BIOLOGICAL AND GEOMORPHOLOGICAL CONDITION IN THE PICTURE SPRING BRANCH SUBWATERSHED, SEVERN RIVER WATERSHED, ANNE ARUNDEL COUNTY, MARYLAND: 2018 - 2019

Prepared for

Anne Arundel County, Maryland
Department of Public Works
Watershed Protection and Restoration Program
2662 Riva Road
Annapolis, MD 21401

Prepared by

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045

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1.0 INTRODUCTION

Anne Arundel County is required to perform physical stream monitoring in the Picture Spring Branch Subwatershed in accordance with their National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit (NPDES permit number MD0068306). The goal of this monitoring effort is to assess the implementation of best management practice (BMP) design criteria from the *2000 Maryland Stormwater Design Manual* approved by Maryland Department of the Environment (MDE). The BMP design criteria were applied to the stormwater management system constructed at the West County Library site, located in Odenton, Maryland, just west of the intersection of State Highways 170 (Telegraph Road) and 175 (Annapolis Road). Specifically, bioretention areas and dry swale structural BMPs, and the nonstructural credit "sheetflow to buffer" were incorporated into the library site development in order to mitigate the effects of stormwater runoff on Picture Spring Branch.

There are four additional stormwater BMPs within the watershed that influence the flows through the study reach. These include a dry detention pond, a retention pond, and two other detention ponds with shallow wetlands. Baseline conditions within the watershed, for both land use and BMP functionality, were developed as part of this long-term study. These conditions are monitored periodically to determine if changes within the watershed affect the conditions found in the stream channel.

To monitor the effectiveness of these BMPs on stream channel protection, the County implemented a monitoring program to characterize the biological and geomorphological conditions of the Picture Spring Branch Subwatershed, located within the Severn River Watershed, in the vicinity of the Odenton/West County Library. Physical condition and habitat monitoring for Picture Spring Branch began in 2003 and is conducted on an annual basis. Biological monitoring to measure overall stream health is also performed.

This report summarizes the results of biological, geomorphological, and physical habitat assessments performed in 2019 with comparisons to previous years' conditions, and discusses the current watershed conditions.

2.0 METHODS

2.1 SAMPLING LOCATIONS

The study area is located in the southwestern portion of the Picture Spring Branch Subwatershed, within the Severn River Watershed in Anne Arundel County, Maryland (Figure 2-1). The study area consists of the North Tributary and South Tributary and encompasses approximately 156 acres of drainage. The land use within the study area is dominated by developed land, with approximately 57% in residential, commercial, and industrial uses (Table 2-1). Less than one-third of the subwatershed (31.3%) is open space or wooded land cover, most of which surrounds the stream valley. Note that drainage areas and land use were updated in 2019 using Anne Arundel County LIDAR (2017) data.

Three biological monitoring locations are located within the study area, which were selected by County staff in 2006 (see Figure 2-1). Two sites were placed on the North Tributary and one site was placed downstream of the confluence with the South Tributary and below Piney Orchard Parkway (MD State Highway 170). Sites were marked in the field using silver tree tags labeled with the site name located at the upstream and downstream ends of each 75-meter sampling segment.

Table 2-1. Summary of land use in the Picture Spring Branch Subwatershed, Anne Arundel County

Land Use	Acres	% of Watershed Area
Commercial	15.8	10.1
Industrial	16.9	10.8
Open Space	6.0	3.8
Residential	56.3	36.0
Transportation	16.8	10.7
Utility	1.6	1.0
Forest	43.0	27.5
Total	**156.4**	**100.0**

Source: Anne Arundel County Department of Public Works

Five previously established cross-sections were remeasured in 2019 as part of the annual geomorphological assessment. Three cross-sections are located along the North Tributary, one is located on the South Tributary, and another is located downstream of Piney Orchard Parkway (see Figure 2-1). Permanent cross-section monuments are located on each bank and consist of iron bolts set in concrete flush to the ground surface.

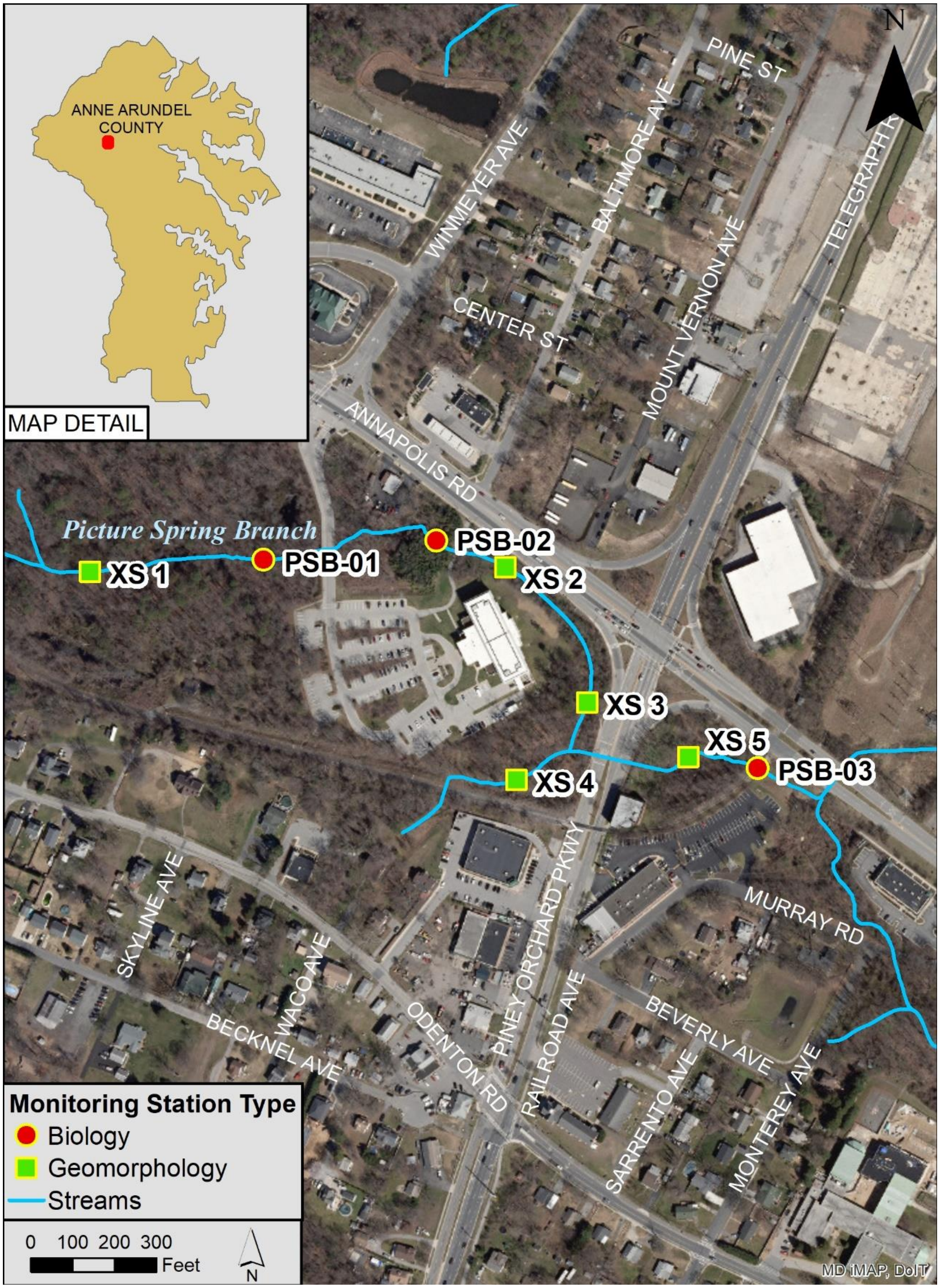

Figure 2-1. Picture Spring Branch study area stream monitoring locations

2.2 FIELD METHODS

All biological assessment data were collected in accordance with the *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (Anne Arundel County 2017), which incorporates many elements of Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS). Geomorphic assessment data were collected in accordance with the standard operating procedures (SOPs) approved for the County's NPDES Program. All methods are consistent with previous years' methods (with applicable updates) to ensure data comparability between years. Collection methods are summarized below. Field data were collected in 2019 by Versar, Inc.

2.2.1 Stream Habitat

To support the biological monitoring, a visual assessment of physical habitat was completed at each monitoring site to evaluate the reach's ability to support aquatic life. Both the MBSS Physical Habitat Index (PHI; Paul et al. 2003) and the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al. 1999) were used to visually assess the physical habitat at each site in conjunction with the spring benthic monitoring. Both habitat assessments consist of a review of biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health.

2.2.2 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected in April 2019 following the MBSS Spring index period protocols (MD DNR 2017) and consistent with the methods specified in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (QAPP; Anne Arundel County 2017). This methodology emphasizes the community composition and relative abundance of benthic macroinvertebrates inhabiting the most taxonomically diverse, or productive, instream habitats. In this sampling approach, a total of twenty jabs are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their dominance within the segment. 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. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs; however, of the aforementioned habitat types, those that are located within moving water are preferred over those in still water.

2.2.3 Water Quality

To supplement the biological and physical sampling, *in situ* water quality was measured at each site. Field tested parameters include pH, specific conductivity, dissolved oxygen, and temperature. All measurements were collected from three locations within each sampling reach (upstream end, midpoint, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. All *in situ* parameters were measured with a YSI ProDSS multiparameter water quality sonde.

2.2.4 Geomorphic Assessment

Geomorphic assessments included a survey of the longitudinal profile, measurement of permanent cross-sections, and representative pebble counts. Data from these measurements were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen 1996), which can be found in Appendix A.

The longitudinal profile was performed throughout the entire study area, totaling 1,968 linear feet along the North Tributary and continuing below Telegraph Road (Maryland Route 170) and 356 linear feet along the South Tributary. The goal of the longitudinal profile was to identify indicators and elevations of the bankfull discharge (i.e., bankfull indicators) and to determine the bankfull water surface slope throughout the study reach. Once bankfull indicators were identified and elevation measurements made, channel thalweg and water surface elevations were also recorded.

The cross-section surveys were performed at the five permanent cross-section locations (Figure 2-1). Photos were taken of upstream, downstream, left bank, and right bank views at each cross-section location. Photographs are included in Appendix B. Cross-section surveys consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- Monument elevations
- Changes in topography
- Top of each channel bank
- Elevations of bankfull indicators
- Edge of water during the time of survey
- Thalweg or deepest elevation along active channel
- Depositional and erosional features within the channel

During the cross-sectional survey, the following measurements and calculations of the bankfull channel, which are critical for determining the Rosgen stream type of each reach, were also collected:

- Bankfull Width (Wbkf): the width of the channel at the elevation of bankfull discharge or at the stage that defines the bankfull channel.
- Mean Depth (dbkf): the mean depth of the bankfull channel.
- Bankfull Cross-sectional Area (Abkf): the area of the bankfull channel, estimated as the product of bankfull width and mean depth.
- Width Depth Ratio (Wbkf/dbkf): the ratio of the bankfull width to mean depth.

- Maximum Depth (dmbkf): the maximum depth of the bankfull channel, or the difference between the thalweg elevation and the bankfull discharge elevation.
- Width of Floodprone Area (Wfpa): the width of the channel at a stage of twice the maximum depth. If the width of the floodprone area was far outside of the channel, its value was visually estimated or paced off.
- Entrenchment Ratio (ER): the ratio of the width of the floodprone area versus bankfull width.
- Sinuosity (K): ratio of the stream length versus the valley length or the valley slope divided by the channel slope. Sinuosity was visually estimated or the valley length was paced off so that an estimate could be calculated.

To quantify the distribution of channel substrate particle sizes within the study area, a modified Wolman pebble count (Rosgen 1996) was performed at each cross-section location. Reach-wide proportional counts were used. Each pebble count consists of stratifying the reach based on the frequency of channel features in that reach (e.g., riffle, run, pool, glide) and measuring 100 particles across ten transects (i.e., 10 particles in each of 10 transects). The transects are allocated across all feature types in the proportion at which they occur within the reach. The intermediate axis of each measured pebble is recorded. The goal of the pebble count is to measure 100 particles across the bankfull width of the channel and calculate the median substrate particle size (i.e., D50) of the reach. This value is used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). If a channel was clearly a sand or silt bed channel with no distinct variation in material size, the pebble count was not performed, and the D50 was visually estimated. However, if the channel did have variation in bed material size from feature to feature, a full pebble count was performed.

2.3 DATA ANALYSIS

2.3.1 Aquatic Habitat

At each monitoring site, stream physical habitat was visually assessed utilizing the Maryland Biological Stream Survey (MBSS) Physical Habitat Index (PHI; Paul et al. 2003). The PHI was developed in part based on the EPA’s Rapid Bioassessment Protocol (RBP; Barbour et al. 1999), and has been specifically calibrated to each of Maryland’s physiographic regions. The habitat metrics for coastal plain streams include epifaunal substrate, percent shading, remoteness (i.e., distance to the nearest road), instream habitat, bank stability, and instream woody debris and rootwads. The metrics selected represent a mixture of physical habitat characteristics including geomorphology, habitat complexity for aquatic biota, riparian condition, and surrounding land use.

To calculate PHI at each site, six parameters were given a numerical score and a categorical rating. The raw scores are then transformed into a scaled score (0-100 scale) as described in Paul et al. (2003), and the six scaled scores are averaged into an aggregate final PHI score. Narrative condition descriptions and scoring ranges for the PHI are displayed in Table 2-2.

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: Epifaunal substrate/available cover, Embeddedness, Velocity/depth regime, Sediment deposition, Channel flow status, Channel alteration, Frequency of riffles/bends, Bank stability, Vegetative protection, and Riparian vegetative zone width (Barbour et al. 1999). In the field, each parameter was 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 individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. Because adequate reference conditions currently do not exist for Anne Arundel County, the percent comparability was calculated based on western coastal plain reference site conditions obtained from work done in Prince George's County streams (Stribling et al. 1999). The percent of reference score, or percent comparability score, was then used to place each site into corresponding narrative rating categories. The ranges are shown in Table 2-3.

