Assessment of the biological health of streams on the Patuxent Research Refuge within Anne Arundel County: Results from Round 2 of the Anne Arundel County Biological Monitoring Program

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I. Introduction. In 2003, the Anne Arundel County Office of Environmental & Cultural Resources (now the Department of Public Works, Watershed Protection and Restoration Program) incorporated physical, chemical, and biological assessments into their stream monitoring program in an effort to document and track changes in the ecological condition of Countywide stream resources. In 2004, a Biological Monitoring and Assessment Program for Anne Arundel County, Maryland was developed by Hill and Stribling with the input of County staff and a technical advisory group comprised of local, State, and Federal government officials, as well as representatives from academia. Under the Countywide Biological Monitoring Program, biology and stream habitat, as well as geomorphological and water quality parameters, are assessed at approximately 240 sites throughout the entire County (i.e., 10 sites per Primary Sampling Unit or PSU) over a 5-year period using a randomized rotating-basin design. Further information describing the Countywide Biological Monitoring and Assessment Program design can be found in Victoria et al (2009).

Anne Arundel County (County) has sought and received permission to perform biological sampling on the streams located within the Patuxent Research Refuge (Refuge), located near Maryland City, Maryland, for the Countywide Biological Monitoring and Assessment Program. This permission was granted with a variety of conditions, including the need to share all data collected with Refuge personnel. The purpose of this brief report is to summarize our findings of the biological conditions within the Refuge during the Round Two (2009 – 2013) sampling years of the Program. In 2009, one site within the Refuge area was sampled for the Little Patuxent River primary sampling unit (PSU). In 2011, nine other sites within the Refuge were sampled for the Upper Patuxent River PSU.

II. Methods. Field data collection was conducted in accordance with the methods described in the Quality Assurance Project Plan (KCI 2011) which are summarized below. Figure 1 shows Round Two sample site locations within the Refuge.

A. Field and Laboratory Methods

1. Site Identification in the Field

Sampled sites were initially chosen using a random sample design. Sites were then located in the field using topographic maps and handheld GPS units for navigation to pre-selected coordinates, which mark the mid-point of each site. A 75-meter segment of stream was measured following the thalweg, and both upstream and downstream ends were flagged and labeled.

2. Benthic Sampling and Processing

At each site, benthic macroinvertebrates were collected from a 75-meter reach by sampling approximately 20 ft^2 of surface area with a D-frame net (595 µm mesh), with an emphasis on the most productive habitat types (e.g., riffles, snags, vegetated banks, sandy bottom) found within the reach. The most productive habitat types, in order of sampling preference include riffles, snags/logs that create a partial dam or are in a run area, undercut banks and associated root mats in moving water, detrital/sand areas in moving water, and clay/peat materials on the banks or bed. Habitats in running waters are also preferred to those in stagnant areas. Samples are primarily collected by jabbing the net into a habitat type (snags, root wads, etc.) to dislodge organisms or by disturbing the

bottom substrate just upstream of the net allowing organisms to wash into the net. Larger surfaces such as logs or cobbles are often scrubbed by hand to further dislodge organisms. All sampled material (including leaf litter, small woody debris, and sediment) was composited in a 595 µm sieve bucket, placed in one or more one-liter sample containers and preserved in 70 - 80% ethanol. Internal and external labels were completed for each container. Samples were tracked on chain-of-custody forms and transported to the laboratory for sorting.

All taxonomic identifications were completed by an outside expert laboratory. Prior to identification, the sample was subsampled down to the target number of bugs needed for a 100 insect assessment (80 to 120 insects, total). Subsamplng of the original sample involved spreading the entire sample on a Caton gridded tray (Caton 1991) with 30 square grids (6-cm each), which allows isolation of physically defined amounts of sample material (leaf litter detritus, sticks, substrate particles) from the total sample and the separation/removal of the organisms from that material. A minimum of four grids were selected at random and sorted to completion until the target number of organisms (100 ± 20%) was reached. If more than 40 organisms are found in the first grid, the original four grids are re-spread on a separate Caton tray and another four grids are then randomly selected for sorting, and consecutive grids are selected until the target number is reached.

3. Benthic Taxonomy

Primary taxonomy on each sample (Boward and Friedman 2000) was performed by the contract laboratory and individual organisms were identified primarily to genus level. In some cases, (e.g., when individuals were early instars or had damaged or missing diagnostic morphological features), identification was left at genus-group, subfamily, or family level. Taxonomic data were received in Excel spreadsheets. Functional feeding group, habit, and tolerance value designations were assigned to each taxon according to Merritt and Cummins (1996), Barbour et al. (1999), and Stribling et al. (1998). The tolerance value assigned to each taxon is based on its ability to survive and reproduce in the presence of chemical pollution, hydrologic alteration, or habitat degradation (Stribling et al. 1998, Bressler et al. 2006).

4. Stream Physical Habitat Assessments Methods

Physical habitat quality was visually assessed at each site using the USEPA Rapid Bioassessment Protocol (RBP; Barbour and Stribling 1994; Barbour et al. 1999). The RBP evaluates 10 parameters that describe instream physical characteristics, channel morphology, and riparian vegetation and stream bank structure. Each parameter was scored as either optimal, suboptimal, marginal, or poor and given a corresponding score based on a 20-point scale (20 = best, 0 = worst), or 10-point scale for individual bank parameters. The following 10 parameters were evaluated:

- pool substrate characterization
- epifaunal substrate/available cover
- pool variability
- sediment deposition
- channel flow status
- channel alteration
- channel sinuosity
- bank stability

- vegetative protection
- riparian vegetative zone width

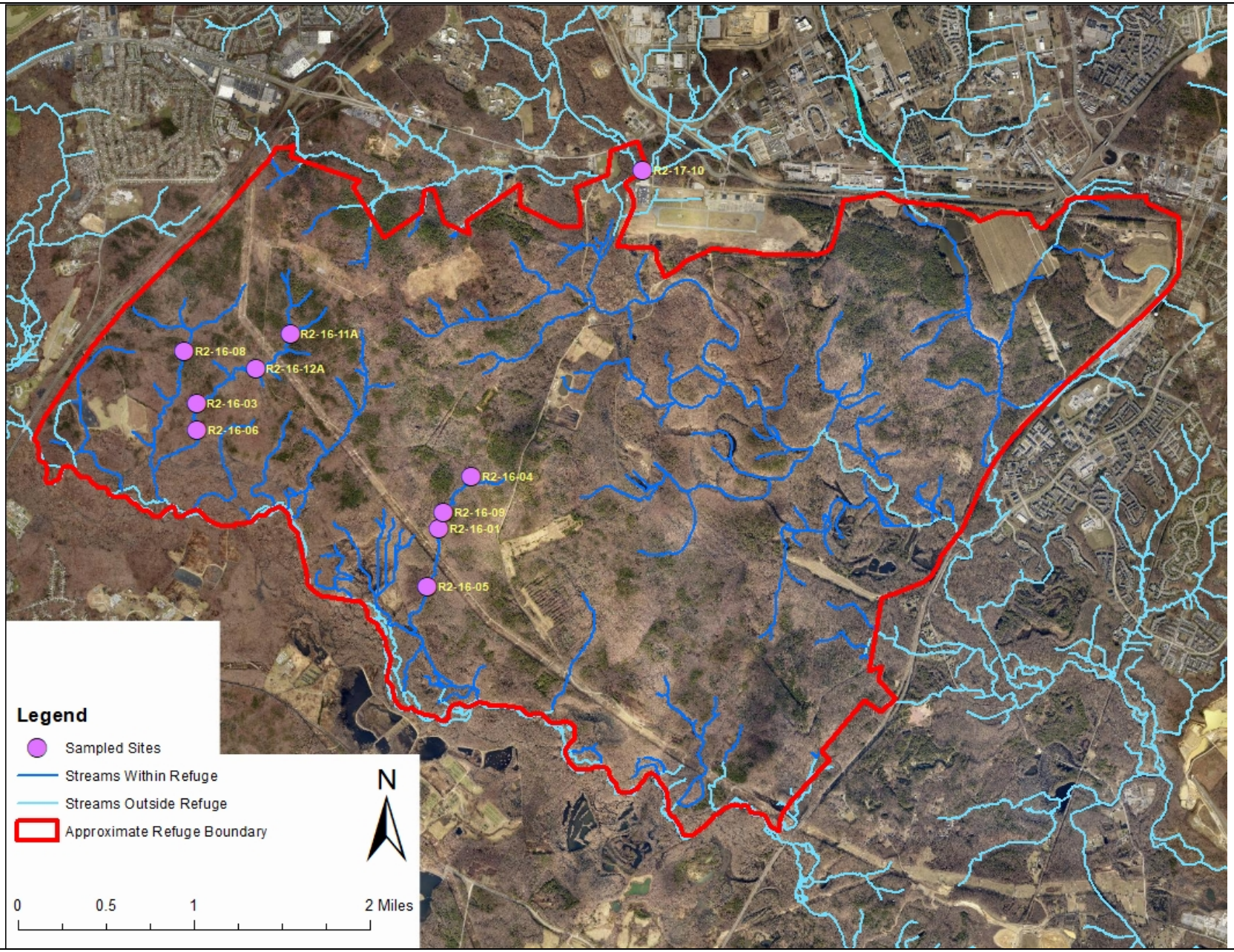

Figure 1. Location of County Round 2 biological sample stations within the Patuxent Research Refuge.

