# BIOLOGICAL AND GEOMORPHOLOGICAL CONDITION IN THE PICTURE SPRING BRANCH SUBWATERSHED, SEVERN RIVER WATERSHED, ANNE ARUNDEL COUNTY, MARYLAND: 2013 - 2014

Prepared for

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**APPENDICES**



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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 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 and 175. 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.

In addition, there are four other BMPs within the watershed that are providing detention for stormwater that are impacting 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. Stormwater facilities were not required to be mapped or inspected in 2014.

To monitor the effectiveness of these BMPs on stream channel protection, the County has implemented a NPDES 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 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 2014 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 155 acres of drainage. The land use within the Picture Spring Branch study area is dominated by developed land, with over 56% residential, commercial, and industrial uses (Table 2-1). Less than one-third of the subwatershed (31.6%) is open space or wooded land cover, most of which surrounds the stream valley.

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 | 15.6 | 10.0% |
| Industrial | 16.3 | 10.5% |
| Open Space | 6.0 | 3.9% |
| Residential | 56.0 | 36.1% |
| Transportation | 16.8 | 10.8% |
| Utility | 1.6 | 1.1% |
| Forest | 43.0 | 27.7% |
| **Total** | **155.3** | |

Source: Anne Arundel County Department of Public Works

Five permanent cross sections were previously established for the County's NPDES Program and were measured again in 2014 as part of the 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 were placed on each bank and consist of iron bolts set in concrete flush to the ground surface.

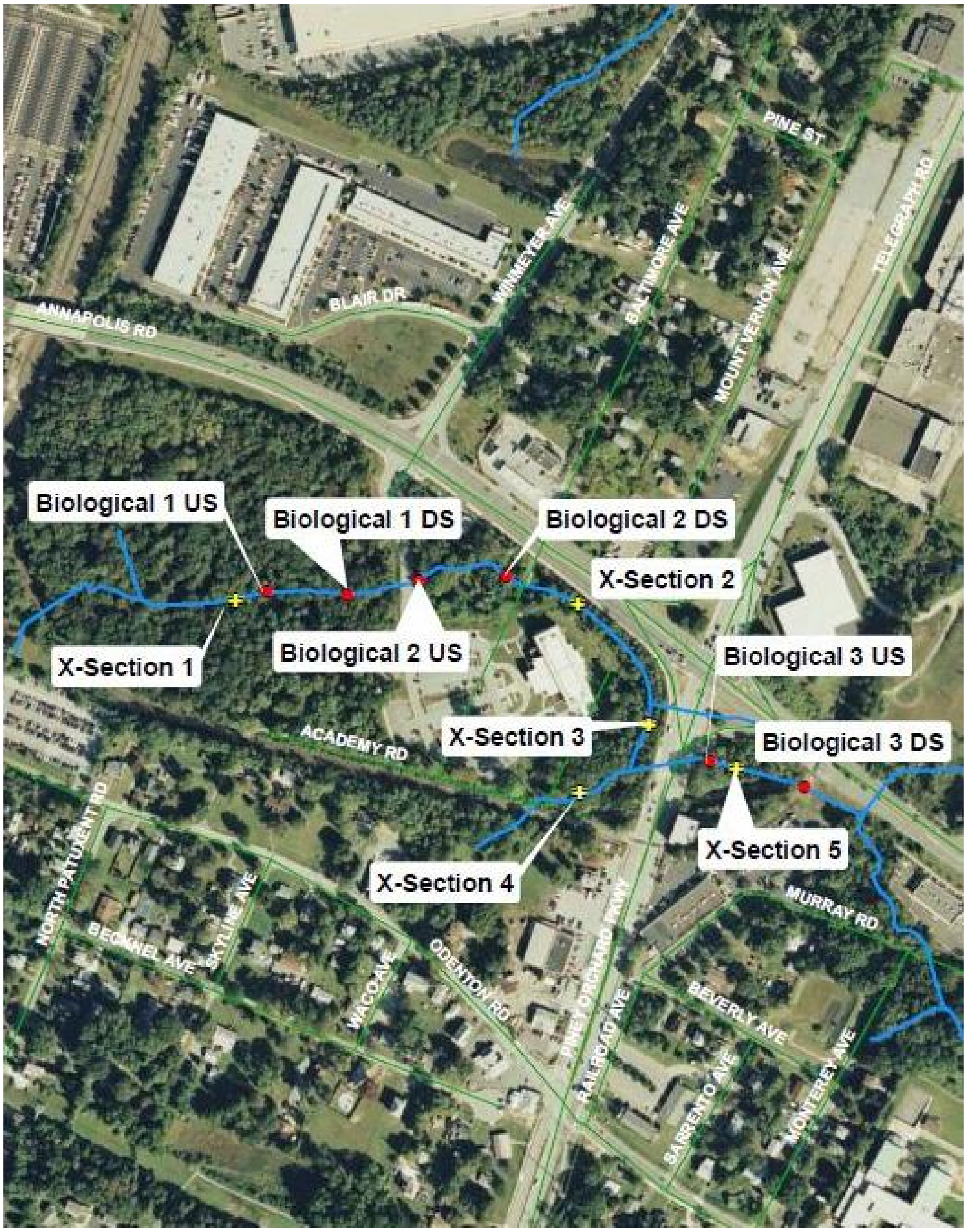


Figure 2-1. Picture Spring Branch study area stream monitoring locations

## 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 2010), 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 2014 by Versar, Inc., a consultant to Anne Arundel County.

### 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's Physical Habitat Index (PHI; Paul et al. 2003) and the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for high 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 March 2014 following the MBSS Spring index period protocols (MD DNR 2010) and consistent with the methods specified in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (QAPP; Anne Arundel County 2010). 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, temperature, and turbidity. With the exception of turbidity, which was measured once at the upstream end of the site, 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 6820 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 D.

The longitudinal profile was performed throughout the entire study area, totaling 1967 linear feet along the North Tributary and continuing below Telegraph Road, and 353 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 the bankfull indicators were identified, elevation data on the channel thalweg, water surface, and bankfull indicators were also collected.

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 E. 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 Environmental Protection Agency'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 Rapid Bioassessment Protocol (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 2010). 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 gird was picked entirely of macroinvertebrates under a bright light source. This process was repeated until a count of 120 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 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 plains 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.

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 2004) 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 D: Rosgen Stream Classification. As illustrated in Appendix D, 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 E: 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). | |

## 2.4 LAND USE AND STORMWATER MANAGEMENT ASSESSMENT

### 2.4.1 Picture Spring Branch Watershed BMP Inspection

The Picture Spring Branch watershed contains 14 BMPs, as shown in Figure 2-2. An overview of the BMPs compiled in 2013 is presented in Table 2-8. No land use assessment or BMP inspections were conducted in 2014.

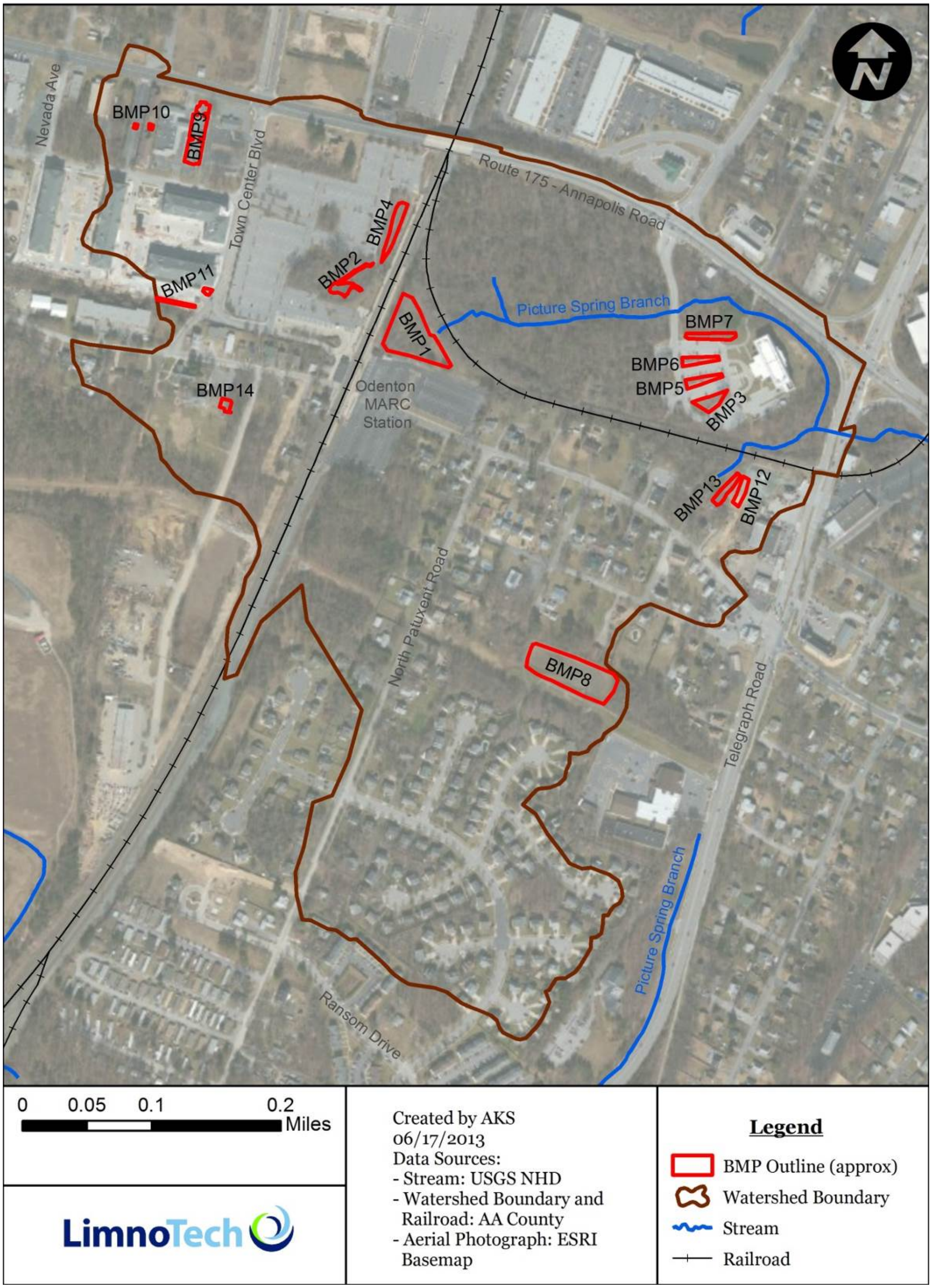


Figure 2-2. Picture Spring Branch BMPs (Figure from Versar, Inc. 2013)

Table 2-8. Picture Spring Branch BMP overview (Table from Versar, Inc. 2013)

| Picture Spring Branch BMP[a] | AA County Urban BMP Database ID | BMP Type[b] | Drainage Area (acres)[c] | Location | Address | Presumed Owner |
|---|---|---|---|---|---|---|
| 1 | AA004443 | DP | 2.1 | Odenton MARC Station Parking Lot | Odenton MARC Station | MTA |
| 2 | not found in 2012 database | WP | - | Odenton MARC Station Parking Lot | Odenton MARC Station | MTA |
| 3 | AA012418 | BR | 3 | West County Library Parking Lot | 1325 Annapolis Road | County |
| 4 | not found in 2012 database | WP | - | Odenton MARC Station Parking Lot | Odenton MARC Station | MTA |
| 5 | AA012419 | BR | 3 | West County Library Parking Lot | 1325 Annapolis Road | County |
| 6 | AA012420 | BR | 3 | West County Library Parking Lot | 1325 Annapolis Road | County |
| 7 | AA012421 | SW | 3 | West County Library Parking Lot | 1325 Annapolis Road | County |
| 8 | AA002445 | EDSD | 36.86 | Peach Tree East Neighborhood | Peach Leaf Court | County |
| 9 | AA004558 | UGS | 2 | Donaldson Funeral Home Parking Lot | 1411 Annapolis Road | County |
| 10 | AA000692 | ITCE | - | Odenton Commerce Center Parking Lot | 1413A Annapolis Road | County |
| 11 | AA009976<br>AA009977<br>AA009978<br>AA009980 | IT | 3 | The Village at Odenton Parking Lot | Town Center Boulevard | County |
| 12 | AA012190 | UGS | 1.9 | Walgreens Parking Lot | 8374 Piney Orchard Parkway | County |
| 13 | AA012189 | SF | 1.9 | Walgreens Parking Lot | 8374 Piney Orchard Parkway | County |
| 14 | AA004926 | ITCE | 2.97 | Epiphany Episcopal Church Playground | 1419 Odenton Road | Private |

(a) Numbering system carried over from the 2012 BMP inspection report.
(b) BMP type carried over from the 2012 BMP inspection report or copied from the 2012 AA County Urban BMP database. See List of Acronyms in Appendix F.
(c) Drainage areas copied from the 2012 AA County Urban BMP database. Some drainage areas are missing in the Urban BMP database.

