraded
Water Quality Conditions	Low pH; High Conductivity; Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 182.18

Land Cover	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Developed Land	126.28	97.80	69.31	56.80
Forested Land	31.56	40.60	17.32	23.60
Open Land	6.42	19.20	3.53	11.10
Agricultural Land	17.93	14.60	9.84	8.50

Impervious Surface	2021 Acres	2010 Acres	2021 % Area	2010 % Area
Impervious Land	11.11	16.13	6.10	9.40

Site ID 21-L2M-05-21

Revist of site R2-21-04

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2010 Spring
Dissolved Oxygen (mg/L)	10.81	6.75	10.77
Turbidity (NTU)	5.48	15.7	3.55
Temperature (°C)	15.4	21.5	10.9
pH (Standard Units)	6.35	6.63	6.66
Specific Conductivity (µS/cm)	271.7	296.8	185.9

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.091	Chloride (mg/L)	31.956
Total Nitrogen (mg/L)	1.020	Magnesium (mg/L)	2.796
Orthophosphate (mg/L)	0.030	Calcium (mg/L)	10.01
Total Ammonia N (mg/L)	0.019	Total Copper (µg/L)	0.390
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	11.244
Nitrate-N (mg/L)	0.899	Total Lead (µg/L)	0.213
Total Kjehldal N (mg/L)	0.119	Turbidity (NTU)	5.2
Dissolved Organic C (mg/L)	2.480		
Total Organic C (mg/L)	2.644		
Hardness (mg eq. $CaCO_3$/L)	36.51		

Geomorphic Assessment

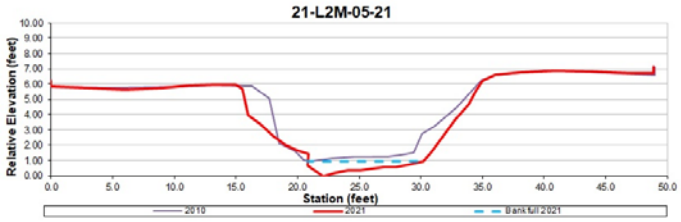
Rosgen Level II Classification Data

	2021	2010		2021	2010
Drainage Area (mi²)	0.28		Sinuosity	2.16	1.70
Bankfull Width (ft)	9.4	11.0	D50 (mm)	1.40	2.30
Mean Bankfull Depth (ft)	0.5	0.7	Adjustments?	None	None
Floodprone Width (ft)	11.9	12.7			
Entrenchment Ratio	1.3	1.2			
Width to Depth Ratio	18.2	14.8			
Cross Sectional Area (ft²)	4.8	8.2			
Water Surface Slope (%)	0.550	0.580			

Rosgen Stream Type

2021	2010
F5/4	**F4/6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	6.70	36.10	7.00	37.70
Shading	80	78.67	95	99.94
Epifaunal Substrate	5	51.35	8	69.15
Instream Habitat	7	66.26	7	66.84
Instream Woody Debris	19	100.00	2	69.34
Bank Stability	4.67	48.31	5.00	50.00

	2021 Score	2010 Score
MPHI Habitat Score	63.45	65.49
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2010 Score		2021 Score	2010 Score
Epifaunal Substrate/Available Cover	6	8	Bank Stability - Right Bank	2	3
Pool Substrate Characterization	11	7	Bank Stability - Left Bank	1	2
Pool Variability	6	6	Vegetative Protection - Right Bank	5	5
Sediment Deposition	7	6	Vegetative Protection - Left Bank	2	3
Channel Flow Status	9	11	Riparian Veg. Zone Width - Right Bank	9	9
Channel Alteration	20	18	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	15	15			

	2021 Score	2010 Score
RBP Habitat Score	103	103
RBP Rating	Partially Supporting	Partially Supporting

Site ID 21-L2M-05-21

Revist of site R2-21-04

Biological Assessments

BIBI Metric Values	2021	2010
Total Taxa	16	20
EPT Taxa	3	3
Ephemeroptera Taxa	1	0
% Intolerant to Urban	3.67	38.50
% Ephemeroptera	0.92	0.00
Scraper Taxa	1	3
% Climbers	10.09	3.80

FIBI Metric Values (2021 only)	
Abundance per m²	4.09
Adj. No. of Benthic Species	2.04
% Tolerant	93.49
% Gen., Omni., Invert.	94.46
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	83.06

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00	3.00
BIBI Rating	Fair	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American Eel	1
Blacknose Dace	255
Eastern Mudminnow	32
Least Brook Lamprey	17
Rosyside Dace	2

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	1
Chaetocladius	2
Chloroperlidae	1
Diamesa	1
Diplectrona	1
Diplocladius	2
Eukiefferiella	5
Hydrobaenus	15
Naididae	6
Nematoda	2
Orthocladiinae	3
Orthocladius	48
Parametriocnemus	7
Polypedilum	11
Potthastia	1
Simulium	2
Tvetenia	1

Original Visit	Number
Amphinemura	28
Caecidotea	7
Calopteryx	1
Chironomini	1
Cryptochironomus	1
Gammarus	17
Hexatoma	1
Hydrobaenus	2
Ironoquia	16
Neophylax	3
Orthocladius	7
Parametriocnemus	2
Pedicia	1
Polypedilum	3
Saetheria	1
Simulium	2
Stegopterna	1
Stenelmis	1
Tipula	1
Tubificidae	5
Tvetenia	3

Site ID: 21-R3M-04-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
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) 217.72

Land Cover	Acres	% Area
Developed Land	139.74	64.19
Forested Land	47.54	21.84
Open Land	7.59	3.49
Agricultural Land	22.84	10.49

Impervious Surface	Acres	% Area
Impervious Land	12.33	5.66

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.76
Turbidity (NTU)	5.15
Temperature (°C)	12.1
pH (Standard Units)	6.64
Specific Conductivity (µS/cm)	272.8

Laboratory Measurements

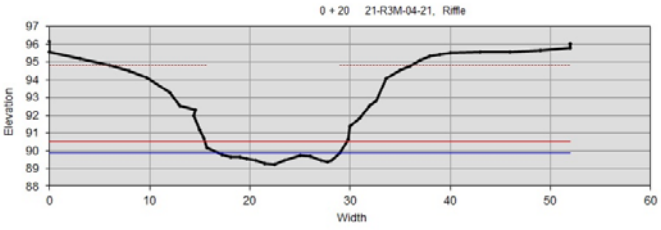
Total Phosphorus (mg/L)	0.058	Chloride (mg/L)	30.513
Total Nitrogen (mg/L)	1.029	Magnesium (mg/L)	2.962
Orthophosphate (mg/L)	0.016	Calcium (mg/L)	10.28
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.433
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	11.735
Nitrate-N (mg/L)	0.911	Total Lead (µg/L)	0.226
Total Kjehldal N (mg/L)	0.116	Turbidity (NTU)	4.5
Dissolved Organic C (mg/L)	2.304		
Total Organic C (mg/L)	2.225		
Hardness (mg eq. $CaCO_3$/L)	37.87		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.34	Sinuosity	1.56
Bankfull Width (ft)	12.3	D50 (mm)	2.80
Mean Bankfull Depth (ft)	0.3	Adjustments?	None
Floodprone Width (ft)	14.2		
Entrenchment Ratio	1.2		
Width to Depth Ratio	36.1	**Rosgen Stream Type**	**F4/5**
Cross Sectional Area (ft²)	4.2		
Water Surface Slope (%)	0.47		

Cross-sectional Survey



Site ID: 21-R3M-04-21

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	7.21
% Ephemeroptera	4.50
Scraper Taxa	1
% Climbers	23.42

FIBI Metric Values

Abundance per m²	4.57
Adj. No. of Benthic Species	3.22
% Tolerant	92.31
% Gen., Omni., Invert.	98.14
% Round-bodied Suckers	0.27
% Abund. Dominant Taxon	89.66

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Acerpenna	5
Amphinemura	3
Amphipoda	1
Brillia	1
Chaetocladius	1
Diamesa	2
Eukiefferiella	1
Hydrobaenus	11
Ironoquia	1
Naididae	1
Orthocladius	44
Parametriocnemus	11
Polypedilum	26
Simulium	2
Tvetenia	1

Fish Taxa

American Eel	7
Blacknose Dace	338
Creek Chubsucker	1
Eastern Mosquitofish	1
Eastern Mudminnow	4
Fallfish	4
Green Sunfish	2
Least Brook Lamprey	7
Rosyside Dace	9
Tessellated Darter	4

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	8
Pool Variability	6
Sediment Deposition	7
Channel Flow Status	7
Channel Alteration	20
Channel Sinuosity	12
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	4
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	100
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.81	47.44
Shading	85	84.56
Epifaunal Substrate	4	44.38
Instream Habitat	5	53.34
Instream Woody Debris	14	100.00
Bank Stability	3.33	40.83

MPHI Habitat Score	61.76
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 21-R3M-07-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2323.77

Land Cover	Acres	% Area
Developed Land	688.87	29.64
Forested Land	943.18	40.59
Open Land	138.19	5.95
Agricultural Land	553.52	23.82

Impervious Surface	Acres	% Area
Impervious Land	79.96	3.44

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.59
Turbidity (NTU)	4.25
Temperature (°C)	12
pH (Standard Units)	6.59
Specific Conductivity (µS/cm)	238

Laboratory Measurements

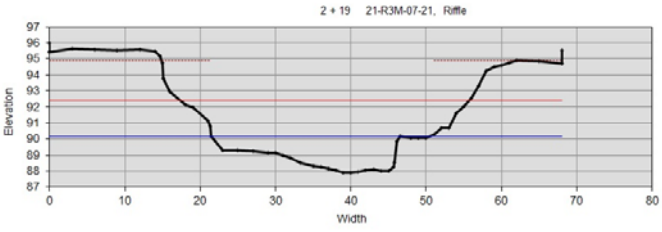
Total Phosphorus (mg/L)	0.058	Chloride (mg/L)	19.735
Total Nitrogen (mg/L)	1.052	Magnesium (mg/L)	2.838
Orthophosphate (mg/L)	0.023	Calcium (mg/L)	10.33
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	0.509
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	7.893
Nitrate-N (mg/L)	0.943	Total Lead (µg/L)	0.136
Total Kjehldal N (mg/L)	0.107	Turbidity (NTU)	3.6
Dissolved Organic C (mg/L)	2.308		
Total Organic C (mg/L)	2.414		
Hardness (mg eq. $CaCO_3$/L)	37.48		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	3.63	Sinuosity	1.27
Bankfull Width (ft)	28.6	D50 (mm)	0.81
Mean Bankfull Depth (ft)	1.3	Adjustments?	None
Floodprone Width (ft)	38.4		
Entrenchment Ratio	1.3		
Width to Depth Ratio	21.9	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	37.4		
Water Surface Slope (%)	0.31		

Cross-sectional Survey



Site ID: 21-R3M-07-21

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	9.43
% Ephemeroptera	5.66
Scraper Taxa	2
% Climbers	26.42

FIBI Metric Values

Abundance per m²	1.84
Adj. No. of Benthic Species	0.85
% Tolerant	51.98
% Gen., Omni., Invert.	92.66
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	31.83

BIBI Metric Scores

Total Taxa	3
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	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	6
Ancyronyx	1
Brillia	1
Cheumatopsyche	2
Corynoneura	1
Cricotopus	1
Cricotopus/Orthocladius	1
Diamesa	1
Eukiefferiella	1
Gammarus	4
Hydrobaenus	4
Leuctridae	2
Neoplasta	2
Orthocladius	31
Polypedilum	27
Rheotanytarsus	16
Synurella	2
Tanytarsus	1
Thienemannimyia Gr.	2

Fish Taxa

American Eel	39
Blacknose Dace	169
Bluespotted Sunfish	2
Eastern Mosquitofish	23
Eastern Mudminnow	2
Fallfish	77
Green Sunfish	1
Least Brook Lamprey	28
Rosyside Dace	30
Satinfin Shiner	22
Sea Lamprey	11
Swallowtail Shiner	23
Tessellated Darter	104

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	95
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.64	57.29
Shading	75	73.32
Epifaunal Substrate	8	52.19
Instream Habitat	8	45.75
Instream Woody Debris	18	87.21
Bank Stability	13.00	80.63

MPHI Habitat Score	66.06
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Eastern Cricket Frog

Mussels

None Observed

Site ID: 21-R3M-10-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Fair
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1571.08

Land Cover	Acres	% Area
Developed Land	386.17	24.58
Forested Land	638.03	40.61
Open Land	125.00	7.96
Agricultural Land	421.87	26.85

Impervious Surface	Acres	% Area
Impervious Land	53.76	3.42

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.4
Turbidity (NTU)	5.28
Temperature (°C)	17.1
pH (Standard Units)	6.89
Specific Conductivity (µS/cm)	226

Laboratory Measurements

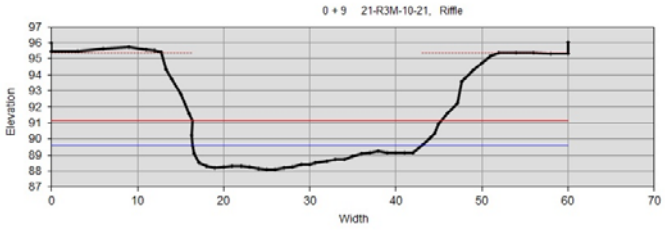
Total Phosphorus (mg/L)	0.085	Chloride (mg/L)	19.148
Total Nitrogen (mg/L)	1.070	Magnesium (mg/L)	2.557
Orthophosphate (mg/L)	0.036	Calcium (mg/L)	10.45
Total Ammonia N (mg/L)	0.010	Total Copper (µg/L)	0.563
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	5.535
Nitrate-N (mg/L)	0.951	Total Lead (µg/L)	0.132
Total Kjehldal N (mg/L)	0.116	Turbidity (NTU)	4.3
Dissolved Organic C (mg/L)	2.350		
Total Organic C (mg/L)	2.437		
Hardness (mg eq. $CaCO_3$/L)	36.62		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.45	Sinuosity	1.15
Bankfull Width (ft)	26.6	D50 (mm)	5.40
Mean Bankfull Depth (ft)	1.0	Adjustments?	None
Floodprone Width (ft)	28.9		
Entrenchment Ratio	1.1		
Width to Depth Ratio	26.5	**Rosgen Stream Type**	**F4**
Cross Sectional Area (ft²)	26.7		
Water Surface Slope (%)	0.48		

Cross-sectional Survey



Site ID: 21-R3M-10-21

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	7
Ephemeroptera Taxa	3
% Intolerant to Urban	9.71
% Ephemeroptera	6.80
Scraper Taxa	2
% Climbers	19.42

FIBI Metric Values

Abundance per m²	2.74
Adj. No. of Benthic Species	0.97
% Tolerant	61.65
% Gen., Omni., Invert.	94.70
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	46.82

BIBI Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
% 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	5
% Gen., Omni., Invert.	3
% 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	5
Amphinemura	1
Calopteryx	1
Cheumatopsyche	1
Conchapelopia	1
Cricotopus	1
Diamesa	1
Ephemerella	1
Haploperla	2
Hydrobaenus	7
Ironoquia	3
Leptophlebiidae	1
Microtendipes	2
Naididae	2
Neoplasta	1
Orthocladius	38
Polypedilum	17
Rheotanytarsus	5
Saetheria	8
Stenelmis	1
Tanytarsus	2
Tvetenia	2

Fish Taxa

American Eel	17
Blacknose Dace	221
Eastern Mosquitofish	6
Eastern Mudminnow	1
Fallfish	69
Green Sunfish	2
Least Brook Lamprey	22
Rosyside Dace	21
Satinfin Shiner	25
Sea Lamprey	3
Swallowtail Shiner	18
Tessellated Darter	67

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	7
Pool Variability	6
Sediment Deposition	8
Channel Flow Status	8
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	4
Bank Stability - Left Bank	2
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	98
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.25	33.63
Shading	65	63.55
Epifaunal Substrate	8	54.74
Instream Habitat	7	44.21
Instream Woody Debris	10	67.98
Bank Stability	12.00	77.46

MPHI Habitat Score	56.93
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Orconectes limosis

Herpetofauna

Northern Water Snake

Northern Two-Lined Salamander

Mussels

None Observed

Site ID: 21-R3M-13-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Good
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High Conductivity; Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 681.11

Land Cover	Acres	% Area
Developed Land	134.51	19.75
Forested Land	188.56	27.68
Open Land	114.48	16.81
Agricultural Land	243.56	35.76

Impervious Surface	Acres	% Area
Impervious Land	21.68	3.18

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.62
Turbidity (NTU)	6.69
Temperature (°C)	12.5
pH (Standard Units)	6.83
Specific Conductivity (µS/cm)	258

Laboratory Measurements

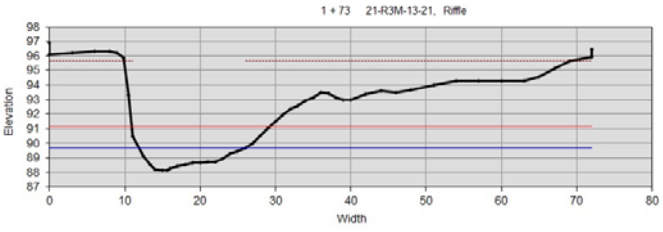
Total Phosphorus (mg/L)	0.114	Chloride (mg/L)	21.597
Total Nitrogen (mg/L)	1.857	Magnesium (mg/L)	2.645
Orthophosphate (mg/L)	0.053	Calcium (mg/L)	14.45
Total Ammonia N (mg/L)	0.022	Total Copper (µg/L)	0.373
Nitrite-N (mg/L)	0.009	Total Zinc (µg/L)	5.799
Nitrate-N (mg/L)	1.777	Total Lead (µg/L)	0.110
Total Kjehldal N (mg/L)	0.071	Turbidity (NTU)	5.5
Dissolved Organic C (mg/L)	2.426		
Total Organic C (mg/L)	2.436		
Hardness (mg eq. $CaCO_3$/L)	46.97		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.06	Sinuosity	1.50
Bankfull Width (ft)	14.1	D50 (mm)	0.45
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	18.5		
Entrenchment Ratio	1.3		
Width to Depth Ratio	15.4	**Rosgen Stream Type**	**F5/4**
Cross Sectional Area (ft²)	12.9		
Water Surface Slope (%)	0.25		