5. *Water Quality*

Specific Conductivity, dissolved oxygen, pH, and temperature were measured at each site using a multiparameter water quality meter, which was calibrated according to the specifications provided by the manufacturer. All calibrations were recorded on a calibration log sheet.

6. *Geomorphic Assessment*

Geomorphic surveys were conducted within the 75-meter segments at each site in the Refuge. Geomorphic assessment measurements included a longitudinal profile survey, a cross section survey, and pebble counts. Data from these measurements were recorded on field forms and used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen 1996). Using basic geomorphic parameters described in greater detail below, stream reaches were classified into one of 42 basic stream types. Details on each of the types can be found in Rosgen (1996) and are briefly described in the Data Analysis section of this report.

The longitudinal profile was performed throughout the 75-meter reach length of each site. The purpose of the longitudinal profile was to identify indicators and elevations of the bankfull discharge (bankfull indicators) and to determine the bankfull water surface slope throughout the reach. Once the bankfull indicators were identified, elevation data on the channel thalweg, water surface, and bankfull indicator were collected, at a minimum, at the upstream and downstream ends of the representative reach on the same bed feature.

The cross section surveys were performed at channel transects that were installed in riffles as close to the midpoint of the 75-meter reach as possible. If no riffles existed within the reach, cross sections were installed in a nearby run or glide within a straight transitional reach (i.e., not in the pool of a meander). Typically, cross section monuments, consisting of iron reinforcement bars hammered to within six inches of the ground surface and topped with yellow caps, are installed at each location. However, due to the potential dangers associated with unexploded ordinances that exist throughout this part of the PWR, no monuments were installed at any of the study sites. The photos at each cross section were located using the GPS.

Each cross section survey consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- changes in topography,
- top of each channel bank,
- elevations of bankfull indicators,
- edge of water during time of survey,
- thalweg or deepest elevation along active channel, and
- depositional and erosional features within the channel.

During the cross section survey, the following measurements and calculations of the bankfull channel that are critical for determining the stream type of each reach also were 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 divided by the 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 divided by bankfull width.
- Sinuosity (K): ratio of the stream length divided by 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. In some cases, this parameter was estimated using GIS digital maps.

To determine the size of channel substrate within the 75-meter reach segments, a Wolman Pebble Count (Wolman 1954) was performed, which consists of stratifying the reach based on its frequency of pools, riffles, runs, and glides. The goal of the pebble count is to measure the intermediate axis of 100 particles across ten transects, or ten particles in each of ten transects across the bankfull width and calculate the median particle size, the D50, of the reach. This value was then used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). The number of transects performed in each bed feature was determined by measuring or visually estimating the percentage of reach length for each type of bed feature. For example, if riffles covered 20 percent of the reach length, then 20 percent of the pebble count, or two transects, were performed in riffles. 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 changes in bed material size from feature to feature, a full pebble count was performed.

B. Data Analysis

1. Data Structure

Benthic macroinvertebrate, physical habitat, and water quality data were entered into MS Excel for processing and analysis, including taxonomic and count data, raw physical habitat scores, the calculation of metric values, physical habitat and water quality rankings, and BIBI values.

2. Physical Habitat

The 10 RBP metric scores are summed to obtain a final habitat score, which is then compared to a reference condition score. However, since there was no RBP data for reference sites within Anne Arundel, a reference condition based on similar studies from Prince George's County, Maryland (Stribling et al. 1999) was used. The values were compared to the maximum possible score (168) for overall percent comparability for each site.

Table 1 provides narrative ratings that correspond to physical habitat quality scores. These scores express the potential of a stream or watershed to support a healthy biological community. Percentages and their narrative ratings were adapted from Plafkin et al. (1989).

Table 1. EPA RBP Scoring

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

Source: Stribling et al. 1999

3. *Benthic Index of Biotic Integrity (BIBI)*

The biological indicator is based on the Index of Biological Integrity (IBI; Karr et al. 1986), which uses characteristics of the benthic macroinvertebrate assemblage structure and function to assess the overall water resource condition. Benthic IBI (BIBI) were developed by the MBSS and calibrated for different geographic areas of Maryland (Stribling et al. 1998). In 2005, MBSS revised the BIBI (Southerland et al. 2005). The revised benthic metrics calculated in this report were those selected and calibrated specifically for Maryland Coastal Plain streams. The seven metrics calculated for each of the benthic macroinvertebrate samples were:

- **Total number of taxa.** The taxa richness of a community is commonly used as a qualitative measure of stream water and habitat quality. Stream degradation generally causes a decrease in the total number of taxa.
- **Number of EPT taxa.** Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally sensitive to degraded stream conditions. A low number of taxa representing these orders is indicative of stream degradation.
- **Number of Ephemeroptera.** Mayflies are generally sensitive to pollution and the number of mayfly genera represented by individuals in a sample can be an indicator of stream conditions, generally decreasing with increasing stress.
- **Percent Intolerant to Urban.** This is the percentage of the benthic sample that is intolerant to urban stressors. This metric decreases with increased stream degradation.
- **Percent Ephemeroptera**. The degree to which mayflies dominate the community can indicate the relative success of these generally pollution intolerant individuals in sustaining reproduction. The presence of stresses will reduce the abundance of mayflies relative to other, more tolerant individuals; although, some mayfly groups, such as several genera of the family Baetidae, are known to increase in numbers in cases of nutrient enrichment.
- **Number of Scrapers.** Specialized feeders such as scrapers tend to be more sensitive species and are thought to be well represented in healthy streams, and tend to decrease with increasing stressors.

- **Percent Climbers.** This is the percentage of the benthic sample living primarily on stem type surfaces. Climbers tend to decrease with increasing stressors.

Table 2. MBSS BIBI Metrics

Metric	Threshold		
	1	**3**	**5**
Number of Taxa	< 14	14-21	>= 22
Number of EPT Taxa	< 2	2-4	>= 5
Number of Ephemeroptera Taxa	< 1	1	>= 2
Percent Intolerant to Urban	<10	10-27	>= 28
Percent Ephemeroptera	< 0.8	0.8-10.9	>= 11
Number of Scraper Taxa	< 1	1	>= 2
Percent Climbers	< 0.9	0.9-7.9	>= 8

Source: Southerland et al. (2005)

Each metric was scored on a 5, 3, 1 basis (5 being the best, 1 being the worst) according to stream health. Metric scoring criteria are listed in Table 2. Overall biological index scores are obtained by summing of the seven metric scores for each site, and dividing by the number of metrics (7). Using the format established by MBSS, the resulting value is then compared to the index scoring criteria for translation into narrative categories (Table 3). An average score for all data collected on the Refuge is presented in the next section.

Table 3. MBSS BIBI Scoring

BIBI Score	Narrative Ranking	Characteristics
4.0 – 5.0	Good	Comparable to reference streams considered to be minimally impacted, biological metrics fall within the upper 50 % 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.

4. Water Quality

Water quality data were compared to Maryland water quality standards for Use I streams. Use I streams have designated uses for water contact recreation and protection of nontidal warm water aquatic life. Table 4 lists the water quality standards for these streams. While there is no formal standard for conductivity, Morgan et al. (2007) have analyzed MBSS data and determined that BIBIs below Fair are associated with conductivity values greater 247 uS/cm. This value is used as an informal criterion for this parameter.

5. 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). This comparison is a crucial step in verifying whether field determined bankfull estimates are appropriate or within a range of known values for drainage basins of similar size. Determination of bankfull indicators can be difficult in potentially impacted streams like those assessed for this report. To be cautious, field staff would typically identify two or more possible topographic features within the cross section as possible bankfull indicators.