Table 2-2. Maryland Biological Stream Survey PHI scoring

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

Table 2-3. EPA Rapid Bioassessment Protocol (RBP) scoring

Percent of Reference Score	**Narrative**
90-100	Comparable to Reference
75.1-89.9	Supporting
60.1-75	Partially Supporting
0-60	Non-Supporting

2.3.2 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were processed and subsampled according to MBSS methods described in the MBSS laboratory methods manual (Boward and Freidman, 2000) and as briefly summarized in the *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (Anne Arundel County 2017). Subsampling is conducted to standardize the sample size and reduce variation caused by field collection methods. In brief, the sample was washed of preservative in a 0.595mm screen and spread evenly across a tray comprised of 100 numbered 5cm x 5cm grids. A random number between one and 100 was selected and the selected grid was picked entirely of macroinvertebrates under a bright light source. This process was repeated until a count of 120 organisms was reached. The 120 organism target was used following MBSS methods to allow for specimens that are missing parts or are early instars, which cannot be properly identified.

The samples were taxonomically identified by Versar taxonomists certified by the Society for Freshwater Science (SFS) (formerly known as the North American Benthological Society, NABS). The taxonomic level for most organisms was genus level when possible, with the exception of Oligochaeta which were identified to the family level. Early instars or damaged specimens were identified to the lowest possible level. Oligochaeta and Chironomidae specimens were permanently slide mounted for identification. Counts and identifications were recorded on a laboratory bench sheet and entered into a master database for analysis. A list of all taxa identified is provided in Appendix C: Master Benthic Macroinvertebrate Taxa List.

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. Tolerance values were obtained from Bressler et al. (2005).

Raw values from each metric are given a score of 1, 3, or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions: Coastal Plain, Piedmont and Combined Highlands. The Coastal Plain, and Piedmont regions are divided by the Fall Line. The current study area is located within the Coastal Plain region. Table 2-4 shows the thresholds for the determination of the metric scoring. The metrics calculated for Coastal Plain streams are as follows:

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.

Number of EPT Taxa – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

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.

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 out of 10. As impairment increases the percent of intolerant taxa decreases.

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.

Number Scraper Taxa – Equals the number of taxa in the sample that have evolved to scrape their food from the substrate in their environment. As the levels of stressors or pollution rise, there is an expected decrease in the numbers of Scraper taxa.

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.

Table 2-4. Biological condition scoring for the coastal plain metrics

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	1.9-1.0	< 1.0
Percent Intolerant Urban	≥ 28	10-27	< 10
Percent Ephemeroptera	≥ 11	0.8-10.9	< 0.8
Number Scraper Taxa	≥ 2	1.9-1.0	< 1.0
Percent Climbers	≥ 8.0	0.9-7.9	< 0.9

All of the metric scores are summed and then averaged to obtain the final BIBI score. Table 2-5 shows the scores and narrative rankings of the MBSS BIBI. The QA/QC information for these calculations is included in Appendix D.

Table 2-5. Maryland Biological Stream Survey BIBI scoring

BIBI Score	Narrative Ranking	Characteristics
4.0-5.0	Good	Comparable to reference conditions, stream considered to be minimally impacted, biological metrics fall within upper 50th percentile of reference site conditions.
3.0-3.9	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of minimally impacted streams.
2.0-2.9	Poor	Significant deviation from reference conditions, indicating some degradation. On average, biological metrics fall below the 10th percentile of reference site values.
1.0-1.9	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of minimally impacted streams, indicating severe degradation. On average, most or all metrics fall below the 10th percentile of reference site values.

2.3.3 Water Quality

Data were compared to the standards for Use I streams listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-3 Water Quality* and shown in Table 2-6.

Table 2-6. Maryland COMAR water quality standards for Use I streams

Parameter	Standard
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No existing standard
Turbidity (NTU)	Maximum of 150 NTU and maximum monthly average of 50 NTU
Total Dissolved Solids (mg/L)	No existing standard
Temperature (C)	Maximum of 32 °C (90 °F) or ambient temperature, whichever is greater
Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3 Water Quality	

2.3.4 Geomorphic Assessment

Geomorphic field data were compared to regional relationships of bankfull channel geometry developed by the USFWS for streams in the Maryland Coastal Plain (McCandless 2003) and by Anne Arundel County Department of Public Works (AADPW 2002) for urban streams within the County. Estimates of the bankfull channel parameters, the longitudinal profile survey, the cross-section survey, and the pebble count data were entered into *The Reference Reach Spreadsheet* (Mecklenburg 2006) and analyzed for each assessment site. These data were used to identify each stream reach as one of the stream types categorized by the Rosgen Stream Classification (Rosgen 1996). In the Rosgen Classification methodology, streams are categorized based on their measured field values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials according to the table in Appendix A: Rosgen Stream Classification. As illustrated in Appendix A, the Rosgen Stream Classification categorizes streams into broad stream types, which are identified by the letters Aa, A, B, C, D, DA, E, F, and G. Table 2-7 includes general descriptions of each Rosgen stream type. A summary of the stream types identified for the streams in this study is included in Appendix B: Geomorphic Assessment Results.

Table 2-7. Rosgen Stream Classification types

Channel Type	General Description
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
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.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, 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 streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
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.

Source: Rosgen (1996).

3.0 RESULTS

3.1 AQUATIC HABITAT

In spring 2019, physical habitat quality at all three Picture Spring Branch sites was rated as “Partially Degraded” by the Maryland PHI. The most upstream reach, PSB-01, received the highest PHI score of 79.86. At this site, there is substantial riparian buffer with well-vegetated banks throughout the 75m reach that provide ample shading. Site PSB-02, located between the Winmeyer Avenue and Baltimore Avenue culverts, received a PHI score of 77.80. Site PSB-03, downstream of Maryland Route 170, received a PHI score of 73.85. Remoteness scores at PSB-02 and PSB-03 are very low due to the close proximity of roads and parking lots surrounding the stream reach; however, banks exhibited only minor erosion at these sites and woody debris and rootwads were present in sufficient amounts for colonization of benthic macroinvertebrates. Lower PHI scores at PSB-02 and PSB-03 were primarily driven by lower remoteness and shading scores relative to PSB-01. Table 3-1 shows the PHI scores for the sampling sites within the Picture Spring Branch study area. Data for individual parameters are listed in Appendix E: Biological Assessment Results.

Using RBP, physical habitat quality was evaluated and rated “Supporting” for one site (PSB-01) and “Partially Supporting” for two sites (PSB-02 and PSB-03). Index scores ranged from a low of 73 at PSB-03 to a high of 77 at PSB-01. Generally, the Picture Spring Branch sites had optimal or sub-optimal scores for channel flow status and channel alteration, and sub-optimal or marginal scores for bank stability, vegetative protection, and riparian zone width. The relatively low RBP score at PSB-03 was driven by marginal scores for pool variability, sediment deposition, and channel sinuosity (Table 3-1).

Table 3-1. PHI and RBP physical habitat assessment results - 2019

Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
PSB-01	79.86	Partially Degraded	77	Supporting
PSB-02	77.80	Partially Degraded	75	Partially Supporting
PSB-03	73.85	Partially Degraded	73	Partially Supporting

3.2 BENTHIC MACROINVERTEBRATES

Biological condition was rated as “Fair” at sites PSB-01 and PSB-02 and “Poor” at site PSB-03. No Ephemeroptera taxa were found in any of the Picture Spring Branch benthic subsamples. PSB-01, the most upstream site within the North Tributary, had a BIBI score of 3.29. The benthic subsample was comprised of 30 taxa, dominated by individuals of the collecting midge genera *Chironomus* and *Parametriocnemus*. Climbers made up 16.13% of the sample and 10.48%

of the sample was comprised of urban intolerant taxa, which were the primary factors driving a higher BIBI rating at this site.

Site PSB-02, located on the North Tributary, also received a BIBI score of 3.29. Of the 25 taxa present in the subsample, two were EPT taxa and 17.56% were intolerant to urban stressors. The majority of individuals (67.18%) in the subsample were in the non-biting midge family Chironomidae. Fifty-two percent of the subsample was comprised of just five genera (*Micropsectra*, *Chironomus*, *Orthocladius*, *Parametriocnemus*, and *Limnophyes)* from the family Chironomidae.

Downstream of State Highway 170, site PSB-03 received a BIBI score of 2.71, maintaining the narrative rating decrease seen from the “Fair” rating received in 2017. This subsample was comprised of 33 taxa, 55.32% of which were in the family Chironomidae. The small percentage of intolerant urban taxa (8.57%) and lack of EPT taxa (only one EPT taxon was present in the sample) are the primary cause for the lower BIBI score relative to the other Picture Spring Branch sites. Table 3-2 contains the BIBI scores and corresponding narrative condition ratings for each sampling location. Detailed data on each site can be found in Appendix E.

Table 3-2. Benthic macroinvertebrate assessment results - 2019

Site	BIBI Score	Narrative Rating
PSB-01	3.29	Fair
PSB-02	3.29	Fair
PSB-03	2.71	Poor

3.3 WATER QUALITY

All water quality measurements met Maryland’s water quality standards for Use I streams (Table 3-3). Conductivity values were elevated at all sites compared to 2018 values and are relatively high compared to most coastal plain streams. Stream conductivity is affected by inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations, many of which are generally found at elevated concentrations in urban streams (Paul and Meyer 2001). Increased stream ion concentrations (measured as conductivity) in urban systems typically result from runoff over impervious surfaces, deicing chemicals, passage through pipes, and exposure to other infrastructure (Cushman 2006, Morgan et al. 2012).

Table 3-3. Water Quality Measurement Results - 2019					
Site	**pH SU**	**Temperature °C**	**Dissolved Oxygen mg/L**	**Conductivity µS/cm**	**Turbidity NTU**
PSB-01	7.9	12.23	9.55	1448	10.6
PSB-02	7.39	13.37	7.94	1706	12.1
PSB-03	7.13	14.23	7.56	1832	6.8

3.4 GEOMORPHIC ASSESSMENT

The geomorphic assessment field data were compared to both the Maryland Coastal Plain (MCP) regional relationships of bankfull channel geometry (McCandless 2003) and relationships for gauged urban Coastal Plain streams developed specifically for Anne Arundel County (AADPW 2002) to determine how bankfull characteristics observed in the field compared to those predicted by the MCP and urban relationships. Comparisons of bankfull width, bankfull cross-sectional area, and mean bankfull depth are shown in Figures 3-1, 3-2, and 3-3, respectively. In 2019, bankfull width values fell between the MCP and urban curve values at three sites, with two points wider than predicted by either curve. All bankfull cross-sectional area field data values fell between the MCP curve and urban curve predictions. Field data for mean bankfull depth mainly fell between the MCP curve and urban curve predictions, with one site more shallow than predicted by either curve. Overall, most of the field data fell somewhere between the MCP and urban relationships. However, the regional curves were developed using streams with drainage areas ranging from 0.3 to 89.7 square miles, with the majority of data collected in watersheds greater than one square-mile with low (zero to three percent) imperviousness. Thus, it is possible that stream channels with smaller drainage areas and more imperviousness, such as those studied in this assessment (ranging from 0.07 to 0.23 square miles), exhibit greater variability in channel dimensions when compared to the MCP relationships. Additionally, the Rosgen method is best used on streams that are free to adjust their lateral boundaries under the current discharge regime experienced by the system (Rosgen 1996), conditions which do not necessarily exist in the study area. For example, cross-sections 2, 3, and 5 are underlain by concrete trapezoidal channels, possibly making the accurate determination of the bankfull indicators in the field at these locations problematic. Regardless, given the high imperviousness of the study drainage area and the modified nature of the channel, it is not surprising that the field data deviated in many cases from the MCP curve and were more closely matched to urban curve predictions for bankfull width.

Based on the Rosgen Classification scheme, two sites were classified as E channels, two sites as F channels, and one site was classified as a C channel (Table 3-4). Water surface slopes along the study area ranged from 0.0021 ft/ft to 0.027 ft/ft. All five sites had channel substrates dominated by sand with D50 values that ranged from 0.09 mm to 0.22 mm. Detailed summaries of the geomorphic data and stream types are included in Appendix B: Geomorphic Assessment Results.

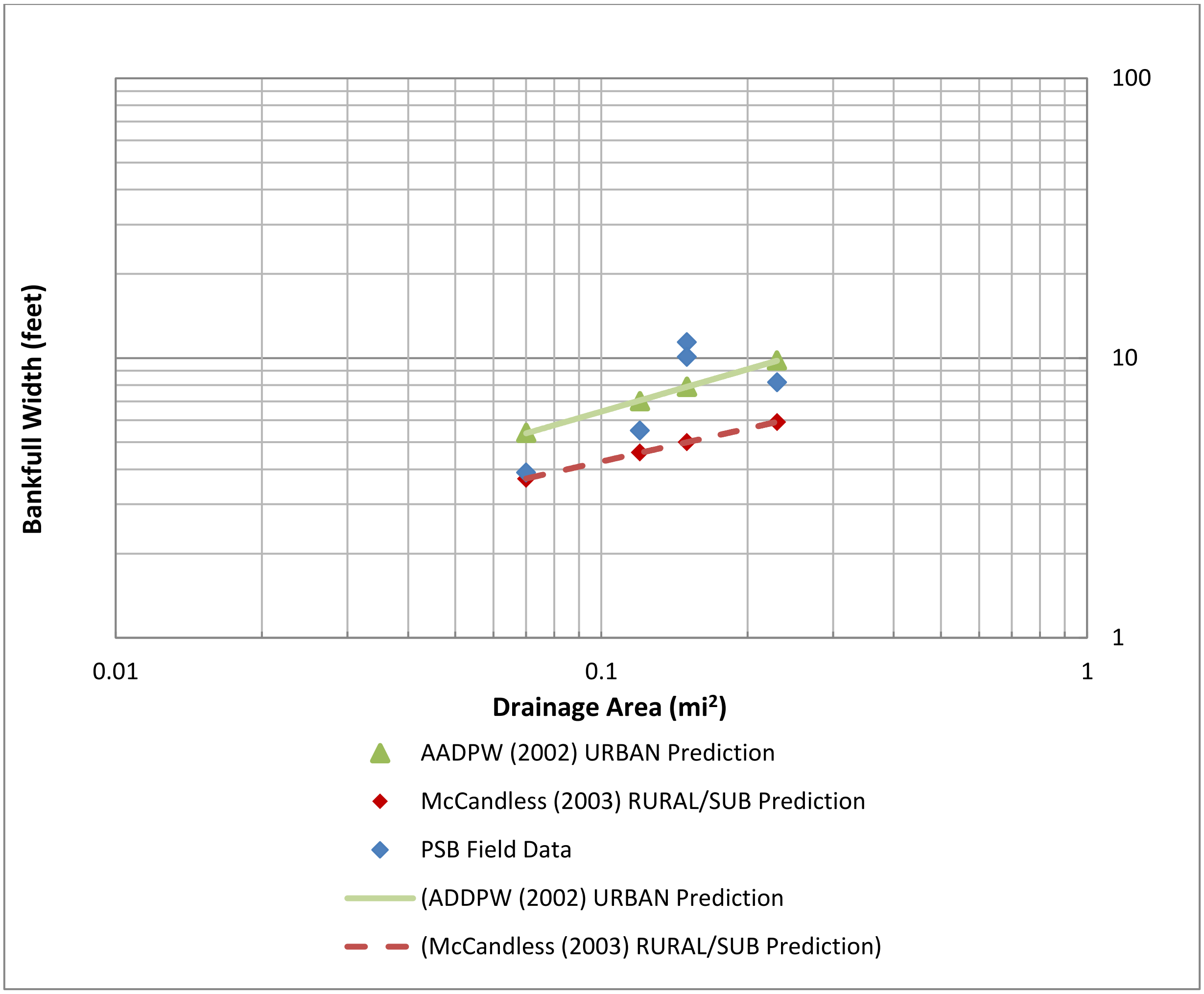

Figure 3-1. Comparison of the bankfull width drainage area relationship between Picture Spring Branch (PSB) 2019 field data and regional relationship curve data