# 3.0 RESULTS

## 3.1 AQUATIC HABITAT

Physical habitat quality within the Picture Spring Branch study area was primarily rated as "Degraded" by the Maryland PHI. However, the most upstream reach, PSB-01, received the highest score (77.7), and was rated as "Partially Degraded." Remoteness was rated very low at PSB-01; however, there was substantial riparian buffer throughout this reach providing adequate shading, banks exhibited only minor erosion and were well-vegetated, and woody debris and rootwads were present in sufficient amounts for colonization of benthic macroinvertebrates. Site PSB-02, located between the Winmeyer Avenue and Baltimore Avenue culverts, received a score of 64.7 and a narrative rating of "Degraded." Remoteness was rated very low due to the immediate proximity to the parking lot and roads surrounding the stream reach. This reach also received a low score for epifaunal substrate and marginal scores for instream habitat and percent shading. The site downstream of Maryland Route 170 (PSB-03) also received a "Degraded" habitat rating (PHI score of 65.7), primarily due to a very low remoteness score, a low score for shading and epifaunal substrate, and a marginal score for instream habitat. 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 B.

Physical habitat quality was also evaluated with the RBP and rated "Partially Supporting" for two sites and "Supporting" for one site (Table 3-1). Index scores varied somewhat and ranged from a low of 71 at PSB-03 to a high of 78 at PSB-01. All sites scored low for velocity/depth regime metric. PSB-02 also scored low in sediment composition and epifaunal substrate/cover while PSB-03 also rated low in epifaunal substrate/cover and embeddedness.

Table 3-1. PHI and RBP physical habitat assessment results - 2014

| Site | PHI Score | PHI Narrative Rating | RBP Score | RBP Narrative Rating |
|---|---|---|---|---|
| PSB-01 | 77.7 | Partially Degraded | 78 | Supporting |
| PSB-02 | 64.7 | Degraded | 75 | Partially Supporting |
| PSB-03 | 65.7 | Degraded | 71 | Partially Supporting |

## 3.2 BENTHIC MACROINVERTEBRATES

The biological condition rated "Poor" at all 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 B: Biological Assessment Results.

The most upstream site within the North Tributary (PSB-01) had a BIBI score of 2.43, which is slightly lower than its 2013 BIBI score. This site is well-buffered by a young deciduous forest. The macroinvertebrate community was represented by 18 taxa, three of which were sensitive EPT taxa. The sample had a very low abundance of 61 individual organisms. This could be due to the colder than average temperatures during the March 2014. The sample was dominated by individuals of the family Pisidiidae, a small to minute freshwater bivalve mollusc (Tolerance Value (TV)=6.5), followed by the taxa Prodiamesa (TV=6.6). Overall, 0% of the individuals present were intolerant to urban stressors. However, the complete lack of Ephemeroptera taxa in the subsample indicates that stressors such as sedimentation may be affecting the biological community. Climbers made up 7% of the sample.

Table 3-2. Benthic macroinvertebrate assessment results - 2014

| Site | BIBI Score | Narrative Rating |
|---|---|---|
| PSB-01 | 2.43 | Poor |
| PSB-02 | 2.71 | Poor |
| PSB-03 | 2.43 | Poor |

Site PSB-02, also located on the North Tributary, received a BIBI score of 2.71 in 2014, a decrease from its 3.29 score in 2013. Of the 17 taxa present in the subsample, 14% were intolerant to urban stressors, and one taxa was the sensitive EPT taxa. The dominant taxa at this site was Zavrelimyia in the family Chironomidae (TV=5.3) and the taxa Physa (TV=7). This site also had a lack of Ephemeroptera taxa and a low percentage of climbers, possibly due to heavy sedimentation and a general lack of riffle habitat.

Downstream of State Highway 170, site PSB-03 received a BIBI score of 2.43, a decrease from its 3.00 score in 2013. Overall, this site had a total of 16 taxa identified, including three sensitive EPT taxa. However, only 2.3% of the individuals present in the subsample were intolerant to urban stressors, suggesting an increase in urban stressors at this sampling location. Ephemeroptera taxa were absent from the subsample. The benthic community was dominated by the taxa Parametriocnemus, generally tolerant midges of the Chironomidae family.

## 3.3 WATER QUALITY

All water quality measurements were within Maryland's Use I stream standards (Table 3-3). Conductivity values were relatively high compared to most coastal plain streams, but are within the range of those found in other urban, or highly impervious, drainage areas in Maryland (DNR, 2001, 2003, 2005; KCI, 2009a; Hill and Crunkleton, 2009). 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, passage through pipes, and exposure to other infrastructure (Cushman 2006).

| Table 3-3. Water Quality Measurement Results - 2014 | | | | | |
|---|---|---|---|---|---|
| | **pH** | **Temperature** | **Dissolved Oxygen** | **Conductivity** | **Turbidity** |
| **Site** | **unit** | **°C** | **mg/L** | **µS/cm** | **NTU** |
| PSB-01 | 6.44 | 12.47 | 9.06 | 1544 | 2.4 |
| PSB-02 | 6.85 | 11.18 | 9.22 | 1446 | 2.7 |
| PSB-03 | 6.83 | 10.63 | 10.82 | 1495 | 4.2 |

## 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 gaged 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. Bankfull width values tended to loosely fit the predictions of the urban curve, with most points wider than predicted due to the engineered channel design. All bankfull cross-section 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 falling just below the MCP curve. Overall, it appears that some of the field data were not consistent with the MCP relationships, however, it should be noted that the regional curves were developed using streams with drainage areas ranging from 0.3 to 89.7 square miles, with the majority of the 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, 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, one site was classified as a C channel, one as an E channel, and three sites were classified as F channels (Table 3-4). Water surface slopes along the study area ranged from 0.001 ft/ft to 0.02 ft/ft. All sites had channel substrates dominated by sand. Detailed summaries of the geomorphic data and stream types are included in Appendix E: Geomorphic Assessment Results.

| Table 3-4. Rosgen Classification Results - 2014 | | | |
|---|---|---|---|
| **Cross Section** | **Classification** | **D50 (mm)** | **Water Surface Slope (ft/ft)** |
| XS-1 | C5 | 0.19 | 0.007 |
| XS-2 | F5 | 0.18 | 0.003 |
| XS-3 | F5 | 0.23 | 0.005 |
| XS-4 | E5 | 0.56 | 0.020 |
| XS-5 | F5 | 0.52 | 0.003 |

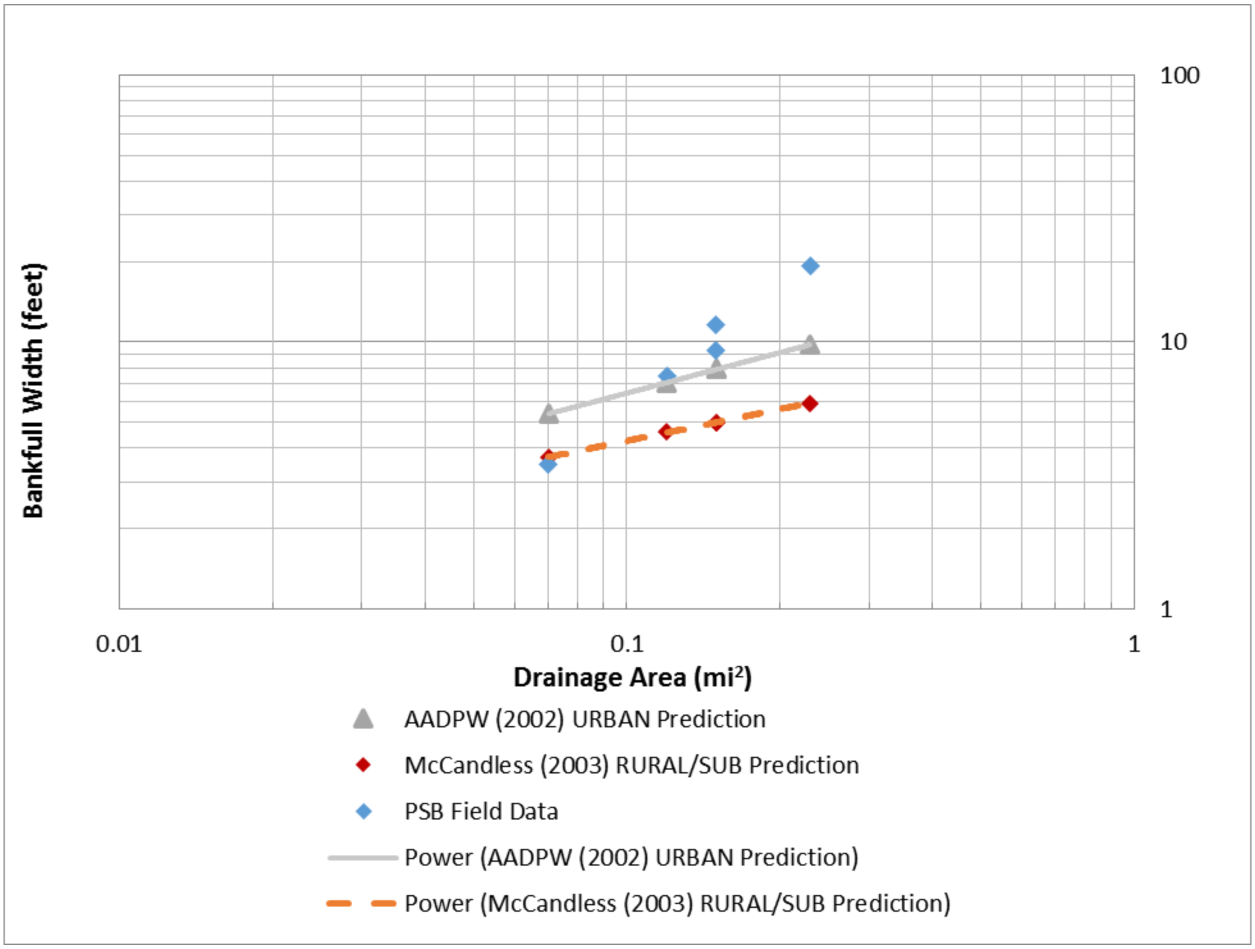


Figure 3-1. Comparison of the bankfull width drainage area relationship between Picture Spring Branch (PSB) 2014 field data and regional relationship curve data