Table 4. Maryland COMAR Standards

Parameter	Standard
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	Informal standard: 247 uS/cm
Turbidity (NTU)	Maximum of 150 NTU and maximum monthly average of 50 NTU
Temperature (°C)	Maximum of 32°C (90°F) or ambient temperature, whichever is greater

Source: COMAR 26.08.02.03-3

Occasionally, changes to the field-called bankfull indicator were made in the office if, based upon an inspection of the plotted cross section and photographs, another identified indicator or obvious slope break or other observable feature gave better agreement with the regional relationships that have been well established in this physiographic region. However, no changes to the field-derived call were made if there was no obvious other potential indicator observable in the cross section and only one bankfull indicator was called in the field or if there was reasonable (±15% of the expected value for the drainage area upstream of the sample point) agreement between the original call and the Coastal Plain regional relationships.

After field data were compared to the regional relationships and determined to be accurate estimates of the bankfull channel parameters, the longitudinal profile survey, the cross section survey, and the pebble count data were analyzed for each assessment site. These data were then used to identify each stream reach as one of the stream types categorized by the Rosgen Stream Classification (Rosgen 1996). In this 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 B: Rosgen Stream Classification. As described in Rosgen (1996), the classification system categorizes streams into broad stream types, which are identified by the letters, A, G, F, B, E, C, D, and DA. Additionally, when a numeric code for dominant bed material is added, a total of 41 unique types exist in this scheme.

The most entrenched streams are the A, G, and F channels. In these streams, flood flows are confined to their channels with little relief provided by a floodplain. Type A streams generally occur in narrow high relief valleys and are generally narrow, deep, confined, and entrenched streams with cascading step-pools and low sinuosity. These streams can be very stable if the bed material consists mainly of bedrock or boulders. Type G streams occur in moderate gradient valleys and also are generally narrow and deep. These streams also have step-pool systems, but are generally more sinuous and gully-like than A

streams. G streams are considered unstable and commonly have grade control problems and high bank erosion rates. Type F streams occur in more gentle gradients and have higher width/depth ratios than A and G streams. F streams are generally entrenched in highly weathered materials that make these streams laterally unstable. These streams usually have riffle-pool morphologies, greater sinuosity than A and G streams, and high bank erosion rates (Rosgen 1994; Rosgen 1996).

Type B streams are moderately entrenched. These streams have better floodplain connectivity than the entrenched A, G, and F streams. B streams are found in narrow valleys of moderate relief and generally have very stable planforms, profiles, and banks. Riffles and rapids dominate these channels with intermittent pools (Rosgen 1994; Rosgen 1996).

The least entrenched single thread channels are the type E and C streams. Type E streams are commonly narrow and deep but have very wide and well-developed floodplains. These streams are highly sinuous with well-vegetated banks, a riffle-pool morphology, and low gradients; occurring in broad valleys and meadows. E streams are generally very stable, efficiently conveying flood flows and transporting sediment. Type C streams have wider and shallower channels with well-developed floodplains and very broad valleys. These streams have riffle-pool morphology, point bar depositional features, and well-defined meandering channels (Rosgen 1994; Rosgen 1996).

Type D and DA streams are multi-thread streams (Rosgen 1994; Rosgen 1996). These stream types are very uncommon in the mid-Atlantic and are very rare in Anne Arundel County. None were observed during this assessment and so are not discussed further.

To facilitate the data analysis and classification work, an Excel spreadsheet developed by the Ohio Department of Fish and Game's Division of Soil and Water Conservation specifically designed for Rosgen stream classification was used to analyze the channel data collected and help classify the stream reaches.

Because the goal of the geomorphic assessment component of this study is to support the biological assessments, a full set of geomorphic parameters was not collected. Additionally, not all sites were assessed and classified due to serious violations of this scheme's requirements associated with a particular site's attributes. Therefore, the data have certain limitations that should be noted:

- An assessment reach length of between 10 and 20 bankfull channel widths is typically required for classification purposes. Depending upon the location of random biological site, some reaches met this criterion while others did not. Consequently, while it is unlikely that a change in stream type would occur using a properly sized assessment reach, any classifications reported here should be considered subject to refinement during future reassessment work.
- Typically, stream classification using the Rosgen methodology (Rosgen 1996) is best performed on riffle or step cross sections. Many of the 75-meter reaches assessed in this study did not contain riffles, although transition reaches between meanders were frequently identified and used for cross section placement.
- Pebble count data were collected for stream classification purposes only and are not appropriate for use in hydraulic calculations of bankfull velocity and discharge. This

is particularly the case for the many sand bed channels in the study area, where data on the dune height would be used instead of the 84th percentile particle size, or D84, in hydraulic calculations. Dune height data were not collected for this study.

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

A summary of the stream types identified for the streams in this study is included in Appendix B: Geomorphic Assessment Results.

Table 5. Summary of biological, habitat and geomorphic conditions observed in the Patuxent Research Refuge.

Station	BIBI	BIBI Condition	RBP	RBP Habitat Condition	PSU	Year Sampled	Rosgen Stream Type
R2-16-06	2.43	Poor	149	Supporting	Upper Patuxent	2011	E5
R2-16-03	2.71	Poor	155	Comparable to Reference	Upper Patuxent	2011	E5/4
R2-16-04	2.14	Poor	96	Non-supporting	Upper Patuxent	2011	C5b → F5b
R2-16-12A	2.71	Poor	117	Partially Supporting	Upper Patuxent	2011	G5/4c
R2-16-05	1.57	Very Poor	150	Comparable to Reference	Upper Patuxent	2011	E5
R2-16-01	2.14	Poor	161	Comparable to Reference	Upper Patuxent	2011	E5/6
R2-16-09	1.86	Very Poor	167	Comparable to Reference	Upper Patuxent	2011	E5
R2-16-08	3.00	Fair	147	Supporting	Upper Patuxent	2011	F4/5
R2-16-11A	1.86	Very Poor	145	Supporting	Upper Patuxent	2011	G4/5c
R2-17-10	3.00	Fair	98	Non-supporting	Little Patuxent	2009	*ND*
Averages (SD ±)	**2.34 (0.50)**	**Poor**	**139 (26)**	**Comparable to Reference**			

ND = no data

III. Result. Conditions within the Refuge are summarized in Table 5 and Figure 2. Overall, benthic macroinvertebrate populations indicate poor biological health. Eighty percent of sites (8 of 10) had "Poor" or" Very Poor" biological scores. BIBIs ranged from a low of 1.57 at site R2-16-05 to a high of 3.00 at sites R2-16-08 and R2-17-10.

Habitat scores show good quality habitat throughout the Refuge. Approximately 70% were judged as having "Comparable to Reference" or "Supporting" habitat conditions. Only two sites were judged "Non-supporting," the lowest category in the ranking scheme.

Of the sites assessed in the Refuge, Rosgen classification was performed at nine locations, with one site (R2-17-10) not classified due to a clear manipulation of channel form associated with extensive bank and bed stabilization. Five of nine were classified as E type streams, two of nine were classified as either G or B types streams, while the two remaining sites were classified as an F type stream. The assessment reaches had mostly sand-dominated bottoms.

Water chemistry conditions are summarized in Table 6. The sites showed no serious impairments in dissolved oxygen, temperature, or conductivity. Dissolved oxygen values were above 5 mg/L at for all samples. No temperature values exceeded the acceptable

maximum value of 32° C. While there is no state standard for this parameter, conductivity values were also in an acceptable range for streams in the Coastal Plain based upon the best professional judgment of the authors, although measurement trended toward the lower range (~100µS/cm) of acceptable values (9 of 16 <100µS/cm).

For pH, the all sites average at 4.88 was much lower than the minimum of 6.5 associated with State criteria, with a total of 9 of 10 sites below this critical value. A total of 90% were below 5.5, a value typically associated with stress in fish populations. The only site above the 6.5 threshold was R2-17-10, which had a pH value of 7.28.

Table 6. Summary of water quality observations at biological sample stations.