Cross-sectional Survey



Site ID: 21-R3M-13-21

Biological Assessments

BIBI Metric Values

Total Taxa	10
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	0.95
% Ephemeroptera	0.95
Scraper Taxa	1
% Climbers	17.14

FIBI Metric Values

Abundance per m²	1.70
Adj. No. of Benthic Species	1.37
% Tolerant	85.60
% Gen., Omni., Invert.	97.38
% Round-bodied Suckers	2.88
% Abund. Dominant Taxon	59.42

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	1
Chaetocladius	1
Cricotopus/Orthocladius	1
Eukiefferiella	3
Gammarus	1
Hydrobaenus	6
Naididae	2
Orthocladiinae	1
Orthocladius	66
Parametriocnemus	4
Polypedilum	18
Simulium	1

Fish Taxa

American Eel	20
Blacknose Dace	227
Creek Chubsucker	11
Fallfish	3
Green Sunfish	17
Least Brook Lamprey	10
Pumpkinseed	2
Rosyside Dace	10
Satinfin Shiner	1
Tessellated Darter	80
White Sucker	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	91
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	14.37	77.37
Shading	70	68.32
Epifaunal Substrate	9	66.00
Instream Habitat	12	80.50
Instream Woody Debris	29	100.00
Bank Stability	6.00	54.77

MPHI Habitat Score	74.49
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Snapping Turtle

Northern Two-lined Salamander

Mussels

None Observed

Site ID 22-L1M-01-21

Revist of site R1-22-16A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2005

Downstream View - 2005

Summary Results

	2021 Data	2005 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Low pH; High Conductivity; Elevated Nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 110.15

Land Cover	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Developed Land	34.55	29.13	31.37	24.40
Forested Land	39.61	57.67	35.96	48.30
Open Land	11.48	17.91	10.42	15.00
Agricultural Land	24.51	14.57	22.25	12.20

Impervious Surface	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Impervious Land	3.28	4.78	2.98	6.50

Site ID 22-L1M-01-21

Revist of site R1-22-16A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2005 Spring
Dissolved Oxygen (mg/L)	11.74	8.1	11.25
Turbidity (NTU)	5.22	27.1	n/a
Temperature (°C)	13.1	18.1	9.9
pH (Standard Units)	6.05	6.6	6.41
Specific Conductivity (µS/cm)	342.5	227.4	191

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.071	Chloride (mg/L)	40.968
Total Nitrogen (mg/L)	0.682	Magnesium (mg/L)	2.537
Orthophosphate (mg/L)	0.015	Calcium (mg/L)	16.94
Total Ammonia N (mg/L)	0.007	Total Copper (µg/L)	0.463
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	8.303
Nitrate-N (mg/L)	0.545	Total Lead (µg/L)	0.140
Total Kjehldal N (mg/L)	0.134	Turbidity (NTU)	5.9
Dissolved Organic C (mg/L)	1.336		
Total Organic C (mg/L)	1.463		
Hardness (mg eq. $CaCO_3$/L)	52.75		

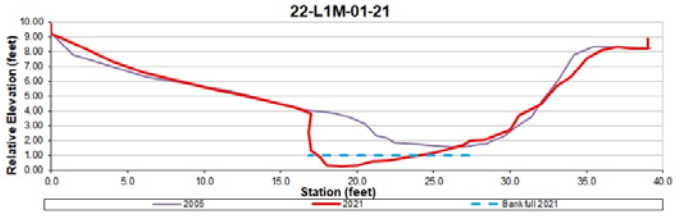
Geomorphic Assessment

Rosgen Level II Classification Data

	2021	2005		2021	2005
Drainage Area (mi²)	0.17		Sinuosity	1.08	1.20
Bankfull Width (ft)	10.5	8.4	D50 (mm)	0.26	0.43
Mean Bankfull Depth (ft)	1.1	0.5	Adjustments?	SIN +0.1	↓ER
Floodprone Width (ft)	13.6	10.1			
Entrenchment Ratio	1.3	1.2			
Width to Depth Ratio	9.4	15.9			
Cross Sectional Area (ft²)	11.7	4.5			
Water Surface Slope (%)	0.560	0.800			

Rosgen Stream Type	
2021	2005
G5c	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	12.23	65.85	n/a	67.57
Shading	90	91.34	95	99.94
Epifaunal Substrate	4	48.82	4	48.29
Instream Habitat	5	60.31	6	65.04
Instream Woody Debris	15	100.00	5	82.36
Bank Stability	3.33	40.83	n/a	65.19

	2021 Score	2005 Score
MPHI Habitat Score	67.86	71.40
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2005 Score		2021 Score	2005 Score
Epifaunal Substrate/Available Cover	6	4	Bank Stability - Right Bank	1	3
Pool Substrate Characterization	7	6	Bank Stability - Left Bank	3	3
Pool Variability	8	5	Vegetative Protection - Right Bank	5	8
Sediment Deposition	7	8	Vegetative Protection - Left Bank	5	8
Channel Flow Status	10	9	Riparian Veg. Zone Width - Right Bank	10	9
Channel Alteration	20	17	Riparian Veg. Zone Width - Left Bank	10	9
Channel Sinuosity	7	6			

	2021 Score	2005 Score
RBP Habitat Score	99	95
RBP Rating	Non-Supporting	Non-supporting

Site ID 22-L1M-01-21

Revist of site R1-22-16A

Biological Assessments

BIBI Metric Values	2021	2005
Total Taxa	14	17
EPT Taxa	1	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.95	9.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	1
% Climbers	12.38	8.00

FIBI Metric Values (2021 only)	
Abundance per m²	2.38
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	99.36

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

FIBI Metric Scores (2021 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	2.43	2.43
BIBI Rating	Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Two-Lined Salamander

Fish Taxa	Number
Blacknose Dace	310
Green Sunfish	2

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	4
Diamesa	4
Diplocladius	6
Eukiefferiella	2
Gammarus	2
Hydrobaenus	1
Naididae	2
Neophylax	1
Orthocladius	42
Parametriocnemus	24
Polypedilum	12
Simulium	1
Tanytarsus	1
Thienemanniella	2
Tipula	1

Original Visit	Number
Caecidotea	7
Chaetocladius	3
Cricotopus/Orthocladius	19
Diplocladius	3
Gammarus	36
Hydatophylax	1
Hydroporinae	1
Lype	3
Microvelia	1
Oligochaeta	5
Paratendipes	1
Pisidium	2
Polypedilum	7
Pseudorthocladius	1
Rheocricotopus	8
Synurella	1
Xylotopus	1

Site ID 22-L1M-02-21

Revist of site R1-22-05

Upstream View - 2021

Downstream View - 2021

Upstream View - 2005

Downstream View - 2005

Summary Results

	2021 Data	2005 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Elevated Nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 280.99

Land Cover	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Developed Land	50.86	30.48	18.10	11.80
Forested Land	81.33	90.66	28.94	35.10
Open Land	4.75	3.10	1.69	1.20
Agricultural Land	144.05	134.32	51.26	52.00

Impervious Surface	2021 Acres	2005 Acres	2021 % Area	2005 % Area
Impervious Land	5.06	10.33	1.80	2.30

Site ID 22-L1M-02-21

Revist of site R1-22-05

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2005 Spring
Dissolved Oxygen (mg/L)	11.2	8.69	5.6
Turbidity (NTU)	4.6	7.82	19.7
Temperature (°C)	10.3	20.8	15.05
pH (Standard Units)	6.91	7	6.35
Specific Conductivity (µS/cm)	139	149	139

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.059	Chloride (mg/L)	12.695
Total Nitrogen (mg/L)	1.358	Magnesium (mg/L)	2.382
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	13.16
Total Ammonia N (mg/L)	0.022	Total Copper (µg/L)	0.283
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	9.757
Nitrate-N (mg/L)	1.323	Total Lead (µg/L)	0.126
Total Kjehldal N (mg/L)	0.033	Turbidity (NTU)	6.3
Dissolved Organic C (mg/L)	1.545		
Total Organic C (mg/L)	1.557		
Hardness (mg eq. $CaCO_3$/L)	42.67		

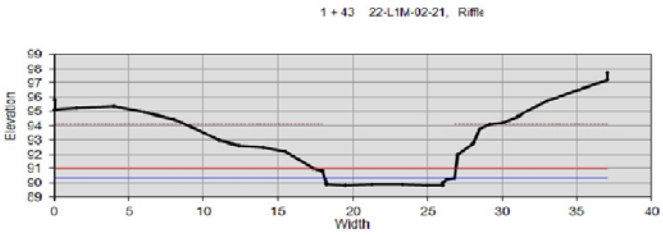
Geomorphic Assessment

Rosgen Level II Classification Data

	2021	2005		2021	2005
Drainage Area (mi²)	0.44		Sinuosity	1.12	1.10
Bankfull Width (ft)	8.7	9.4	D50 (mm)	0.23	2.67
Mean Bankfull Depth (ft)	0.5	0.9	Adjustments?	SIN +0.1	↑Sin, ↓ER
Floodprone Width (ft)	9.3	13.0			
Entrenchment Ratio	1.1	1.4			
Width to Depth Ratio	18.2	10.3			
Cross Sectional Area (ft²)	4.2	8.5			
Water Surface Slope (%)	0.810	0.400			

Rosgen Stream Type	
2021	2005
F5/4	**G4c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	7.49	40.34	n/a	39.70
Shading	90	91.34	90	91.34
Epifaunal Substrate	4	42.72	5	49.08
Instream Habitat	5	50.73	2	34.94
Instream Woody Debris	7	78.59	8	82.50
Bank Stability	8.00	63.25	n/a	74.16

	2021 Score	2005 Score
MPHI Habitat Score	61.16	61.96
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2005 Score		2021 Score	2005 Score
Epifaunal Substrate/Available Cover	9	2	Bank Stability - Right Bank	2	3
Pool Substrate Characterization	8	6	Bank Stability - Left Bank	2	3
Pool Variability	8	1	Vegetative Protection - Right Bank	5	5
Sediment Deposition	8	5	Vegetative Protection - Left Bank	5	5
Channel Flow Status	13	11	Riparian Veg. Zone Width - Right Bank	8	8
Channel Alteration	15	16	Riparian Veg. Zone Width - Left Bank	4	8
Channel Sinuosity	6	9			

	2021 Score	2005 Score
RBP Habitat Score	93	82
RBP Rating	Non-Supporting	Non-supporting

Site ID 22-L1M-02-21

Revist of site R1-22-05

Biological Assessments

BIBI Metric Values	2021	2005
Total Taxa	17	17
EPT Taxa	4	4
Ephemeroptera Taxa	1	0
% Intolerant to Urban	5.04	8.16
% Ephemeroptera	0.84	0.00
Scraper Taxa	1	1
% Climbers	16.81	16.30

FIBI Metric Values (2021 only)	
Abundance per m²	0.34
Adj. No. of Benthic Species	1.24
% Tolerant	82.14
% Gen., Omni., Invert.	82.14
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	82.14

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 (2021 only)	
Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00	2.43
BIBI Rating	Fair	Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Wood Frog

Fish Taxa

Fish Taxa	Number
Blacknose Dace	46
Least Brook Lamprey	10

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	1
Amphinemura	3
Amphipoda	10
Corynoneura	1
Cricotopus	18
Dicranota	1
Diplectrona	1
Eukiefferiella	4
Gammarus	17
Ironoquia	1
Limnophyes	1
Orthocladius	23
Paracladopelma	1
Parametriocnemus	4
Polypedilum	20
Simulium	1
Stenelmis	2
Tvetenia	10

Original Visit	Number
Amphinemura	1
Ceratopogon	1
Chrysops	1
Diplectrona	1
Gammarus	63
Helichus	1
Hydatophylax	1
Ironoquia	3
Micropsectra	2
Nigronia	1
Oligochaeta	2
Parakiefferiella	1
Parametriocnemus	1
Polypedilum	12
Rheotanytarsus	4
Tipula	2
Tvetenia	1

Site ID 22-L2M-01-21

Revist of site R2-22-12A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2013

Downstream View - 2013

Summary Results

	2021 Data	2013 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	Low pH; Elevated Nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 91.52

Land Cover	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Developed Land	20.57	29.58	22.47	28.59
Forested Land	19.25	18.96	21.04	18.33
Open Land	0.31	2.47	0.34	2.39
Agricultural Land	51.39	52.43	56.15	50.69

Impervious Surface	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Impervious Land	1.88	3.87	2.05	3.74

Site ID 22-L2M-01-21

Revist of site R2-22-12A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2013 Spring
Dissolved Oxygen (mg/L)	11.74	8.47	9.26
Turbidity (NTU)	7.8	11.2	15.5
Temperature (°C)	8.4	20.8	17.07
pH (Standard Units)	6.16	6.38	6.33
Specific Conductivity (µS/cm)	163.5	238.2	123.2

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.075	Chloride (mg/L)	15.193
Total Nitrogen (mg/L)	3.570	Magnesium (mg/L)	2.267
Orthophosphate (mg/L)	0.015	Calcium (mg/L)	15.77
Total Ammonia N (mg/L)	0.023	Total Copper (µg/L)	0.316
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	13.196
Nitrate-N (mg/L)	3.545	Total Lead (µg/L)	0.222
Total Kjehldal N (mg/L)	0.024	Turbidity (NTU)	6.2
Dissolved Organic C (mg/L)	1.214		
Total Organic C (mg/L)	1.487		
Hardness (mg eq. $CaCO_3$/L)	48.71		

Geomorphic Assessment

Rosgen Level II Classification Data

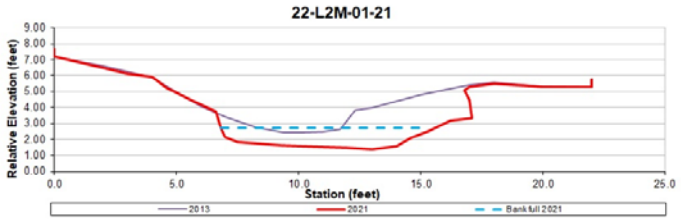
	2021	2013
Drainage Area (mi²)	0.14	
Bankfull Width (ft)	8.8	5.1
Mean Bankfull Depth (ft)	1.0	0.7
Floodprone Width (ft)	10.9	8.3
Entrenchment Ratio	1.2	1.6
Width to Depth Ratio	8.9	7.3
Cross Sectional Area (ft²)	8.7	3.6
Water Surface Slope (%)	0.600	0.760

	2021	2013
Sinuosity	1.06	1.00
D50 (mm)	0.11	0.22
Adjustments?	SIN +0.1	Yes, ER - 0.2

Rosgen Stream Type

2021	2013
G5c	**G4/5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	13.16	70.88	13.00	70.01
Shading	85	84.56	75	73.32
Epifaunal Substrate	3	44.22	7	66.66
Instream Habitat	4	56.66	7	72.05
Instream Woody Debris	8	94.25	4	81.03
Bank Stability	4.00	44.72	12.00	77.46

	2021 Score	2013 Score
MPHI Habitat Score	65.88	73.42
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2013 Score		2021 Score	2013 Score
Epifaunal Substrate/Available Cover	6	7	Bank Stability - Right Bank	1	6
Pool Substrate Characterization	7	8	Bank Stability - Left Bank	3	6
Pool Variability	3	7	Vegetative Protection - Right Bank	6	6
Sediment Deposition	12	10	Vegetative Protection - Left Bank	6	6
Channel Flow Status	16	13	Riparian Veg. Zone Width - Right Bank	4	2
Channel Alteration	20	15	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	6			

	2021 Score	2013 Score
RBP Habitat Score	101	102
RBP Rating	Partially Supporting	Partially Supporting

Site ID 22-L2M-01-21

Revist of site R2-22-12A

Biological Assessments

BIBI Metric Values	2021	2013
Total Taxa	25	14
EPT Taxa	3	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	8.91	23.80
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	11.88	0.00

FIBI Metric Values (2021 only)	
Abundance per m²	0.90
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	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	3	3
% Climbers	5	1

FIBI Metric Scores (2021 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	2.71	2.14
BIBI Rating	Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-Lined Salamander

Northern Green Frog

Fish Taxa	Number
Blacknose Dace	49

Benthic Macroinvertebrate Taxa

2021	Number
Amphinemura	1
Caecidotea	2
Ceratopogoninae	1
Chaetocladius	5
Corynoneura	1
Cricotopus	2
Diplectrona	6
Diplocladius	4
Empididae	1
Eukiefferiella	1
Gammarus	13
Hydrobaenus	1
Hydropsyche	2
Hydropsychidae	1
Naididae	8
Nematoda	1
Orthocladiinae	1
Orthocladius	12
Parametriocnemus	19
Polypedilum	11
Simulium	1
Tanypodinae	1
Tanytarsus	1
Thienemanniella	2
Tipula	1
Tvetenia	1
Zavrelimyia	1

Original Visit	Number
Amphinemura	13
Amphipoda	15
Caecidotea	10
Chironomidae	1
Cricotopus/Orthocladius	11
Diplocladius	5
Gammarus	6
Hydrobaenus	4
Ironoquia	2
Naididae	10
Nematomorpha	1
Neoporus	5
Orthocladius	1
Parametriocnemus	5
Pisidium	1
Plecoptera	1
Thienemanniella	2
Tubificidae	8