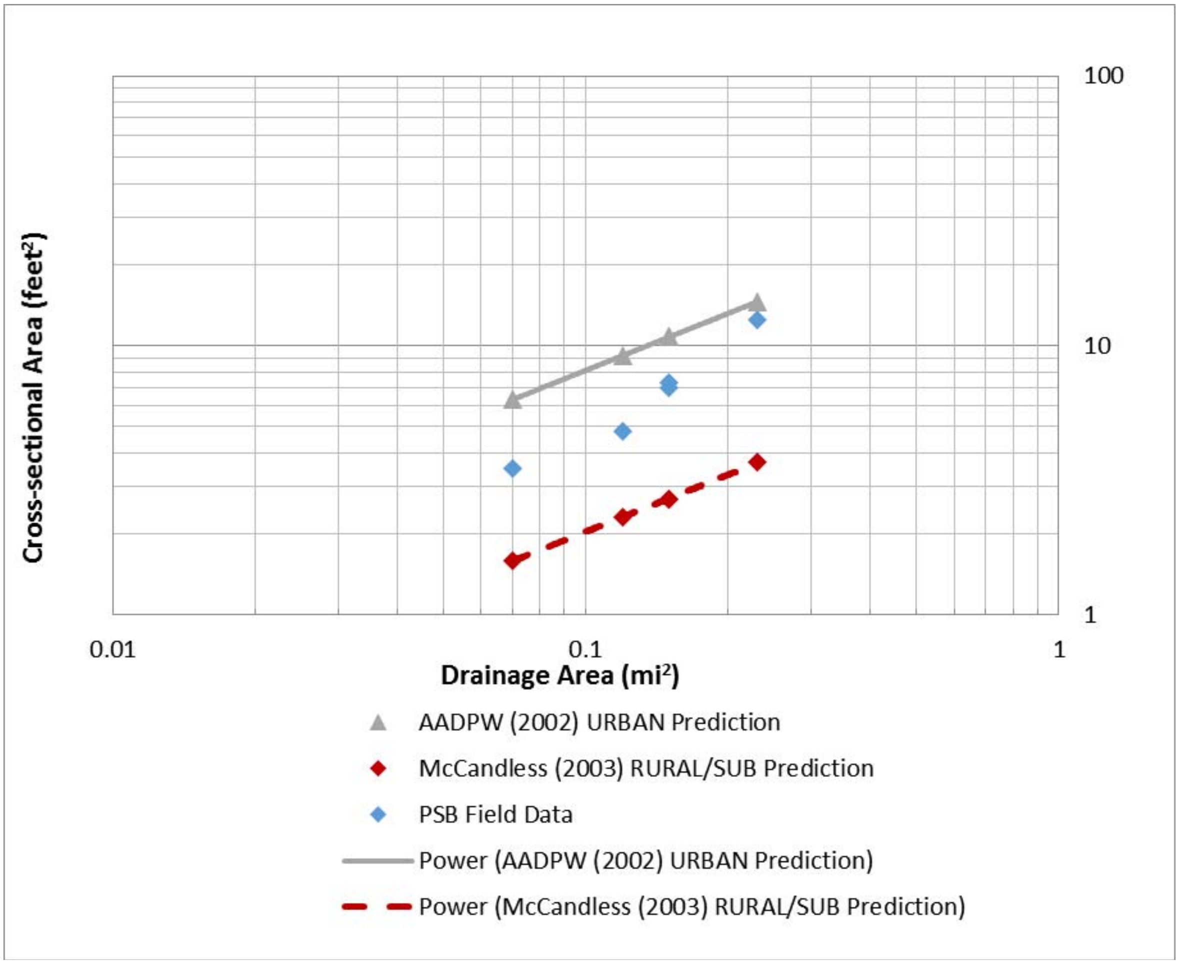


Figure 3-2. Comparison of the bankfull cross-sectional area drainage area relationship between Picture Spring Branch 2014 field data and regional relationship curve data

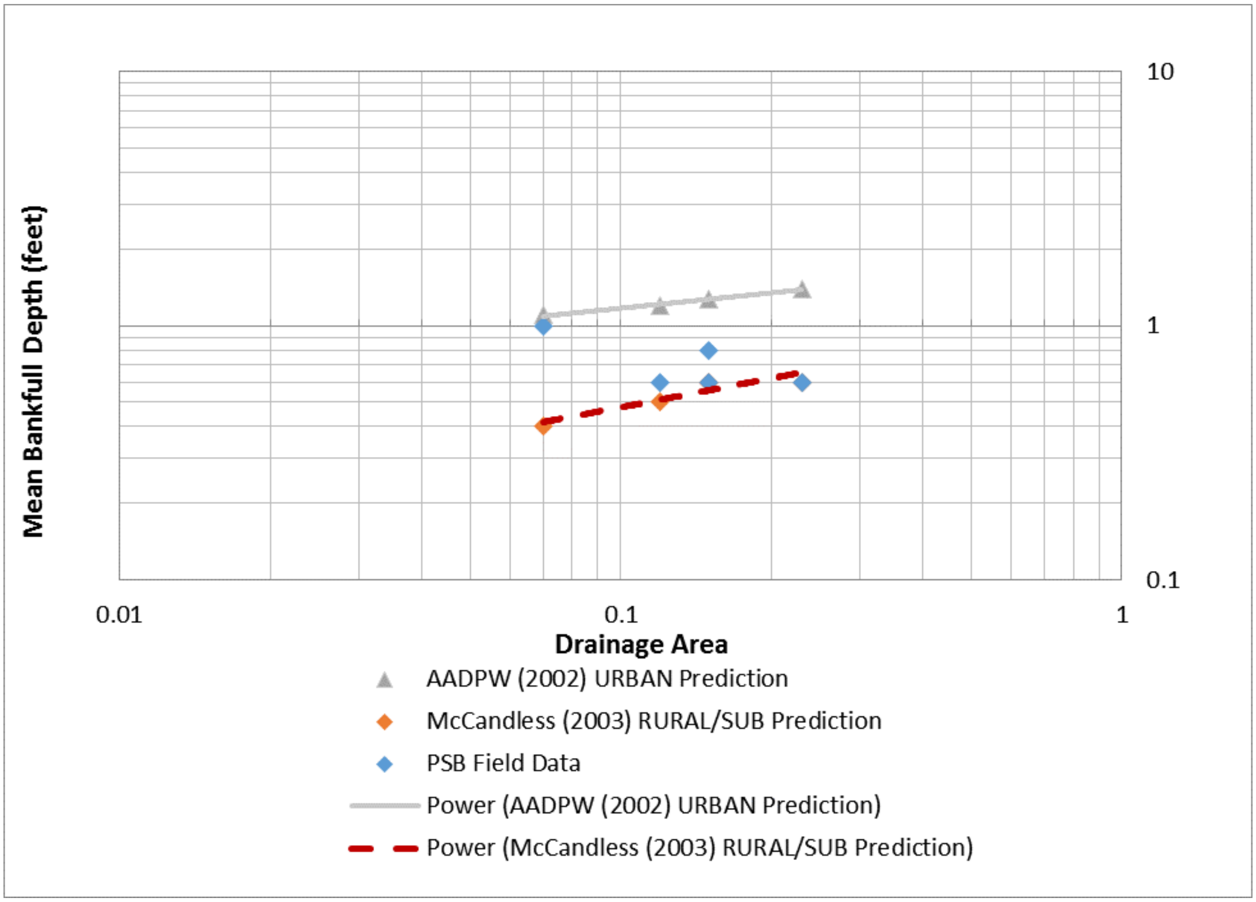


Figure 3-3. Comparison of the mean bankfull depth drainage area relationship between Picture Spring Branch 2014 field data and regional relationship curve data

The channel located in the well-forested, upper portion of the North Tributary at cross section 1 exhibited 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. As a result, best professional judgment was applied and the final decision was to assign a C5 classification in order to be consistent with the prior classifications, since there is little evidence to indicate that the channel has evolved from a C to E type channel. F channels were identified at cross sections 2, 3, and 5, which had been altered in the past with concrete trapezoidal channels. The channel along this segment of the North Tributary and downstream of Maryland State Highway 170 was overwidened as a result of the channelization, 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.

An E channel was identified at cross section 4 on the South Tributary, which appeared to have been channelized in the past and is piped underground for a significant distance upstream, further modifying its hydrology. However, the South Tributary is not overwidened and is significantly steeper 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 became noticeably entrenched and showed 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 E5 classification primarily based on the entrenchment and width/depth ratios measured at the cross section location. 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 E). Over the next year, as seen in the 2014 survey, aggradation occurred affecting the bed level by raising it approximately 0.5 feet. Analysis of the longitudinal profile overlay from 2007 through 2014 shows considerable downcutting between stations 1+00 and 2+20 since 2007 (Appendix E). However, during 2014 the pool near station 2+00 has mostly filled in. The headcut and large scour pool between stations 2+68 and 2+90 just downstream from this eroded section have not worsened. It is recommended that this area continue to be monitored, since 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 2014 (Appendix E). Numerous man-made structures (i.e., culverts, concrete-lined channel) throughout this reach are providing adequate grade control, preventing substantial channel degradation.

# 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. Given the presence in the watershed of the large MARC train station Park & Ride lots, which likely receive large quantities of de-icing salts, and two adjacent detention/shallow wetland ponds, which 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 was rated “Partially Degraded” to “Degraded” throughout the study area, which is exactly the same as the ratings from 2013 (Table 4-1). The “Partially Degraded” site was located along the wooded upper reach of the North Tributary, which had a substantial riparian buffer, adequate shading, minor bank erosion, and sufficient instream woody debris and rootwads. These factors increase the potential of the stream to support a diverse macroinvertebrate community. Sites PSB-02 and PSB-03 had marginal riparian buffers and scored very low for remoteness due to their proximities to Routes 170 and 175. The scores for instream habitat and epifaunal substrate were also lower than upstream, but the reduced PHI scores were primarily due to the remoteness measure, which cannot improve over time.

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 can be attributed to two primary factors: 1) changes in the quantity of woody debris, which not only affects direct scoring of this parameter, but also indirectly influences scoring for epifaunal substrate and instream habitat; and 2) variability in qualitative visual assessment scoring between field crews.

In 2013 and 2014, 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 scores for 2013 and 2014 were calculated using the updated method.

In 2014, the benthic macroinvertebrate community at all three sites within the Picture Spring Branch study area was rated as “Poor”, which is considered to be a minimally degraded biological condition. One site in 2013 was rated “Poor.” Overall, taxa diversity and the number of Ephemeroptera was decreased in 2014 in all three sites as compared to previous years. Intolerant individuals at sites ranged from 0% (PSB-01) to 14% (PSB-02) of the total specimens. The numbers of sensitive EPT taxa were lower at PSB-02 (1 taxa) than at the other two sites

(3 taxa, each). However, no Ephemeroptera taxa were found at any of the sites during this sampling period.

Table 4-1. PHI scores from 2006 to 2014

| Site | | PSB-01 | PSB-02 | PSB-03 |
|---|---|---|---|---|
| 2006 | PHI Score | 66.0 | 60.1 | 50.9 |
| | Rating | Degraded | Degraded | Severely Degraded |
| 2007 | PHI Score | 79.6 | 69.5 | 69.5 |
| | Rating | Partially Degraded | Partially Degraded | Partially Degraded |
| 2008 | PHI Score | 84.5 | 73.0 | 73.3 |
| | Rating | Minimally Degraded | Partially Degraded | Partially Degraded |
| 2009 | PHI Score | 76.4 | 65.9 | 58.6 |
| | Rating | Partially Degraded | Degraded | Degraded |
| 2010 | PHI Score | 84.3 | 72.4 | 73.8 |
| | Rating | Minimally Degraded | Partially Degraded | Partially Degraded |
| 2011 | PHI Score | 83.3 | 73.4 | 71.9 |
| | Rating | Minimally Degraded | Partially Degraded | Partially Degraded |
| 2012 | PHI Score | 83.9 | 74.8 | 73.2 |
| | Rating | Minimally Degraded | Partially Degraded | Partially Degraded |
| 2013 | PHI Score | 77.2 | 62.6 | 57.2 |
| | Rating | Partially Degraded | Degraded | Degraded |
| 2014 | PHI Score | 77.7 | 64.7 | 65.7 |
| | Rating | Partially Degraded | Degraded | Degraded |