Parameter (units)	**Average (SD±)**	**Minimum-Maximum**	**% Observations Exceeding COMAR Standards**
Dissolved Oxygen (mg/L)	8.59 (1.95)	5.58-10.90	0
Specific Conductivity (µS/cm)	211.36 (492.19)	46.6-1612	Not Applicable
Temperature (deg, C)	13.36 (2.06)	9.7-16.7	10
pH (units)	4.88 (0.90)	4.2-7.28	90

IV. Conclusions. The last assessment of the Refuge by the Program reported similar results as reported here for Round 2 (Victoria and Markusic 2009). The mean BIBI was higher in 2009 (2.56 ±0.63 versus 2.34 ±0.50), but using statistical methods developed by MBSS (Southerland et al. 2005) to evaluate changes in mean BIBI scores over time, there is no significant difference between these two scores, although the scoring trend appears to be downward. In this summarization of Round 2 biological data, conditions within Refuge streams, as measured by the BIBI, appear moderately to remain moderately impaired and have not changed significantly compared to conditions observed in 2009. The sites were dominated by tolerant invertebrates like amphipods and midges. Some stoneflies and blackflies were also observed at these sample points. See Appendix B for details on the specific invertebrates found during this work.

Water quality conditions described for these stations were nearly identical to those reported in Victoria and Markusic (2009). Dissolved oxygen, conductivity, and temperature were very similar to each other. Mean conductivity was higher in recent sampling versus past work (~2ll µS/cm versus ~74 µS/cm), but that difference can be attributed to a single high value collected at the most urbanized station assessed (~30% impervious). Regarding pH, Victoria and Markusic (2009) reported very low values in the Refuge and called for conformation of these values and possible correction of the underlying cause, if possible. The mean pH reported by Victoria and Markusic (2009) was 5.40±1.53 while 4.88±0.90 was observed during this work. Crunkelton et al. (2011), however, state in their report that the Primary Sampling Unit containing Refuge property is underlain by acidic soil types, which they suggest might be a possible cause of these low values, but they did not rule out anthropogenic factors as a contributing factor. So

while it is possible that these low pH values represent the natural conditions of streams in this part of the Refuge, the underlying cause would need to be determined before a firm conclusion about how typical or not such values are for this area.

Generally, habitat and biological community conditions tend to be related. The quality of reach habitat conditions dictates the level of potential biological health that a particular site can achieve, all other factors being equal. In essence, this means that sites with "Good" BIBI scores tend to be associated with "Comparable" habitat, those with "Fair" BIBIs scores tend to have "Supporting" habitat, and so on.

When biological community health and habitat conditions do not correlate well, it is a possible indicator of human impacts, which tend to manifest themselves in two basic ways. First, when biological conditions are better than expected for the habitat quality observed (i.e. - a BIBI of "Good" and a habitat rating of "Partially Supporting" or "Non-supporting"), nutrient enrichment from agricultural activities or other sources is often suspected. Such enrichment can cause indirect, detrimental changes in the ecological conditions of a stream system. For example, mild eutrophication can alter stream food-webs such that some invertebrate groups are favored over others, resulting in a loss of biodiversity (Dang et al. 2009, Evans-White et al. 2009). While such condition changes can shift some metrics favorably (e.g., increasing total taxa observed), these changes can be indicative of a stream system out of balance. Conversely, when biological conditions are worse than expected for the observed habitat quality (i.e.- a BIBI of "Poor" and a habitat rating of "Comparable to Reference" or "Supporting"), then pollutant impacts, excessive high flow conditions, geomorphic instability, or some other stressor might be the causative agent.

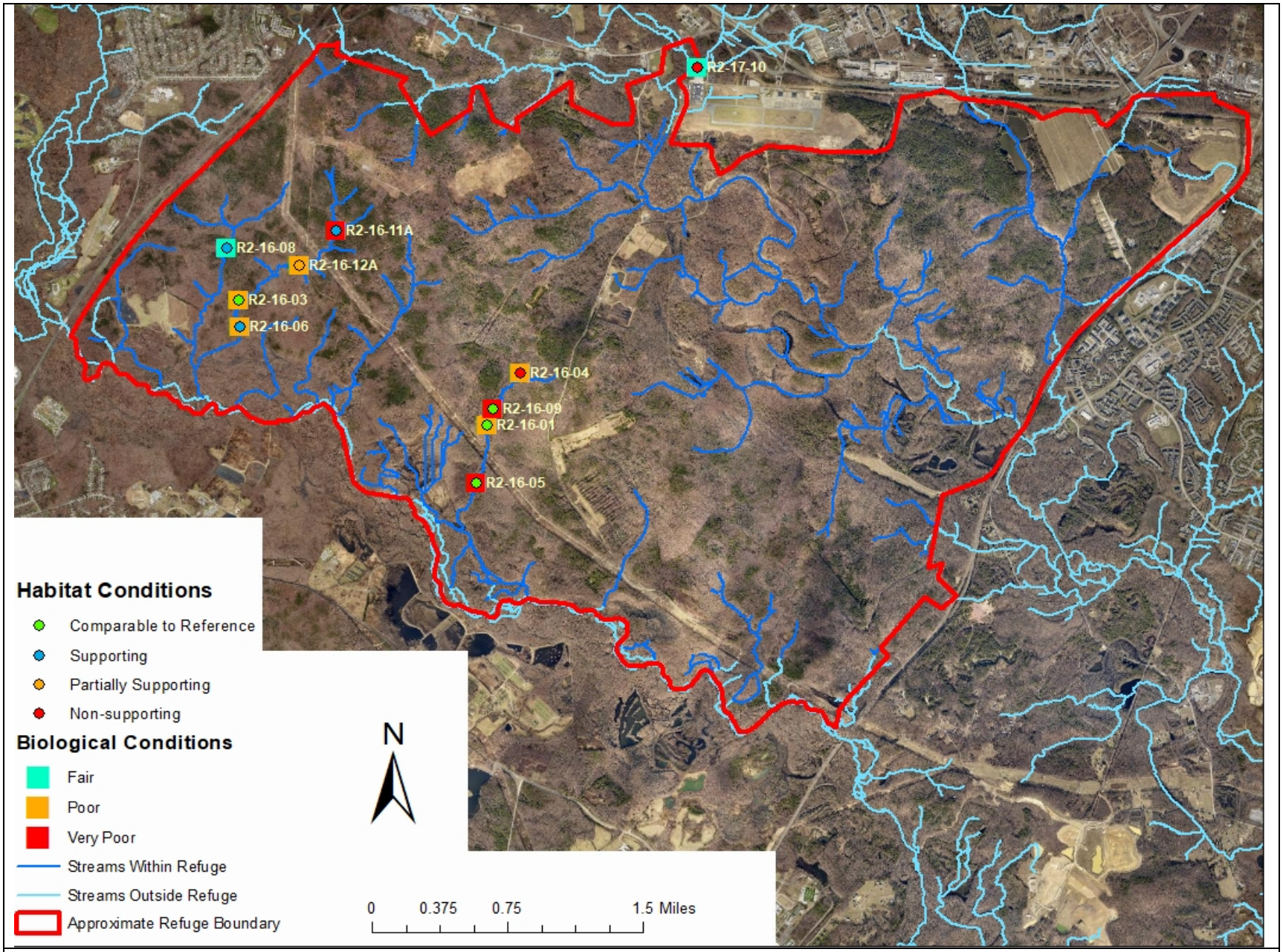

Figure 2. Biological and habitat conditions observed within the Refuge.

This relationship is explored in Table 7. Sites R2-16-01, R2-16-03, R2-16-05, R2-16-09, R2-16-06, and R2-16-11A show more impairment in their biological communities than would be expected from the available habitat characterized during this assessment. Specific impacts to water quality within the upstream drainage areas, such as contaminant inputs from any agricultural or landscaping activities, should be investigated.

Sites R2-16-04 and R2-17-10 show slightly better benthic communities than their habitat assessment would indicate; both sites had Non-Supporting RBP scores.

Two sites, R2-16-08 and R2-16-12A appear to have biological communities indicative of their supporting habitat.

Table 7. Comparison of sample site biological scores to EPA RBP habitat condition.

EPA RBP Habitat Scores	BIBI Score			
	Good	Fair	Poor	Very Poor
Comparable to Reference			R2-16-01 R2-16-03	R2-16-05 R2-16-09
Supporting		R2-16-08	R2-16-06	R2-16-11A
Partially Supporting			R2-16-12A	
Non-Supporting		R2-17-10	R2-16-04	

Green cells contain stations where the biological community was less impaired than the habitat scores would predict.
Orange cells contain stations where biological community matched available habitat.
Pink cells contain stations where the biological community was more impaired than the habitat scores would predict.