Site ID 22-L2M-02-21

Revist of site R2-22-01

Upstream View - 2021

Downstream View - 2021

Upstream View - 2013

Downstream View - 2013

Summary Results

	2021 Data	2013 Data
Benthic Macroinvertebrate Community	Good	Fair
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3786.10

Land Cover	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Developed Land	993.35	848.71	26.24	23.33
Forested Land	1262.61	1306.56	33.35	35.91
Open Land	181.36	269.93	4.79	7.42
Agricultural Land	1348.79	1212.92	35.62	33.34

Impervious Surface	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Impervious Land	125.21	149.73	3.31	4.12

Site ID 22-L2M-02-21

Revist of site R2-22-01

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2013 Spring
Dissolved Oxygen (mg/L)	10.82	6.82	10.56
Turbidity (NTU)	12.3	15.3	11.9
Temperature (°C)	13.3	24	17.37
pH (Standard Units)	7.11	7.08	7.15
Specific Conductivity (µS/cm)	179	195	163.07

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.156	Chloride (mg/L)	23.407
Total Nitrogen (mg/L)	0.706	Magnesium (mg/L)	2.711
Orthophosphate (mg/L)	0.016	Calcium (mg/L)	15.33
Total Ammonia N (mg/L)	0.047	Total Copper (µg/L)	0.449
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	2.088
Nitrate-N (mg/L)	0.374	Total Lead (µg/L)	0.300
Total Kjehldal N (mg/L)	0.326	Turbidity (NTU)	16.7
Dissolved Organic C (mg/L)	5.090		
Total Organic C (mg/L)	5.339		
Hardness (mg eq. $CaCO_3$/L)	49.44		

Geomorphic Assessment

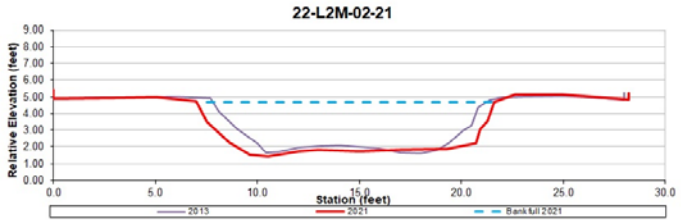
Rosgen Level II Classification Data

	2021	2013		2021	2013
Drainage Area (mi²)	5.92		Sinuosity	1.15	1.10
Bankfull Width (ft)	14.6	13.6	D50 (mm)	2.00	0.12
Mean Bankfull Depth (ft)	2.7	2.5	Adjustments?	SIN +0.4	None
Floodprone Width (ft)	50.0	207.0			
Entrenchment Ratio	3.4	15.2			
Width to Depth Ratio	5.5	5.6			
Cross Sectional Area (ft²)	38.8	33.4			
Water Surface Slope (%)	0.200	0.290			

Rosgen Stream Type

2021	2013
E4	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	9.59	51.66	12.00	64.62
Shading	85	84.56	75	73.32
Epifaunal Substrate	11	66.44	13	78.32
Instream Habitat	13	68.50	13	68.90
Instream Woody Debris	23	96.48	20	88.05
Bank Stability	13.13	81.04	10.00	70.71

	2021 Score	2013 Score
MPHI Habitat Score	74.78	73.99
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2013 Score		2021 Score	2013 Score
Epifaunal Substrate/Available Cover	11	13	Bank Stability - Right Bank	5	7
Pool Substrate Characterization	12	13	Bank Stability - Left Bank	2	3
Pool Variability	10	12	Vegetative Protection - Right Bank	5	8
Sediment Deposition	10	12	Vegetative Protection - Left Bank	5	4
Channel Flow Status	14	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	11			

	2021 Score	2013 Score
RBP Habitat Score	120	142
RBP Rating	Partially Supporting	Supporting

Site ID 22-L2M-02-21

Revist of site R2-22-01

Biological Assessments

BIBI Metric Values	2021	2013
Total Taxa	19	15
EPT Taxa	6	3
Ephemeroptera Taxa	2	1
% Intolerant to Urban	16.96	15.30
% Ephemeroptera	37.50	41.53
Scraper Taxa	5	1
% Climbers	14.29	0.00

FIBI Metric Values (2021 only)	
Abundance per m²	0.47
Adj. No. of Benthic Species	0.37
% Tolerant	62.50
% Gen., Omni., Invert.	97.12
% Round-bodied Suckers	8.65
% Abund. Dominant Taxon	31.73

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

FIBI Metric Scores (2021 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	5
% Abund. Dominant Taxon	5

BIBI Score	4.43	3.00
BIBI Rating	Good	Fair

FIBI Score	4.33
FIBI Rating	Good

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

Elliptio complanata

Herpetofauna

Southern Leopard Frog

Northern Green Frog

Wood Frog

Fish Taxa

Fish Taxa	Number
American Eel	2
Blacknose Dace	3
Bluegill	1
Brown Bullhead	1
Creek Chubsucker	9
Eastern Mosquitofish	1
Eastern Mudminnow	7
Fallfish	4
Green Sunfish	33
Redfin Pickerel	3
Swallowtail Shiner	8
Tessellated Darter	17
Yellow Bullhead	15

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	3
Ancyronyx	1
Baetidae	8
Caecidotea	1
Cheumatopsyche	9
Dubiraphia	3
Hemerodromia	1
Hydropsyche	3
Hydroptilidae	1
Maccaffertium	7
Macronychus	2
Orthocladius	1
Parakiefferiella	1
Parametriocnemus	1
Perlesta	1
Perlidae	1
Plauditus	27
Polypedilum	13
Simulium	21
Stenelmis	2
Tvetenia	5

Original Visit	Number
Acentrella	49
Asellidae	1
Caecidotea	12
Crangonyx	2
Cricotopus/Orthocladius	9
Dicranota	1
Ironoquia	1
Lumbriculidae	2
Naididae	28
Nematomorpha	2
Perlesta	3
Pisidium	1
Potthastia	2
Simuliidae	1
Stenelmis	1
Tubificidae	3

Site ID: 22-R3M-04-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 932.32

Land Cover	Acres	% Area
Developed Land	233.94	25.09
Forested Land	234.53	25.16
Open Land	25.77	2.76
Agricultural Land	438.07	46.99

Impervious Surface	Acres	% Area
Impervious Land	29.32	3.14

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.97
Turbidity (NTU)	3.1
Temperature (°C)	8.1
pH (Standard Units)	6.66
Specific Conductivity (µS/cm)	180

Laboratory Measurements

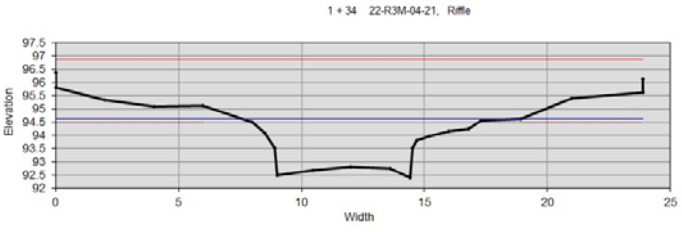
Total Phosphorus (mg/L)	0.049	Chloride (mg/L)	22.729
Total Nitrogen (mg/L)	2.622	Magnesium (mg/L)	2.870
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	15.97
Total Ammonia N (mg/L)	0.026	Total Copper (µg/L)	0.715
Nitrite-N (mg/L)	0.008	Total Zinc (µg/L)	11.599
Nitrate-N (mg/L)	2.481	Total Lead (µg/L)	0.123
Total Kjehldal N (mg/L)	0.134	Turbidity (NTU)	6.0
Dissolved Organic C (mg/L)	2.478		
Total Organic C (mg/L)	2.072		
Hardness (mg eq. $CaCO_3$/L)	51.70		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.46	Sinuosity	1.07
Bankfull Width (ft)	11.3	D50 (mm)	0.35
Mean Bankfull Depth (ft)	1.1	Adjustments?	SIN +0.4
Floodprone Width (ft)	50.0		
Entrenchment Ratio	4.4		
Width to Depth Ratio	10.0	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	12.9		
Water Surface Slope (%)	0.27		

Cross-sectional Survey



Site ID: 22-R3M-04-21

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	4
Ephemeroptera Taxa	2
% Intolerant to Urban	2.70
% Ephemeroptera	3.60
Scraper Taxa	0
% Climbers	59.46

FIBI Metric Values

Abundance per m²	3.51
Adj. No. of Benthic Species	0.59
% Tolerant	80.69
% Gen., Omni., Invert.	96.31
% Round-bodied Suckers	14.53
% Abund. Dominant Taxon	64.43

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	3
Amphipoda	1
Baetis	1
Boyeria	1
Cheumatopsyche	2
Diplocladius	1
Eukiefferiella	1
Hydropsyche	3
Orthocladiinae	1
Orthocladius	9
Parametriocnemus	3
Phaenopsectra	1
Polypedilum	63
Rheotanytarsus	6
Simuliidae	6
Simulium	5
Sphaeriidae	1
Tanytarsus	1
Thienemannimyia Gr.	1
Tvetenia	1

Fish Taxa

American Eel	3
Creek Chubsucker	67
Eastern Mosquitofish	3
Eastern Mudminnow	297
Green Sunfish	48
Redfin Pickerel	17
Tessellated Darter	10
Yellow Bullhead	16

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	13
Pool Substrate Characterization	14
Pool Variability	13
Sediment Deposition	8
Channel Flow Status	16
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	6
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	3
Vegetative Protection - Left Bank	3
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	129
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.61	62.52
Shading	35	36.34
Epifaunal Substrate	14	93.00
Instream Habitat	15	93.94
Instream Woody Debris	30	100.00
Bank Stability	12.53	79.16

MPHI Habitat Score	77.49
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Pickerel Frog

Southern Leopard Frog

Northern Water Snake

Common Five-lined Skink

Northern Spring Peeper

Site ID: 22-R3M-08-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Good
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) 3672.95

Land Cover

	Acres	% Area
Developed Land	954.55	25.99
Forested Land	1195.11	32.54
Open Land	174.50	4.75
Agricultural Land	1348.79	36.72

Impervious Surface

	Acres	% Area
Impervious Land	122.37	3.33

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.6
Turbidity (NTU)	11.8
Temperature (°C)	10.9
pH (Standard Units)	6.99
Specific Conductivity (µS/cm)	305.5

Laboratory Measurements

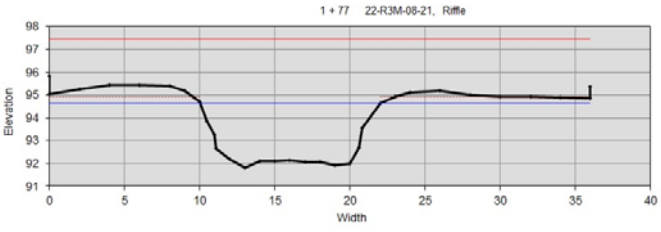
Total Phosphorus (mg/L)	0.097	Chloride (mg/L)	25.114
Total Nitrogen (mg/L)	0.978	Magnesium (mg/L)	2.924
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	15.74
Total Ammonia N (mg/L)	0.020	Total Copper (µg/L)	0.510
Nitrite-N (mg/L)	0.012	Total Zinc (µg/L)	2.828
Nitrate-N (mg/L)	0.651	Total Lead (µg/L)	0.233
Total Kjehldal N (mg/L)	0.315	Turbidity (NTU)	10.4
Dissolved Organic C (mg/L)	4.088		
Total Organic C (mg/L)	4.781		
Hardness (mg eq. $CaCO_3$/L)	51.34		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	5.74	Sinuosity	1.46
Bankfull Width (ft)	11.9	D50 (mm)	0.07
Mean Bankfull Depth (ft)	2.2	Adjustments?	None
Floodprone Width (ft)	500.0		
Entrenchment Ratio	41.8		
Width to Depth Ratio	5.5	**Rosgen Stream Type**	**E5/6**
Cross Sectional Area (ft²)	26.0		
Water Surface Slope (%)	0.39		

Cross-sectional Survey



Site ID: 22-R3M-08-21

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	5
Ephemeroptera Taxa	2
% Intolerant to Urban	47.06
% Ephemeroptera	6.86
Scraper Taxa	3
% Climbers	5.88

FIBI Metric Values

Abundance per m²	1.82
Adj. No. of Benthic Species	0.37
% Tolerant	42.19
% Gen., Omni., Invert.	98.44
% Round-bodied Suckers	21.88
% Abund. Dominant Taxon	23.05

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	4.14
BIBI Rating	Good

FIBI Score	4.67
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	2
Cheumatopsyche	6
Cricotopus	2
Heptageniidae	1
Hydropsyche	3
Hydropsychidae	4
Isoperla	3
Maccaffertium	4
Macronychus	1
Naididae	1
Orthocladius	20
Parametriocnemus	1
Polypedilum	5
Prosimulium	38
Rheocricotopus	2
Rheotanytarsus	3
Simuliidae	1
Simulium	3
Stenelmis	1
Tanytarsus	1

Fish Taxa

American Eel	4
Blacknose Dace	3
Bluegill	3
Brown Bullhead	1
Creek Chubsucker	56
Eastern Mosquitofish	22
Eastern Mudminnow	1
Fallfish	21
Golden Shiner	8
Green Sunfish	59
Northern Snakehead	2
Redfin Pickerel	2
Rosyside Dace	2
Satinfin Shiner	1
Swallowtail Shiner	23
Tessellated Darter	30
White Sucker	1
Yellow Bullhead	17

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	8
Pool Variability	15
Sediment Deposition	16
Channel Flow Status	19
Channel Alteration	20
Channel Sinuosity	11
Bank Stability - Right Bank	1
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	2
Vegetative Protection - Left Bank	2
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	127
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	13.40	72.13
Shading	5	0.00
Epifaunal Substrate	8	49.21
Instream Habitat	11	57.71
Instream Woody Debris	14	70.20
Bank Stability	6.00	54.77

MPHI Habitat Score	50.67
MPHI Rating	Severely Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Water Snake

Common Five-lined Skink

Fowler's Toad

Northern Spring Peeper

Mussels

None Observed

Site ID: 22-R3M-09-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 94.68

Land Cover	Acres	% Area
Developed Land	20.57	21.72
Forested Land	20.90	22.07
Open Land	0.31	0.33
Agricultural Land	52.90	55.87

Impervious Surface	Acres	% Area
Impervious Land	1.96	2.07

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.93
Turbidity (NTU)	5.7
Temperature (°C)	5.8
pH (Standard Units)	6.25
Specific Conductivity (µS/cm)	160.8

Laboratory Measurements

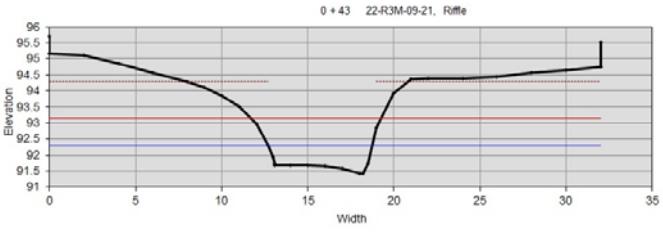
Total Phosphorus (mg/L)	0.062	Chloride (mg/L)	14.882
Total Nitrogen (mg/L)	3.452	Magnesium (mg/L)	2.472
Orthophosphate (mg/L)	0.009	Calcium (mg/L)	16.16
Total Ammonia N (mg/L)	0.021	Total Copper (µg/L)	0.323
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	14.725
Nitrate-N (mg/L)	3.437	Total Lead (µg/L)	0.223
Total Kjehldal N (mg/L)	0.013	Turbidity (NTU)	6.2
Dissolved Organic C (mg/L)	1.078		
Total Organic C (mg/L)	1.156		
Hardness (mg eq. $CaCO_3$/L)	50.53		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.15	Sinuosity	1.08
Bankfull Width (ft)	6.1	D50 (mm)	1.20
Mean Bankfull Depth (ft)	0.6	Adjustments?	SIN +0.1
Floodprone Width (ft)	7.7		
Entrenchment Ratio	1.3		
Width to Depth Ratio	9.6	**Rosgen Stream Type**	**G5/4c**
Cross Sectional Area (ft²)	3.8		
Water Surface Slope (%)	0.8		

Cross-sectional Survey



Site ID: 22-R3M-09-21

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	11.11
% Ephemeroptera	1.71
Scraper Taxa	2
% Climbers	23.08

FIBI Metric Values

Abundance per m²	2.69
Adj. No. of Benthic Species	100.93
% Tolerant	99.17
% Gen., Omni., Invert.	99.17
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	99.17

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
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	1
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.57
BIBI Rating	Fair

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Acerpenna	2
Caecidotea	2
Cordulegaster	1
Cricotopus	1
Cricotopus/Orthocladius	1
Diplectrona	3
Gammarus	21
Hydrobaenus	1
Naididae	6
Nanocladius	1
Neophylax	4
Orthocladius	11
Ostracoda	2
Parametriocnemus	25
Polypedilum	25
Pseudolimnophila	1
Rheotanytarsus	1
Simulium	3
Tanytarsus	2
Thienemannimyia Gr.	4

Fish Taxa

Blacknose Dace	240
Least Brook Lamprey	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	8
Pool Variability	8
Sediment Deposition	15
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	1
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	4
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	115
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	13.65	73.48
Shading	95	99.94
Epifaunal Substrate	4	49.80
Instream Habitat	6	67.41
Instream Woody Debris	18	100.00
Bank Stability	6.83	58.45

MPHI Habitat Score	74.85
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Northern Water Snake

Mussels

None Observed

Site ID: 22-R3M-17-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 137.86

Land Cover	Acres	% Area
Developed Land	47.81	34.68
Forested Land	53.82	39.04
Open Land	11.57	8.39
Agricultural Land	24.66	17.89

Impervious Surface	Acres	% Area
Impervious Land	5.04	3.66

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.06
Turbidity (NTU)	3.2
Temperature (°C)	11.4
pH (Standard Units)	6.89
Specific Conductivity (µS/cm)	202