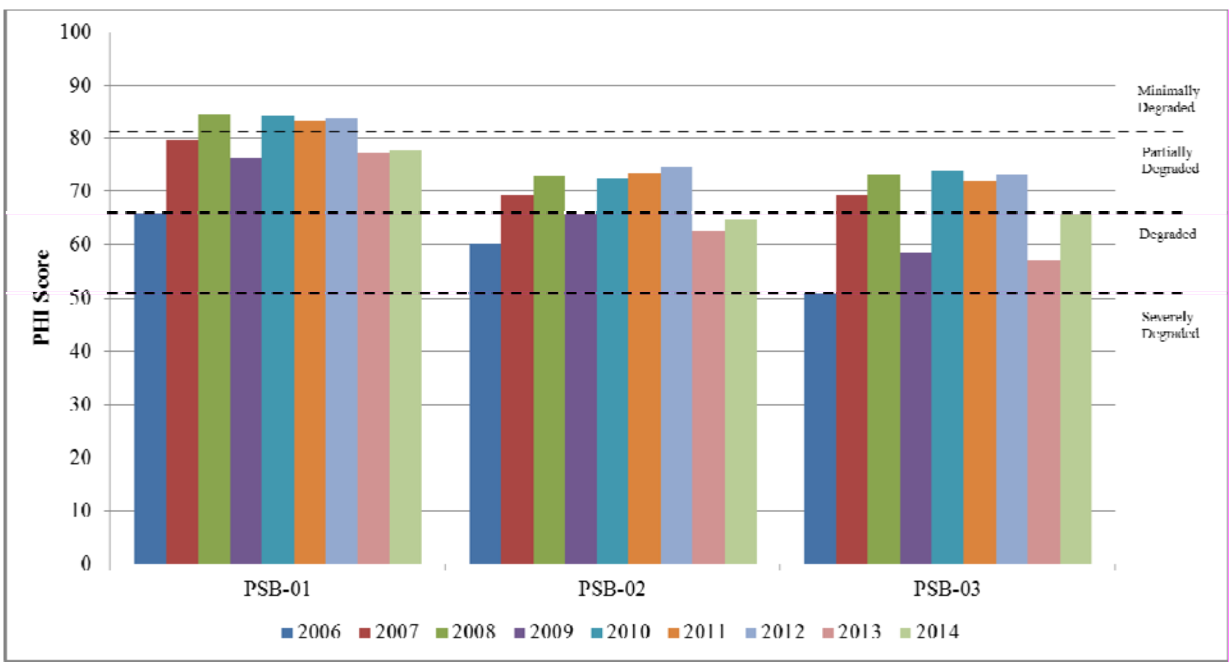


Figure 4-1. Comparison of PHI Habitat Scores from 2006 through 2014

BIBI scores decreased at all three sites between 2013 and 2014 (Table 4-2). The narrative ratings at one site stayed constant from 2013 to 2014, however, two sites decreased to “Fair” from “Poor”. Figure 4-2 provides a visual comparison of BIBI scores over time, which shows scores fluctuating from year to year.

Table 4-2. BIBI scores from 2006 to 2014

| Site | | PSB-01 | PSB-02 | PSB-03 |
|---|---|---|---|---|
| 2006 | BIBI Score | 3.00 | 2.71 | 2.43 |
| | Rating | Fair | Poor | Poor |
| 2007 | BIBI Score | 3.29 | 3.00 | 3.57 |
| | Rating | Fair | Fair | Fair |
| 2008 | BIBI Score | 3.86 | 3.00 | 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 | 3.00 | 2.43 |
| | Rating | Poor | Fair | Poor |
| 2011 | BIBI Score | 3.29 | 3.29 | 2.71 |
| | Rating | Fair | Fair | Poor |
| 2012 | BIBI Score | 3.29 | 3.00 | 3.00 |
| | Rating | Fair | Fair | Fair |
| 2013 | BIBI Score | 2.71 | 3.29 | 3.00 |
| | Rating | Poor | Fair | Fair |
| 2014 | BIBI Score | 2.43 | 2.71 | 2.43 |
| | Rating | Poor | Poor | Poor |

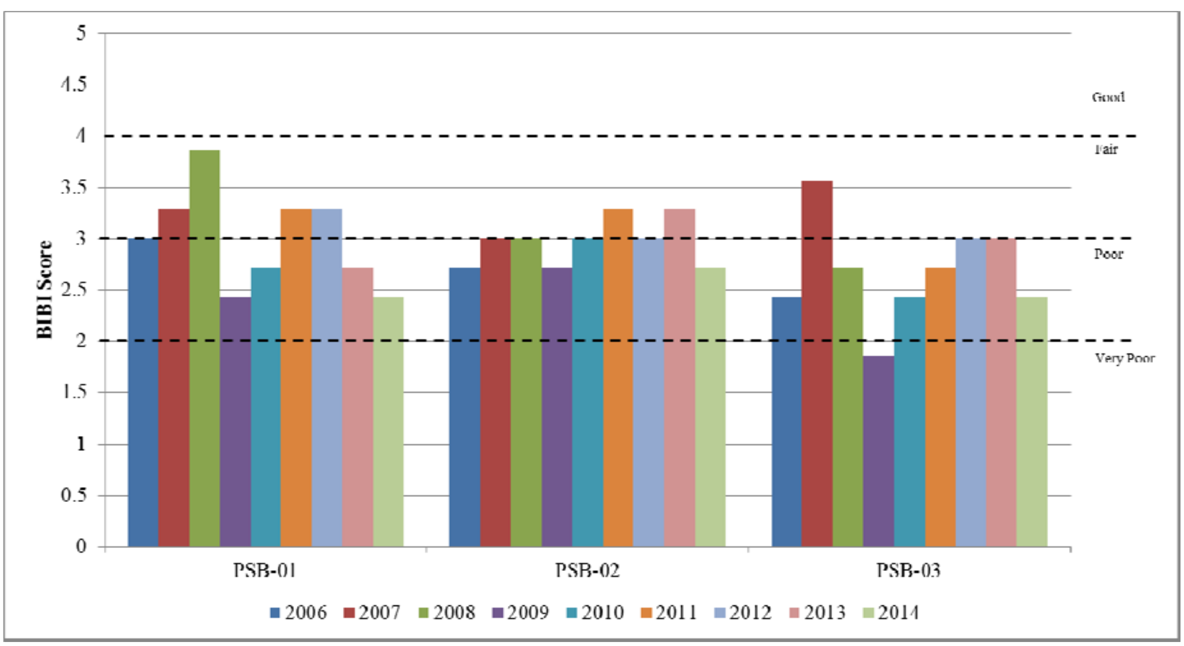


Figure 4-2. Comparison of BIBI Scores from 2006 through 2014

## 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 parallel and adjacent to the stream channel. Consequently, stream reaches in the vicinity of cross sections XS-2, XS-3, and XS-5, on the North Tributary and mainstem have been overwidened resulting 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, especially below Route 170 where a more natural stream pattern is emerging. These cross sections also appeared quite stable during recent years, having shown very little change from previous surveys, with the exception of XS-5 which experienced notable aggradation across its total width between 2011 and 2012. However, between 2012 and 2013 the right side stream bed at XS-5 eroded slightly while the left side had no change. The 2014 survey continued to show left side erosion. Past channelization also appears to have occurred on the South Tributary in the vicinity of cross section XS-4. The slope of the South Tributary is much greater than that of the North Tributary, and the channel is showing signs of active downcutting. The least disturbed reach in the Picture Spring Branch study area is in the vicinity of cross section XS-1 in the well-forested upper portion of the North Tributary, which is classified as a C5 channel.

To compare changes in cross sectional area over time, cross sectional area from 2011 through 2014 was calculated using the top of bank elevation from the baseline survey in order 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 the baseline reference elevation, instead they used the corresponding years top of bank elevation for calculating cross sectional area, and consequently these values are not directly comparable to the cross sectional areas reported in 2011 through 2014. Comparison of baseline cross sectional area is however comparable to 2011 through 2014 since all calculations are made using the same top of bank elevation. Channel dimensions appear moderately constant for three out of the five cross sections, compared to baseline conditions (Table 4-3). Only very minor changes were observed from baseline conditions in cross section XS-2, showing signs of minor aggradation in this overwidened reach. On the other hand, cross sections XS-1 and XS-4 have experienced a 37.5% and 31.6% increase over baseline conditions, respectively. Not surprisingly, these are the only two sections not located in an engineered or partially-armored channel. However, when comparing the most recent four years of data, only minor changes are shown where XS-1 has degraded by 9.3% while XS-4 has aggraded by 7.5%. Although cross section XS-4 has filled in slightly between 2013 and 2014, notable stream bed erosion is apparent. Between 2012 and 2013, the cross section area of XS-4 increased significantly by 62.8%. Cross sections XS-3 and XS-5 decreased in cross-section areas between the baseline assessment and the 2014 survey by 8.4% and 8.2%, respectively. These two station also show a similar change between 2011 and 2014 surveys by a decrease of 5.5% and 6.3%, respectively. During 2014 survey, slight deposition was seen along the right bank of cross section XS-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 |
| **% Change 2003-2014** | 37.5[c] | -2.8 | -8.4 | 31.6 | -8.2 |
| **% Change 2011-2014** | -9.3 | -0.7 | -5.5 | 7.5 | -6.3 |

[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).

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# APPENDIX A

# 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.

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. This check consisted of entirely resorting one randomly selected sample to a sorting consistency above ninety percent efficiency. This QC resulted in a sorting efficiency above 95%, 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 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 B

# BIOLOGICAL ASSESSMENT RESULTS

# Picture Spring Branch Site PSB-01

Sampled: 3/21/2014

## Biological Condition

Benthic Macroinvertebrate IBI

| | |
|---|---|
| Narrative Rating | Poor |
| BIBI Score | 2.43 |

| Metric | Value | Score |
|---|---|---|
| Total Taxa | 18 | 3 |
| EPT Taxa | 3 | 3 |
| Number Ephemeroptera | 0 | 1 |
| % Intolerant to Urban | 0.00 | 1 |
| % Ephemeroptera | 0 | 1 |
| Scraper Taxa | 2 | 5 |
| % Climbers | 6.56 | 3 |

Benthic Macroinvertebrate Taxa List

| Taxa | Count |
|---|---|
| Dytiscidae | 2 |
| Empididae | 2 |
| Helichus | 2 |
| Helius | 1 |
| Limnephilidae | 4 |
| Limnophila | 1 |
| Molanna | 1 |
| Parametriocnemus | 4 |
| Paraphaenocladius | 1 |
| Phaenopsectra | 1 |
| Pisidiidae | 25 |
| Prodiamesa | 5 |
| Psychomyiidae | 1 |
| Stratiomyidae | 2 |
| Tanypodinae | 2 |
| Thienemannimyia group | 3 |
| Tubificidae | 3 |
| Zavrelimyia | 1 |

## Physical Habitat

Maryland Biological Stream Survey PHI

| | |
|---|---|
| Narrative Rating | Partially Degraded |
| PHI Score | 77.69 |

| Metric | Score |
|---|---|
| Drainage area (acres) | 76.80 |
| Remoteness | 42.78 |
| Percent Shading | 73.32 |
| Epifaunal Substrate | 91.83 |
| Instream Habitat | 86.20 |
| Instream Wood Debris | 100.00 |
| Bank Stability | 71.98 |

Rapid Bioassessment Protocal

| | |
|---|---|
| Narrative Rating | Supporting |
| RBP Score | 78 |

| Metric | Score |
|---|---|
| Epifaunal Substrate / Cover | 10 |
| Embeddedness | 8 |
| Velocity / Depth Regime | 6 |
| Sediment Deposition | 9 |
| Channel Flow Status | 16 |
| Channel Alteration | 20 |
| Frequency of Riffles | 16 |
| Bank Stability | 8(Left)/8(Right) |
| Vegetative Protection | 6(Left)/6(Right) |
| Riparian Veg Zone Width | 9(Left)/9(Right) |

## Water Chemistry

| | |
|---|---|
| Dissolved Oxygen (mg/L) | 9.06 |
| pH | 6.44 |
| Specific Conductance (µS/cm) | 1544 |
| Temperature (°C) | 12.47 |
| Turbidity (NTUs) | 2.4 |

# Picture Spring Branch Site PSB-02

Sampled: 3/21/2014

## Biological Condition

Benthic Macroinvertebrate IBI

| | |
|---|---|
| Narrative Rating | Poor |
| BIBI Score | 2.71 |

| Metric | Value | Score |
|---|---|---|
| Total Taxa | 17 | 3 |
| EPT Taxa | 1 | 1 |
| Number Ephemeroptera | 0 | 1 |
| % Intolerant to Urban | 13.93 | 3 |
| % Ephemeroptera | 0 | 1 |
| Scraper Taxa | 4 | 5 |
| % Climbers | 17.21 | 5 |