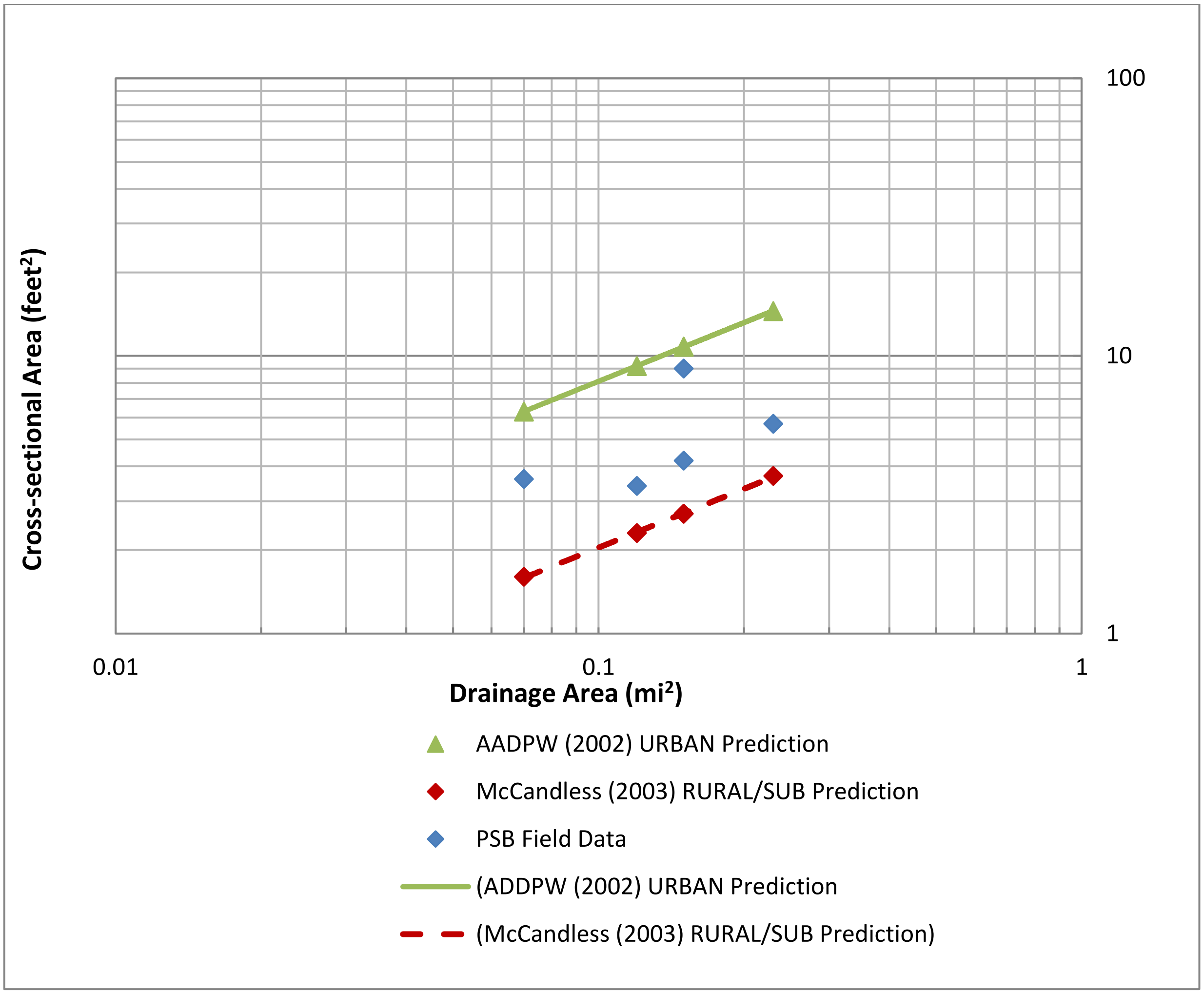

Figure 3-2. Comparison of the bankfull cross-sectional area drainage area relationship between Picture Spring Branch (PSB) 2019 field data and regional relationship curve data

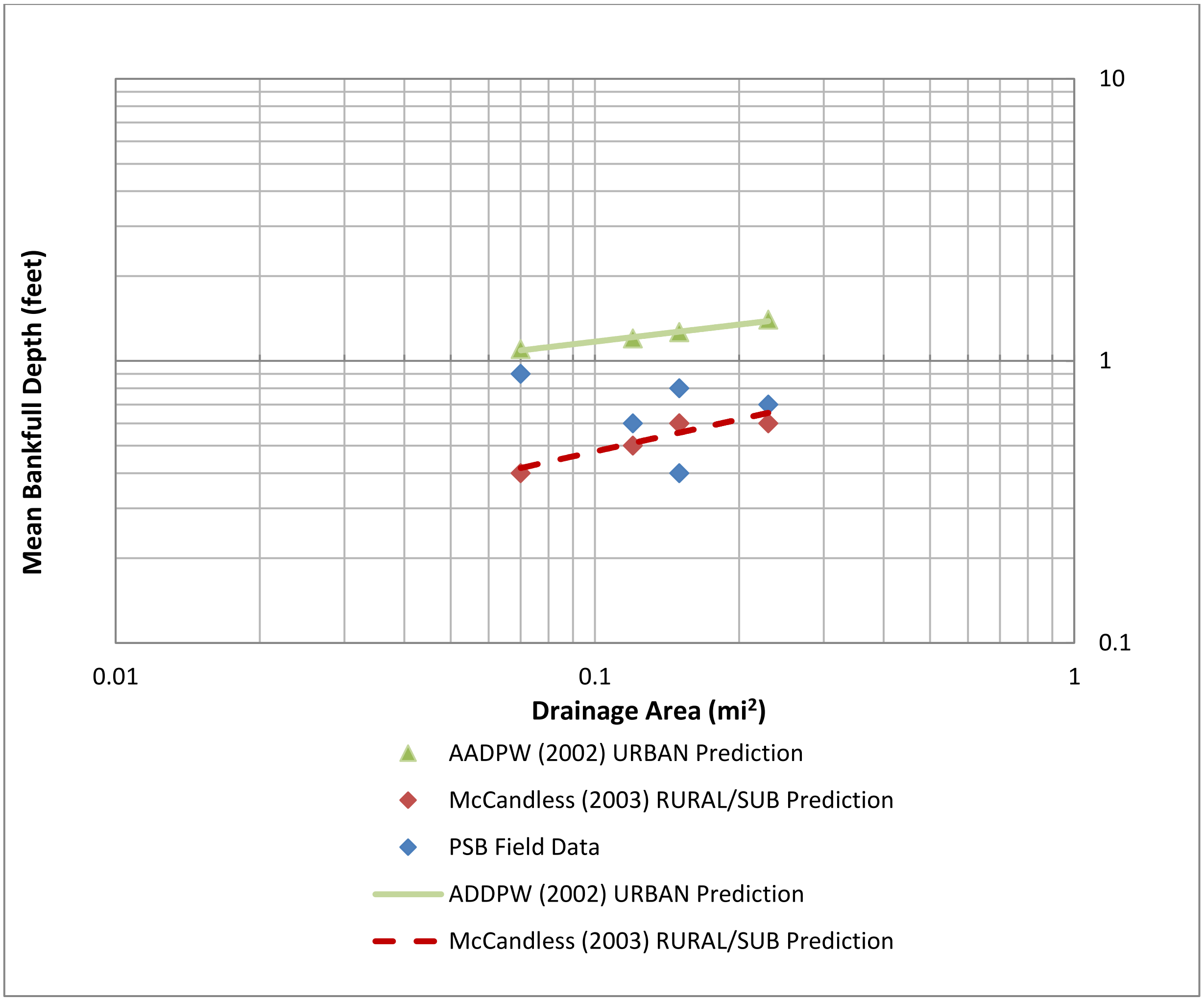

Figure 3-3. Comparison of the mean bankfull depth drainage area relationship between Picture Spring Branch (PSB) 2019 field data and regional relationship curve data

Table 3-4. Rosgen Classification Results - 2019

Cross-section	Classification	D50 (mm)	Water Surface Slope (ft/ft)
XS-1	E5	0.09	0.0062
XS-2	F5	0.10	0.0021
XS-3	F5	0.09	0.0049
XS-4	E5b	0.22	0.027
XS-5	C5	0.10	0.004

Cross-section 1, located in the well-forested upper portion of the North Tributary continues to exhibit characteristics typical of both C and E type channels, as well as some characteristics that fit neither. For example, E channels are typically very sinuous; however, this reach had very little sinuosity. Likewise, C channels often have numerous point bars, which were not common along this reach. Based on these characteristics, in 2017 best professional judgment was applied and the classification was changed from a C5 to an E5 given the decreased entrenchment and width/depth ratio. The same conditions were still present in 2018 and 2019 and the channel remains classified as an E5.

F5 channels were identified at cross-sections 2 and 3 which are located on the North Tributary upstream of Maryland State Highway 170. The stream segment along this portion of the North Tributary was over-widened as a result of past alteration with the installation of a concrete trapezoidal channel. However, it continues to adjust by filling with sediment and woody debris, thus establishing a more “natural” stream channel within the man-made, engineered channel.

Cross-section 5, located downstream of Maryland State Highway 170, remains classified as a C5 channel with entrenchment and width/depth ratios similar to those measured in 2017 and 2018. The Rosgen classification at this cross-section previously changed from an F5 in 2014, to a C5 in 2015.

An E5b channel was identified at cross-section 4 on the South Tributary. This reach appears to have been channelized in the past and is piped underground for a significant distance upstream, further modifying its hydrology. In comparison to the North Tributary, the South Tributary is not over-widened and has a steeper longitudinal gradient than the North Tributary. Indicators were observed that show some limited floodplain connectivity along the upstream portion of the tributary where the cross-section is located. However, just downstream of the cross-section location, the channel is noticeably entrenched and shows signs of active downcutting. While it is possible that this reach may exhibit both B and E characteristics along different portions of the reach, it was assigned an E5b classification in 2019, primarily based on the entrenchment and width/depth ratios measured at the cross-section location, as well as the channel slope within the vicinity of the cross-section. In addition, evidence of recent downcutting (e.g., nick points) suggests that the reach is unstable and is likely shifting from an E channel to a B channel. Significant changes in the shape of this cross-section were observed during the 2013 survey, as the channel had noticeably deepened and widened since the 2012 survey (Appendix B). Over the next year, aggradation occurred affecting the bed level by raising it approximately 0.5 feet. From 2014 to 2015, the channel shifted slightly but remained stable in terms of aggradation or deepening. Noticeable aggradation occurred again in 2016 with an approximate 0.5-foot rise in bed elevation, but the bed was stable between the 2016 and 2018 surveys. Between 2018 and 2019, the stream experienced downcutting (approximately 0.3 ft) and erosion (slightly less than one foot at the most affected area) at/near the right bank.

Analysis of the South Tributary longitudinal profile overlay from 2007 through 2019 shows considerable downcutting between stations 1+00 and 2+20 (Appendix B). However, during 2014, the pool near station 2+00 had mostly filled in. This trend continued in 2015, with the pool working its way up the reach to station 1+80. In 2016, the pool remained at station 1+80 but deepened by almost a foot with no additional changes occurring in 2017. In 2018, the pool shifted slightly downstream and deepened by about half a foot. In 2019, the pool filled in slightly, losing about

0.3 feet in depth. The headcut and large scour pool between stations 2+68 and 2+90 just downstream from this eroded section have not increased in height nor depth. However, in 2016 this scour pool shifted downstream by several feet. Furthermore, aggradation raised the channel bed by almost a foot between 2017 and 2018. Little change was observed in this area between 2018 and 2019. It is recommended that this area continue to be monitored, as further erosion could eventually lead to undermining of the concrete-lined channel just downstream.

An overlay of North Tributary longitudinal profiles shows little change occurring to this reach from 2007 through 2019 (Appendix B). Numerous man-made structures (i.e., culverts, concrete-lined channel) throughout this reach appear to be providing adequate grade control, preventing substantial channel degradation. In one portion of the reach between cross-sections 1 and 2 (profile stations 383 – 454), notable aggradation has occurred particularly between 2016 and 2019. This is the area just above the Winmeyer Avenue culvert.

4.0 SUMMARY AND CONCLUSIONS

4.1 BIOLOGICAL ASSESSMENT SUMMARY

Water quality measurements showed all parameters within COMAR standards. Conductivity levels at all of the sampling sites continue to be elevated, which is likely due to the high percent of impervious surfaces within the drainage area and the resulting stormwater runoff. In urban systems, high conductivity may be an indicator of road salt usage (Morgan et al. 2012, Southerland et al. 2007, Kaushal et al. 2005); however, chloride concentrations are often necessary to confirm whether road salts are a primary source. The large MARC train station Park & Ride lots in the watershed likely receive large quantities of de-icing salts, and two adjacent detention/shallow wetland ponds may accumulate the salts and slowly release them through the groundwater. It is plausible that road salt application is responsible, at least in part, for the observed elevated conductivity.