Laboratory Measurements

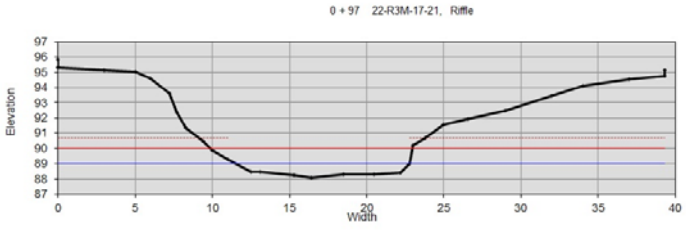
Total Phosphorus (mg/L)	0.063	Chloride (mg/L)	32.144
Total Nitrogen (mg/L)	0.559	Magnesium (mg/L)	2.524
Orthophosphate (mg/L)	0.014	Calcium (mg/L)	16.19
Total Ammonia N (mg/L)	0.016	Total Copper (µg/L)	0.248
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	9.674
Nitrate-N (mg/L)	0.473	Total Lead (µg/L)	0.093
Total Kjehldal N (mg/L)	0.086	Turbidity (NTU)	4.4
Dissolved Organic C (mg/L)	1.524		
Total Organic C (mg/L)	1.560		
Hardness (mg eq. $CaCO_3$/L)	50.82		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.22	Sinuosity	1.09
Bankfull Width (ft)	11.4	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.7	Adjustments?	SIN +0.1
Floodprone Width (ft)	13.1		
Entrenchment Ratio	1.2		
Width to Depth Ratio	16.8	**Rosgen Stream Type**	**F6**
Cross Sectional Area (ft²)	7.7		
Water Surface Slope (%)	0.3		

Cross-sectional Survey



Site ID: 22-R3M-17-21

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	4.63
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	2.78

FIBI Metric Values

Abundance per m²	0.69
Adj. No. of Benthic Species	3.50
% Tolerant	99.01
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	64.36

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	4
Caecidotea	4
Ceratopogoninae	1
Chaetocladius	6
Chironomus	3
Cricotopus	1
Diamesa	1
Diplectrona	1
Diplocladius	1
Dytiscidae	4
Eukiefferiella	5
Gammarus	7
Hydrobaenus	2
Naididae	3
Orthocladius	58
Polypedilum	3
Thienemanniella	1
Tvetenia	3

Fish Taxa

American Eel	1
Blacknose Dace	65
Eastern Mudminnow	3
Green Sunfish	29
Tessellated Darter	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	8
Pool Variability	5
Sediment Deposition	8
Channel Flow Status	13
Channel Alteration	20
Channel Sinuosity	6
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	101
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.13	49.17
Shading	95	99.94
Epifaunal Substrate	5	53.17
Instream Habitat	6	63.56
Instream Woody Debris	7	86.65
Bank Stability	5.00	50.00

MPHI Habitat Score	67.08
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Wood Frog

Northern Green Frog

Mussels

None Observed

Site ID 23-L1M-01-21

Revist of site R1-23-09

Upstream View - 2021

Downstream View - 2021

Upstream View - 2008

Downstream View - 2008

Summary Results

	2021 Data	2008 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	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	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2278.49

Land Cover	2021 Acres	2008 Acres	2021 % Area	2008 % Area
Developed Land	455.42	466.12	19.99	20.22
Forested Land	913.59	971.17	40.10	42.13
Open Land	62.90	59.23	2.76	2.57
Agricultural Land	846.58	808.71	37.16	35.08

Impervious Surface	2021 Acres	2008 Acres	2021 % Area	2008 % Area
Impervious Land	56.29	92.21	2.47	3.33

Site ID 23-L1M-01-21

Revist of site R1-23-09

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2008 Spring
Dissolved Oxygen (mg/L)	10.47	8.21	13.28
Turbidity (NTU)	4.64	9.42	n/a
Temperature (°C)	14.3	23.9	9.54
pH (Standard Units)	6.65	6.74	6.78
Specific Conductivity (µS/cm)	261.4	204.3	154

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.103	Chloride (mg/L)	16.518
Total Nitrogen (mg/L)	1.452	Magnesium (mg/L)	2.522
Orthophosphate (mg/L)	0.038	Calcium (mg/L)	11.72
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.344
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	8.154
Nitrate-N (mg/L)	1.332	Total Lead (µg/L)	0.085
Total Kjehldal N (mg/L)	0.114	Turbidity (NTU)	4.2
Dissolved Organic C (mg/L)	1.894		
Total Organic C (mg/L)	1.801		
Hardness (mg eq. $CaCO_3$/L)	39.65		

Geomorphic Assessment

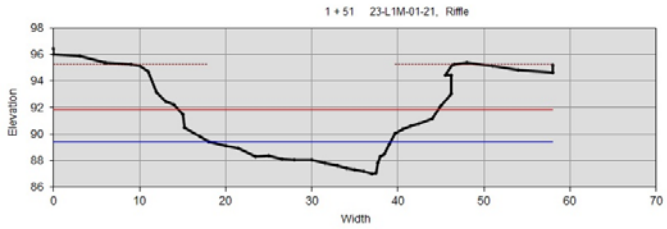
Rosgen Level II Classification Data

	2021	2008		2021	2008
Drainage Area (mi²)	3.56		Sinuosity	1.44	1.00
Bankfull Width (ft)	21.1	13.1	D50 (mm)	0.30	0.36
Mean Bankfull Depth (ft)	1.3	2.3	Adjustments?	ER -0.1	↓ER
Floodprone Width (ft)	30.3	30.0			
Entrenchment Ratio	1.4	2.3			
Width to Depth Ratio	16.9	5.6			
Cross Sectional Area (ft²)	26.5	30.6			
Water Surface Slope (%)	0.250	0.188			

Rosgen Stream Type

2021	2008
F5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	13.97	75.23	10.00	53.85
Shading	70	68.32	85	84.56
Epifaunal Substrate	11	69.75	9	58.05
Instream Habitat	13	73.69	14	79.12
Instream Woody Debris	15	78.56	10	63.64
Bank Stability	2.67	36.52	10.00	70.71

	2021 Score	2008 Score
MPHI Habitat Score	67.01	68.32
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2008 Score		2021 Score	2008 Score
Epifaunal Substrate/Available Cover	12	14	Bank Stability - Right Bank	1	6
Pool Substrate Characterization	13	9	Bank Stability - Left Bank	3	4
Pool Variability	16	9	Vegetative Protection - Right Bank	3	6
Sediment Deposition	4	6	Vegetative Protection - Left Bank	3	4
Channel Flow Status	8	11	Riparian Veg. Zone Width - Right Bank	10	8
Channel Alteration	15	13	Riparian Veg. Zone Width - Left Bank	7	8
Channel Sinuosity	10	6			

	2021 Score	2008 Score
RBP Habitat Score	105	104
RBP Rating	Partially Supporting	Partially Supporting

Site ID 23-L1M-01-21

Revist of site R1-23-09

Biological Assessments

BIBI Metric Values	2021	2008
Total Taxa	15	20
EPT Taxa	3	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	21.90	1.68
% Ephemeroptera	20.95	0.84
Scraper Taxa	1	1
% Climbers	31.43	1.68

FIBI Metric Values (2021 only)	
Abundance per m²	0.59
Adj. No. of Benthic Species	0.85
% Tolerant	59.79
% Gen., Omni., Invert.	93.30
% Round-bodied Suckers	1.55
% Abund. Dominant Taxon	24.23

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

FIBI Metric Scores (2021 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	3
% Abund. Dominant Taxon	5

BIBI Score	3.57	2.43
BIBI Rating	Fair	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Two-lined Salamander

Northern Spring Peeper

Fish Taxa	Number
American Eel	15
Blacknose Dace	47
Bluegill	7
Brown Bullhead	1
Creek Chubsucker	3
Fallfish	45
Green Sunfish	30
Least Brook Lamprey	12
Northern Snakehead	1
Pumpkinseed	3
Tessellated Darter	23
White Sucker	5
Yellow Bullhead	2

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	22
Amphinemura	1
Cheumatopsyche	2
Cricotopus	2
Eukiefferiella	1
Gammarus	1
Hydrobaenus	29
Naididae	1
Neoplasta	1
Orthocladius	4
Polypedilum	33
Rheotanytarsus	1
Simulium	5
Thienemanniella	1
Thienemannimyia Gr.	1

Original Visit	Number
Ablabesmyia	1
Baetidae	1
Corynoneura	1
Cricotopus/Orthocladius	27
Culicoides	1
Diplocladius	22
Enchytraeidae	1
Eukiefferiella	1
Gammarus	3
Hydrobaenus	18
Hydroporinae	1
Limnodrilus	2
Menetus	1
Nais	24
Polypedilum	2
Prosimulium	1
Simulium	3
Stictochironomus	4
Thienemannimyia	2
Tubificinae	3

Site ID 23-L1M-02-21

Revist of site R1-23-07

Upstream View - 2021

Downstream View - 2021

Upstream View - 2008

Downstream View - 2008

Summary Results

	2021 Data	2008 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated Nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 34.98

Land Cover	2021 Acres	2008 Acres	2021 % Area	2008 % Area
Developed Land	5.81	4.76	16.61	11.41
Forested Land	23.52	27.17	67.22	65.13
Open Land	0.00	0.00	0.00	0.00
Agricultural Land	5.66	9.79	16.17	23.46

Impervious Surface	2021 Acres	2008 Acres	2021 % Area	2008 % Area
Impervious Land	0.21	1.67	0.59	1.32

Site ID 23-L1M-02-21

Revist of site R1-23-07

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2008 Spring
Dissolved Oxygen (mg/L)	10.52	10.21	10.27
Turbidity (NTU)	2.82	19.3	n/a
Temperature (°C)	13.2	20.2	8.14
pH (Standard Units)	6.61	6.77	6.47
Specific Conductivity (µS/cm)	205.3	202.3	102

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.114	Chloride (mg/L)	10.473
Total Nitrogen (mg/L)	1.902	Magnesium (mg/L)	3.041
Orthophosphate (mg/L)	0.084	Calcium (mg/L)	13.87
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	0.450
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	15.602
Nitrate-N (mg/L)	1.877	Total Lead (µg/L)	0.128
Total Kjehldal N (mg/L)	0.022	Turbidity (NTU)	2.6
Dissolved Organic C (mg/L)	2.232		
Total Organic C (mg/L)	2.155		
Hardness (mg eq. $CaCO_3$/L)	47.16		

Geomorphic Assessment

Rosgen Level II Classification Data

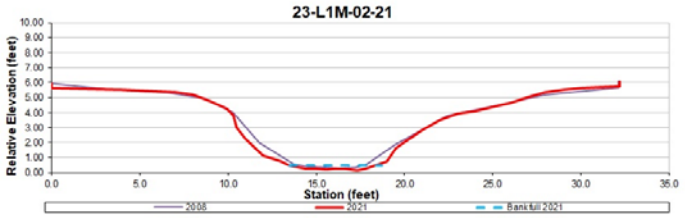
	2021	2008
Drainage Area (mi²)	0.05	
Bankfull Width (ft)	4.8	7.6
Mean Bankfull Depth (ft)	0.2	1.2
Floodprone Width (ft)	6.1	11.8
Entrenchment Ratio	1.3	1.6
Width to Depth Ratio	22.9	6.5
Cross Sectional Area (ft²)	1.0	8.8
Water Surface Slope (%)	1.300	1.450

	2021	2008
Sinuosity	1.13	1.10
D50 (mm)	0.23	0.25
Adjustments?	SIN +0.1	↓ER

Rosgen Stream Type

2021	2008
F5	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	10.50	56.56	8.00	43.08
Shading	95	99.94	100	100.00
Epifaunal Substrate	3	50.48	3	49.33
Instream Habitat	1	49.86	5	70.25
Instream Woody Debris	9	100.00	9	100.00
Bank Stability	4.50	47.44	9.00	67.08

	2021 Score	2008 Score
MPHI Habitat Score	67.38	71.63
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2008 Score		2021 Score	2008 Score
Epifaunal Substrate/Available Cover	2	5	Bank Stability - Right Bank	2	5
Pool Substrate Characterization	4	6	Bank Stability - Left Bank	2	4
Pool Variability	2	4	Vegetative Protection - Right Bank	4	5
Sediment Deposition	11	9	Vegetative Protection - Left Bank	3	4
Channel Flow Status	10	8	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	5			

	2021 Score	2008 Score
RBP Habitat Score	86	95
RBP Rating	Non-Supporting	Non-supporting

Site ID 23-L1M-02-21

Revist of site R1-23-07

Biological Assessments

BIBI Metric Values	2021	2008
Total Taxa	18	20
EPT Taxa	2	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	13.45	3.96
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	0.84	0.99

FIBI Metric Values (2021 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	3	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	3	1
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	1	3

FIBI Metric Scores (2021 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	1.86	1.86
BIBI Rating	Very Poor	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern Cricket Frog

Fish Taxa	Number
NO FISH	

Benthic Macroinvertebrate Taxa

2021	Number
Amphinemura	4
Amphipoda	2
Caecidotea	6
Chaetocladius	29
Dicranota	5
Diplocladius	1
Dytiscidae	1
Eukiefferiella	5
Gammarus	38
Ironoquia	1
Naididae	4
Orthocladius	3
Parametriocnemus	8
Rheocricotopus	1
Synurella	1
Tanytarsus	1
Thienemanniella	7
Turbellaria	1
Tvetenia	1

Original Visit	Number
Bezzia/Palpomyia	1
Caecidotea	3
Chaetocladius	47
Corynoneura	1
Cricotopus/Orthocladius	1
Culicoides	2
Diplocladius	22
Enchytraeidae	1
Hydroporinae	1
Ironoquia	1
Krenopelopia	1
Limnodrilus	5
Musculium/Sphaerium	1
Neophylax	1
Pisidiidae	6
Pristina	1
Rheocricotopus	2
Tanytarsus	1
Tubificinae	2
Veliidae	1

Site ID 23-L2M-02-21

Revist of site R2-23-01

Upstream View - 2021

Downstream View - 2021

Upstream View - 2013

Downstream View - 2013

Summary Results

	2021 Data	2013 Data
Benthic Macroinvertebrate Community	Fair	Good
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 232.51

Land Cover	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Developed Land	27.56	28.58	11.85	12.72
Forested Land	143.94	139.28	61.91	61.97
Open Land	1.01	1.44	0.43	0.64
Agricultural Land	59.99	55.45	25.80	24.67

Impervious Surface	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Impervious Land	2.07	4.90	0.89	2.18

Site ID 23-L2M-02-21

Revist of site R2-23-01

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2013 Spring
Dissolved Oxygen (mg/L)	11.73	7.79	11.34
Turbidity (NTU)	4.68	6.46	4.99
Temperature (°C)	10.1	20.7	12.5
pH (Standard Units)	6.5	6.46	6.52
Specific Conductivity (µS/cm)	158.1	189.4	94.9

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.032	Chloride (mg/L)	14.665
Total Nitrogen (mg/L)	0.539	Magnesium (mg/L)	2.578
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	6.781
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.365
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	13.373
Nitrate-N (mg/L)	0.421	Total Lead (µg/L)	0.121
Total Kjehldal N (mg/L)	0.118	Turbidity (NTU)	4.2
Dissolved Organic C (mg/L)	2.470		
Total Organic C (mg/L)	2.512		
Hardness (mg eq. $CaCO_3$/L)	27.55		

Geomorphic Assessment

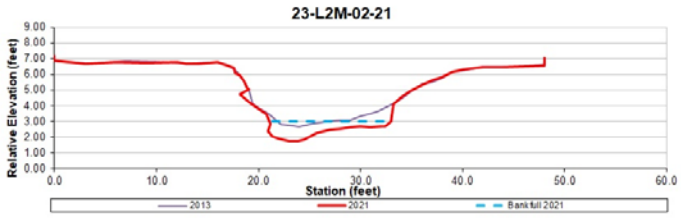
Rosgen Level II Classification Data

	2021	2013		2021	2013
Drainage Area (mi²)	0.36		Sinuosity	1.30	1.30
Bankfull Width (ft)	11.9	11.1	D50 (mm)	6.00	0.40
Mean Bankfull Depth (ft)	0.7	0.6	Adjustments?	None	None
Floodprone Width (ft)	14.6	15.2			
Entrenchment Ratio	1.2	1.4			
Width to Depth Ratio	17.5	19.1			
Cross Sectional Area (ft²)	8.1	6.4			
Water Surface Slope (%)	0.550	0.640			

Rosgen Stream Type

2021	2013
F4	**F4/5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	14.05	75.67	19.00	100.00
Shading	80	78.67	96	100.00
Epifaunal Substrate	9	73.00	13	96.46
Instream Habitat	11	85.96	11	86.30
Instream Woody Debris	10	89.61	10	89.99
Bank Stability	3.33	40.83	14.00	83.67

	2021 Score	2013 Score
MPHI Habitat Score	73.95	92.74
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2021 Score	2013 Score		2021 Score	2013 Score
Epifaunal Substrate/Available Cover	8	13	Bank Stability - Right Bank	4	7
Pool Substrate Characterization	11	12	Bank Stability - Left Bank	4	7
Pool Variability	4	10	Vegetative Protection - Right Bank	7	8
Sediment Deposition	7	11	Vegetative Protection - Left Bank	7	8
Channel Flow Status	10	12	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	9	13			

	2021 Score	2013 Score
RBP Habitat Score	111	141
RBP Rating	Partially Supporting	Supporting

Site ID 23-L2M-02-21

Revist of site R2-23-01

Biological Assessments

BIBI Metric Values	2021	2013
Total Taxa	21	29
EPT Taxa	6	7
Ephemeroptera Taxa	1	2
% Intolerant to Urban	5.71	53.50
% Ephemeroptera	3.81	9.90
Scraper Taxa	1	3
% Climbers	8.57	6.93