Benthic Macroinvertebrate Taxa List

| Taxa | Count |
|---|---|
| Calopteryx | 2 |
| Chaetocladius | 5 |
| Chironomini | 1 |
| Chironomus | 3 |
| Fossaria | 2 |
| Hemerodromia | 1 |
| Lymnaeidae | 1 |
| Orthocladius | 5 |
| Parametriocnemus | 14 |
| Phaenopsectra | 2 |
| Physa | 16 |
| Pisidium | 10 |
| Polycentropus | 3 |
| Procladius | 14 |
| Prodiamesa | 5 |
| Stenelmis | 1 |
| Tanypodinae | 5 |
| Zavrelimyia | 32 |

## Physical Habitat

Maryland Biological Stream Survey PHI

| | |
|---|---|
| Narrative Rating | Degraded |
| PHI Score | 64.69 |

| Metric | Score |
|---|---|
| Drainage area (acres) | 96.00 |
| Remoteness | 15.79 |
| Percent Shading | 68.32 |
| Epifaunal Substrate | 61.33 |
| Instream Habitat | 67.27 |
| Instream Wood Debris | 100.00 |
| Bank Stability | 75.45 |

Rapid Bioassessment Protocal

| | |
|---|---|
| Narrative Rating | Partially Supporting |
| RBP Score | 72 |

| Metric | Score |
|---|---|
| Epifaunal Substrate / Cover | 7 |
| Embeddedness | 9 |
| Velocity / Depth Regime | 4 |
| Sediment Deposition | 5 |
| Channel Flow Status | 19 |
| Channel Alteration | 17 |
| Frequency of Riffles | 17 |
| Bank Stability | 9(Left)/9(Right) |
| Vegetative Protection | 6(Left)/6(Right) |
| Riparian Veg Zone Width | 7(Left)/6(Right) |

## Water Chemistry

| | |
|---|---|
| Dissolved Oxygen (mg/L) | 9.22 |
| pH | 6.85 |
| Specific Conductance (µS/cm) | 1446 |
| Temperature (°C) | 11.18 |
| Turbidity (NTUs) | 2.7 |

# Picture Spring Branch Site PSB-03

Sampled: 3/21/2014

## Biological Condition

Benthic Macroinvertebrate IBI

| | |
|---|---|
| Narrative Rating | Poor |
| BIBI Score | 2.43 |

| Metric | Value | Score |
|---|---|---|
| Total Taxa | 16 | 3 |
| EPT Taxa | 3 | 3 |
| Number Ephemeroptera | 0 | 1 |
| % Intolerant to Urban | 2.33 | 1 |
| % Ephemeroptera | 0 | 1 |
| Scraper Taxa | 2 | 5 |
| % Climbers | 6.98 | 3 |

Benthic Macroinvertebrate Taxa List

| Taxa | Count |
|---|---|
| Calopteryx | 4 |
| Cheumatopsyche | 1 |
| Chimarra | 1 |
| Conchapelopia | 18 |
| Crangonyx | 1 |
| Girardia | 1 |
| Gomphidae | 1 |
| Hydrobaenus | 5 |
| Micropsectra | 1 |
| Nigronia | 1 |
| Orthocladius | 20 |
| Parametriocnemus | 69 |
| Phaenopsectra | 2 |
| Physa | 1 |
| Pisidium | 1 |
| Pycnopsyche | 2 |

## Physical Habitat

Maryland Biological Stream Survey PHI

| | |
|---|---|
| Narrative Rating | Degraded |
| PHI Score | 65.70 |

| Metric | Score |
|---|---|
| Drainage area (acres) | 147.20 |
| Remoteness | 15.79 |
| Percent Shading | 58.94 |
| Epifaunal Substrate | 64.36 |
| Instream Habitat | 85.09 |
| Instream Wood Debris | 100.00 |
| Bank Stability | 70.02 |

Rapid Bioassessment Protocal

| | |
|---|---|
| Narrative Rating | Partially Supporting |
| RBP Score | 71 |

| Metric | Score |
|---|---|
| Epifaunal Substrate / Cover | 7 |
| Embeddedness | 7 |
| Velocity / Depth Regime | 8 |
| Sediment Deposition | 10 |
| Channel Flow Status | 16 |
| Channel Alteration | 15 |
| Frequency of Riffles | 10 |
| Bank Stability | 9(Left)/9(Right) |
| Vegetative Protection | 7(Left)/7(Right) |
| Riparian Veg Zone Width | 6(Left)/9(Right) |

## Water Chemistry

| | |
|---|---|
| Dissolved Oxygen (mg/L) | 10.82 |
| pH | 6.83 |
| Specific Conductance (µS/cm) | 1495 |
| Temperature (°C) | 10.63 |
| Turbidity (NTUs) | 4.2 |

# APPENDIX C

# MASTER BENTHIC MACROINVERTEBRATE TAXA LIST

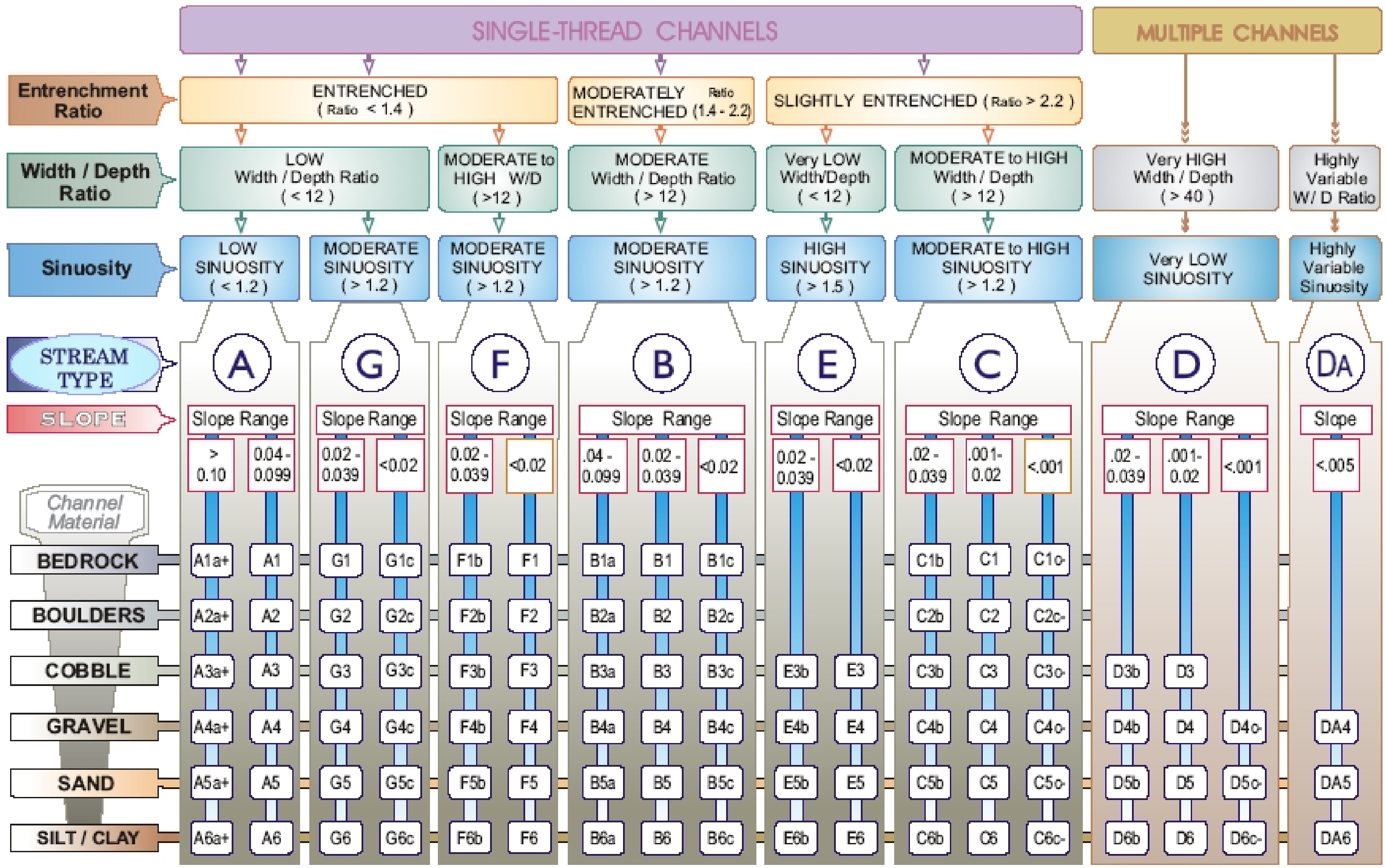
| Order | Family | Genus | Final ID | FFG[(a)] | Habit[(b)] | Tolerance Value[(c)] |
|---|---|---|---|---|---|---|
| Amphipoda | Crangonyctidae | Crangonyx | Crangonyx | Collector | sp | 6.7 |
| Basommatophora | Lymnaeidae | | Lymnaeidae | Scraper | cb | 6.9 |
| Basommatophora | Lymnaeidae | Fossaria | Fossaria | Scraper | cb | 6.9 |
| Basommatophora | Physidae | Physa | Physa | Scraper | cb | 7 |
| Coleoptera | Dryopidae | Helichus | Helichus | Scraper | cn | 6.4 |
| Coleoptera | Dytiscidae | | Dytiscidae | Predator | sw, dv | 5.4 |
| Coleoptera | Elmidae | Stenelmis | Stenelmis | Scraper | cn | 7.1 |
| Diptera | Chironomidae | Chaetocladius | Chaetocladius | Collector | sp | 7 |
| Diptera | Chironomidae | Chironomini | Chironomini | | | 5.9 |
| Diptera | Chironomidae | Chironomus | Chironomus | Collector | bu | 4.6 |
| Diptera | Chironomidae | Conchapelopia | Conchapelopia | Predator | sp | 6.1 |
| Diptera | Chironomidae | Hydrobaenus | Hydrobaenus | Scraper | sp | 7.2 |
| Diptera | Chironomidae | Micropsectra | Micropsectra | Collector | cb, sp | 2.1 |
| Diptera | Chironomidae | Orthocladius | Orthocladius | Collector | sp, bu | 9.2 |
| Diptera | Chironomidae | Parametriocnemus | Parametriocnemus | Collector | sp | 4.6 |
| Diptera | Chironomidae | Paraphaenocladius | Paraphaenocladius | Collector | sp | 4 |
| Diptera | Chironomidae | Phaenopsectra | Phaenopsectra | Collector | cn | 8.7 |
| Diptera | Chironomidae | Procladius | Procladius | Predator | sp | 1.2 |
| Diptera | Chironomidae | Prodiamesa | Prodiamesa | Collector | bu, sp | 6.6 |
| Diptera | Chironomidae | Tanypodinae | Tanypodinae | Predator | | 7.5 |
| Diptera | Chironomidae | Thienemannimyia group | Thienemannimyia group | Predator | sp | 8.2 |
| Diptera | Chironomidae | Zavrelimyia | Zavrelimyia | Predator | sp | 5.3 |
| Diptera | Empididae | | Empididae | Predator | sp, bu | 7.5 |
| Diptera | Empididae | Hemerodromia | Hemerodromia | Predator | sp, bu | 7.9 |
| Diptera | Stratiomyidae | | Stratiomyidae | Collector | | |
| Diptera | Tipulidae | Helius | Helius | Predator | sp, bu | 3.6 |
| Diptera | Tipulidae | Limnophila | Limnophila | Predator | bu | 4.8 |
| Megaloptera | Corydalidae | Nigronia | Nigronia | Predator | cn, cb | 1.4 |
| Odonata | Calopterygidae | Calopteryx | Calopteryx | Predator | cb | 8.3 |
| Odonata | Gomphidae | | Gomphidae | Predator | bu | 2.2 |
| Trichoptera | Hydropsychidae | Cheumatopsyche | Cheumatopsyche | Filterer | cn | 6.5 |
| Trichoptera | Limnephilidae | | Limnephilidae | Shredder | cb, sp, cn | 3.4 |
| Trichoptera | Limnephilidae | Pycnopsyche | Pycnopsyche | Shredder | sp, cb, cn | 3.1 |
| Trichoptera | Molannidae | Molanna | Molanna | Scraper | sp, cn | 6 |
| Trichoptera | Philopotamidae | Chimarra | Chimarra | Filterer | cn | 4.4 |
| Trichoptera | Polycentropodidae | Polycentropus | Polycentropus | Filterer | cn | 1.1 |
| Trichoptera | Psychomyiidae | | Psychomyiidae | | | 4.9 |
| Tricladida | Dugesiidae | Girardia | Girardia | Predator | sp | 9.3 |
| Tubificida | Tubificidae | | Tubificidae | Collector | cn | 8.4 |
| Veneroida | Pisidiidae | | Pisidiidae | Filterer | | 6.5 |
| 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