Physical habitat PHI ratings were “Partially Degraded” at all three Picture Spring Branch sites. Although the narrative rating remained the same at these three stations, the PHI scores at all three sites showed an increase from 2018 scores (Table 4-1). The slight increase in scores is primarily a result of improvements in the quality of epifaunal substrate and instream habitat. While the epifaunal substrate score remained the same and instream habitat score slightly decreased at PSB-01, the minor change in physical habitat score from 2018 could be attributed to a large increase in the amount of woody debris present for colonization. During the past five years of monitoring, PHI scores have fluctuated slightly from year to year (Figure 4-1). Fluctuations in annual physical habitat scores may be attributed to two primary factors: 1) changes in habitat suitable for colonization (i.e., changes in substrate/embeddedness and changes in the quantity of woody debris) affects direct scoring of this parameter, and also indirectly influences scoring for epifaunal substrate and instream habitat; and 2) variability in qualitative visual assessment scoring between field crews. In 2013, the updated MBSS PHI methods (Paul et al. 2003) were used to calculate PHI instead of the original MBSS methods (Hall et al. 2002) which had been used in the Picture Spring Branch watershed reports from prior years. Scores for 2006-2012 shown in Table 4-1 and Figure 4-1 were calculated using the original method, while the scores for 2013-2018 were calculated using the updated method.

Physical habitat RBP ratings were “Supporting” at PSB-01 and “Partially Supporting” at PSB-02 and PSB-03. Although the narrative rating remained the same at these three stations from 2018 to 2019, the RBP scores at all three sites showed minor fluctuations from 2018 scores (PSB-01 decreasing slightly, PSB-02 remaining the same, and PSB-03 increasing slightly; Table 4-1). This change in scores was primarily a result of minor differences in the quality of epifaunal substrate and bank stability. During the past five years of monitoring, RBP scores have fluctuated slightly from year to year, but for the most part have not been large enough to change the narrative ratings at each site (Figure 4-2); these fluctuations may be the result of variability in qualitative visual assessment scoring between field crews.

Table 4-1. PHI and RBP scores from 2006 to 2019

Site		PSB-01	PSB-02	PSB-03
2006	PHI Score	66.0	60.1	50.9
	Rating	Degraded	Degraded	Severely Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2007	PHI Score	79.6	69.5	69.5
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2008	PHI Score	84.5	73.0	73.3
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2009	PHI Score	76.4	65.9	58.6
	Rating	Partially Degraded	Degraded	Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2010	PHI Score	84.3	72.4	73.8
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2011	PHI Score	83.3	73.4	71.9
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2012	PHI Score	83.9	74.8	73.2
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
	RBP Score	No Data Collected	No Data Collected	No Data Collected
	Rating			
2013	PHI Score	77.2	62.6	57.2
	Rating	Partially Degraded	Degraded	Degraded
	RBP Score	82	71	70
	Rating	Supporting	Partially Supporting	Partially Supporting
2014	PHI Score	77.7	64.7	65.7
	Rating	Partially Degraded	Degraded	Degraded
	RBP Score	78	72	71
	Rating	Supporting	Partially Supporting	Partially Supporting
2015	PHI Score	72.1	64.4	60.5
	Rating	Partially Degraded	Degraded	Degraded
	RBP Score	79	63	62
	Rating	Supporting	Partially Supporting	Partially Supporting
2016	PHI Score	79.0	67.8	68.0
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
	RBP Score	80	69	72
	Rating	Supporting	Partially Supporting	Partially Supporting

Table 4-1. Continued				
Site		**PSB-01**	**PSB-02**	**PSB-03**
2017	PHI Score	81.1	71.5	71.2
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
	RBP Score	86	76	79
	Rating	Supporting	Supporting	Supporting
2018	PHI Score	76.7	69.6	68.2
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
	RBP Score	79	75	70
	Rating	Supporting	Partially Supporting	Partially Supporting
2019	PHI Score	79.9	77.8	73.9
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
	RBP Score	77	75	73
	Rating	Supporting	Partially Supporting	Partially Supporting

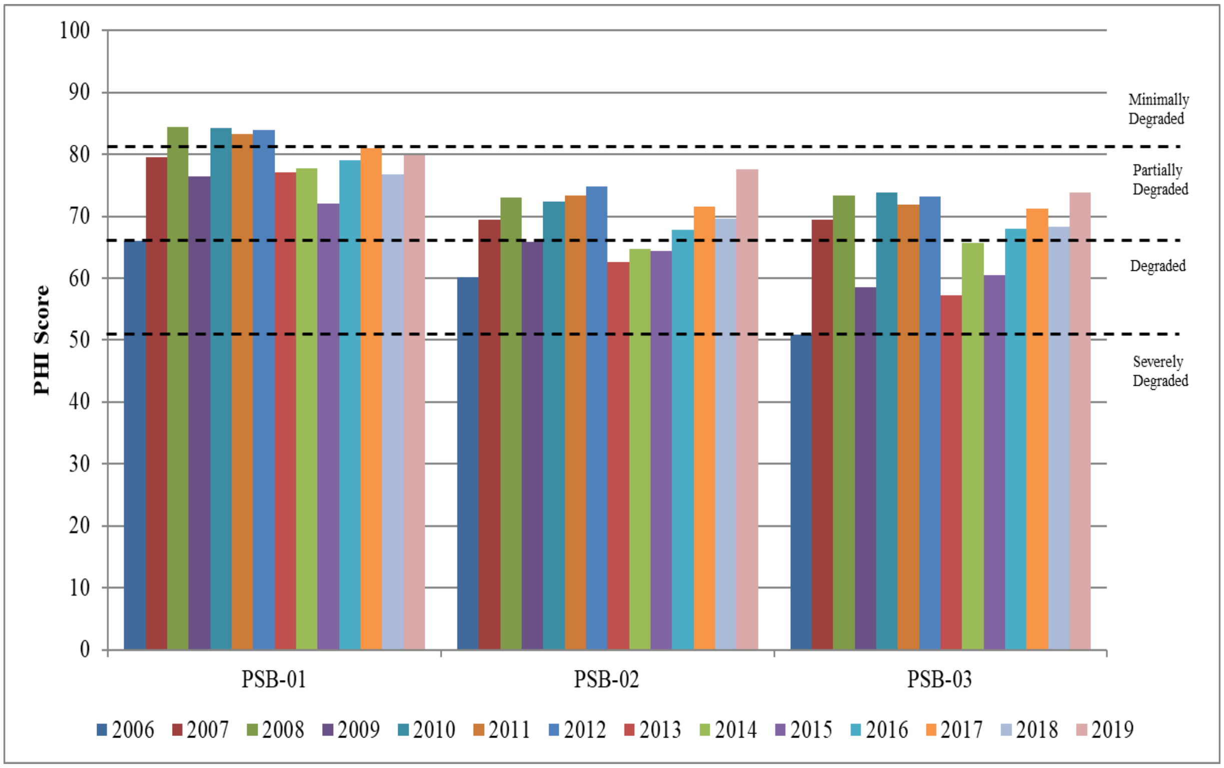

Figure 4-1. Comparison of PHI Habitat Scores from 2006 through 2019

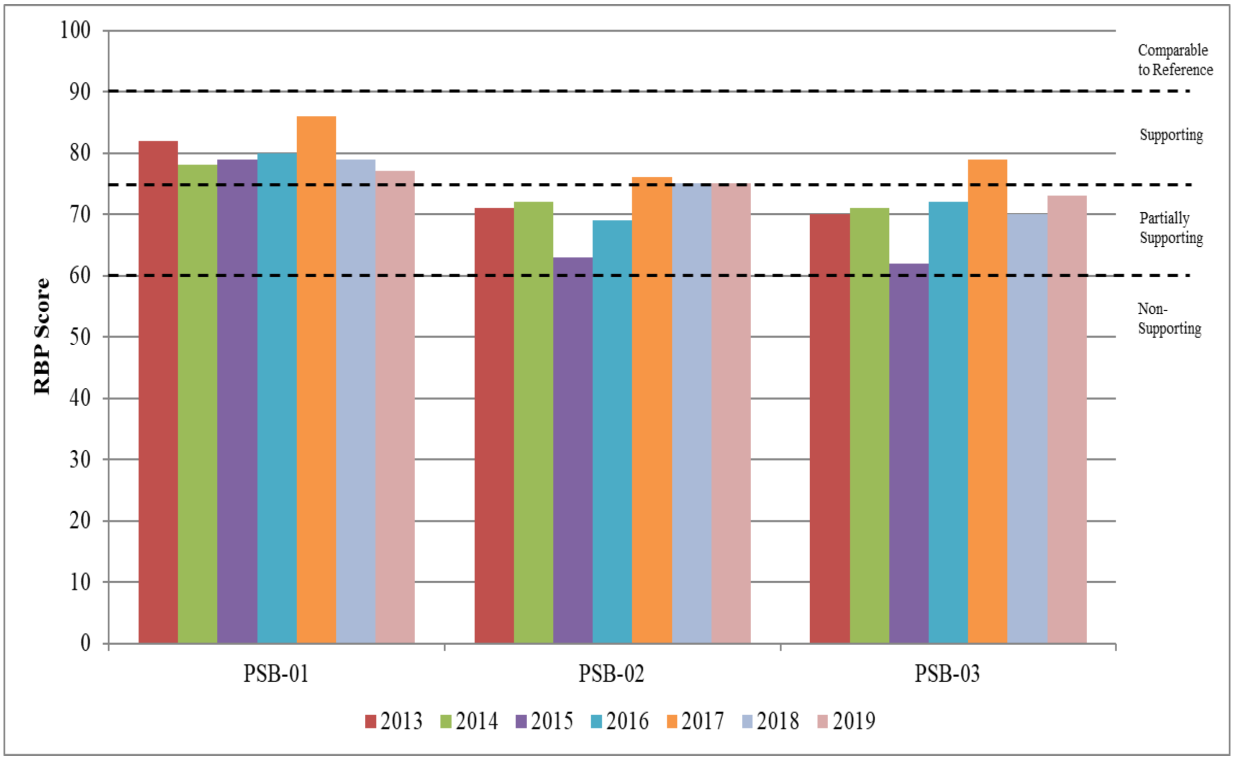

Figure 4-2. Comparison of RBP Habitat Scores from 2013 through 2019

In 2019, the benthic macroinvertebrate community at one site within the Picture Spring Branch study area was rated as "Poor", while the other two sites received a "Fair" rating. These ratings remained the same from 2018 but represent a slight decrease in BIBI scores since 2017, when all three sites received a "Fair" rating. Taxa diversity remained the same or slightly increased across all sites in 2019, and no Ephemeroptera taxa were found at any site during the 2019 sampling period.

BIBI scores decreased at PSB-01 and increased at PSB-02 but were unchanged at PSB-03 (Table 4-2). The score at PSB-01 decreased due to a decrease in percent of urban intolerant taxa, and the score at PSB-02 increased due to a larger percentage of taxa intolerant to urbanization. Figure 4-3 provides a visual comparison of BIBI scores over time and shows scores fluctuating from year to year.

Table 4-2. BIBI scores from 2006 to 2019

Site		PSB-01	PSB-02	PSB-03
2006	BIBI Score	3	2.71	2.43
	Rating	Fair	Poor	Poor
2007	BIBI Score	3.29	3	3.57
	Rating	Fair	Fair	Fair
2008	BIBI Score	3.86	3	2.71
	Rating	Fair	Fair	Poor
2009	BIBI Score	2.43	2.71	1.86
	Rating	Poor	Poor	Very Poor
2010	BIBI Score	2.71	3	2.43
	Rating	Poor	Fair	Poor
2011	BIBI Score	3.29	3.29	2.71
	Rating	Fair	Fair	Poor
2012	BIBI Score	3.29	3	3
	Rating	Fair	Fair	Poor
2013	BIBI Score	2.71	3.29	3
	Rating	Poor	Fair	Fair
2014	BIBI Score	2.43	2.71	2.43
	Rating	Poor	Poor	Poor
2015	BIBI Score	2.43	2.71	3
	Rating	Poor	Poor	Fair
2016	BIBI Score	3.29	3	3.29
	Rating	Fair	Fair	Fair
2017	BIBI Score	3.57	3.57	3
	Rating	Fair	Fair	Fair
2018	BIBI Score	3.57	3	2.71
	Rating	Fair	Fair	Poor
2019	BIBI Score	3.29	3.29	2.71
	Rating	Fair	Fair	Poor