FIBI Metric Values (2021 only)	
Abundance per m²	1.88
Adj. No. of Benthic Species	2.99
% Tolerant	89.27
% Gen., Omni., Invert.	99.14
% Round-bodied Suckers	0.43
% Abund. Dominant Taxon	48.93

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	3
% Abund. Dominant Taxon	3

BIBI Score	3.29	4.43
BIBI Rating	Fair	Good

FIBI Score	3.67
FIBI Rating	Fair

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern Cricket Frog

Fish Taxa	Number
American Eel	14
Blacknose Dace	114
Creek Chub	80
Creek Chubsucker	1
Eastern Mosquitofish	3
Eastern Mudminnow	5
Green Sunfish	7
Least Brook Lamprey	2
Rosyside Dace	2
Satinfin Shiner	3
Tessellated Darter	2

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	4
Amphinemura	1
Brillia	1
Capniidae	1
Ceratopogoninae	1
Chaetocladius	2
Cheumatopsyche	1
Chloroperlidae	1
Diplocladius	1
Eukiefferiella	1
Hydrobaenus	39
Limnephilidae	1
Naididae	3
Orthocladiinae	4
Orthocladius	23
Parametriocnemus	3
Paratendipes	1
Polypedilum	7
Rheocricotopus	1
Simulium	6
Tanytarsus	1
Thienemannimyia Gr.	2

Original Visit	Number
Ablabesmyia	1
Acerpenna	8
Amphinemura	9
Crangonyctidae	1
Cricotopus/Orthocladius	7
Diplectrona	1
Diplocladius	4
Dromogomphus	1
Eurylophella	2
Helichus	1
Hexatoma	2
Hydrobaenus	2
Ironoquia	3
Lumbricidae	1
Naididae	1
Neoporus	1
Oecetis	1
Parametriocnemus	3
Polypedilum	2
Probezzia	1
Prostoma	2
Pseudolimnophila	1
Rheocricotopus	4
Simulium	1
Stegopterna	1
Sweltsa	30
Tanytarsus	4
Thienemannimyia Gr.	1
Tubificidae	5

Site ID 23-L2M-03-21

Revist of site R2-23-04

Upstream View - 2021

Downstream View - 2021

Upstream View - 2013

Downstream View - 2013

Summary Results

	2021 Data	2013 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 99.01

Land Cover	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Developed Land	14.48	9.09	14.62	9.08
Forested Land	61.98	67.97	62.60	67.89
Open Land	0.18	0.53	0.18	0.53
Agricultural Land	22.38	22.53	22.60	22.50

Impervious Surface	2021 Acres	2013 Acres	2021 % Area	2013 % Area
Impervious Land	1.06	0.87	1.07	0.87

Site ID 23-L2M-03-21

Revist of site R2-23-04

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2013 Spring
Dissolved Oxygen (mg/L)	9.42	2.73	9.81
Turbidity (NTU)	38.5	35.6	7.78
Temperature (°C)	17.7	22.2	20.2
pH (Standard Units)	6.51	6	6.59
Specific Conductivity (µS/cm)	228	183.1	146.37

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.310	Chloride (mg/L)	14.140
Total Nitrogen (mg/L)	0.411	Magnesium (mg/L)	2.026
Orthophosphate (mg/L)	0.038	Calcium (mg/L)	12.42
Total Ammonia N (mg/L)	0.028	Total Copper (µg/L)	0.921
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	8.447
Nitrate-N (mg/L)	0.082	Total Lead (µg/L)	1.012
Total Kjehldal N (mg/L)	0.327	Turbidity (NTU)	37.7
Dissolved Organic C (mg/L)	3.827		
Total Organic C (mg/L)	4.085		
Hardness (mg eq. $CaCO_3$/L)	39.36		

Geomorphic Assessment

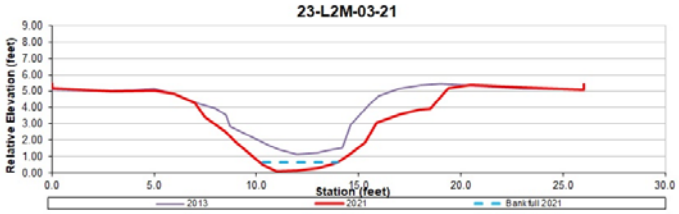
Rosgen Level II Classification Data

	2021	2013		2021	2013
Drainage Area (mi²)	0.15		Sinuosity	1.14	1.10
Bankfull Width (ft)	3.8	4.0	D50 (mm)	0.08	0.08
Mean Bankfull Depth (ft)	0.3	0.5	Adjustments?	SIN +0.1	None
Floodprone Width (ft)	4.9	5.5			
Entrenchment Ratio	1.3	1.4			
Width to Depth Ratio	11.2	7.6			
Cross Sectional Area (ft²)	1.3	2.1			
Water Surface Slope (%)	0.840	1.400			

Rosgen Stream Type

2021	2013
G5c	**Transitional**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	12.25	65.97	10.00	53.85
Shading	95	99.94	95	99.94
Epifaunal Substrate	2	37.89	5	55.25
Instream Habitat	3	50.31	4	55.74
Instream Woody Debris	9	96.31	4	81.40
Bank Stability	0.00	0.00	4.00	44.72

	2021 Score	2013 Score
MPHI Habitat Score	58.40	65.15
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2013 Score		2021 Score	2013 Score
Epifaunal Substrate/Available Cover	2	5	Bank Stability - Right Bank	1	2
Pool Substrate Characterization	6	7	Bank Stability - Left Bank	1	2
Pool Variability	6	7	Vegetative Protection - Right Bank	4	4
Sediment Deposition	7	5	Vegetative Protection - Left Bank	4	4
Channel Flow Status	12	12	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	19	Riparian Veg. Zone Width - Left Bank	4	9
Channel Sinuosity	7	9			

	2021 Score	2013 Score
RBP Habitat Score	83	95
RBP Rating	Non-Supporting	Non-Supporting

Site ID 23-L2M-03-21

Revist of site R2-23-04

Biological Assessments

BIBI Metric Values	2021	2013
Total Taxa	14	21
EPT Taxa	1	4
Ephemeroptera Taxa	1	0
% Intolerant to Urban	7.63	39.40
% Ephemeroptera	3.39	0.00
Scraper Taxa	0	1
% Climbers	5.08	1.01

FIBI Metric Values (2021 only)	
Abundance per m²	0.79
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	88.00

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

FIBI Metric Scores (2021 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	2.71
BIBI Rating	Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern Cricket Frog

Northern Two-lined Salamander

Fish Taxa	Number
Blacknose Dace	44
Creek Chub	6

Benthic Macroinvertebrate Taxa

2021	Number
Acerpenna	4
Caecidotea	3
Cordulegaster	1
Dicranota	1
Diplocladius	8
Gammarus	22
Lepidoptera	1
Naididae	6
Orthocladius	29
Parametriocnemus	31
Polypedilum	6
Rheocricotopus	4
Thienemannimyia Gr.	1
Tipula	1

Original Visit	Number
Amphinemura	10
Amphipoda	8
Asellidae	5
Berosus	1
Bezzia/Palpomyia	1
Caecidotea	24
Chrysops	1
Cricotopus/Orthocladius	10
Diplocladius	5
Gammarus	6
Hydrobaenus	3
Ironoquia	1
Isoperla	1
Lumbriculidae	3
Oemopteryx	1
Ormosia	1
Orthocladiinae	2
Parametriocnemus	1
Pseudorthocladius	1
Rheocricotopus	2
Stegopterna	1
Synurella	1
Tubificidae	10

Site ID: 23-R3M-01-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 484.36

Land Cover	Acres	% Area
Developed Land	57.75	11.92
Forested Land	244.31	50.44
Open Land	25.35	5.23
Agricultural Land	156.95	32.40

Impervious Surface	Acres	% Area
Impervious Land	6.84	1.41

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.01
Turbidity (NTU)	3.27
Temperature (°C)	14.4
pH (Standard Units)	6.77
Specific Conductivity (µS/cm)	147.5

Laboratory Measurements

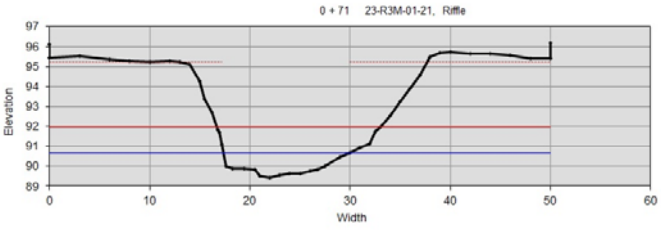
Total Phosphorus (mg/L)	0.121	Chloride (mg/L)	17.448
Total Nitrogen (mg/L)	1.490	Magnesium (mg/L)	2.378
Orthophosphate (mg/L)	0.067	Calcium (mg/L)	12.23
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.266
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	6.519
Nitrate-N (mg/L)	1.359	Total Lead (µg/L)	0.071
Total Kjehldal N (mg/L)	0.127	Turbidity (NTU)	3.6
Dissolved Organic C (mg/L)	1.574		
Total Organic C (mg/L)	1.623		
Hardness (mg eq. $CaCO_3$/L)	40.33		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.76	Sinuosity	1.11
Bankfull Width (ft)	12.7	D50 (mm)	8.60
Mean Bankfull Depth (ft)	0.8	Adjustments?	SIN +0.1
Floodprone Width (ft)	16.2		
Entrenchment Ratio	1.3		
Width to Depth Ratio	15.3	**Rosgen Stream Type**	**F4**
Cross Sectional Area (ft²)	10.5		
Water Surface Slope (%)	0.99		

Cross-sectional Survey



Site ID: 23-R3M-01-21

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	8.40
% Ephemeroptera	5.04
Scraper Taxa	1
% Climbers	11.76

FIBI Metric Values

Abundance per m²	1.54
Adj. No. of Benthic Species	0.83
% Tolerant	86.67
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.61
% Abund. Dominant Taxon	49.09

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
% Intolerant to Urban	1
% Ephemeroptera	3
Scraper Taxa	3
% 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	3.00
BIBI Rating	Fair

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Acerpenna	6
Amphinemura	2
Caecidotea	2
Cricotopus	2
Diamesa	7
Diplocladius	2
Eukiefferiella	1
Hydrobaenus	59
Limnephilidae	1
Naididae	1
Neoplasta	1
Orthocladius	15
Parametriocnemus	2
Polypedilum	13
Rheotanytarsus	2
Simulium	3

Fish Taxa

American Eel	5
Blacknose Dace	81
Creek Chubsucker	1
Fallfish	16
Green Sunfish	58
Tessellated Darter	3
White Sucker	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	10
Pool Variability	9
Sediment Deposition	8
Channel Flow Status	10
Channel Alteration	20
Channel Sinuosity	7
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	100
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	13.52	72.81
Shading	85	84.56
Epifaunal Substrate	7	56.60
Instream Habitat	7	56.25
Instream Woody Debris	6	69.47
Bank Stability	0.67	18.26

MPHI Habitat Score	59.66
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Green Frog

Northern Two-lined Salamander

Northern Spring Peeper

Wood Frog

Mussels

None Observed

Site ID: 23-R3M-03-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 59.84

Land Cover	Acres	% Area
Developed Land	5.23	8.74
Forested Land	26.96	45.06
Open Land	0.00	0.00
Agricultural Land	27.65	46.20

Impervious Surface	Acres	% Area
Impervious Land	0.39	0.65

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	13.14
Turbidity (NTU)	10.2
Temperature (°C)	12
pH (Standard Units)	6.15
Specific Conductivity (µS/cm)	214

Laboratory Measurements

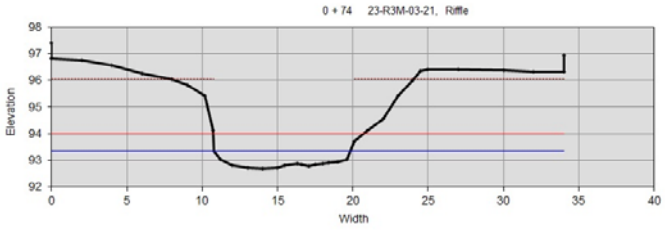
Total Phosphorus (mg/L)	0.074	Chloride (mg/L)	7.141
Total Nitrogen (mg/L)	2.024	Magnesium (mg/L)	2.154
Orthophosphate (mg/L)	0.016	Calcium (mg/L)	15.25
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	0.407
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	15.810
Nitrate-N (mg/L)	2.032	Total Lead (µg/L)	0.204
Total Kjehldal N (mg/L)	0.000	Turbidity (NTU)	9.4
Dissolved Organic C (mg/L)	1.908		
Total Organic C (mg/L)	1.934		
Hardness (mg eq. $CaCO_3$/L)	46.95		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.09	Sinuosity	1.21
Bankfull Width (ft)	9.0	D50 (mm)	1.40
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	10.1		
Entrenchment Ratio	1.1		
Width to Depth Ratio	18.3	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	4.4		
Water Surface Slope (%)	1.6		

Cross-sectional Survey



Site ID: 23-R3M-03-21

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	18.69
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	10.28

FIBI Metric Values

Abundance per m²	1.33
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	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	1
% 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	2.14
BIBI Rating	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Caecidotea	17
Chaetocladius	7
Chironomini	1
Dicranota	3
Diplocladius	1
Dytiscidae	2
Eukiefferiella	17
Gammarus	4
Naididae	16
Orthocladius	11
Parametriocnemus	6
Polypedilum	11
Simulium	1
Thienemanniella	1
Turbellaria	3
Tvetenia	6

Fish Taxa

Blacknose Dace	95

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	6
Pool Variability	3
Sediment Deposition	8
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	2
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	90
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	15.76	84.88
Shading	95	99.94
Epifaunal Substrate	5	58.60
Instream Habitat	4	61.01
Instream Woody Debris	10	100.00
Bank Stability	6.00	54.77

MPHI Habitat Score	76.53
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-Lined Salamander

American Bullfrog

Mussels

None Observed

Site ID: 23-R3M-04-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 470.15

Land Cover	Acres	% Area
Developed Land	133.33	28.36
Forested Land	209.52	44.56
Open Land	33.29	7.08
Agricultural Land	94.01	20.00

Impervious Surface	Acres	% Area
Impervious Land	12.50	2.66

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.52
Turbidity (NTU)	4.35
Temperature (°C)	13.2
pH (Standard Units)	6.61
Specific Conductivity (µS/cm)	205.3

Laboratory Measurements

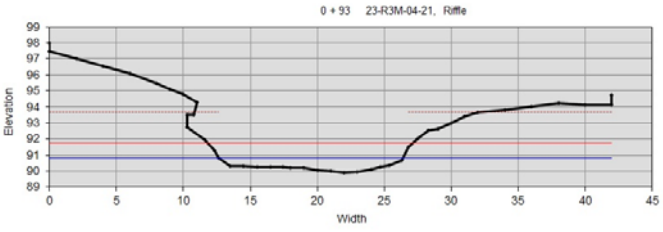
Total Phosphorus (mg/L)	0.044	Chloride (mg/L)	15.177
Total Nitrogen (mg/L)	0.829	Magnesium (mg/L)	2.889
Orthophosphate (mg/L)	0.017	Calcium (mg/L)	8.04
Total Ammonia N (mg/L)	0.009	Total Copper (µg/L)	0.607
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	7.583
Nitrate-N (mg/L)	0.723	Total Lead (µg/L)	0.243
Total Kjehldal N (mg/L)	0.105	Turbidity (NTU)	3.6
Dissolved Organic C (mg/L)	3.549		
Total Organic C (mg/L)	3.737		
Hardness (mg eq. $CaCO_3$/L)	31.97		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.73	Sinuosity	1.21
Bankfull Width (ft)	13.8	D50 (mm)	0.81
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	15.3		
Entrenchment Ratio	1.1		
Width to Depth Ratio	22.2	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	8.6		
Water Surface Slope (%)	0.47		

Cross-sectional Survey



Site ID: 23-R3M-04-21

Biological Assessments

BIBI Metric Values

Total Taxa	27
EPT Taxa	6
Ephemeroptera Taxa	0
% Intolerant to Urban	39.13
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	4.35

FIBI Metric Values

Abundance per m²	0.74
Adj. No. of Benthic Species	1.69
% Tolerant	57.14
% Gen., Omni., Invert.	95.43
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	33.71

BIBI Metric Scores

Total Taxa	5
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	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Amphinemura	2
Amphipoda	8
Caecidotea	9
Calopteryx	1
Ceratopogoninae	2
Chaetocladius	1
Chloroperlidae	3
Corynoneura	7
Diplectrona	1
Eukiefferiella	6
Gammarus	12
Haploperla	23
Hexatoma	1
Hydrobaenus	1
Ironoquia	2
Leuctridae	1
Orthocladius	8
Polycentropus	1
Polypedilum	2
Rheocricotopus	1
Simulium	5
Synurella	4
Tanytarsus	2
Thienemanniella	5
Thienemannimyia Gr.	3
Tipula	1
Turbellaria	1
Tvetenia	1
Zavrelimyia	1

Fish Taxa

American Eel	14
Blacknose Dace	59
Creek Chub	32
Green Sunfish	2
Least Brook Lamprey	8
Rosyside Dace	53
Tessellated Darter	7

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	7
Pool Variability	4
Sediment Deposition	6
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	3
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	101
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	14.45	77.79
Shading	95	99.94
Epifaunal Substrate	10	74.22
Instream Habitat	11	78.75
Instream Woody Debris	13	90.51
Bank Stability	10.00	70.71

MPHI Habitat Score	81.99
MPHI Rating	Minimally Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Northern Two-Lined Salamander