# ROSGEN STREAM CLASSIFICATION

# The Key to the Rosgen Classification of Natural Rivers




KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

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

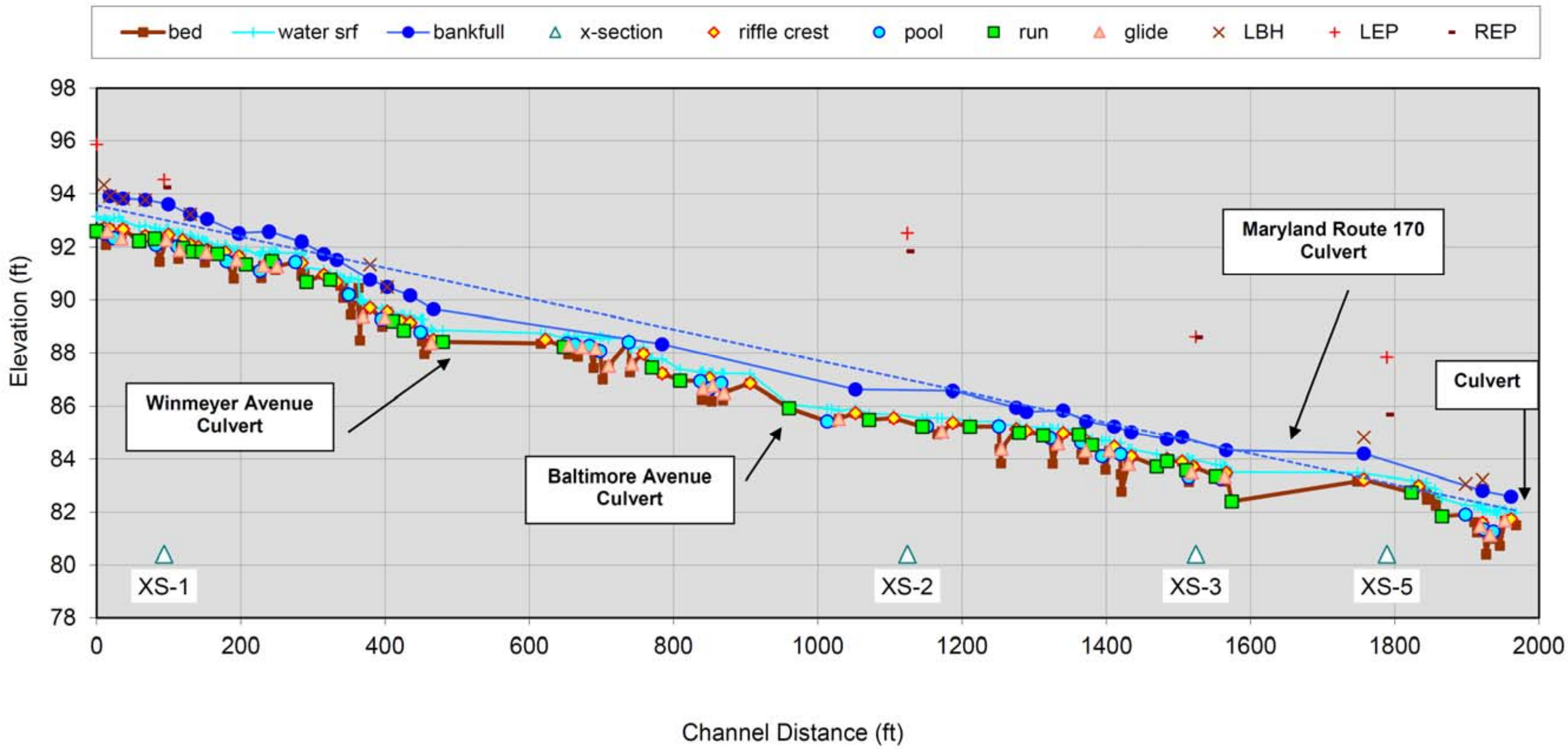
# APPENDIX E

# GEOMORPHIC ASSESSMENT RESULTS

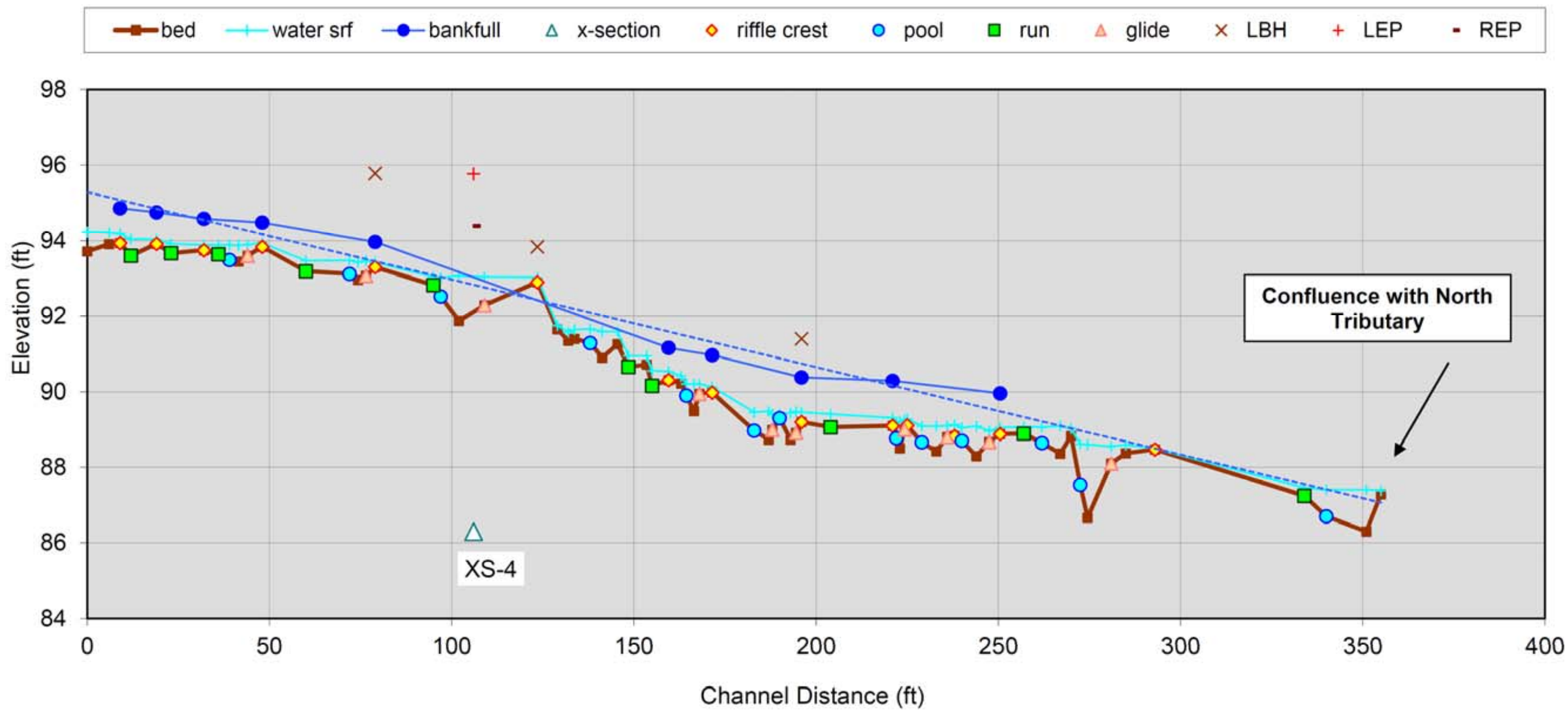
# Picture Spring Branch
# 2014 Geomorphic Assessment Results Summary

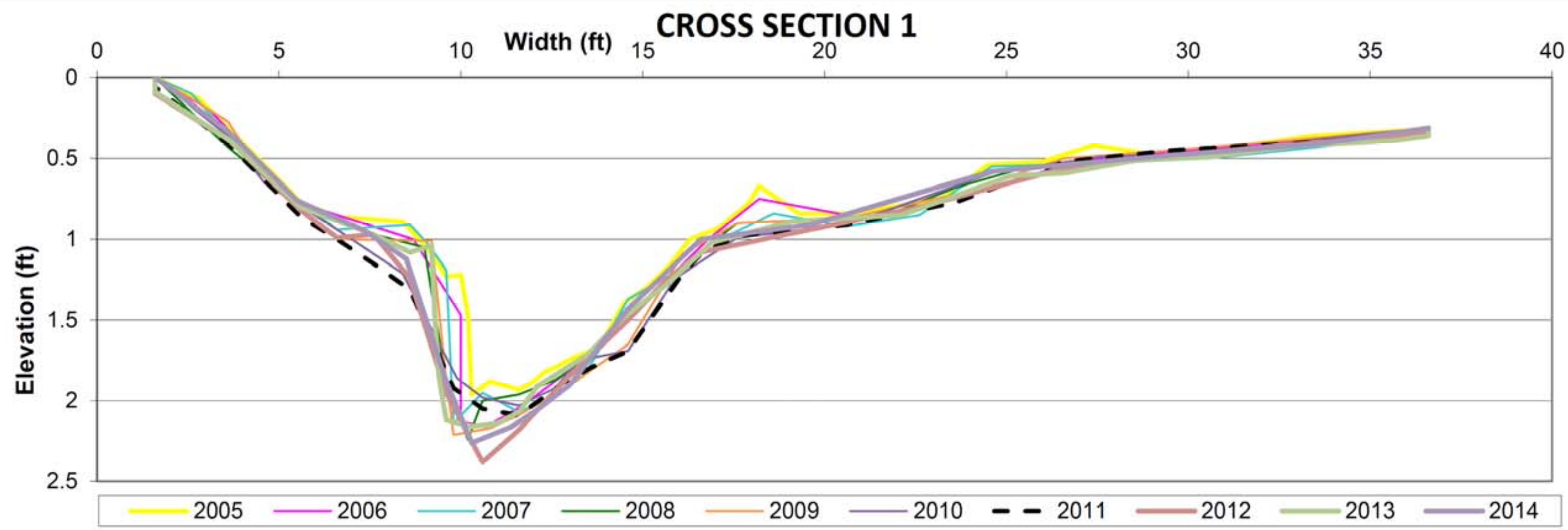
| Assessment Parameter | Cross Section | | | | |
|---|---|---|---|---|---|
| | XS-1 Run @ Sta. 0+93.5 | XS-2 Run @ Sta. 11+24 | XS-3 Run @ Sta. 15+24 | XS-4 Run @ Sta. 1+06 on South Tributary | XS-5 Run @ Sta. 17+89 |
| **Classification** | C5 | F5 | F5 | E5 | F5 |
| **Bankfull Width (ft)** | 7.5 | 9.3 | 11.6 | 3.5 | 19.2 |
| **Mean Depth (ft)** | 0.6 | 0.8 | .06 | 1.0 | 0.6 |
| **Bankfull X-Sec Area (sq ft)** | 4.8 | 7.3 | 7.0 | 3.5 | 12.4 |
| **Width:Depth Ratio** | 11.7 | 11.7 | 19.1 | 3.5 | 29.7 |
| **Flood-Prone Width (ft)** | 53.8 | 15.2 | 14.0 | 24.2 | 30.6 |
| **Entrenchment Ratio** | 7.1 | 1.6 | 1.2 | 6.9 | 1.6 |
| **D50(mm)** | 0.19 | 0.18 | 0.23 | 0.56 | 0.52 |
| **Water Surface Slope (ft/ft)** | 0.007 | 0.003 | 0.005 | 0.02 | 0.003 |
| **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 ↑, WD↑ | Sin ↑, ER ↓, WD↑ | Sin ↑ | Sin ↑ | Sin ↑, ER ↓ |