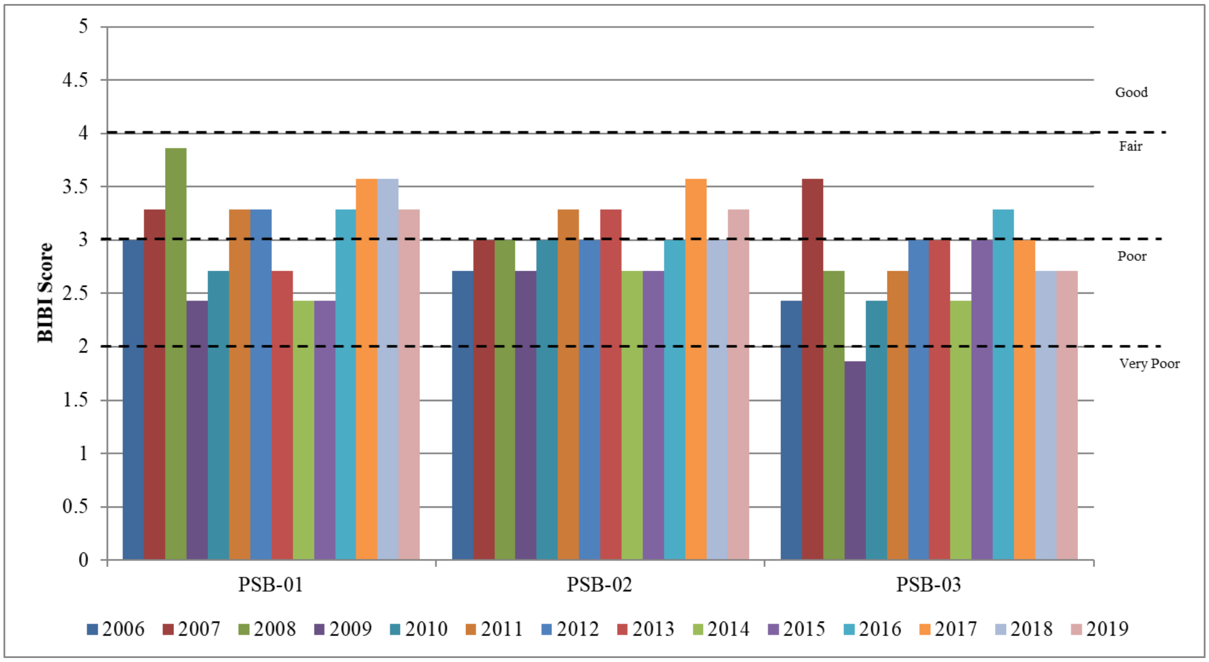

Figure 4-3. Comparison of BIBI Scores from 2006 through 2019

4.2 GEOMORPHIC ASSESSMENT SURVEY

The majority of the streams within the Picture Spring Branch study area have been altered by past channelization and the installation of concrete-lined channels, resulting from modifications made to accommodate runoff from Maryland State Highways 170 and 175, running both perpendicular and parallel to the stream channel, respectively. Consequently, stream reaches in the vicinity of cross-sections 2, 3, and 5, on the North Tributary and mainstem were over-widened. Channelization and over-widening at cross-sections 2 and 3 resulted in F channels at these locations. A notable amount of sediment has deposited in these concrete channels in the past and it appears as though these channels have become naturalized. This is particularly evident downstream of Route 170 where a more natural stream pattern is emerging, resulting in cross-section 5 changing from an F channel in 2014 to a C channel in 2015. Cross-sections 2 and 3 appeared quite stable during recent years, having shown very little change from previous surveys. Cross-section 5 experienced notable aggradation across its total width between 2011 and 2012. Between 2012 and 2019 the right-side stream bed at cross-section 5 continued to erode while the left side had nominal change from 2014 to 2019.

Past channelization also appears to have occurred on the South Tributary in the vicinity of cross-section 4. The slope of the South Tributary is much greater than that of the North Tributary, and the channel showed signs of active downcutting between 2003 and 2013. Between 2018 and 2019, the channel bed has downcut approximately 0.3 ft further and the right bank has experienced up to one foot of erosion, resulting in increased channel dimensions between 2018 and 2019.

Historically, the stream reach in the Picture Spring Branch study area that appeared least disturbed was in the vicinity of cross-section 1. This section of stream is in a forested upper portion of the North Tributary and had historically been classified as a C stream type during the early years of this study. Due to recent downcutting and widening, this reach was re-classified as an E5 channel in 2017 and has remained an E5 through 2018 and 2019, as downcutting and widening have continued.

To compare changes over time, the cross-sectional area from 2011 through 2019 was calculated using the top of bank elevation from the baseline survey to standardize comparisons and reduce variability among more subjective bankfull elevation reference points, or even changes that can occur to top of bank elevations from year to year. It is important to note that calculations prior to 2011 did not use this baseline reference elevation; instead, the corresponding year's top of bank elevation was used to calculate cross-sectional area. Consequently, these values are not directly comparable to the cross-sectional areas reported in 2011 through 2019. Comparison of baseline cross-sectional area is, however, comparable from 2011 through 2019 as all calculations are made using the same top of bank elevation.

Channel dimensions appear moderately constant for three of the five cross-sections compared to baseline conditions (Table 4-3). The stream channel at cross-sections 2, 3, and 5 has remained relatively stable, with cross-sectional area decreasing only 4.7%, 7.5%, and 3.9%, respectively, since the beginning of the study in 2003. In contrast, larger increases in cross-sectional areas have occurred at the smaller cross-sections 1 and 4. Partially due to recent channel deepening and also influenced by discrepancies in calculations, cross-sectional area at cross-section 1 increased 75% from baseline conditions in 2005. Cross-section 4, which had remained relatively stable during 2016-2018, eroded and downcut between 2018 and 2019, resulting in a cross-sectional area increase almost 40% from baseline conditions. Unsurprisingly, cross-sections 1 and 4 are located in portions of stream where there has been no engineering or armoring of the stream channel, while the other three cross-sections have been channelized. Cross-section 1 is also located upstream of the stormwater BMPs implemented in the watershed as part of the West County Library project, so is therefore unaffected by their presence. These cross-sections are also the smallest of the five, so any changes in cross-sectional area will seem magnified. When examining changes in cross-sectional area since 2011, when calculations were standardized as discussed above, the changes in cross-sectional area decrease at each cross-section to much lower percentages. Cross-sections 1 and 4 still exhibit the greatest overall percent change using these standardized calculations due to erosion and deepening at these stations (Table 4-3).

Table 4-3. Summary of cross-sectional area (square feet) at the five cross-sections and changes over time

Cross-section[(a)]	XS-1	XS-2	XS-3	XS-4	XS-5
July 2003	ND	146.0	84.5	7.6	35.5
Jan 2005	6.4	164.4	83.2	5.5	35.2
March 2006	7.6	143.9	81.0	7.6	34.0
March 2007	6.8	142.6	81.1	7.6	32.9
May 2008	6.3	141.5	81.5	7.4	34.9
July 2009	6.8	142.8	80.8	8.4	33.4
May 2010	6.0	145.2	80.5	9.7	34.5
July 2011[(b)]	9.7	143.0	81.9	9.3	34.8
April 2012[(b)]	8.0	143.1	81.8	9.2	28.4
July 2013[(b)]	8.6	142.8	80.4	10.5	30.9
June 2014 [(b)]	8.8	141.9	77.4	10.0	32.6
June 2015 [(b)]	10.2	143.0	80.9	10.3	31.6
March 2016 [(b)]	9.8	144.7	75.4	9.6	33.2
February 2017[(b)]	10.2	143.3	78.6	9.3	32.7
March 2018[(b)]	10.0	141.3	78.8	9.2	34.2
March 2019[(b)]	11.2	139.2	78.2	10.6	34.1
% Change 2003-2019	75.0[(c)]	-4.7	-7.5	39.5	-3.9
% Change 2011-2019	15.4	-2.6	-4.5	14.0	-2.0

(a) All values listed here are for top of bank area
(b) Values obtained using reference elevations (top of bank) from baseline measurements
(c) % change from 2005
ND = No Data

4.3 GENERAL CONCLUSIONS

Based upon the data collected over the course of this study, it appears that the development of the West County Library site has not accelerated the degradation of this system. While physical habitat and biological conditions have fluctuated slightly from year to year, the overall conditions have changed minimally when compared to baseline data. It is likely that the best management practices installed within the watershed have reduced the impact of some stressors affecting the stream (i.e., hydrologic alteration) such that the system has begun to stabilize from past alteration and land use modifications (i.e., extensive channelization).

5.0 REFERENCES

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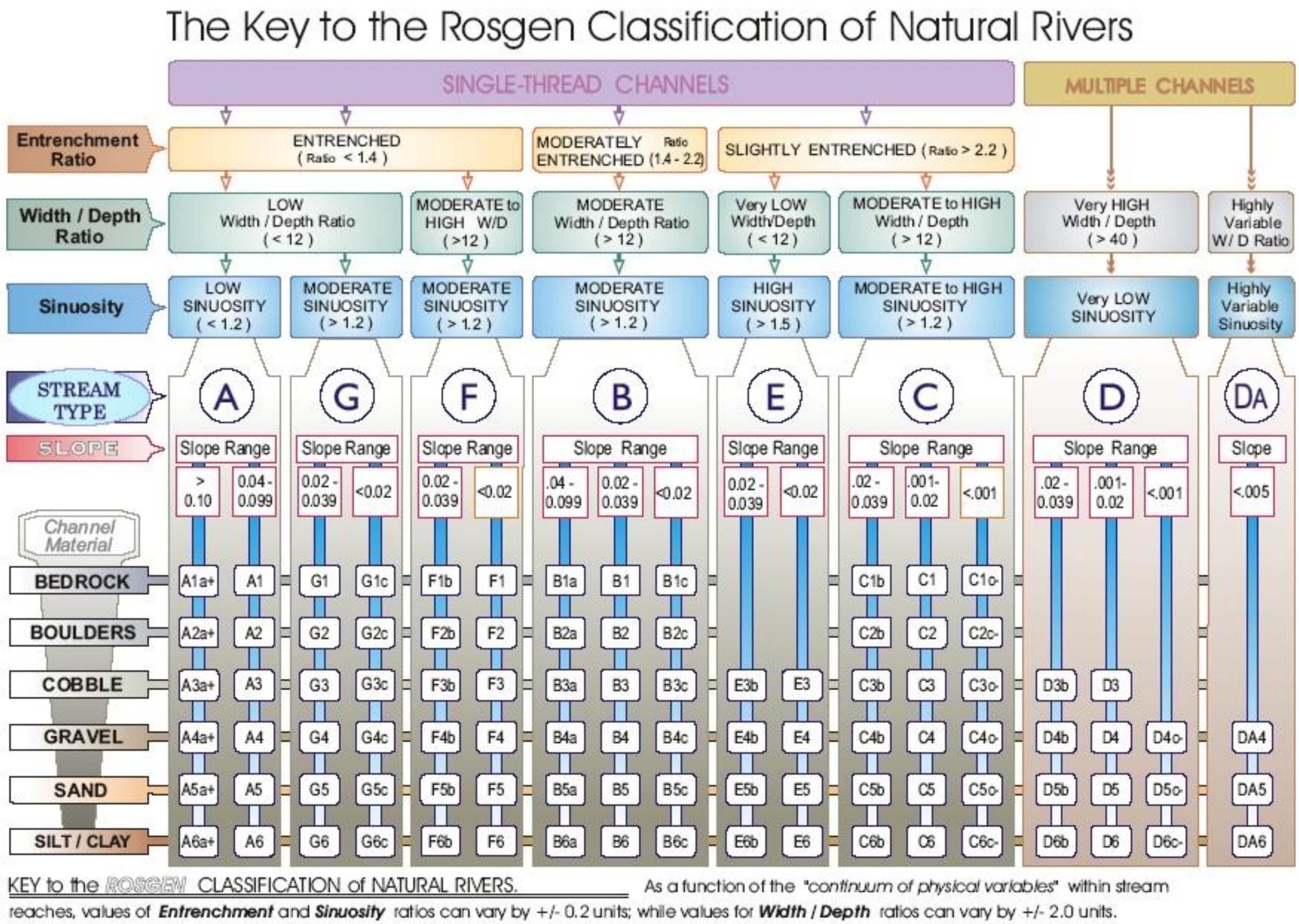
APPENDIX A

ROSGEN STREAM CLASSIFICATION



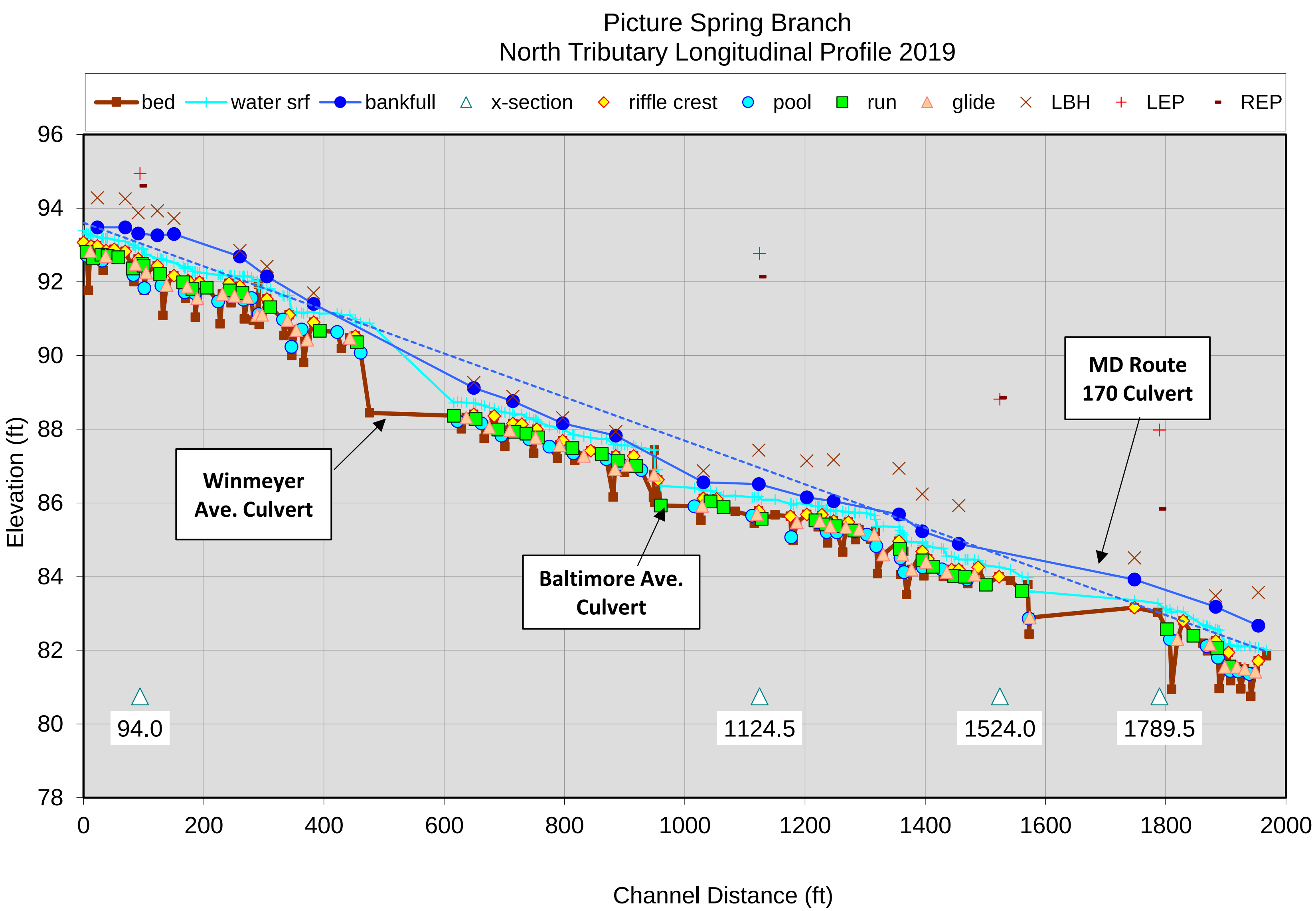
Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