Land use and land cover conditions, discussed only briefly here, are thoroughly characterized in Crunkleton et al. (2012) and Victoria et al. (2011). Current dominant land uses and relatively low impervious surface amounts in the Refuge lead to a logical expectation of high quality biological communities at these sites. Nearly every site (9 out of 10) had much less than 10 percent impervious surface contributing to the upstream drainage areas and most were nearly 100 percent forested and have been for many years.

However, it is possible that biological communities in these streams have not reestablished themselves and are still recovering from past impacts associated with this area's use as a military installation or from previous agricultural practices. The impacts of historical land uses have been shown to have severe impacts on current populations of benthic macroinvertebrates (Harding et al. 1998).

Benthic community composition did not track well with geomorphic characteristics for some sites in the Refuge. In fact, one of the least impaired communities observed in the Refuge was found in a stream type typically associated with instability conditions. Site R2-16-08 was rated as in "Fair" health and yet had a F4/5 Rosgen stream type present. As described previously, these types typically have high channel shear stress and generate excessive sediment relative to other stream types. Regardless of the impact on benthic community health, nearly 45% of sites sampled had stream types considered unstable in this classification system. In comparison to the last assessment, this represents an increase in the presence of unstable types, as only 38% of assessed streams classified into unstable categories (Victoria and Markusic 2009). As this stability assessment work was done at probability-based sites in both assessments and there has been an increase of unstable sites, it is possible that significant instability exists broadly in the stream systems draining the Refuge and that stability conditions might be trending in an undesirable direction. However, additional geomorphic assessment work would need to be performed to ultimately determine the amount of potentially unstable stream reaches present.

Based upon the information presented here, the following recommendations are made:

Investigate Potential Water Quality Impacts. All sampled sites, apart from R2-17-10 and R2-16-08, have biological communities depressed relative to available habitat quality; eight out of eight sites that had a Poor or Very Poor score had a pH below the 6.5 standard. Investigations should be conducted upstream of these sites to determine if on-going impairments exist associated with known or unknown activities occurring in the contributing drainage areas.

Evaluate Stream Stability Throughout Refuge. Almost half (40%) of the sites had apparent stability problems associated with their determined stream type, potentially representing a possible increase in overall stream instability within the Refuge. Additional geomorphic assessment is recommended for Refuge streams so that corrective action, as necessary, can be taken to enhance overall stability and sediment delivery to the Patuxent River watershed. The Service's Chesapeake Bay Field Office Stream Assessment Program has the capability to assist the Refuge in performing such an assessment of its streams.

V. References

Barbour, M.T. and J.B. Stribling. 1994. A technique for assessing stream habitat structure. Pp. 156-178, In Proceedings of "Riparian Ecosystems of the Humid U.S. and Management, Functions, and Values." National Association of Conservation Districts. Washington, DC.

Barbour, M.T., J. Gerritsen, B.D. Snyder, J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish, 2nd edition. EPA841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, DC.

Boward, D. and E. Friedman. 2000. Laboratory methods for benthic macroinvertebrate processing and taxonomy. Maryland Biological Stream Survey, Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. CBWP-MANTA-EA-00-6. Annapolis, Maryland. November.

Bressler, D., Paul, M. and J. Stribling. 2005. DRAFT Development of tolerance values for benthic macroinvertebrates in Maryland. Tetra Tech, Inc.

Bressler, D. R., J. B. Stribling, M. J. Paul, and M. A. Hicks. 2006. Stressor tolerance values for benthic macroinvertebrates in Mississippi. Hydrobiologia 573:155-172.

Caton, L.W. 1991. Improving subsampling methods for the EPA “Rapid Bioassessment” benthic protocols. Bulletin of the North American Benthological Society 8(3):317-319.

Crunkleton, M.C., C.R. Hill, and M.J. Pieper. 2011. Aquatic biological assessment of the watersheds of Anne Arundel County, Maryland: 2011. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services (now Watershed Protection and Restoration Program), Annapolis, Maryland. 51 pp., plus Appendices. Available Online: https://www.aacounty.org/departments/public-works/wprp/forms-and-publications/Biological%20Monitoring%20Report/Aquatic_Bioassessment_Annual_Report_Final_2011.pdf

Dang, C.K., S. Harrison, M.M. Sturt, P.S. Giller and M.A.K. Jansen. 2009. Is the elemental composition of stream invertebrates a determinant of tolerance to organic pollution? J. N. Am. Benthol. Soc. 28(4): 778-784.

Evans-White, M.A., W.K. Dodds, D.G. Huggins and D.S. Baker. 2009. Thresholds in macroinvertebrate biodiversity and stoichiometry across water-quality gradients in Central Plains (USA) streams. J. N. Am. Benthol.Soc. 28(4): 855-868.
Flotemersch, J.E., J.B. Stribling, and M.J. Paul. 2006. Concepts and Approaches for the Bioassessment of Non-Wadeable Streams and Rivers. EPA/600/R-06/127. U. S. EPA, Office of Research and Development, Cincinnati, OH

Harding, J.S., E.F. Benfield, P.V. Bolstad, G.S. Helfman and E.B.D. Jones, III. 1998. Stream biodiversity: the ghost of land use past. Proc. Natl. Acad. Sci. 95: 14843-14847.

KCI. 2006. Upper Patuxent River watershed biological monitoring and assessment. Prepared by KCI Technologies, Inc., Hunt Valley, MD, for the Anne Arundel County Office of Environmental and Cultural Resources (now WERS). July 2006. 62 pp.

KCI. 2011. Anne Arundel County Biological Monitoring and Assessment Program. May 2011, Revision 2. Revised by KCI Technologies, Sparks, MD, for the Anne Arundel County Department of Public Works, Annapolis, MD. 46 pp. plus Appendices.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant and I. J. Schlosser. 1986. Assessing biological integrity in running waters. A method and its rationale. Illinois Natural History Survey. Special 36 Publication No. 5. 28 pp.

McCandless, T.L. 2003. Maryland stream survey: Bankfull discharge and channel characteristics of streams in the Coastal Plain hydrologic region. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S03-02.

Merritt, R.W., K.W. Cummins. 1996. An introduction to the aquatic insects of North America. Hunt Publishing Company, Dubuque, Iowa.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22:169-199.

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

Stribling, J.B., B.K. Jessup, J.S. White, D. Boward, M. Hurd, 1998. Development of a Benthic Index of Biotic Integrity for Maryland Streams. Report to Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources. CBWP-MANTA-EA-98-3.

Stribling, J.B., E.W. Leppo, and C. Daley. 1999. Biological Assessment of the Streams and Watersheds of Prince George's County, Maryland. Spring Index Period 1999. PGDER Report No. 99-1. Prince George's County, Department of Environmental Resources, Programs and Planning Division, Largo, MD.

Southerland, M., Rogers, G., Kline, M., Morgan, R., Boward, D., Kazyak, P., Klauda, R., Stranko, S. 2005. New Biological Indicators to Better Assess Maryland Streams. Prepared for Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources.

Tetra Tech, Inc. 1999. Ecological Data Application System (EDAS), Version 3.2. Owings Mills, MD.

Victoria, C and J. Markusic. 2009. Assessment of the biological health of streams on the Patuxent Research Refuge within Anne Arundel County, Maryland. September 2009. Anne Arundel County Department of Public Works, Bureau of Engineering, Watershed Ecosystem and Restoration Services (now the Watershed Protection and Restoration Program), Annapolis, MD. 31 pp. Available Online: https://www.aacounty.org/departments/public-works/wprp/forms-and-publications/PRR%20Biological%20Condtions%20Summary_final.pdf

Victoria, C.J., J. Markusic, J. Stribling, and B.Jessup. 2011. Aquatic biological assessment of the watersheds of Anne Arundel County, Maryland: 2011. Prepared by the Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services (now Watershed Protection and Restoration Program), Annapolis, Maryland and Tetra Tech, Inc., Center for Ecological Sciences, Owings Mills, MD. 51 pp., plus Appendices. Available Online: https://www.aacounty.org/departments/public-works/wprp/forms-and-publications/Biological%20Monitoring%20Report/Aquatic_Bioassessment_Annual_Report_Final_2009.pdf

Wolman, M.G. 1954. A Method of Sampling Coarse River-bed Material. Transactions of American Geophysical Union 35: 951-956.