**Picture Spring Branch**
**North Tributary Longitudinal Profile**



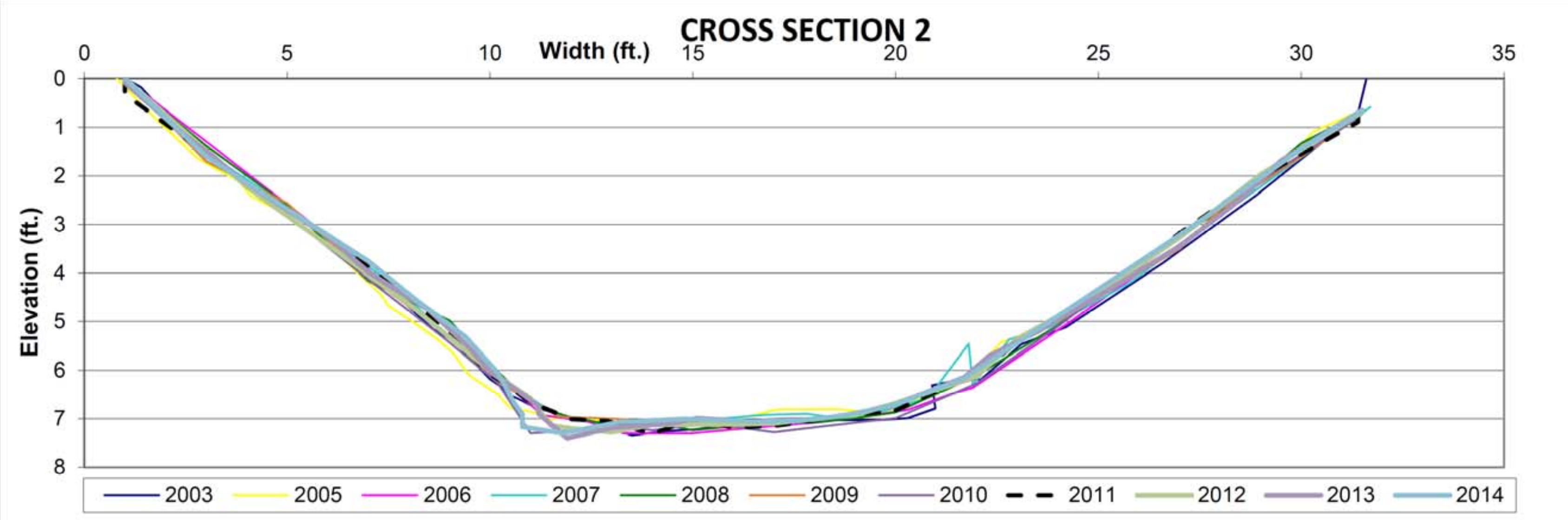
# Picture Spring Branch
## South Tributary Longitudinal Profile






|  |  |
|---|---|
| Upstream View | Downstream View |
|  |  |
| Left Bank View | Right Bank View |

| **2014 Geomorphic Assessment Results** | |
|---|---|
| Bankfull Width ($W_{bkf}$) (feet) | 7.5 |
| Mean Depth ($d_{bkf}$) (feet) | 0.6 |
| Bankfull Cross-sectional Area ($A_{bkf}$) (feet$_2$) | 4.8 |
| Width/Depth Ratio ($W_{bkf}/d_{bkf}$) | 11.7 |
| Width of Flood-prone Area ($W_{fpa}$) (feet) | 53.8 |
| Entrenchment Ratio (ER) = $W_{fpa}/W_{bkf}$ | 7.1 |
| Channel Materials $D_{50}$ (millimeters) | 0.19 |
| Water Surface Slope (S) | 0.007 |
| Sinuosity (K) = stream length/valley length | <1.2 |
| Adjustments? | Sin ↑, WD↑ |
| **STREAM TYPE** | **C5** |



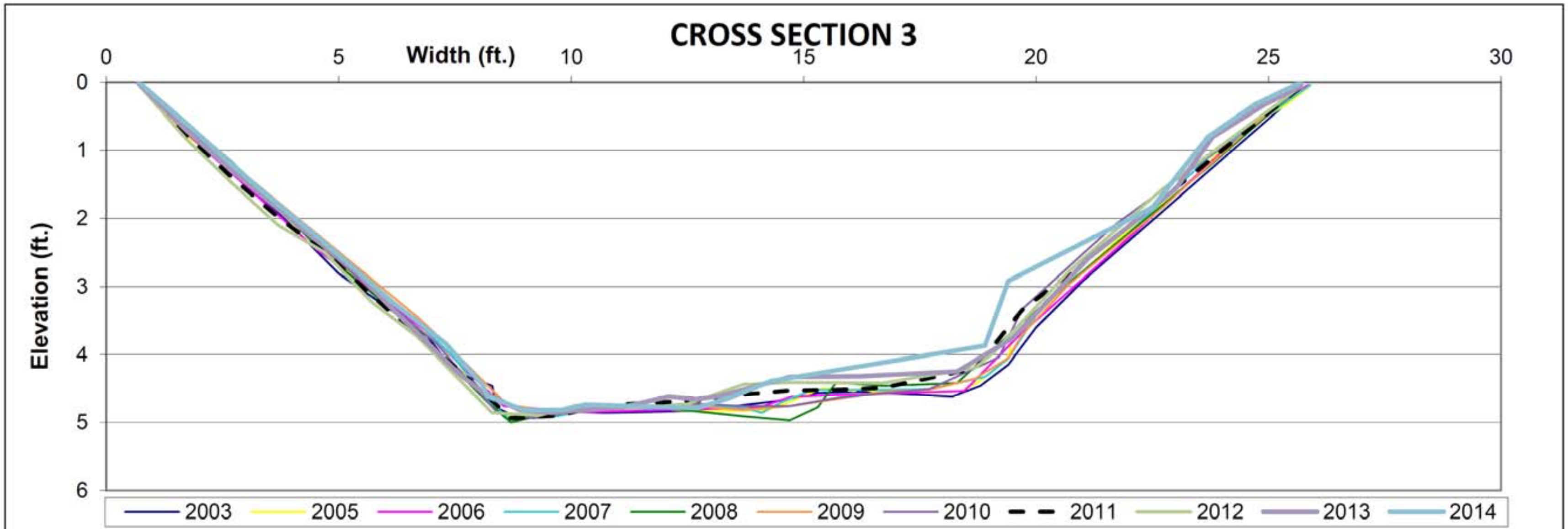

Upstream View

Downstream View

Left Bank View

Right Bank View

| 2014 Geomorphic Assessment Results | |
|---|---|
| Bankfull Width ($W_{bkf}$) (feet) | 9.3 |
| Mean Depth ($d_{bkf}$) (feet) | 0.8 |
| Bankfull Cross-sectional Area ($A_{bkf}$) (feet$_2$) | 7.3 |
| Width/Depth Ratio ($W_{bkf}/d_{bkf}$) | 11.7 |
| Width of Flood-prone Area ($W_{fpa}$) (feet) | 15.2 |
| Entrenchment Ratio (ER) = $W_{fpa}/W_{bkf}$ | 1.6 |
| Channel Materials $D_{50}$ (millimeters) | 0.18 |
| Water Surface Slope (S) | 0.003 |
| Sinuosity (K) = stream length/valley length | <1.2 |
| Adjustments? | Sin ↑, ER ↓, WD↑ |
| **STREAM TYPE** | **F5** |



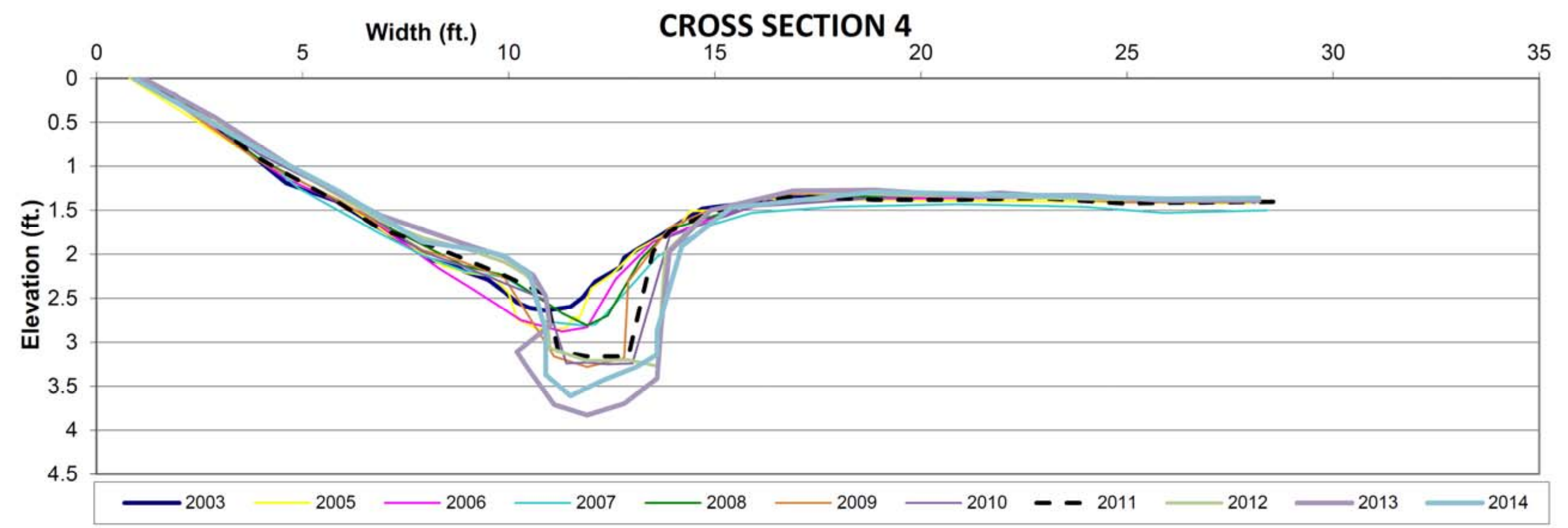

Upstream View

Downstream View

Left Bank View

Right Bank View

| 2014 Geomorphic Assessment Results | |
|---|---|
| Bankfull Width ($W_{bkf}$) (feet) | 11.6 |
| Mean Depth ($d_{bkf}$) (feet) | 0.6 |
| Bankfull Cross-sectional Area ($A_{bkf}$) (feet$_2$) | 7.0 |
| Width/Depth Ratio ($W_{bkf}/d_{bkf}$) | 19.1 |
| Width of Flood-prone Area ($W_{fpa}$) (feet) | 14.0 |
| Entrenchment Ratio (ER) = $W_{fpa}/W_{bkf}$ | 1.2 |
| Channel Materials $D_{50}$ (millimeters) | 0.23 |
| Water Surface Slope (S) | 0.005 |
| Sinuosity (K) = stream length/valley length | <1.2 |
| Adjustments? | Sin ↑ |
| **STREAM TYPE** | **F5** |