APPENDIX B

GEOMORPHIC ASSESSMENT RESULTS

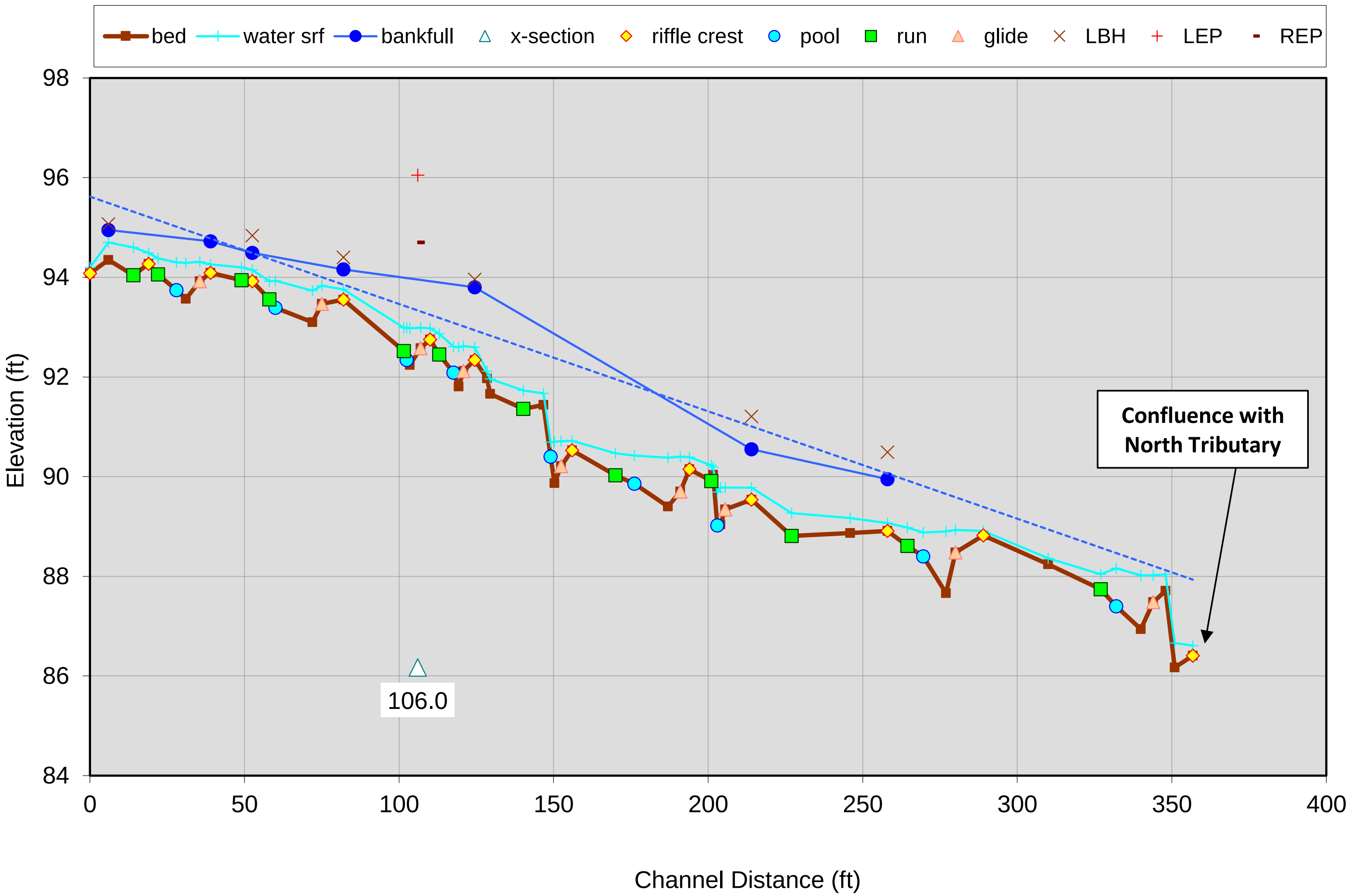
Picture Spring Branch
2019 Geomorphic Assessment Results Summary

Assessment Parameter	Cross-section				
	XS-1 Pool @ Sta. 0+94	XS-2 Run @ Sta. 11+25	XS-3 Pool @ Sta. 15+24	XS-4 Run @ Sta. 1+06 on South Tributary	XS-5 Riffle @ Sta. 17+89
Classification	E5	F5	F5	E5b	C5
Bankfull Width (ft)	5.5	11.4	10.1	3.9	8.2
Mean Depth (ft)	0.6	0.8	0.4	0.9	0.7
Bankfull X-Sec Area (sq ft)	3.4	9.0	4.2	3.6	5.7
Width:Depth Ratio	9.0	14.5	24.6	4.2	11.9
Flood-Prone Width (ft)	19.4	14.7	13.1	9.4	22.0
Entrenchment Ratio	3.5	1.3	1.3	2.4	2.7
D50(mm)	0.09	0.10	0.09	0.22	0.10
Water Surface Slope (ft/ft)	0.0062	0.0021	0.0049	0.027	0.004
Sinuosity	<1.2	<1.2	<1.2	<1.2	<1.2
Drainage Area (mi^2)	0.12	0.15	0.15	0.07	0.23
Adjustments?	Sin ↑	Sin ↑	Sin ↑	Sin ↑	Sin ↑, W/D↑

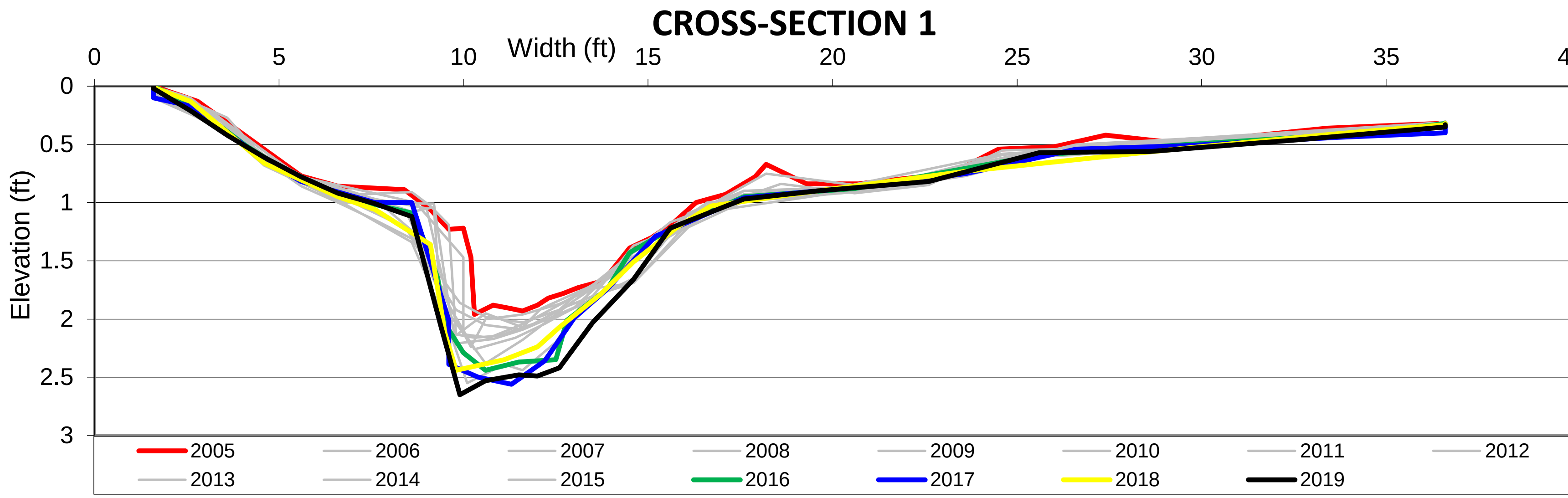


Picture Spring Branch
North Tributary Longitudinal Profile 2019
bed
water srf
bankfull
x-section
riffle crest
pool
run
glide
LBH
LEP
REP
Elevation (ft)
Channel Distance (ft)
Winmeyer Ave. Culvert
Baltimore Ave. Culvert
MD Route 170 Culvert
94.0
1124.5
1524.0
1789.5

Picture Spring Branch
South Tributary Longitudinal Profile 2019



B-5



Upstream View

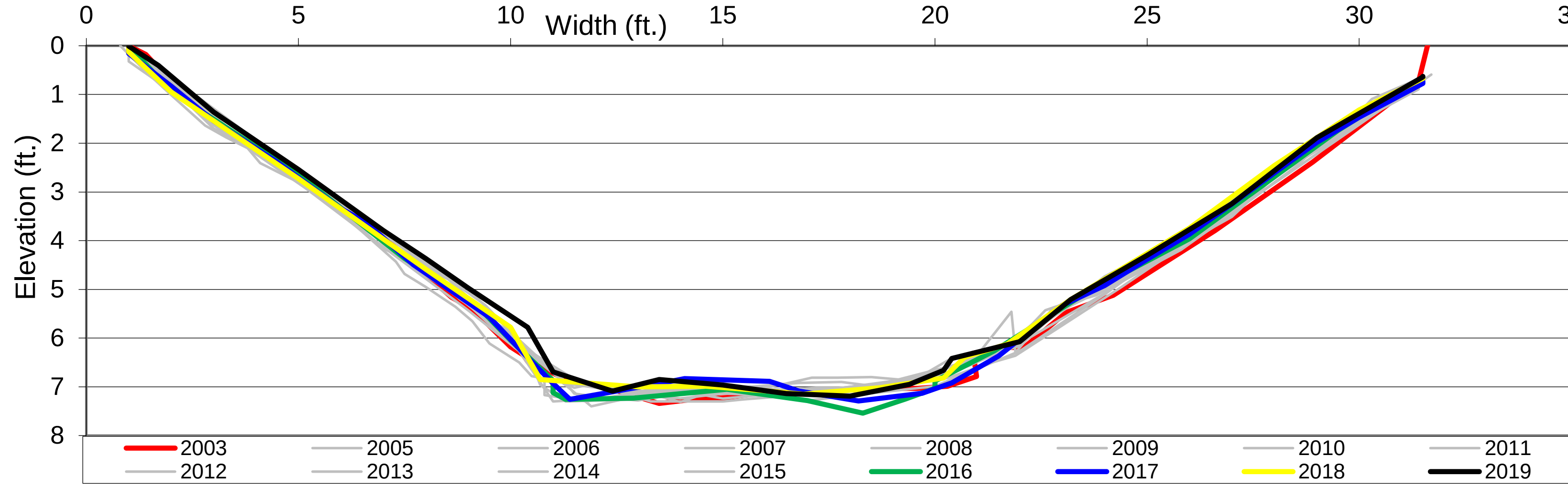
Downstream View

Left Bank View

Right Bank View

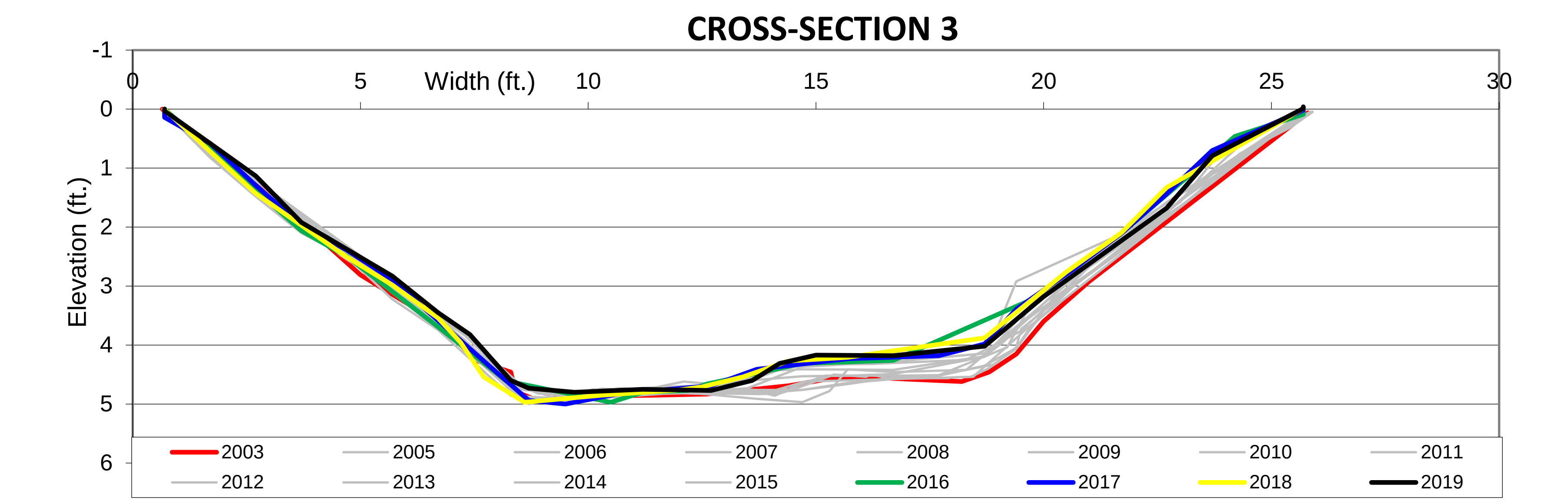
2019 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	5.5
Mean Depth (d_{bkf}) (feet)	0.6
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	3.4
Width/Depth Ratio (W_{bkf}/d_{bkf})	9.0
Width of Flood-prone Area (W_{fpa}) (feet)(feet)	19.4
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	3.5
Channel Materials D_{50} (millimeters)	0.09
Water Surface Slope (S)	0.0062
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**E5**

CROSS-SECTION 2



	
Upstream View	Downstream View
	
Left Bank View	Right Bank View

2019 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	11.4
Mean Depth (d_{bkf}) (feet)	0.8
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	9.0
Width/Depth Ratio (W_{bkf}/d_{bkf})	14.5
Width of Flood-prone Area (W_{fpa}) (feet)	14.7
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.3
Channel Materials D_{50} (millimeters)	0.10
Water Surface Slope (S)	0.0021
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**F5**