Eastern Cricket Frog

Mussels

None Observed

Site ID: 23-R3M-07-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1923.65

Land Cover	Acres	% Area
Developed Land	371.59	19.32
Forested Land	743.67	38.66
Open Land	52.04	2.71
Agricultural Land	756.35	39.32

Impervious Surface	Acres	% Area
Impervious Land	46.72	2.43

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.55
Turbidity (NTU)	3.69
Temperature (°C)	9.8
pH (Standard Units)	6.81
Specific Conductivity (µS/cm)	150

Laboratory Measurements

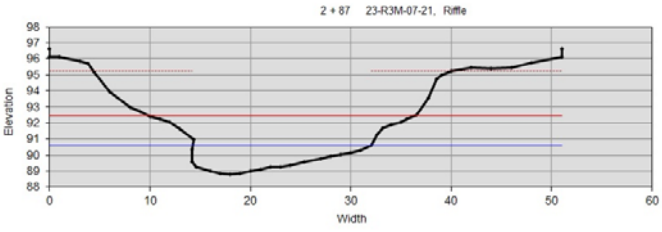
Total Phosphorus (mg/L)	0.084	Chloride (mg/L)	17.335
Total Nitrogen (mg/L)	1.961	Magnesium (mg/L)	2.626
Orthophosphate (mg/L)	0.031	Calcium (mg/L)	12.69
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.326
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	12.086
Nitrate-N (mg/L)	1.832	Total Lead (µg/L)	0.096
Total Kjehldal N (mg/L)	0.126	Turbidity (NTU)	4.3
Dissolved Organic C (mg/L)	1.455		
Total Organic C (mg/L)	1.474		
Hardness (mg eq. $CaCO_3$/L)	42.50		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	3.01	Sinuosity	1.64
Bankfull Width (ft)	17.7	D50 (mm)	0.21
Mean Bankfull Depth (ft)	1.2	Adjustments?	None
Floodprone Width (ft)	26.5		
Entrenchment Ratio	1.5		
Width to Depth Ratio	14.9	**Rosgen Stream Type**	**B5c**
Cross Sectional Area (ft²)	21.0		
Water Surface Slope (%)	0.23		

Cross-sectional Survey



Site ID: 23-R3M-07-21

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	2
Ephemeroptera Taxa	1
% Intolerant to Urban	18.58
% Ephemeroptera	18.58
Scraper Taxa	1
% Climbers	8.85

FIBI Metric Values

Abundance per m²	1.55
Adj. No. of Benthic Species	0.90
% Tolerant	56.14
% Gen., Omni., Invert.	95.03
% Round-bodied Suckers	0.29
% Abund. Dominant Taxon	37.72

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	4.33
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	21
Cheumatopsyche	10
Cricotopus	2
Cryptochironomus	1
Enchytraeidae	1
Gammarus	2
Hydrobaenus	47
Naididae	3
Orthocladius	11
Parametriocnemus	3
Polypedilum	10
Thienemanniella	1
Tvetenia	1

Fish Taxa

American Eel	2
Blacknose Dace	88
Bluegill	1
Brown Bullhead	1
Creek Chubsucker	1
Fallfish	129
Green Sunfish	67
Least Brook Lamprey	17
Tessellated Darter	9
White Sucker	26
Yellow Bullhead	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	10
Pool Variability	13
Sediment Deposition	4
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	12
Bank Stability - Right Bank	1
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	2
Vegetative Protection - Left Bank	2
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	105
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.31	55.53
Shading	65	63.55
Epifaunal Substrate	12	76.66
Instream Habitat	16	92.07
Instream Woody Debris	52	100.00
Bank Stability	5.33	51.64

MPHI Habitat Score	73.24
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-Lined Salamander

Northern Green Frog

Mussels

None Observed

Site ID 24-L1M-03-21

Revist of site R1-24-11A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2006

Downstream View - 2006

Summary Results

	2021 Data	2006 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 79.10

Land Cover	2021 Acres	2006 Acres	2021 % Area	2006 % Area
Developed Land	16.54	7.78	20.91	10.30
Forested Land	19.89	20.14	25.14	26.68
Open Land	0.53	2.46	0.67	3.26
Agricultural Land	42.14	45.12	53.28	59.77

Impervious Surface	2021 Acres	2006 Acres	2021 % Area	2006 % Area
Impervious Land	1.29	3.02	1.63	4.47

Site ID 24-L1M-03-21

Revist of site R1-24-11A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2006 Spring
Dissolved Oxygen (mg/L)	11.33	8.23	5.01
Turbidity (NTU)	14.8	5.1	n/a
Temperature (°C)	9.4	21.4	7.8
pH (Standard Units)	6.91	7.69	6.53
Specific Conductivity (µS/cm)	166	186	207

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.125	Chloride (mg/L)	19.598
Total Nitrogen (mg/L)	2.240	Magnesium (mg/L)	1.793
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	16.6
Total Ammonia N (mg/L)	0.078	Total Copper (µg/L)	0.209
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	1.663
Nitrate-N (mg/L)	1.889	Total Lead (µg/L)	0.232
Total Kjehldal N (mg/L)	0.348	Turbidity (NTU)	14.7
Dissolved Organic C (mg/L)	1.906		
Total Organic C (mg/L)	1.956		
Hardness (mg eq. $CaCO_3$/L)	48.83		

Geomorphic Assessment

Rosgen Level II Classification Data

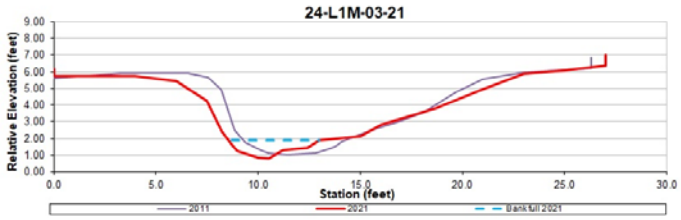
	2021	2006
Drainage Area (mi²)	0.12	
Bankfull Width (ft)	4.5	4.8
Mean Bankfull Depth (ft)	0.6	0.6
Floodprone Width (ft)	8.4	6.9
Entrenchment Ratio	1.9	1.5
Width to Depth Ratio	6.9	8.4
Cross Sectional Area (ft²)	2.9	2.7
Water Surface Slope (%)	1.000	0.760

	2021	2006
Sinuosity	1.10	1.10
D50 (mm)	0.35	0.08
Adjustments?	WD +5.1, SIN +0.1	↑Sin, ↓ER

Rosgen Stream Type

2021	2006
B5c	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	6.92	37.27	14.00	75.39
Shading	90	91.34	95	99.94
Epifaunal Substrate	5	56.79	7	68.71
Instream Habitat	6	69.25	5	64.18
Instream Woody Debris	7	92.94	6	90.51
Bank Stability	7.50	61.24	8.00	63.25

	2021 Score	2006 Score
MPHI Habitat Score	68.14	76.99
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2006 Score		2021 Score	2006 Score
Epifaunal Substrate/Available Cover	7	7	Bank Stability - Right Bank	2	4
Pool Substrate Characterization	6	7	Bank Stability - Left Bank	2	4
Pool Variability	8	6	Vegetative Protection - Right Bank	5	8
Sediment Deposition	13	8	Vegetative Protection - Left Bank	5	10
Channel Flow Status	13	13	Riparian Veg. Zone Width - Right Bank	7	5
Channel Alteration	16	14	Riparian Veg. Zone Width - Left Bank	7	5
Channel Sinuosity	6	7			

	2021 Score	2006 Score
RBP Habitat Score	97	98
RBP Rating	Non-Supporting	Non-supporting

Site ID 24-L1M-03-21

Revist of site R1-24-11A

Biological Assessments

BIBI Metric Values	2021	2006
Total Taxa	20	31
EPT Taxa	0	1
Ephemeroptera Taxa	0	1
% Intolerant to Urban	2.88	5.13
% Ephemeroptera	0.00	1.71
Scraper Taxa	0	0
% Climbers	11.54	17.95

FIBI Metric Values (2021 only)	
Abundance per m²	1.41
Adj. No. of Benthic Species	0.00
% Tolerant	97.78
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	71.11

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

FIBI Metric Scores (2021 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	1.86	2.71
BIBI Rating	Very Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

American Toad

Northern Two-lined Salamander

Fish Taxa	Number
American eel	1
Blacknose dace	12
Eastern mudminnow	32

Benthic Macroinvertebrate Taxa

2021	Number
Caecidotea	1
Ceratopogoninae	1
Cryptochironomus	5
Diplocladius	3
Eukiefferiella	4
Gammarus	3
Lepidoptera	3
Naididae	1
Orthocladius	8
Paracladopelma	1
Parametriocnemus	32
Polypedilum	11
Pseudolimnophila	2
Rheotanytarsus	4
Simulium	4
Sphaeriidae	7
Tanytarsus	1
Thienemanniella	2
Thienemannimyia Gr.	10
Tvetenia	1

Original Visit	Number
Bezzia/Palpomyia	1
Chaetocladius	2
Coenagrionidae	1
Corynoneura	3
Cricotopus/Orthocladius	12
Cryptochironomus	1
Culicoides	3
Curculionidae	1
Diplocladius	18
Gammarus	24
Hemerodromia	1
Limnodrilus	2
Mallochohelea	1
Microspectra	3
Nigronia	1
Orthocladius	1
Parametriocnemus	3
Paraphaenocladius	3
Paratanytarsus	1
Paratendipes	1
Polypedilum	15
Potamothrix	1
Pseudolimnophila	2
Rheocricotopus	4
Rheotanytarsus	1
Stenonema	2
Stilocladius	1
Tanytarsus	2
Thienemannimyia	4
Tipula	1
Zavrelimyia	1

Site ID 24-L1M-04-21

Revist of site R1-24-13A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2006

Downstream View - 2006

Summary Results

	2021 Data	2006 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Elevated Nutrients	Low DO

Land Use/Land Cover Analysis

Total Drainage Area (acres) 320.55

Land Cover	2021 Acres	2006 Acres	2021 % Area	2006 % Area
Developed Land	161.97	86.91	50.53	32.93
Forested Land	53.74	62.03	16.76	23.51
Open Land	14.46	25.47	4.51	9.65
Agricultural Land	90.38	89.48	28.20	33.91

Impervious Surface	2021 Acres	2006 Acres	2021 % Area	2006 % Area
Impervious Land	14.84	10.56	4.63	6.60

Site ID 24-L1M-04-21

Revist of site R1-24-13A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2006 Spring
Dissolved Oxygen (mg/L)	11.55	8.21	2.3
Turbidity (NTU)	8.9	16	n/a
Temperature (°C)	10.8	21	9.58
pH (Standard Units)	7.35	7.1	6.73
Specific Conductivity (µS/cm)	188	191	219

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.100	Chloride (mg/L)	21.431
Total Nitrogen (mg/L)	1.694	Magnesium (mg/L)	2.271
Orthophosphate (mg/L)	0.029	Calcium (mg/L)	18.34
Total Ammonia N (mg/L)	0.042	Total Copper (µg/L)	0.720
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	3.823
Nitrate-N (mg/L)	1.443	Total Lead (µg/L)	0.332
Total Kjehldal N (mg/L)	0.245	Turbidity (NTU)	11.0
Dissolved Organic C (mg/L)	3.379		
Total Organic C (mg/L)	3.463		
Hardness (mg eq. $CaCO_3$/L)	55.15		

Geomorphic Assessment

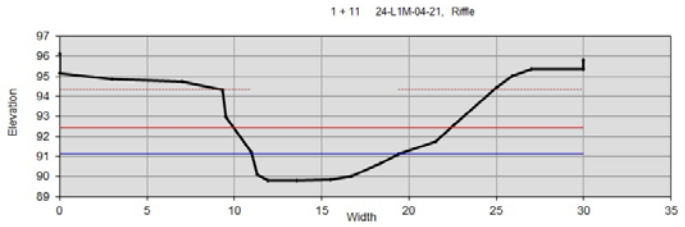
Rosgen Level II Classification Data

	2021	2006		2021	2006
Drainage Area (mi²)	0.50		Sinuosity	1.29	1.20
Bankfull Width (ft)	8.4	6.5	D50 (mm)	0.42	0.07
Mean Bankfull Depth (ft)	1.0	0.8	Adjustments?	ER -0.2	None
Floodprone Width (ft)	12.4	9.1			
Entrenchment Ratio	1.5	1.4			
Width to Depth Ratio	8.3	8.5			
Cross Sectional Area (ft²)	8.4	5.0			
Water Surface Slope (%)	0.400	0.347			

Rosgen Stream Type

2021	2006
G5c	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	10.12	54.47	10.00	53.85
Shading	90	91.34	85	84.56
Epifaunal Substrate	6	53.48	5	48.94
Instream Habitat	6	54.93	3	40.27
Instream Woody Debris	4	68.22	1	61.55
Bank Stability	7.70	62.05	4.00	44.72

	2021 Score	2006 Score
MPHI Habitat Score	64.08	55.65
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2006 Score		2021 Score	2006 Score
Epifaunal Substrate/Available Cover	9	5	Bank Stability - Right Bank	2	2
Pool Substrate Characterization	9	6	Bank Stability - Left Bank	2	2
Pool Variability	5	5	Vegetative Protection - Right Bank	3	5
Sediment Deposition	8	5	Vegetative Protection - Left Bank	5	10
Channel Flow Status	11	10	Riparian Veg. Zone Width - Right Bank	3	2
Channel Alteration	19	16	Riparian Veg. Zone Width - Left Bank	9	2
Channel Sinuosity	8	10			

	2021 Score	2006 Score
RBP Habitat Score	93	80
RBP Rating	Non-Supporting	Non-supporting

Site ID 24-L1M-04-21

Revist of site R1-24-13A

Biological Assessments

BIBI Metric Values	2021	2006
Total Taxa	14	15
EPT Taxa	0	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	1.82	0.89
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	5.45	9.82

FIBI Metric Values (2021 only)	
Abundance per m²	0.63
Adj. No. of Benthic Species	1.11
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	72.34

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

FIBI Metric Scores (2021 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% 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	2.00
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

Cope's Gray Tree Frog

Fish Taxa	Number
Blacknose dace	34
Green sunfish	1
Pumpkinseed	4
Tessellated darter	8

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	5
Caecidotea	1
Chrysops	1
Corynoneura	2
Diamesa	1
Enchytraeidae	1
Eukiefferiella	1
Gammarus	9
Orthocladius	71
Parametriocnemus	4
Polypedilum	6
Pseudorthocladius	1
Rheocricotopus	2
Rheotanytarsus	1
Simulium	4

Original Visit	Number
Chaetocladius	2
Corynoneura	3
Cricotopus/Orthocladius	59
Diplocladius	5
Gammarus	6
Limnephilidae	3
Orthocladius	1
Parametriocnemus	2
Polypedilum	11
Rheocricotopus	12
Simulium	4
Stegopterna	1
Stilocladius	1
Tubificidae	1
Zavrelimyia	1

Site ID 24-L2M-01-21

Revist of site R2-24-03

Upstream View - 2021

Downstream View - 2021

Upstream View - 2012

Downstream View - 2012

Summary Results

	2021 Data	2012 Data
Benthic Macroinvertebrate Community	Poor	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	Elevated Nutrients	High Conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 331.75

Land Cover	2021 Acres	2012 Acres	2021 % Area	2012 % Area
Developed Land	174.79	142.82	52.69	42.06
Forested Land	118.29	162.21	35.66	47.77
Open Land	2.10	3.02	0.63	0.89
Agricultural Land	36.57	31.52	11.02	9.28

Impervious Surface	2021 Acres	2012 Acres	2021 % Area	2012 % Area
Impervious Land	17.31	27.20	5.22	8.00

Site ID 24-L2M-01-21

Revist of site R2-24-03

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2012 Spring
Dissolved Oxygen (mg/L)	11.84	8.07	9.1
Turbidity (NTU)	6.3	8.18	12
Temperature (°C)	9.3	21.2	13.3
pH (Standard Units)	7.03	7.11	7.87
Specific Conductivity (µS/cm)	238	285	262.9

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.099	Chloride (mg/L)	34.693
Total Nitrogen (mg/L)	0.579	Magnesium (mg/L)	1.815
Orthophosphate (mg/L)	0.020	Calcium (mg/L)	21.34
Total Ammonia N (mg/L)	0.028	Total Copper (µg/L)	0.381
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	4.734
Nitrate-N (mg/L)	0.393	Total Lead (µg/L)	0.303
Total Kjehldal N (mg/L)	0.186	Turbidity (NTU)	9.9
Dissolved Organic C (mg/L)	2.021		
Total Organic C (mg/L)	2.177		
Hardness (mg eq. $CaCO_3$/L)	60.76		

Geomorphic Assessment

Rosgen Level II Classification Data

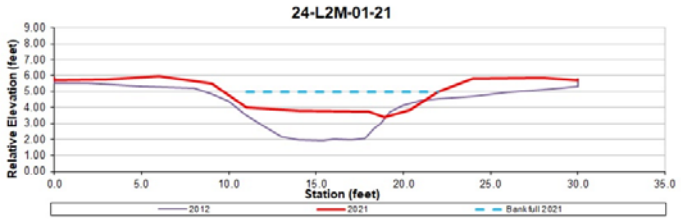
	2021	2012
Drainage Area (mi²)	0.52	
Bankfull Width (ft)	12.3	6.9
Mean Bankfull Depth (ft)	1.0	0.8
Floodprone Width (ft)	300.0	9.7
Entrenchment Ratio	24.4	1.4
Width to Depth Ratio	11.8	8.3
Cross Sectional Area (ft²)	12.8	5.8
Water Surface Slope (%)	0.320	0.270

	2021	2012
Sinuosity	1.05	1.10
D50 (mm)	0.33	0.16
Adjustments?	WD +0.2, SIN +0.2	None