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R2-17-10 Little Patuxent Sampling Unit


Upstream


Downstream

Location/Site Access: Located at Tipton Airport private access Rd.
Latitude/Longitude: 39.09013/-76.76623

Land Use Analysis:

Land Use	Acres	% Area
Airport	29.1	4.4
Commercial	208.9	31.8
Forested Wetland	1.1	0.2
Industrial	8.0	1.2
Open Space	135.0	20.6
Transportation	53.9	8.2
Utility	13.2	2.0
Woods	207.4	31.6
Grand Total	**656.6**	**100.0**

Impervious (acres)	Total Area Above site	% Impervious
220.9	656.6	33.6

Results:

- Biological condition – "Fair"
- Habitat scores "Not Supporting" and "Partially Degraded"
- Habitat assessment results indicate poor and fair conditions at this site, which is in agreement with the diverse biological assemblage.
- Bank, channel, pool, and sediment conditions are mostly marginal.
- Conductivity is high.
- Sample dominated by midges (Parametriocnemus, Orthocladius/Cricotopus) and caddisflies (Chimarra)
- Stream type was not identified because it has been highly modified.

Recommendations:

- Protect the riparian area. Naturalize the riparian areas and channel, if feasible. Investigate sources of high conductivity and existence any other pollutants associated with high imperviousness.

R2-17-10 Little Patuxent Sampling Unit

IBI and Metric Scores

Narrative Rating	**Fair**
Overall Index	**3**
Total Taxa Score	5
EPT Taxa Score	5
Ephemeroptera Taxa Score	3
Intolerant Urban % Score	1
Ephemeroptera % Score	3
Scraper Taxa Score	1
% Climbers	3

Calculated Metric Values

Total Taxa	37
EPT Taxa	5
Ephemeroptera Taxa	1
Intolerant Urban %	3.77
Ephemeroptera %	0.94
Scraper Taxa	0
% Climbers	5.66

Taxa List

Ablabesmyia	3
Ancyronyx	2
Argia	1
Caecidotea	1
Caenis	1
Calopteryx	1
Cheumatopsyche	4
Chimarra	10
Corynoneura	2
Crangonyx	1
Dicrotendipes	1
Dubiraphia	1
Hemerodromia	4
Hydrobaenus	1
Hydropsyche	2
Macronychus	1
Microtendipes	1
Neoplasta	1
Orthocladius/Cricotopus	9
Parametriocnemus	16
Paratanytarsus	2
Paratendipes	6
Phaenopsectra	1
Pisidium	1
Polycentropus	1
Polypedilum	2
Prostoma	1
Rheotanytarsus	4
Stegopterna	1
Stenelmis	7
Stenochironomus	1
Sublettea	1
Tanytarsus	3
Thienemanniella	4
Thienemannimyia genus group	5
Tipula	1
Tvetenia	2
Total Individuals	106

Physical Habitat

EPA Rapid Bioassessment

Bank Stability- Left Bank	4	Pool Variability	8
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	3
Channel Alteration	7	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	9	Sediment Deposition	11
Channel Sinuosity	7	Vegetative Protection (Left Bank)	3
Epifaunal Substrate/Available Cover	13	Vegetative Protection (Right Bank)	6
Pool Substrate Characterization	11		

EPA Habitat Score	98
EPA Narrative Ranking	NS

Maryland Biological Stream Survey PHI

Drainage area (acres)	657	Instream Wood Debris	5
Remoteness	13	Bank Stability	10
Shading	90		
Epifaunal Substrate	11		
Instream Habitat	13		

PHI Score	76.57
PHI Narrative Ranking	partially degraded

Water Chemistry

Dissolved Oxygen (mg/L)	10.9	Specific Conductance (µS/cm)	1612
pH	7.28	Temperature (°C)	9.7

Geomorphic Assessments

Rosgen Level II Classification Data

Drainage Area (mi^2)	1.0	Cross Sectional Area (ft^2)	
Bankfull Width (ft)		Water Surface Slope (%)	
Mean Bankfull Depth (ft)		Sinuosity	
Floodprone Width (ft)		D50 (mm)	
Entrenchment Ratio		Adjustments?	
Width to Depth Ratio		**Rosgen Stream Type**	

Classification not performed due to highly altered nature of stream channel.

R2-16-01 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0606967855 **Longitude:** -76.7878588022

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**211.6**
Cover	**Acres**	**% Area**
Developed Land	**8.5**	**4**
Airport	0	0
Commercial	0.4	0.2
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	8.1	3.8
Utility	0	0
Forest Land	**201.9**	**95.4**
Forested Wetland	0	0
Residential Woods	0	0
Woods	201.9	95.4
Open Land	**1.2**	**0.6**
Open Space	1.2	0.6
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2.7	1.3

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- Caecidotea (intolerant isopod) and Psectrocladius (midge) dominated the sample. Scored high for intolerant percent.
- Measured below COMAR standards for pH.
- Sub-optimal instream habitat and epibenthic substrate. Very stable banks with excellent vegetative protection and riparian width.
- Bimodal distribution of substrate (sand/clay).

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is comparable to reference and biological condition is poor, look for problems with water quality and correct, if possible.

R2-16-01 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	34.7
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	6.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Apsectrotanypus	1
Bezzia_Palpomyia	1
Brillia	1
Caecidotea	32
Corethrella	1
Crangonyctidae	3
Crangonyx	1
Hydroporini	1
Micropsectra	1
Natarsia	1
Orthocladiinae	2
Parametriocnemus	1
Paratendipes	1
Podmosta	2
Polypedilum	1
Psectrocladius	20
Pseudorthocladius	1
Simulium	11
Stygobromus	6
Tanytarsus	5
Thienemannimyia_group	8
TOTAL:	**101**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	10	Pool Variability	11
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	16
Channel Sinuosity	9	Vegetative Protection - Left Bank	10
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	10
Pool Substrate Characterization	13		
RBP Habitat Score			**161**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	19	100	Instream Wood Debris	5	75.88
Shading	90	91.34	Instream Habitat	13	98.02
Epifaunal Substrate	12	91.04	Bank Stability	20	100
PHI Score					**92.71**
PHI Narrative Rating					**Minimally Degraded**

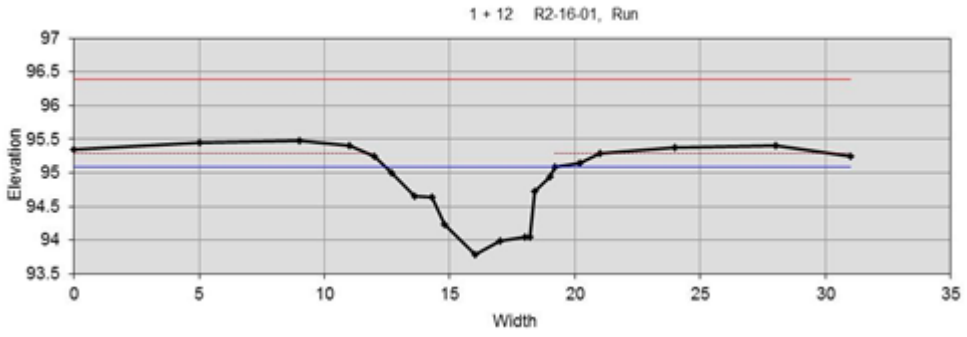
Water Chemistry

Dissolved Oxygen (mg/L)	6.87	pH (SU)	5.17
Turbidity (NTU)	3.39	Specific Conductivity (µS/cm)	55.9
Temperature (°C)	14.2		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.33	Cross Sectional Area (ft^2)	4.98
Bankfull Width (ft)	6.76	Water Surface Slope (%)	0.23
Mean Bankfull Depth (ft)	0.74	Sinuosity	1.14
Floodprone Width (ft)	211	D50 (mm)	0.082
Entrenchment Ratio	31.2	Adjustments?	None
Width to Depth Ratio	9.19	**Rosgen Stream Type**	**E5/6**



R2-16-03 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0710410637 **Longitude:** -76.8134100555

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		312.7
Cover	**Acres**	**% Area**
Developed Land	**30.1**	**9.6**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	11.7	3.7
Utility	18.4	5.9
Forest Land	**278**	**88.9**
Forested Wetland	0	0
Residential Woods	0	0
Woods	278	88.9
Open Land	**4.6**	**1.5**
Open Space	4.6	1.5
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	3	1

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- Leuctra (intolerant stonefly) and Stegopterna (intolerant black fly) dominated the sample. Scored high for intolerant percent.
- Measured below COMAR standards for pH.
- A very sinuous reach with sub-optimal instream habitat and epibenthic substrate. Stable, well-vegetated banks and good riparian width.
- Bimodal distribution of substrate (sand/gravel).