Upstream View

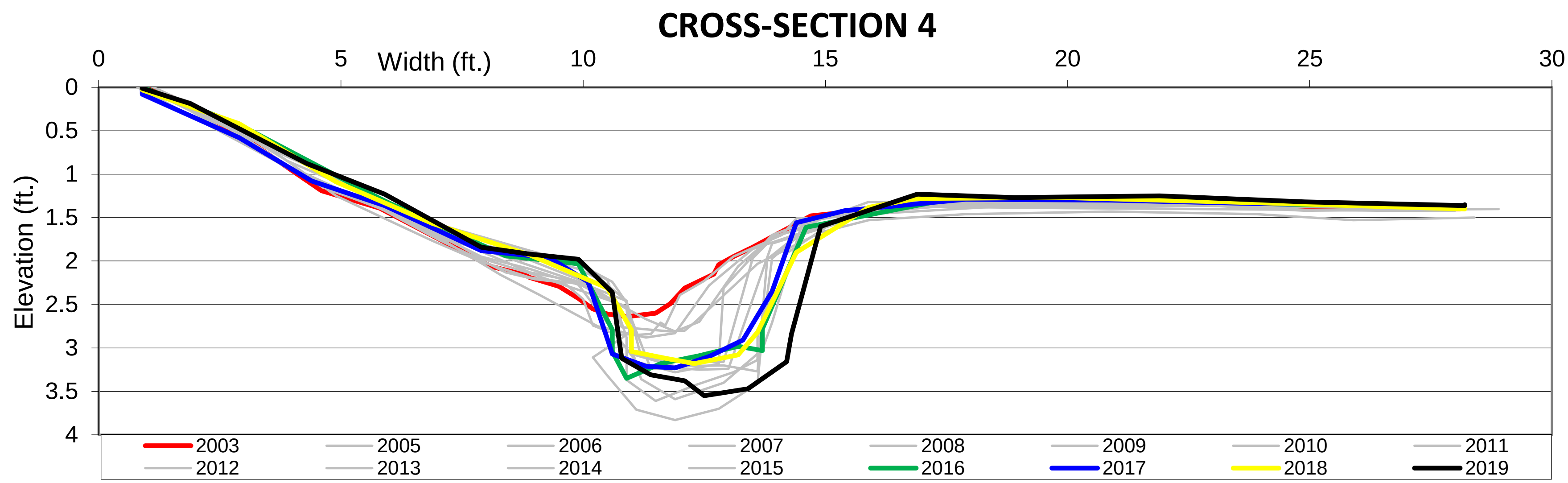
Downstream View

Left Bank View

Right Bank View

2019 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	10.1
Mean Depth (d_{bkf}) (feet)	0.4
Bankfull Cross-sectional Area (A_{bkf}) ($feet^2$)	4.2
Width/Depth Ratio (W_{bkf}/d_{bkf})	24.6
Width of Flood-prone Area (W_{fpa}) (feet)	13.1
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.3
Channel Materials D_{50} (millimeters)	0.09
Water Surface Slope (S)	0.0049
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**F5**



Upstream View

Downstream View

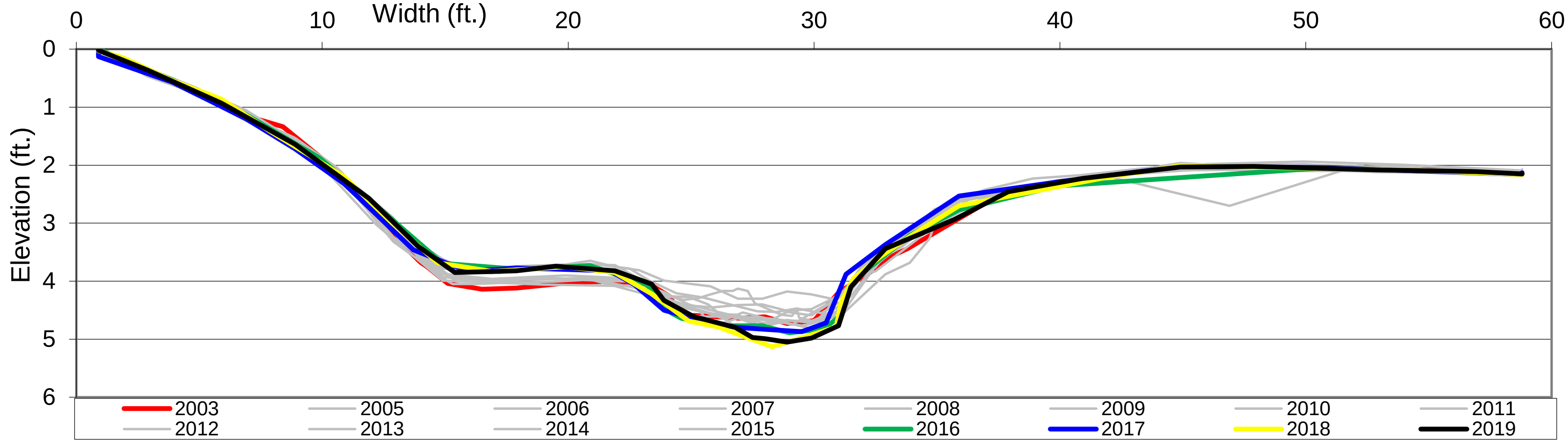
Left Bank View

Right Bank View

2019 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	3.9
Mean Depth (d_{bkf}) (feet)	0.9
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	3.6
Width/Depth Ratio (W_{bkf}/d_{bkf})	4.2
Width of Flood-prone Area (W_{fpa}) (feet)	9.4
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.4
Channel Materials D_{50} (millimeters)	0.22
Water Surface Slope (S)	0.027
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**E5**