Rosgen Stream Type

2021	2012
C5	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	10.31	55.53	12.00	64.62
Shading	83	82.13	80	78.67
Epifaunal Substrate	6	53.25	7	58.91
Instream Habitat	6	54.58	6	54.34
Instream Woody Debris	7	76.71	9	82.36
Bank Stability	15.20	87.18	13.00	80.63

	2021 Score	2012 Score
MPHI Habitat Score	68.23	69.92
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2021 Score	2012 Score		2021 Score	2012 Score
Epifaunal Substrate/Available Cover	7	7	Bank Stability - Right Bank	8	6
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	9	7
Pool Variability	6	2	Vegetative Protection - Right Bank	6	7
Sediment Deposition	6	5	Vegetative Protection - Left Bank	6	7
Channel Flow Status	11	16	Riparian Veg. Zone Width - Right Bank	10	8
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	6	10
Channel Sinuosity	6	10			

	2021 Score	2012 Score
RBP Habitat Score	109	113
RBP Rating	Partially Supporting	Partially Supporting

Site ID 24-L2M-01-21

Revist of site R2-24-03

Biological Assessments

BIBI Metric Values	2021	2012
Total Taxa	16	24
EPT Taxa	2	2
Ephemeroptera Taxa	1	0
% Intolerant to Urban	3.48	6.30
% Ephemeroptera	0.87	0.00
Scraper Taxa	0	1
% Climbers	6.09	10.70

FIBI Metric Values (2021 only)	
Abundance per m²	1.96
Adj. No. of Benthic Species	0.00
% Tolerant	80.84
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	69.73

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

FIBI Metric Scores (2021 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43	2.71
BIBI Rating	Poor	Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

American Toad

Pickerel Frog

Northern Two-lined Salamander

Northern Spring Peeper

Wood Frog

Fish Taxa	Number
Blacknose dace	29
Eastern mosquitofish	50
Eastern mudminnow	182

Benthic Macroinvertebrate Taxa

2021	Number
Amphinemura	2
Amphipoda	18
Baetidae	1
Caecidotea	1
Collembola	1
Diplocladius	7
Eukiefferiella	2
Gammarus	5
Naididae	17
Orthocladius	7
Parametriocnemus	18
Polypedilum	5
Rheocricotopus	4
Tanytarsus	2
Thienemanniella	23
Thienemannimyia Gr.	1
Tipulidae	1

Original Visit	Number
Amphinemura	5
Amphipoda	9
Caecidotea	1
Chironomidae	1
Chironomini	1
Chironomus	1
Conchapelopia	1
Corynoneura	1
Cricotopus/Orthocladius	19
Diplocladius	1
Gammarus	1
Hemiptera	1
Hydrobaenus	1
Hydropsychidae	1
Naididae	1
Nemata	1
Odonata	1
Odontomesa	2
Orthocladiinae	3
Orthocladius	15
Parametriocnemus	3
Polypedilum	12
Rheocricotopus	15
Saldidae	2
Simuliidae	1
Simulium	1
Stegopterna	1
Tipulidae	1
Tubificidae	6
Zavrelimyia	3

Site ID 24-L2M-03-21

Revist of site R2-24-13A

Upstream View - 2021

Downstream View - 2021

Upstream View - 2012

Downstream View - 2012

Summary Results

	2021 Data	2012 Data
Benthic Macroinvertebrate Community	Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated Nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 310.30

Land Cover	2021 Acres	2012 Acres	2021 % Area	2012 % Area
Developed Land	161.49	119.87	52.04	39.69
Forested Land	46.33	61.85	14.93	20.48
Open Land	14.46	26.42	4.66	8.75
Agricultural Land	88.02	93.86	28.37	31.08

Impervious Surface	2021 Acres	2012 Acres	2021 % Area	2012 % Area
Impervious Land	14.64	20.50	4.72	6.80

Site ID 24-L2M-03-21

Revist of site R2-24-13A

Water Chemistry

In Situ Measurements

	2021 Spring	2021 Summer	2012 Spring
Dissolved Oxygen (mg/L)	10.95	8.16	9.3
Turbidity (NTU)	9.9	12.3	13.8
Temperature (°C)	14.6	21.9	15.5
pH (Standard Units)	7.37	7.2	7.28
Specific Conductivity (µS/cm)	185	187	206.3

Laboratory Measurements (collected 2021 only)

Total Phosphorus (mg/L)	0.111	Chloride (mg/L)	21.858
Total Nitrogen (mg/L)	1.481	Magnesium (mg/L)	2.252
Orthophosphate (mg/L)	0.030	Calcium (mg/L)	17.29
Total Ammonia N (mg/L)	0.037	Total Copper (µg/L)	0.779
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	3.576
Nitrate-N (mg/L)	1.272	Total Lead (µg/L)	0.390
Total Kjehldal N (mg/L)	0.202	Turbidity (NTU)	13.3
Dissolved Organic C (mg/L)	3.708		
Total Organic C (mg/L)	3.593		
Hardness (mg eq. $CaCO_3$/L)	52.45		

Geomorphic Assessment

Rosgen Level II Classification Data

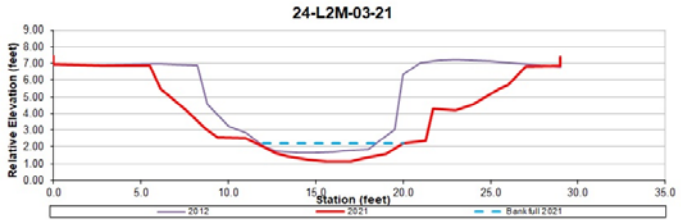
	2021	2012
Drainage Area (mi^2)	0.48	
Bankfull Width (ft)	8.5	8.2
Mean Bankfull Depth (ft)	0.8	0.9
Floodprone Width (ft)	13.0	10.4
Entrenchment Ratio	1.5	1.3
Width to Depth Ratio	11.1	9.0
Cross Sectional Area (ft^2)	6.5	7.6
Water Surface Slope (%)	0.380	0.490

	2021	2012
Sinuosity	1.09	1.10
D50 (mm)	0.47	0.15
Adjustments?	WD +0.9, SIN +0.1	None

Rosgen Stream Type

2021	2012
B5c	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2021 Summer Value	2021 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	8.48	45.64	11.00	59.24
Shading	85	84.56	98	100.00
Epifaunal Substrate	6	53.69	6	53.87
Instream Habitat	7	60.81	5	49.99
Instream Woody Debris	25	100.00	4	68.90
Bank Stability	9.50	68.92	2.00	31.62

	2021 Score	2012 Score
MPHI Habitat Score	68.94	60.60
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2021 Score	2012 Score		2021 Score	2012 Score
Epifaunal Substrate/Available Cover	8	6	Bank Stability - Right Bank	2	1
Pool Substrate Characterization	9	6	Bank Stability - Left Bank	2	1
Pool Variability	8	5	Vegetative Protection - Right Bank	3	2
Sediment Deposition	8	5	Vegetative Protection - Left Bank	5	2
Channel Flow Status	11	15	Riparian Veg. Zone Width - Right Bank	3	8
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	6	9			

	2021 Score	2012 Score
RBP Habitat Score	94	89
RBP Rating	Non-Supporting	Non-Supporting

Site ID 24-L2M-03-21

Revist of site R2-24-13A

Biological Assessments

BIBI Metric Values	2021	2012
Total Taxa	13	11
EPT Taxa	2	2
Ephemeroptera Taxa	1	0
% Intolerant to Urban	0.90	6.40
% Ephemeroptera	0.90	0.00
Scraper Taxa	0	0
% Climbers	7.21	5.50

FIBI Metric Values (2021 only)	
Abundance per m²	0.57
Adj. No. of Benthic Species	1.13
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	46.43

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

FIBI Metric Scores (2021 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.14	1.57
BIBI Rating	Poor	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Fauna (2021 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

Northern Green Frog

Northern Two-lined Salamander

Fish Taxa	Number
Blacknose dace	11
Golden shiner	3
Pumpkinseed	13
Tessellated darter	1

Benthic Macroinvertebrate Taxa

2021	Number
Amphipoda	6
Cheumatopsyche	1
Chrysops	1
Diplocladius	3
Gammarus	16
Naididae	2
Orthocladius	61
Parametriocnemus	6
Plauditus	1
Polypedilum	8
Simulium	3
Stygobromus	1
Thienemanniella	1
Thienemannimyia Gr.	1

Original Visit	Number
Amphinemura	6
Amphipoda	9
Asellidae	1
Chironomini	2
Cricotopus/Orthocladius	20
Dicranota	1
Gammarus	30
Ironoquia	1
Nemata	1
Orthocladiinae	2
Orthocladius	27
Polypedilum	6
Rheocricotopus	1
Simulium	1
Thienemannimyia Gr.	2

Site ID: 24-R3M-01-21

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 58.52

Land Cover	Acres	% Area
Developed Land	12.49	21.34
Forested Land	28.11	48.03
Open Land	4.75	8.11
Agricultural Land	13.18	22.52

Impervious Surface	Acres	% Area
Impervious Land	0.95	1.62

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.51
Turbidity (NTU)	8.8
Temperature (°C)	8
pH (Standard Units)	7.4
Specific Conductivity (µS/cm)	129

Laboratory Measurements

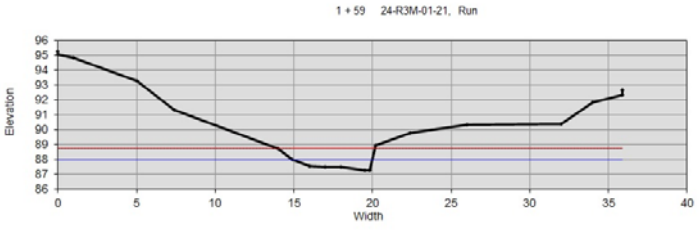
Total Phosphorus (mg/L)	0.056	Chloride (mg/L)	11.822
Total Nitrogen (mg/L)	0.404	Magnesium (mg/L)	2.907
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	11.55
Total Ammonia N (mg/L)	0.037	Total Copper (µg/L)	0.458
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	4.664
Nitrate-N (mg/L)	0.178	Total Lead (µg/L)	0.279
Total Kjehldal N (mg/L)	0.225	Turbidity (NTU)	11.5
Dissolved Organic C (mg/L)	3.863		
Total Organic C (mg/L)	4.160		
Hardness (mg eq. $CaCO_3$/L)	40.81		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.09	Sinuosity	1.06
Bankfull Width (ft)	5.1	D50 (mm)	4.70
Mean Bankfull Depth (ft)	0.5	Adjustments?	SIN +0.1
Floodprone Width (ft)	6.2		
Entrenchment Ratio	1.2		
Width to Depth Ratio	10.7	**Rosgen Stream Type**	**G4c**
Cross Sectional Area (ft²)	2.4		
Water Surface Slope (%)	1.6		

Cross-sectional Survey



Site ID: 24-R3M-01-21

Biological Assessments

BIBI Metric Values

Total Taxa	14
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	4.46
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	0.00

FIBI Metric Values

Abundance per m²	1.12
Adj. No. of Benthic Species	0.00
% Tolerant	90.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	50.00

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	1.29
BIBI Rating	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphinemura	1
Caecidotea	1
Corvnoneura	1
Diplocladius	13
Lumbriculidae	3
Naididae	2
Nemouridae	3
Orthocladius	13
Paracymus	1
Parametriocnemus	26
Paraphaenocladius	1
Rheocricotopus	3
Simuliidae	2
Simulium	41
Zavrelimyia	1

Fish Taxa

American eel	1
Blacknose dace	1
Golden shiner	1
Green sunfish	5
Pumpkinseed	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	8
Pool Variability	9
Sediment Deposition	7
Channel Flow Status	10
Channel Alteration	11
Channel Sinuosity	6
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	8
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	86
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.74	47.09
Shading	85	84.56
Epifaunal Substrate	2	41.32
Instream Habitat	2	50.14
Instream Woody Debris	5	90.43
Bank Stability	10.30	71.77

MPHI Habitat Score	64.22
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Eastern Box Turtle

Mussels

None Observed

Site ID: 24-R3M-02-21

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	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 316.78

Land Cover	Acres	% Area
Developed Land	164.68	51.99
Forested Land	114.27	36.07
Open Land	2.10	0.66
Agricultural Land	35.72	11.28

Impervious Surface	Acres	% Area
Impervious Land	16.52	5.21

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.59
Turbidity (NTU)	5.6
Temperature (°C)	13.1
pH (Standard Units)	7.1
Specific Conductivity (µS/cm)	239

Laboratory Measurements

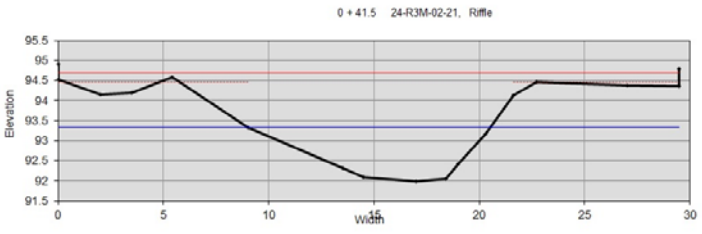
Total Phosphorus (mg/L)	0.132	Chloride (mg/L)	35.474
Total Nitrogen (mg/L)	0.742	Magnesium (mg/L)	2.021
Orthophosphate (mg/L)	0.034	Calcium (mg/L)	21.10
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.344
Nitrite-N (mg/L)	<0.003	Total Zinc (µg/L)	2.800
Nitrate-N (mg/L)	0.361	Total Lead (µg/L)	0.204
Total Kjehldal N (mg/L)	0.380	Turbidity (NTU)	10.6
Dissolved Organic C (mg/L)	2.124		
Total Organic C (mg/L)	2.197		
Hardness (mg eq. $CaCO_3$/L)	61.01		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.49	Sinuosity	1.06
Bankfull Width (ft)	7.6	D50 (mm)	0.20
Mean Bankfull Depth (ft)	0.6	Adjustments?	SIN +0.1
Floodprone Width (ft)	250.0		
Entrenchment Ratio	32.8		
Width to Depth Ratio	12.2	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	4.8		
Water Surface Slope (%)	0.26		

Cross-sectional Survey



Site ID: 24-R3M-02-21

Biological Assessments

BIBI Metric Values

Total Taxa	20
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	3.60
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	4.50

FIBI Metric Values

Abundance per m²	1.74
Adj. No. of Benthic Species	0.00
% Tolerant	96.59
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	76.70

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
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	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	22
Caecidotea	3
Corvnoneura	2
Cryptochironomus	1
Diplocladius	5
Gammarus	17
Hydrobaenus	1
Hydropsyche	1
Limnephilidae	2
Naididae	4
Nemouridae	1
Orthocladius	6
Paracladopelma	1
Parametriocnemus	18
Polypedilum	1
Ptilostomis	1
Pycnopsyche	1
Rheocricotopus	2
Simulium	1
Thienemanniella	18
Thienemannimyia Gr.	1
Zavrelimyia	2

Fish Taxa

Blacknose dace	35
Eastern mosquitofish	6
Eastern mudminnow	135

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	8
Pool Variability	6
Sediment Deposition	6
Channel Flow Status	11
Channel Alteration	20
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	10
Riparian Veg. Zone Width - Left Bank	4

RBP Habitat Score	106
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.04	48.66
Shading	85	84.56
Epifaunal Substrate	7	59.36
Instream Habitat	7	60.60
Instream Woody Debris	13	94.98
Bank Stability	13.27	81.45

MPHI Habitat Score	71.60
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Procambarus clarkii

Herpetofauna

Northern Green Frog

Pickerel Frog

American Toad

Eastern Gartersnake

Northern Spring Peeper

Wood Frog

Mussels

None Observed

Site ID: 24-R3M-08-21

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1454.62

Land Cover	Acres	% Area
Developed Land	605.96	41.66
Forested Land	633.73	43.57
Open Land	43.40	2.98
Agricultural Land	171.54	11.79

Impervious Surface	Acres	% Area
Impervious Land	48.76	3.35

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.53
Turbidity (NTU)	11.8
Temperature (°C)	9.8
pH (Standard Units)	7.45
Specific Conductivity (µS/cm)	174

Laboratory Measurements

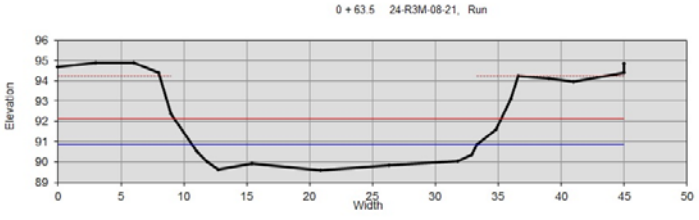
Total Phosphorus (mg/L)	0.110	Chloride (mg/L)	19.879
Total Nitrogen (mg/L)	0.627	Magnesium (mg/L)	2.169
Orthophosphate (mg/L)	0.013	Calcium (mg/L)	17.37
Total Ammonia N (mg/L)	0.066	Total Copper (µg/L)	0.370
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	1.940
Nitrate-N (mg/L)	0.422	Total Lead (µg/L)	0.273
Total Kjehldal N (mg/L)	0.199	Turbidity (NTU)	15.4
Dissolved Organic C (mg/L)	3.046		
Total Organic C (mg/L)	3.156		
Hardness (mg eq. $CaCO_3$/L)	52.30		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.27	Sinuosity	1.12
Bankfull Width (ft)	22.7	D50 (mm)	0.13
Mean Bankfull Depth (ft)	1.0	Adjustments?	SIN +0.1
Floodprone Width (ft)	25.3		
Entrenchment Ratio	1.1		
Width to Depth Ratio	22.6	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	22.7		
Water Surface Slope (%)	0.13		

Cross-sectional Survey



Site ID: 24-R3M-08-21

Biological Assessments

BIBI Metric Values

Total Taxa	14
EPT Taxa	4
Ephemeroptera Taxa	2
% Intolerant to Urban	2.75
% Ephemeroptera	2.75
Scraper Taxa	2
% Climbers	38.53