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is comparable to reference and biological condition is poor, look for problems with water quality and correct, if possible.

R2-16-03 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	17
EPT Taxa	3
Ephemeroptera Taxa	0
%Intolerant Urban	72.5
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	0.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**2.71**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphinemura	4
Caecidotea	1
Ceratopogon	1
Helichus	1
Hydroporini	1
Leuctra	43
Libellulidae	4
Lumbricina	1
Lumbriculidae	1
Parametriocnemus	1
Prosimulium	2
Ptilostomis	1
Simuliidae	9
Simulium	7
Stegopterna	28
Thienemannimyia_group	1
Tipula	2
Tvetenia	1
TOTAL:	**109**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	13
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	16	Sediment Deposition	13
Channel Sinuosity	17	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	13	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	11		
RBP Habitat Score			**155**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	19	100	Instream Wood Debris	3	65.55
Shading	95	99.94	Instream Habitat	12	88.47
Epifaunal Substrate	13	94.31	Bank Stability	15	86.61
PHI Score					**89.14**
PHI Narrative Rating					**Minimally Degraded**

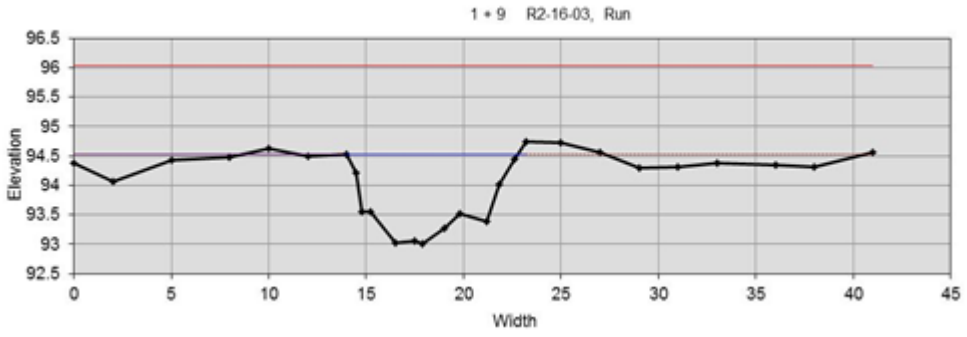
Water Chemistry

Dissolved Oxygen (mg/L)	10.76	pH (SU)	4.83
Turbidity (NTU)	2.8	Specific Conductivity (µS/cm)	46.6
Temperature (°C)	12.83		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.49	Cross Sectional Area (ft^2)	8.97
Bankfull Width (ft)	8.74	Water Surface Slope (%)	0.77
Mean Bankfull Depth (ft)	1.03	Sinuosity	1.56
Floodprone Width (ft)	145	D50 (mm)	1.1
Entrenchment Ratio	16.58	Adjustments?	None
Width to Depth Ratio	8.53	**Rosgen Stream Type**	**E5/4**



R2-16-04 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0649806729 **Longitude:** -76.7844211999

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**51.4**
Cover	**Acres**	**% Area**
Developed Land	**0.9**	**1.7**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	0.9	1.7
Utility	0	0
Forest Land	**49.8**	**97**
Forested Wetland	0	0
Residential Woods	0	0
Woods	49.8	97
Open Land	**0.7**	**1.3**
Open Space	0.7	1.3
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	0.2	0.4

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Partially Degraded"*
- Midges dominated the sample including Tvetenia and Orthocladiinae.
- Measured below COMAR standards for pH.
- Poor instream habitat and epibenthic substrate with woody debris and leaf packs providing habitat for benthos. Moderately unstable bank with a severe headcut in the middle portion of the reach. Good riparian width.
- Stream transitioning from C to F due to a severe headcut and scour pool in middle portion of the reach.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-16-04 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	20
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	12.2
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	4.3

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	3
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Caecidotea	3
Chironomini	3
Crangonyx	1
Culicoides	2
Enchytraeidae	10
Eriopterini	4
Heterotrissocladius	1
Ironoquia	10
Limnophyes	2
Micropsectra	5
Odonata	1
Orthocladiinae	18
Paratendipes	7
Podmosta	2
Pseudorthocladius	6
Simuliidae	1
Stegopterna	3
Stygobromus	1
Thienemannimyia_group	5
Tipula	1
Tubificidae	3
Tvetenia	25
TOTAL:	**114**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	6
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	18	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	6	Sediment Deposition	8
Channel Sinuosity	8	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	5	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	5		
RBP Habitat Score			**96**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Instream Wood Debris	5	91.91
Shading	95	99.94	Instream Habitat	5	68.12
Epifaunal Substrate	5	59.6	Bank Stability	8	63.25
PHI Score					**77.26**
PHI Narrative Rating					**Partially Degraded**

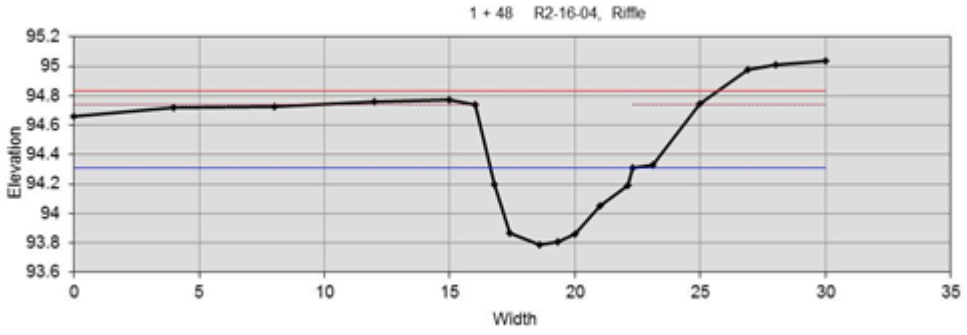
Water Chemistry

Dissolved Oxygen (mg/L)	6.19	pH (SU)	4.27
Turbidity (NTU)	1.52	Specific Conductivity (µS/cm)	54.8
Temperature (°C)	14.53		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.08	Cross Sectional Area (ft^2)	2.02
Bankfull Width (ft)	5.66	Water Surface Slope (%)	3.3
Mean Bankfull Depth (ft)	0.36	Sinuosity	1.09
Floodprone Width (ft)	50	D50 (mm)	0.11
Entrenchment Ratio	8.83	Adjustments?	None
Width to Depth Ratio	15.91	**Rosgen Stream Type**	**C5b→F5b**



R2-16-05 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0559656298 **Longitude:** -76.7890439542

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		377.6
Cover	**Acres**	**% Area**
Developed Land	**27.8**	**7.4**
Airport	0	0
Commercial	1.5	0.4
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	12.4	3.3
Utility	14	3.7
Forest Land	**344.7**	**91.3**
Forested Wetland	0	0
Residential Woods	0	0
Woods	344.7	91.3
Open Land	**2**	**0.5**
Open Space	2	0.5
Open Wetland	0	0
Water	0	0
Agricultural Land	**3.2**	**0.8**
Pasture/Hay	0	0
Row Crops	3.2	0.8
Impervious Surface	**Acres**	**% Area**
Impervious Land	4.2	1.1

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- The black fly, Simulium, and midges, Psectrocladius and Polypedilum, dominated the sample. Scored high for percent climbers because of the presence of Polypedilum.
- Measured below COMAR standards for pH.
- Sub-optimal habitat diversity with an abundance of woody debris. Poor velocity/depth diversity due to multiple beaver dams impacting the reach. Stable, well-vegetated banks and good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is comparable to reference and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-16-05 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	11
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	2.9
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	16.2

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	1
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Caecidotea	2
Chironomini	1
Crangonyctidae	1
Eriopterini	2
Lepidoptera	1
Orthocladiinae	1
Orthocladius	1
Polypedilum	17
Psectrocladius	30
Simulium	46
Stegopterna	1
Thienemannimyia_group	1
Tribelos	1
TOTAL:	**105**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	10	Pool Variability	12
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	17	Sediment Deposition	15
Channel Sinuosity	7	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	14		
RBP Habitat Score			**150**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	20	100	Instream Wood Debris	10	84.12
Shading	75	73.32	Instream Habitat	12	86.54
Epifaunal Substrate	11	81.46	Bank Stability	20	100
PHI Score					**87.57**
PHI Narrative Rating					**Minimally Degraded**