CROSS-SECTION 5



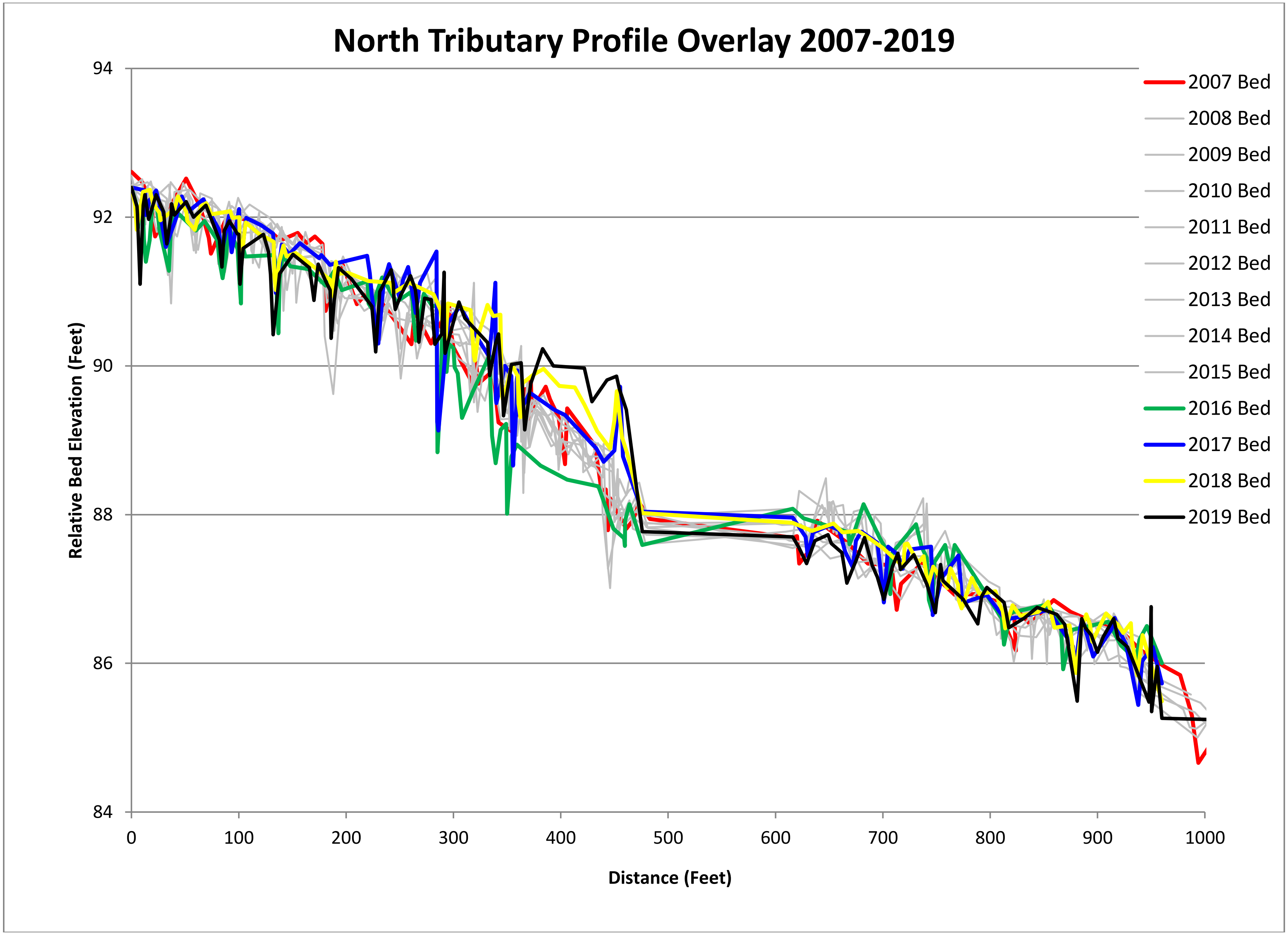
Upstream View

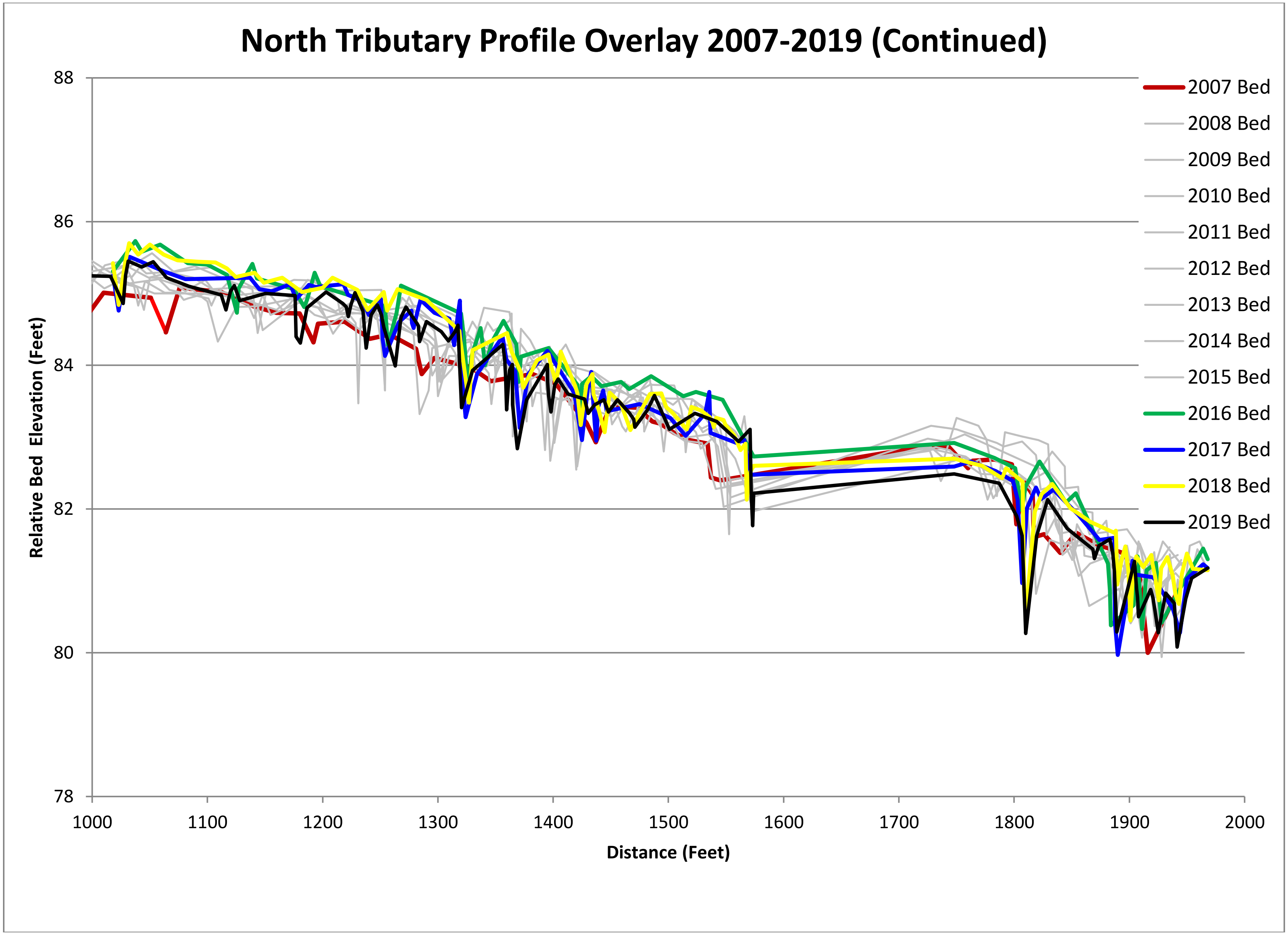
Downstream View

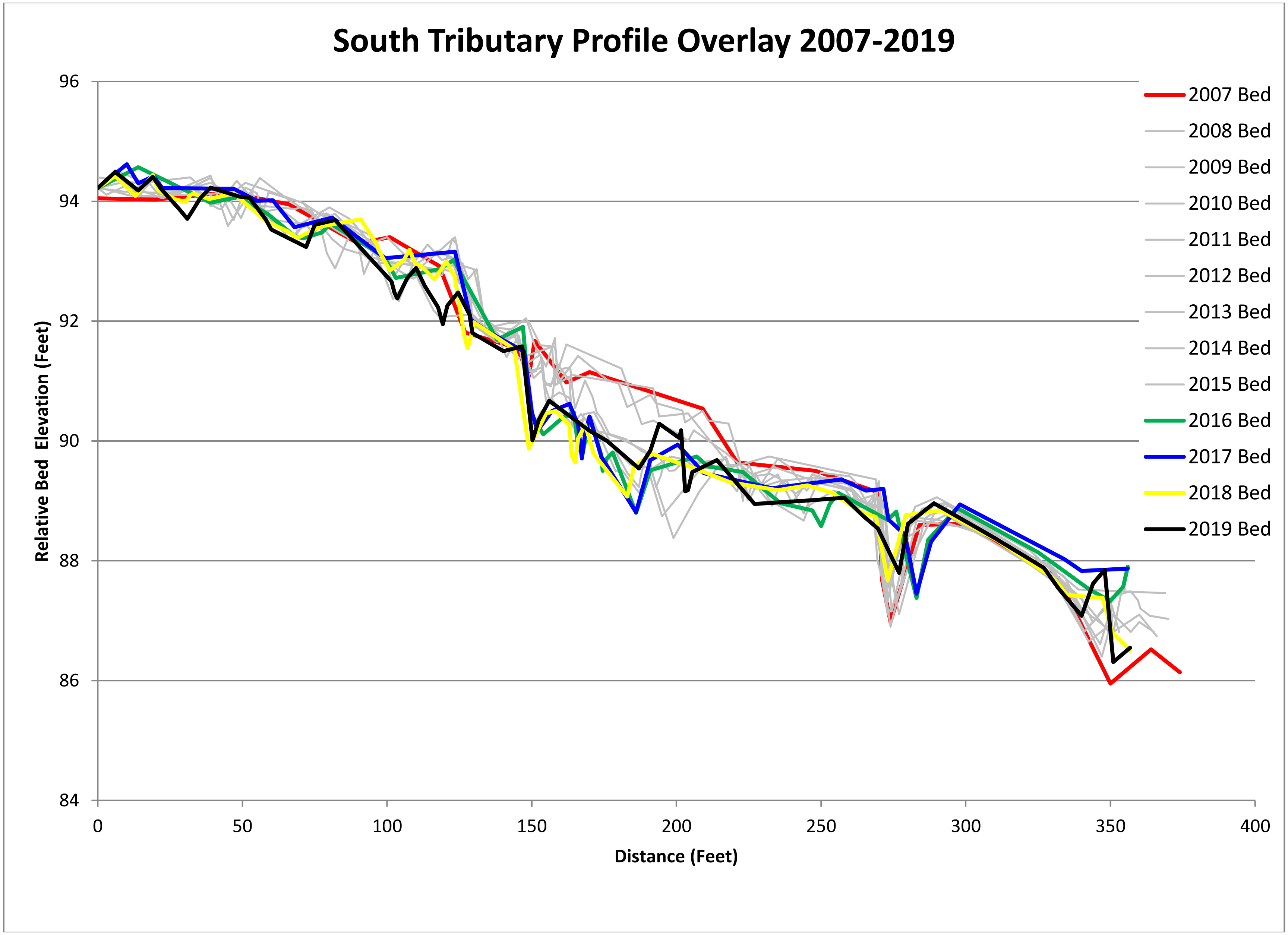
Left Bank View

Right Bank View

2019 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	8.2
Mean Depth (d_{bkf}) (feet)	0.7
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	5.7
Width/Depth Ratio (W_{bkf}/d_{bkf})	11.9
Width of Flood-prone Area (W_{fpa}) (feet)	22.0
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.7
Channel Materials D_{50} (millimeters)	0.10
Water Surface Slope (S)	0.004
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, W/D↑
STREAM TYPE	**C5**


North Tributary Profile Overlay 2007-2019
94
92
90
88
86
84
0
100
200
300
400
500
600
700
800
900
1000
Relative Bed Elevation (Feet)
Distance (Feet)
2007 Bed
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed
2016 Bed
2017 Bed
2018 Bed
2019 Bed


North Tributary Profile Overlay 2007-2019 (Continued)
Relative Bed Elevation (Feet)
Distance (Feet)
88
86
84
82
80
78
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2007 Bed
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed
2016 Bed
2017 Bed
2018 Bed
2019 Bed


South Tributary Profile Overlay 2007-2019
Relative Bed Elevation (Feet)
Distance (Feet)
96
94
92
90
88
86
84
0
50
100
150
200
250
300
350
400
2007 Bed
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed
2016 Bed
2017 Bed
2018 Bed
2019 Bed

APPENDIX C

MASTER BENTHIC MACROINVERTEBRATE TAXA LIST

Order	Family	Genus	Taxon	FFG(a)	Habit(b)	Tolerance Value(c)
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7
Basommatophora	Lymnaeidae		Lymnaeidae	Scraper	cb	6.9
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6
Coleoptera	Dytiscidae		Dytiscidae	Predator	sw, dv	5.4
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1
Coleoptera	Hydrophilidae		Hydrophilidae			4.1
Diptera			Diptera			6
Diptera	Ceratopogonidae		Ceratopogonidae	Predator	sp, bu	3.6
Diptera	Ceratopogonidae	Bezzia	Bezzia	Predator	bu	3.3
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6
Diptera	Chironomidae	Orthocladiinae	Orthocladiinae	Collector		7.6
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Ephydridae		Ephydridae	Collector	bu, sp	
Diptera	Sciomyzidae		Sciomyzidae	Predator	bu	6
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7

Order	Family	Genus	Taxon	FFG[a]	Habit[b]	Tolerance Value[c]
Haplotaxida	Naididae		Naididae	Collector	bu	8.5
Lumbricida	Lumbricidae		Lumbricidae	Collector		10
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3
Odonata	Coenagrionidae	Ischnura	Ischnura	Predator	cb	9
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4
Trichoptera			Trichoptera			4.6
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1
Tubificida	Tubificidae		Tubificidae	Collector	cn	8.4
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7

(a) Functional Feeding Group
(b) Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer Some information for the particular taxa was not available.

(c) Tolerance Values, based on Hilsenhoff, modified for Maryland

APPENDIX D

QUALITY ASSURANCE/QUALITY CONTROL

This section describes all Quality Assurance/Quality Control (QA/QC) procedures implemented for this project including field sampling, laboratory sorting and subsampling, data entry, metric calculation, final IBI calculation, geomorphic field sampling, and classification of stream types.

Field Sampling
Initial QA/QC procedures for benthic macroinvertebrate field sampling included formal training for field crew leaders in MBSS Sampling Protocols. All field crew members have attended at least one MBSS Spring Index Period Training. At least one crew member extensively trained and certified in MBSS sampling protocols was present for each field sampling day. Also during field sampling, each data sheet was double checked for completeness and sample bottle labels were double checked for accuracy. Geomorphic assessment field crews have more than one year of experience conducting similar assessment using the Rosgen Stream Classification Methodology and final data QA/QC is performed by staff with two or more levels of Rosgen training.

Geomorphic assessment survey equipment is calibrated annually and regularly inspected to ensure proper functioning. Cross-section and profile data were digitally plotted and analyzed in Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L for accuracy.

Water quality QA/QC procedures included calibration of the YSI multiprobe meter daily during the sampling season. Dissolved oxygen probe membranes were inspected regularly and replaced when dirty or damaged.

Laboratory Sorting and Subsampling
Sorting QA/QC was conducted on one sample since only seven samples were collected for this survey (the three samples from Picture Spring Branch are analyzed concurrently with three samples taken in Church Creek). This check consisted of entirely resorting the sorted grid cells of one randomly selected sample. This QC met the sorting efficiency criterion of at least 90%, so no further action was required. As a taxonomic QC, one sample was re-identified completely by another Versar SFS-certified taxonomist following the same identification methods stated above. The Percent Difference in Enumeration (PDE) and the Percent Taxonomic Disagreement (PTD) were calculated, and no further action was required since both the PDE and PTD met MBSS and County MQO requirements.

Data Entry
All data entered were double checked by someone other than the person who performed the initial data entry. Any errors found during QA/QC were corrected to ensure 100% accuracy of the data.

Metric and IBI Calculations
Ten percent of metric and IBI calculations were checked by hand using a calculator to ensure correct calculation by the Access database. Any discrepancies were addressed at that time.

Identification of Stream Types
All stream types were determined by hand based on the methods of the Rosgen Stream Classification (Rosgen 1996). Due to the natural variability, or continuum, of streams, adjustments in the values of Width Depth Ratio (+/- 2.0) and Entrenchment Ratio (+/- 0.2) are allowed, which

may result in assigning a different stream type. Therefore, all stream types assigned were checked by a second person and any necessary adjustments were made.

APPENDIX E

BIOLOGICAL ASSESSMENT RESULTS

Picture Spring Branch Site PSB-01

Sampled: 4/29/2019

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Fair
BIBI Score	3.29

Metric	Value	Score
Total Taxa	30	5
EPT Taxa	3	3
Number Ephemeroptera	0	1
% Intolerant to Urban	10.48	3
% Ephemeroptera	0	1
Scraper Taxa	2	5
% Climbers	16.13	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Naididae	15
Tubificidae	3
Dytiscidae	1
Stenelmis	1
Hydrophilidae	1
Diptera	1
Ceratopogonidae	1
Bezzia	1
Ablabesmyia	1
Chaetocladius	1
Chironomus	18
Eukiefferiella	2
Limnophyes	7
Micropsectra	7
Nanocladius	1
Orthocladius	5
Parametriocnemus	22
Phaenopsectra	1
Polypedilum	10
Prodiamesa	1
Rheocricotopus	1
Thienemannimyia group	2
Zavrelimyia	9
Calopteryx	1
Ischnura	1
Leuctra	2
Trichoptera	1
Polycentropus	4
Pisidium	2
Physa	1

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	79.86

Metric	Score
Drainage area (acres)	77.34
Remoteness	42.78
Percent Shading	91.34
Epifaunal Substrate	85.98
Instream Habitat	91.67
Instream Wood Debris	100.00
Bank Stability	67.36

Rapid Bioassessment Protocal

Narrative Rating	Supporting
RBP Score	77

Metric	Score
Epifaunal Substrate / Cover	12
Embeddedness	9
Velocity / Depth Regime	6
Sediment Deposition	9
Channel Flow Status	17
Channel Alteration	19
Frequency of Riffles	14
Bank Stability	6(Left)/6(Right)
Vegetative Protection	6(Left)/6(Right)
Riparian Veg Zone Width	10(Left)/9(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	7.56
pH	7.13
Specific Conductance (µS/cm)	1832
Temperature (°C)	14.23
Turbidity (NTUs)	NS

Picture Spring Branch Site PSB-02

Sampled: 4/29/2019

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Fair
BIBI Score	3.29

Metric	Value	Score
Total Taxa	25	5
EPT Taxa	2	3
Number Ephemeroptera	0	1
% Intolerant to Urban	17.56	3
% Ephemeroptera	0	1
Scraper Taxa	3	5
% Climbers	23.66	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Naididae	4
Lumbricidae	1
Tubificidae	3
Stenelmis	3
Bezzia	1
Chironomus	16
Cricotopus	3
Limnophyes	10
Micropsectra	18
Orthocladius	13
Parametriocnemus	11
Paratanytarsus	2
Paratendipes	1
Polypedilum	1
Rheocricotopus	2
Thienemanniella	2
Thienemannimyia group	5
Zavrelimyia	4
Hemerodromia	1
Sciomyzidae	1
Leuctra	4
Polycentropus	1
Pisidium	12
Lymnaeidae	1
Physa	11

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	77.80

Metric	Score
Drainage area (acres)	82.62
Remoteness	15.79
Percent Shading	84.56
Epifaunal Substrate	91.36
Instream Habitat	100.00
Instream Wood Debris	100.00
Bank Stability	75.11

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	75

Metric	Score
Epifaunal Substrate / Cover	10
Embeddedness	10
Velocity / Depth Regime	6
Sediment Deposition	11
Channel Flow Status	14
Channel Alteration	20
Frequency of Riffles	14
Bank Stability	9(Left)/9(Right)
Vegetative Protection	5(Left)/5(Right)
Riparian Veg Zone Width	5(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	7.94
pH	7.39
Specific Conductance (µS/cm)	1706
Temperature (°C)	13.37
Turbidity (NTUs)	NS

Picture Spring Branch Site PSB-03

Sampled: 4/29/2019

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.71

Metric	Value	Score
Total Taxa	33	5
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	8.57	1
% Ephemeroptera	0	1
Scraper Taxa	5	5
% Climbers	18.44	5

Benthic Macroinvertebrate Taxa List

Taxon	Count
Naididae	16
Lumbricidae	2
Tubificidae	5
Dubiraphia	1
Macronychus	2
Stenelmis	1
Ceratopogonidae	2
Brillia	1
Chaetocladius	1
Chironomus	1
Cricotopus	12
Eukiefferiella	2
Limnophyes	8
Micropsectra	11
Nanocladius	4
Orthocladiinae	1
Orthocladius	5
Parametriocnemus	1
Paratanytarsus	1
Paratendipes	1
Rheotanytarsus	1
Thienemanniella	3
Thienemannimyia group	18
Tvetenia	4
Zavrelimyia	3
Ephydridae	1
Simulium	7
Boyeria	2
Leuctra	1
Crangonyx	10
Pisidium	1
Physa	11
Menetus	1

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	73.85

Metric	Score
Drainage area (acres)	156.43
Remoteness	15.79
Percent Shading	68.32
Epifaunal Substrate	87.20
Instream Habitat	100.00
Instream Wood Debris	100.00
Bank Stability	71.80

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	73

Metric	Score
Epifaunal Substrate / Cover	13
Embeddedness	12
Velocity / Depth Regime	10
Sediment Deposition	10
Channel Flow Status	12
Channel Alteration	15
Frequency of Riffles	10
Bank Stability	6(Left)/7(Right)
Vegetative Protection	6(Left)/6(Right)
Riparian Veg Zone Width	6(Left)/9(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	9.55
pH	7.9
Specific Conductance (µS/cm)	1448
Temperature (°C)	12.23
Turbidity (NTUs)	NS

Select physical habitat parameters (raw scores) 2019			
Site	Epifaunal Substrate (0 – 20)	Instream Habitat (0-20)	Embeddedness (0 – 100%)
PSB-01	10	10	95
PSB-02	12	11	90
PSB-03	13	11	90