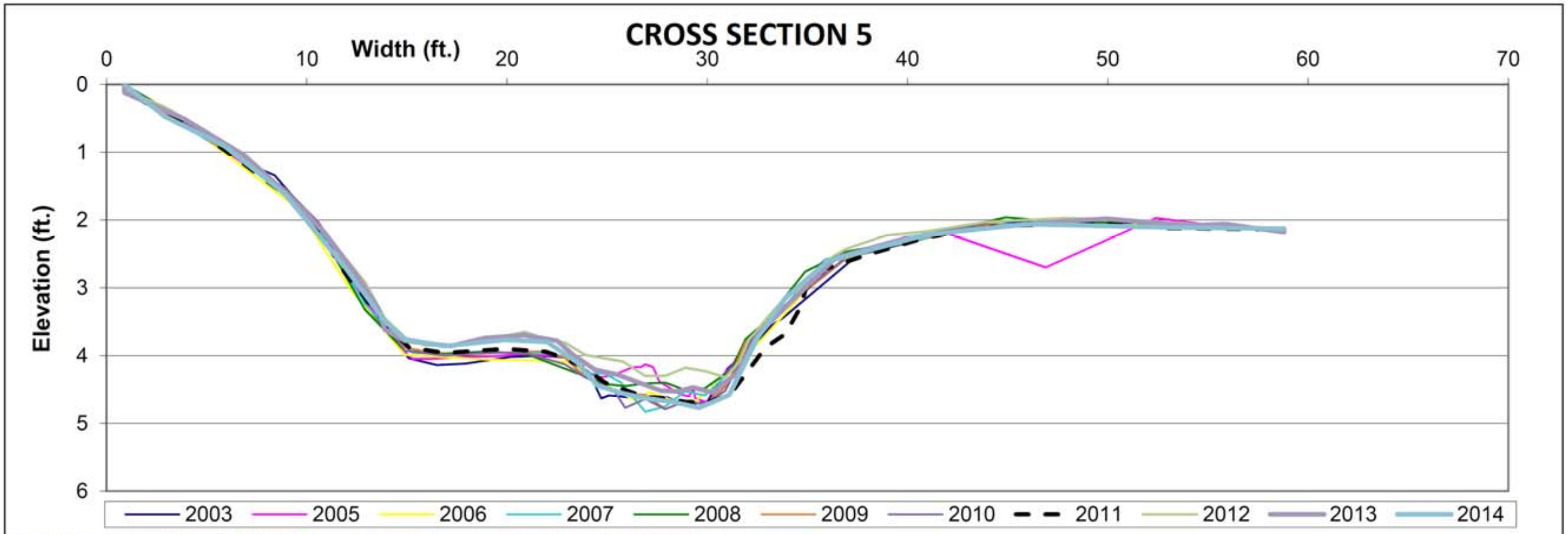

Upstream View

Downstream View

Left Bank View

Right Bank View

| 2014 Geomorphic Assessment Results | |
|---|---|
| Bankfull Width ($W_{bkf}$) (feet) | 3.5 |
| Mean Depth ($d_{bkf}$) (feet) | 1.0 |
| Bankfull Cross-sectional Area ($A_{bkf}$) (feet$^2$) | 3.5 |
| Width/Depth Ratio ($W_{bkf}/d_{bkf}$) | 3.5 |
| Width of Flood-prone Area ($W_{fpa}$) (feet) | 24.2 |
| Entrenchment Ratio (ER) = $W_{fpa}/W_{bkf}$ | 6.9 |
| Channel Materials $D_{50}$ (millimeters) | 0.56 |
| Water Surface Slope (S) | 0.02 |
| Sinuosity (K) = stream length/valley length | <1.2 |
| Adjustments? | Sin ↑ |
| **STREAM TYPE** | **E5** |





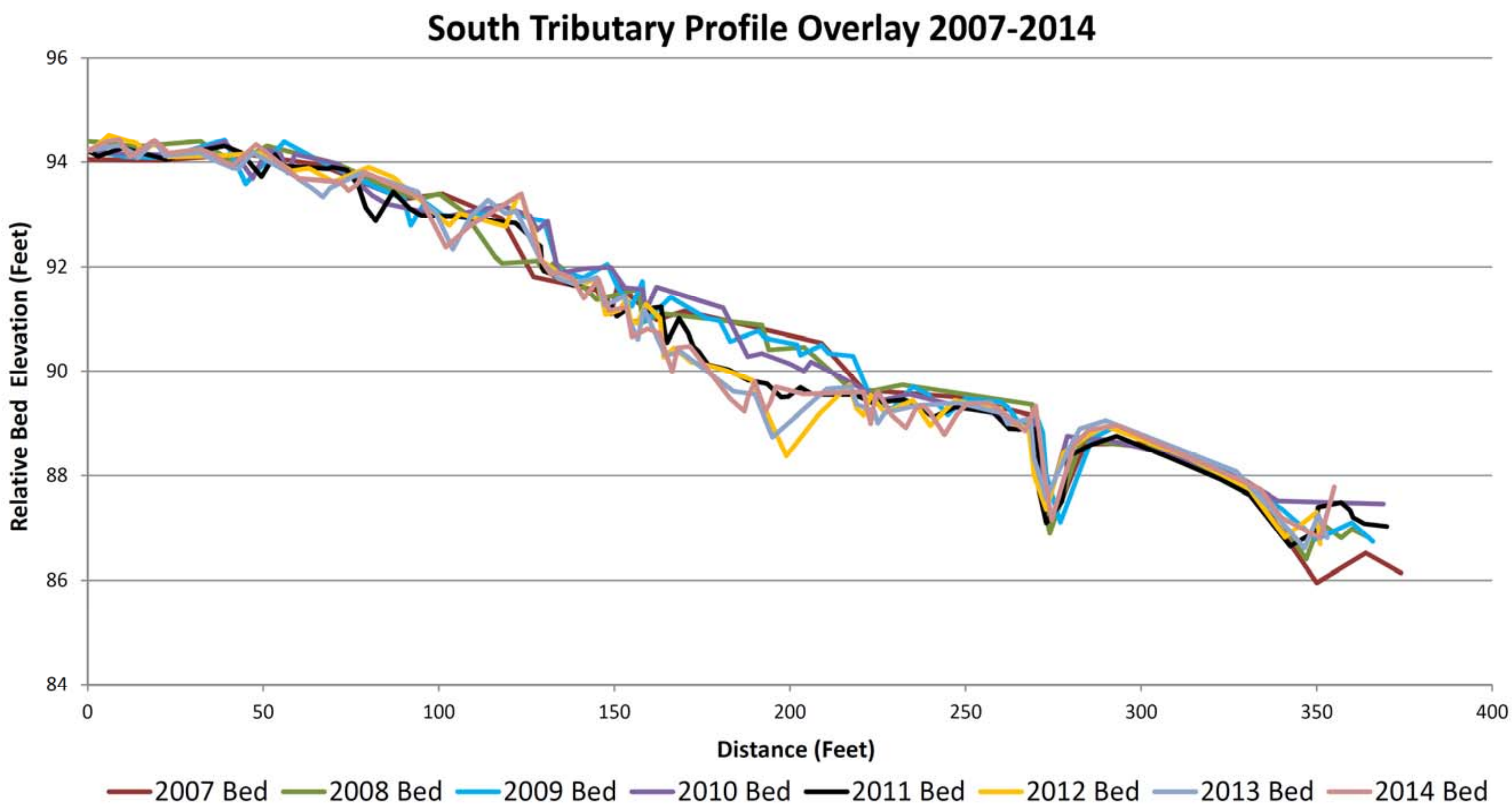
Upstream View

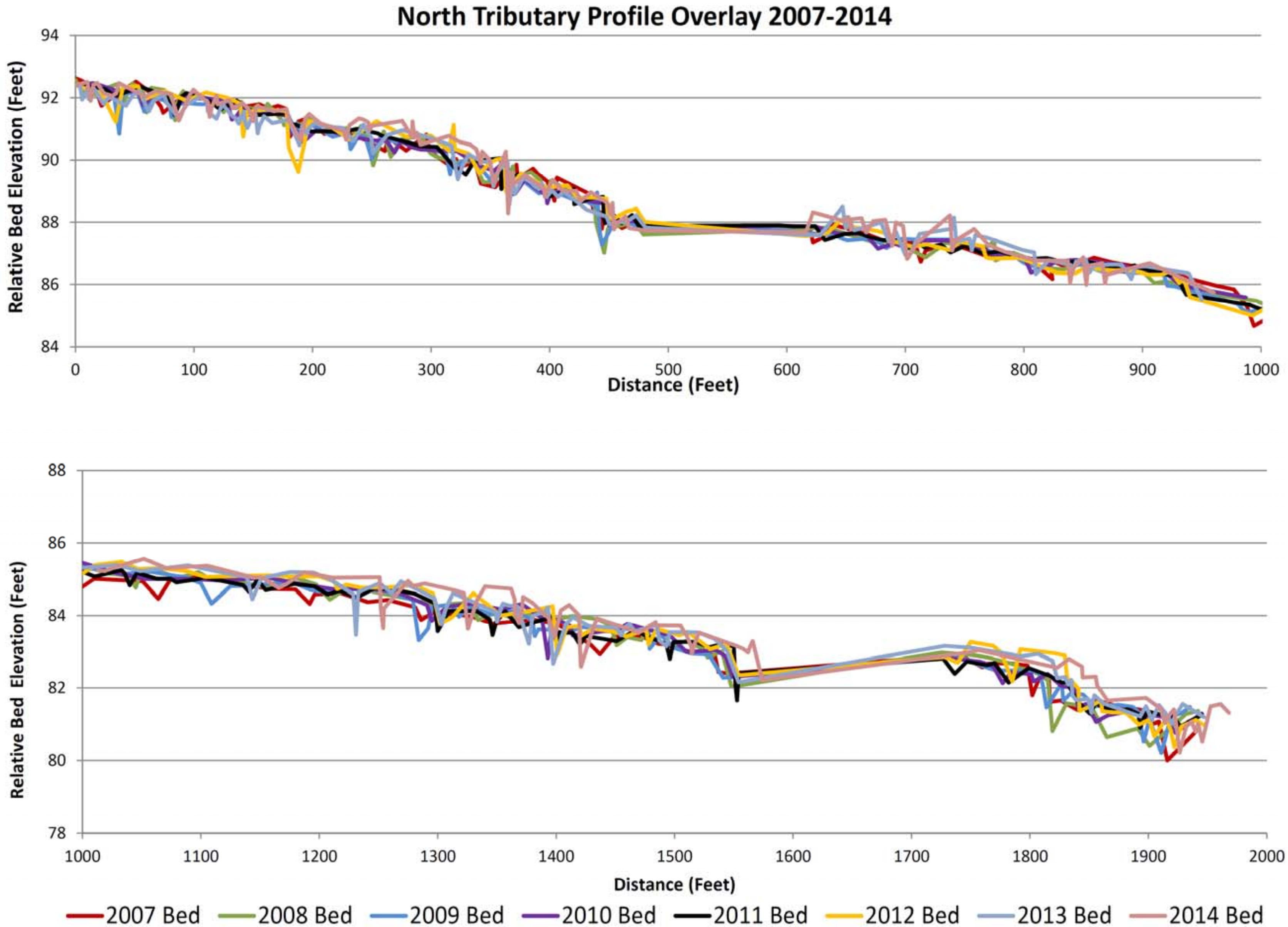

Downstream View


Left Bank View


Right Bank View

| 2014 Geomorphic Assessment Results | |
|---|---|
| Bankfull Width ($W_{bkf}$) (feet) | 19.2 |
| Mean Depth ($d_{bkf}$) (feet) | 0.6 |
| Bankfull Cross-sectional Area ($A_{bkf}$) (feet$_2$) | 12.4 |
| Width/Depth Ratio ($W_{bkf}/d_{bkf}$) | 29.7 |
| Width of Flood-prone Area ($W_{fpa}$) (feet) | 30.6 |
| Entrenchment Ratio (ER) = $W_{fpa}/W_{bkf}$ | 1.6 |
| Channel Materials $D_{50}$ (millimeters) | 0.52 |
| Water Surface Slope (S) | 0.003 |
| Sinuosity (K) = stream length/valley length | <1.2 |
| Adjustments? | Sin ↑, ER ↓ |
| **STREAM TYPE** | **F5** |


South Tributary Profile Overlay 2007-2014
Relative Bed Elevation (Feet)
96
94
92
90
88
86
84
Distance (Feet)
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


North Tributary Profile Overlay 2007-2014
Relative Bed Elevation (Feet)
Distance (Feet)
Relative Bed Elevation (Feet)
Distance (Feet)
2007 Bed
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed

# APPENDIX F

# BMP ACRONYMS

# LIST OF ACRONYMS

| | |
|---|---|
| BMP – | best management practice |
| BR – | bioretention |
| BS – | baysaver (hydrodynamic structure) |
| DP – | dry pond |
| DPW – | department of public works |
| DW – | dry well |
| EDSD – | extended detention structure, dry |
| EDSW – | extended detention structure, wet |
| ESD MB – | environmental site design, micro bioretention |
| ESD PERMP – | environmental site design, permeable pavers |
| ESD – | extended structure dry |
| ESD SGW – | environmental site design, subsurface gravel wetland |
| IB – | infiltration basin |
| IT – | infiltration trench |
| ITPE – | infiltration trench, partial exfiltration |
| SW – | swale |
| USG – | underground storage |
| WP – | wet pond |