FIBI Metric Values

Abundance per m²	0.42
Adj. No. of Benthic Species	0.50
% Tolerant	76.28
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	13.46
% Abund. Dominant Taxon	30.77

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.57
BIBI Rating	Fair

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Acerpenna	1
Baetidae	1
Cheumatopsyche	3
Cryptochironomus	1
Hydrobaenus	3
Ironoquia	2
Maccaffertium	1
Naididae	1
Orthocladius	29
Parametriocnemus	1
Polypedilum	41
Rheocricotopus	2
Simulium	21
Tanytarsus	1
Tipula	1

Fish Taxa

American eel	2
Blacknose dace	1
Bluegill	1
Creek chub	1
Creek chubsucker	21
Eastern mosquitofish	7
Eastern mudminnow	24
Fallfish	3
Golden shiner	16
Green sunfish	21
Pumpkinseed	7
Tessellated darter	48
Warmouth	2
Yellow bullhead	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	10
Pool Variability	10
Sediment Deposition	7
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	3
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	108
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.09	38.17
Shading	73	71.29
Epifaunal Substrate	11	72.67
Instream Habitat	11	67.19
Instream Woody Debris	35	100.00
Bank Stability	8.90	66.71

MPHI Habitat Score	69.34
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Procambarus clarkii

Herpetofauna

Northern Green Frog

American Bullfrog

Southern Leopard Frog

Pickerel Frog

Eastern Box Turtle

Eastern Cricket Frog

Mussels

None Observed

Site ID: 24-R3M-09-21

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	Elevated Nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 100.32

Land Cover	Acres	% Area
Developed Land	24.20	24.12
Forested Land	54.79	54.62
Open Land	4.75	4.73
Agricultural Land	16.58	16.53

Impervious Surface	Acres	% Area
Impervious Land	1.89	1.88

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.68
Turbidity (NTU)	10.5
Temperature (°C)	16.8
pH (Standard Units)	6.61
Specific Conductivity (µS/cm)	140

Laboratory Measurements

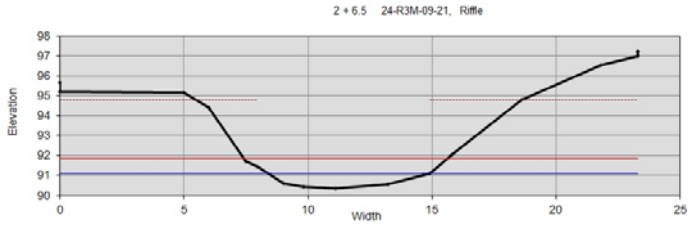
Total Phosphorus (mg/L)	0.107	Chloride (mg/L)	14.438
Total Nitrogen (mg/L)	0.439	Magnesium (mg/L)	2.220
Orthophosphate (mg/L)	0.041	Calcium (mg/L)	13.90
Total Ammonia N (mg/L)	0.021	Total Copper (µg/L)	0.520
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	4.457
Nitrate-N (mg/L)	0.228	Total Lead (µg/L)	0.403
Total Kjehldal N (mg/L)	0.208	Turbidity (NTU)	13.4
Dissolved Organic C (mg/L)	3.839		
Total Organic C (mg/L)	3.921		
Hardness (mg eq. $CaCO_3$/L)	43.85		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.16	Sinuosity	1.12
Bankfull Width (ft)	6.5	D50 (mm)	0.76
Mean Bankfull Depth (ft)	0.5	Adjustments?	SIN +0.1
Floodprone Width (ft)	8.1		
Entrenchment Ratio	1.2		
Width to Depth Ratio	12.5	**Rosgen Stream Type**	**F4/5**
Cross Sectional Area (ft²)	3.4		
Water Surface Slope (%)	0.72		

Cross-sectional Survey



Site ID: 24-R3M-09-21

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	16.81
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	6.19

FIBI Metric Values

Abundance per m²	0.37
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	66.67

BIBI Metric Scores

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

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

Amphinemura	18
Chaetocladius	3
Diamesa	6
Diplocladius	3
Gammarus	1
Naididae	1
Nematoda	2
Nemouridae	1
Orthocladius	31
Parametriocnemus	28
Physidae	2
Polypedilum	5
Pseudorthocladius	1
Rheocricotopus	1
Simulium	7
Sphaeriidae	1
Zavrelimyia	2

Fish Taxa

Blacknose dace	6
Bluegill	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	9
Pool Variability	4
Sediment Deposition	8
Channel Flow Status	12
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	4
Vegetative Protection - Left Bank	4
Riparian Veg. Zone Width - Right Bank	4
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	88
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	5.64	30.37
Shading	80	78.67
Epifaunal Substrate	4	49.43
Instream Habitat	3	50.17
Instream Woody Debris	6	87.29
Bank Stability	8.70	65.96

MPHI Habitat Score	60.32
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Eastern Box Turtle

Pickerel Frog

Mussels

None Observed

Appendix E: Water Quality Data

Sampling Unit	Sample 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)	Total Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg equivalent $CaCO_3$/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
Cabin Branch	23-L1M-01-21	03/23/21	15:00	16.52	0.1029	1.4524	0.0375	0.0076	0.0067	1.332	0.1139	1.801 α	1.894	2.522	11.72	39.65	0.344	8.15	0.085	4.2
	23-L1M-02-21	04/15/21	13:00	10.47	0.1137	1.9015	0.0839	0.0117	< 0.0028	1.877	0.0223	2.155 α	2.232	3.041	13.87	47.16	0.450	15.60	0.128	2.6
	23-L2M-02-21	03/30/21	10:30	14.67	0.0320	0.5393	0.0057	0.0136	< 0.0028	0.421	0.1178	2.512	2.470	2.578	6.78	27.55	0.365	13.37	0.121	4.2
	23-L2M-03-21	03/30/21	15:00	14.14	0.3098	0.4109	0.0384	0.0284	< 0.0028	0.082	0.3269	4.085	3.827	2.026	12.42	39.36	0.921	8.45	1.012	37.7
	23-R3M-01-21	03/11/21	13:30	17.45	0.1207	1.4902	0.0669	0.0081	0.0041	1.359	0.1272	1.623	1.574	2.378	12.23	40.33	0.266	6.52	0.071	3.6
	23-R3M-03-21	04/19/21	15:00	7.14	0.0743	2.0241 *	0.0156	0.0117	< 0.0028	2.032	-0.0098	1.934	1.908	2.154	15.25	46.95	0.407	15.81	0.204	9.4
	23-R3M-04-21	04/15/21	10:30	15.18	0.0440	0.8289	0.0170	0.0085	< 0.0028	0.723	0.1048	3.737	3.549	2.889	8.04	31.97	0.607	7.58	0.243	3.6
	23-R3M-07-21	03/11/21	10:00	17.34	0.0839	1.9614	0.0313	0.0139	0.0037	1.832	0.1259	1.474	1.455	2.626	12.69	42.50	0.326	12.09	0.096	4.3
	Average ± SD			**14.11 ± 3.60**	**0.1102 ± 0.0866**	**1.3261 ± 0.6512**	**0.0370 ± 0.0266**	**0.0129 ± 0.0067**	**0.0036 ± 0.0014**	**1.207 ± 0.725**	**0.1161 ± 0.0996**	**2.415 ± 0.981**	**2.363 ± 0.883**	**2.527 ± 0.342**	**11.62 ± 2.84**	**39.43 ± 6.80**	**0.461 ± 0.212**	**10.95 ± 3.73**	**0.245 ± 0.316**	**8.7 ± 11.9**
Ferry Branch	21-L1M-01-21	04/06/21	13:00	31.52	0.0826	1.0822	0.0220	0.0126	< 0.0028	0.933	0.1469	2.134	2.070	2.830	10.15	37.00	0.383	11.21	0.204	5.8
	21-L1M-05-21	03/16/21	10:00	41.56	0.1070	1.4275	0.0112	0.0436	0.0044	1.283	0.1402	2.428	2.249	3.866	11.76	45.28	0.455	11.01	0.247	9.0
	21-L2M-02-21	03/16/21	13:00	37.32	0.1358	1.4576	0.0244	0.0331	0.0041	1.258	0.1951	2.798	2.370	3.584	11.06	42.38	0.562	9.49	0.276	10.4
	21-L2M-05-21	04/13/21	13:10	31.96	0.0912	1.0204	0.0304	0.0186	< 0.0028	0.899	0.1188	2.644	2.480	2.796	10.01	36.51	0.390	11.24	0.213	5.2
	21-R3M-04-21	04/06/21	10:00	30.51	0.0575	1.0289	0.0162	0.0141	< 0.0028	0.911	0.1164	2.225 α	2.304	2.962	10.28	37.87	0.433	11.74	0.226	4.5
	21-R3M-07-21	04/07/21	10:30	19.74	0.0582	1.0520	0.0229	0.0116	< 0.0028	0.943	0.1073	2.414	2.308	2.838	10.33	37.48	0.509	7.89	0.136	3.6
	21-R3M-10-21	04/07/21	14:00	19.15	0.0845	1.0697	0.0357	0.0100	0.0032	0.951	0.1155	2.437	2.350	2.557	10.45	36.62	0.563	5.54	0.132	4.3
	21-R3M-13-21	04/13/21	12:20	21.60	0.1139	1.8569	0.0526	0.0224	0.0085	1.777	0.0711	2.436	2.426	2.645	14.45	46.97	0.373	5.80	0.110	5.5
	Average ± SD			**29.17 ± 8.30**	**0.0913 ± 0.0270**	**1.2494 ± 0.3034**	**0.0269 ± 0.0129**	**0.0208 ± 0.0119**	**0.0039 ± 0.0020**	**1.119 ± 0.308**	**0.1264 ± 0.0359**	**2.440 ± 0.211**	**2.319 ± 0.124**	**3.010 ± 0.465**	**11.06 ± 1.48**	**40.01 ± 4.24**	**0.459 ± 0.078**	**9.24 ± 2.53**	**0.193 ± 0.060**	**6.0 ± 2.4**
Hall Creek	24-L1M-03-21	03/17/21	13:00	19.60	0.1251	2.2403	0.0060	0.0781	0.0042	1.889	0.3476	1.956	1.906	1.793	16.60	48.83	0.209	1.66	0.232	14.7
	24-L1M-04-21	03/30/21	12:00	21.43	0.1004	1.6940	0.0293	0.0423	0.0061	1.443	0.2452	3.463	3.379	2.271	18.34	55.15	0.720	3.82	0.332	11.0
	24-L2M-01-21	03/11/21	10:05	34.69	0.0994	0.5792	0.0197	0.0284	< 0.0028	0.393	0.1855	2.177	2.021	1.815	21.34	60.76	0.381	4.73	0.303	9.9
	24-L2M-03-21	03/30/21	14:00	21.86	0.1106	1.4806	0.0295	0.0365	0.0068	1.272	0.2022	3.593 α	3.708	2.252	17.29	52.45	0.779	3.58	0.390	13.3
	24-R3M-01-21	03/16/21	13:30	11.82	0.0562	0.4043	0.0106	0.0371	< 0.0028	0.178	0.2247	4.160	3.863	2.907	11.55	40.81	0.458	4.66	0.279	11.5
	24-R3M-02-21	03/11/21	13:00	35.47	0.1320	0.7421	0.0340	0.0144	< 0.0028	0.361	0.3801	2.197	2.124	2.021	21.10	61.01	0.344	2.80	0.204	10.6
	24-R3M-08-21	04/05/21	9:00	19.88	0.1097	0.6266	0.0134	0.0663	0.0060	0.422	0.1990	3.156	3.046	2.169	17.37	52.30	0.370	1.94	0.273	15.4
	24-R3M-09-21	04/05/21	14:00	14.44	0.1071	0.4387	0.0409	0.0205	0.0028	0.228	0.2077	3.921	3.839	2.220	13.90	43.85	0.520	4.46	0.403	13.4
	Average ± SD			**22.40 ± 8.56**	**0.1051 ± 0.0228**	**1.0257 ± 0.6865**	**0.0229 ± 0.0124**	**0.0405 ± 0.0218**	**0.0043 ± 0.0017**	**0.773 ± 0.658**	**0.2490 ± 0.0736**	**3.078 ± 0.858**	**2.986 ± 0.847**	**2.181 ± 0.349**	**17.19 ± 3.31**	**51.90 ± 7.27**	**0.473 ± 0.194**	**3.46 ± 1.21**	**0.302 ± 0.070**	**12.5 ± 2.0**
Herring Bay	15-L1M-01-21	03/15/21	15:00	14.46	0.0790	0.2248	0.0207	0.0083	< 0.0028	0.032	0.1908	3.954	3.937	2.095	12.66	40.24	0.315	1.17	0.092	4.5
	15-L1M-02-21	03/16/21	9:00	27.38	0.1069	0.6599	0.0187	0.0151	0.0030	0.458	0.1989	2.773	2.514	2.505	14.25	45.90	0.374	7.84	0.240	10.4
	15-L2M-02-21	03/17/21	9:00	20.99	0.1177	0.9379	0.0105	0.0447	< 0.0028	0.763	0.1721	2.807	2.648	2.529	13.53	44.20	0.394	8.31	0.220	11.8
	15-L2M-07-21	03/22/21	11:30	39.93	0.0729	1.1677	0.0080	0.0382	0.0050	0.891	0.2715	2.680 α	2.687	2.918	18.07	57.14	0.514	7.09	0.229	10.8
	15-R3M-01-21	03/30/21	10:00	50.50	0.1882	1.2434	0.1567	0.0080	< 0.0028	1.077	0.1667	2.209 α	2.220	5.790	24.59	85.24	0.430	4.07	0.144	3.9
	15-R3M-03-21	04/07/21	10:15	19.50	0.2207	0.6228	0.0227	0.0196	0.0055	0.381	0.2365	3.788	3.579	2.777	13.73	45.72	0.624	6.00	0.515	24.5
	15-R3M-04-21	04/07/21	8:30	19.47	0.1930	0.6022	0.0224	0.0255	0.0047	0.346	0.2511	4.005	3.860	2.752	13.92	46.09	0.611	5.96	0.487	22.2
	15-R3M-05-21	03/15/21	11:00	14.39	0.1163	0.2706	0.0209	0.0270	< 0.0028	0.047	0.2240	3.191 α	3.196	2.180	17.63	53.00	0.331	2.86	0.156	9.8
	Average ± SD			**25.83 ± 12.95**	**0.1368 ± 0.056**	**0.7162 ± 0.3772**	**0.0351 ± 0.0495**	**0.0233 ± 0.0133**	**0.0037 ± 0.0012**	**0.499 ± 0.381**	**0.2140 ± 0.0379**	**3.176 ± 0.671**	**3.080 ± 0.655**	**2.943 ± 1.185**	**16.05 ± 3.97**	**52.19 ± 14.36**	**0.449 ± 0.121**	**5.41 ± 2.51**	**0.260 ± 0.157**	**12.2 ± 7.5**
Lyons Creek	22-L1M-01-21	03/22/21	15:00	40.97	0.0705	0.6819	0.0145	0.0072	0.0030	0.545	0.1335	1.463	1.336	2.537	16.94	52.75	0.463	8.30	0.140	5.9
	22-L1M-02-21	04/20/21	9:00	12.70	0.0593	1.3581	0.0105	0.0223	< 0.0028	1.323	0.0330	1.557	1.545	2.382	13.16	42.67	0.283	9.76	0.126	6.3
	22-L2M-01-21	03/15/21	12:30	15.19	0.0751	3.5704	0.0153	0.0232	< 0.0028	3.545	0.0238	1.487	1.214	2.267	15.77	48.71	0.316	13.20	0.222	6.2
	22-L2M-02-21	04/20/21	11:00	23.41	0.1561	0.7060	0.0164	0.0470	0.0062	0.374	0.3262	5.339	5.090	2.711	15.33	49.44	0.449	2.09	0.300	16.7
	22-R3M-04-21	03/23/21	9:30	22.73	0.0489	2.6221	0.0069	0.0263	0.0079	2.481	0.1337	2.072 α	2.478	2.870	15.97	51.70	0.715	11.60	0.123	6.0
	22-R3M-08-21	03/23/21	10:30	25.11	0.0965	0.9775	0.0108	0.0199	0.0117	0.651	0.3145	4.781	4.088	2.924	15.74	51.34	0.510	2.83	0.233	10.4
	22-R3M-09-21	03/15/21	10:30	14.88	0.0620	3.4524 *	0.0090	0.0214	< 0.0028	3.437	0.0132	1.156	1.078	2.472	16.16	50.53	0.323	14.73	0.223	6.2
	22-R3M-17-21	04/19/21	11:30	32.14	0.0632	0.5586	0.0136	0.0164	< 0.0028	0.473	0.0858	1.560	1.524	2.524	16.19	50.82	0.248	9.67	0.093	4.4
	Average ± SD			**23.39 ± 9.58**	**0.0790 ± 0.0342**	**1.7409 ± 1.2746**	**0.0121 ± 0.0033**	**0.0230 ± 0.0113**	**0.0050 ± 0.0033**	**1.604 ± 1.352**	**0.1330 ± 0.1247**	**2.427 ± 1.651**	**2.294 ± 1.502**	**2.586 ± 0.231**	**15.66 ± 1.11**	**49.75 ± 3.13**	**0.413 ± 0.154**	**9.02 ± 4.54**	**0.183 ± 0.072**	**7.8 ± 4.0**

* Although the inorganic nitrogen or phosphorus exceeds the total dissolved nitrogen or phosphorus value, the excess is within the precision of the analytical technique and, therefore, not statistically significant.

< Sample concentration was below the method detection limit, so the method detection limit is the reported value.

α Although the dissolved organic carbon concentration exceeds the total dissolved organic carbon value, the excess is within the precision of the analytical technique and, therefore, not statistically significant.