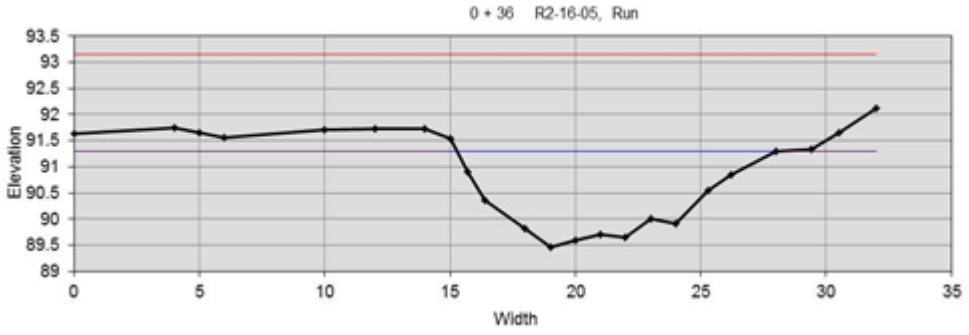
Water Chemistry

Dissolved Oxygen (mg/L)	5.58	pH (SU)	4.29
Turbidity (NTU)	4.21	Specific Conductivity (µS/cm)	53
Temperature (°C)	12.27		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.59	Cross Sectional Area (ft^2)	14.34
Bankfull Width (ft)	12.73	Water Surface Slope (%)	0.92
Mean Bankfull Depth (ft)	1.13	Sinuosity	1.04
Floodprone Width (ft)	88	D50 (mm)	0.097
Entrenchment Ratio	6.91	Adjustments?	None
Width to Depth Ratio	11.31	**Rosgen Stream Type**	**E5**



R2-16-06 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0688470987 **Longitude:** -76.8133717848

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**324.8**
Cover	**Acres**	**% Area**
Developed Land	**30.1**	**9.3**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	11.7	3.6
Utility	18.4	5.7
Forest Land	**290.1**	**89.3**
Forested Wetland	0	0
Residential Woods	0	0
Woods	290.1	89.3
Open Land	**4.6**	**1.4**
Open Space	4.6	1.4
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	3	0.9

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Black flies (Simulium and Stegopterna) dominated the sample. Scored high for intolerant percent.
- Measured below COMAR standards for pH.
- Sub-optimal habitat diversity. Stable, well-vegetated banks and good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is poor, look for problems with water quality and correct, if possible.

R2-16-06 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	4
Ephemeroptera Taxa	0
%Intolerant Urban	50.5
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	1.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphinemura	3
Caecidotea	2
Ceratopogonidae	1
Enchytraeidae	1
Ironoquia	1
Lepidoptera	1
Leuctra	11
Libellulidae	1
Lumbriculidae	1
Micropsectra	1
Orthocladiinae	2
Paranemoura	2
Paraphaenocladius	1
Plecoptera	2
Prosimulium	1
Psectrocladius	5
Rheocricotopus	1
Simuliidae	7
Simulium	32
Stegopterna	34
Tanytarsus	1
TOTAL:	**111**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	12
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	17	Sediment Deposition	14
Channel Sinuosity	14	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	13		
RBP Habitat Score			**149**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	18	96.93	Instream Wood Debris	4	68.07
Shading	95	99.94	Instream Habitat	11	82.53
Epifaunal Substrate	11	82.44	Bank Stability	15	86.61
PHI Score					**86.09**
PHI Narrative Rating					**Minimally Degraded**

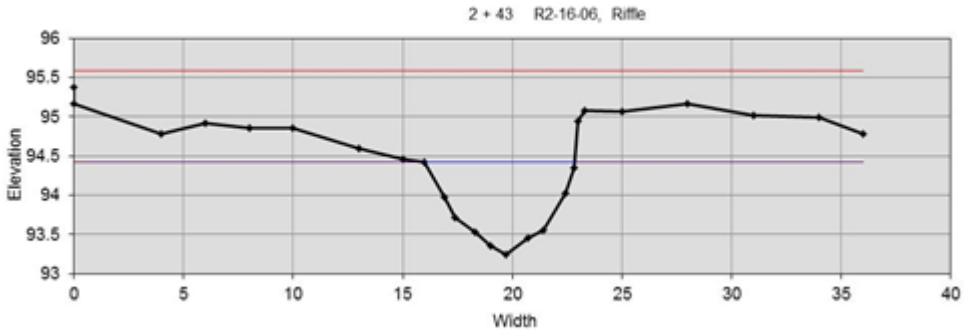
Water Chemistry

Dissolved Oxygen (mg/L)	10.15	pH (SU)	4.81
Turbidity (NTU)	3.76	Specific Conductivity (µS/cm)	47
Temperature (°C)	11.1		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.51	Cross Sectional Area (ft^2)	5.11
Bankfull Width (ft)	6.82	Water Surface Slope (%)	0.1
Mean Bankfull Depth (ft)	0.75	Sinuosity	1.27
Floodprone Width (ft)	130	D50 (mm)	0.32
Entrenchment Ratio	19.05	Adjustments?	None
Width to Depth Ratio	9.11	**Rosgen Stream Type**	**E5**



R2-16-08 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.075369021 **Longitude:** -76.8146504384

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**295.2**
Cover	**Acres**	**% Area**
Developed Land	**26**	**8.8**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	10.2	3.5
Utility	15.8	5.3
Forest Land	**268.6**	**91**
Forested Wetland	0	0
Residential Woods	0	0
Woods	268.6	91
Open Land	**0.7**	**0.2**
Open Space	0.7	0.2
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	3.1	1

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Simulium (black fly) and Psectrocladius (midge) dominated the sample. Scored high for percent climbers because of the presence of Polypedilum (midge).
- Measured below COMAR standards for pH.
- Most habitat parameters received sub-optimal scores. Incised reach with areas of active bank erosion; however, banks are well vegetated with good riparian width.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-16-08 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	26
EPT Taxa	6
Ephemeroptera Taxa	0
%Intolerant Urban	61.3
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	0.9

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**3**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amphinemura	45
Bezzia_Palpomyia	4
Caecidotea	1
Ceratopogonidae	1
Chironomidae	1
Diplectrona	1
Enchytraeidae	1
Ironoquia	1
Leuctra	9
Lumbricina	2
Lumbriculidae	6
Musculium	1
Parametriocnemus	4
Prosimulium	2
Pycnopsyche	1
Rheocricotopus	3
Rheotanytarsus	1
Simuliidae	4
Simulium	5
Stegopterna	7
Stempellinella	1
Thienemannimyia_group	1
Tribelos	1
Tubificidae	2
TOTAL:	**105**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	13
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	10
Channel Sinuosity	20	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	12		
RBP Habitat Score			**147**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Instream Wood Debris	3	66.2
Shading	95	99.94	Instream Habitat	13	94.61
Epifaunal Substrate	14	100	Bank Stability	10	70.71
PHI Score					**84.47**
PHI Narrative Rating					**Minimally Degraded**

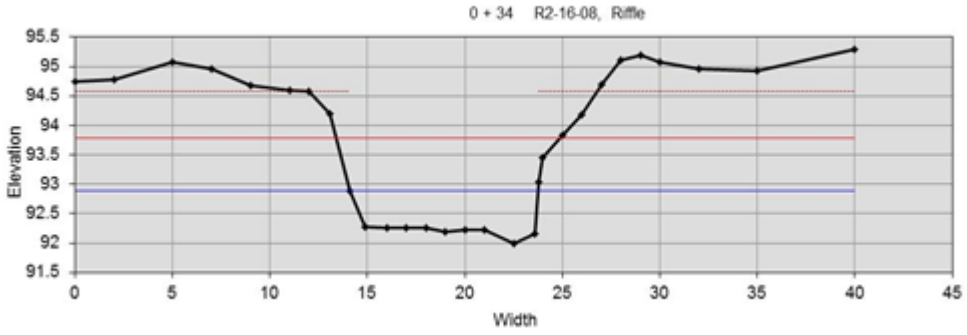
Water Chemistry

Dissolved Oxygen (mg/L)	9.3	pH (SU)	5
Turbidity (NTU)	5.42	Specific Conductivity (µS/cm)	65.1
Temperature (°C)	12.63		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.46	Cross Sectional Area (ft^2)	6.37
Bankfull Width (ft)	9.67	Water Surface Slope (%)	0.69
Mean Bankfull Depth (ft)	0.66	Sinuosity	1.47
Floodprone Width (ft)	11.48	D50 (mm)	2.6
Entrenchment Ratio	1.19	Adjustments?	None
Width to Depth Ratio	14.68	**Rosgen Stream Type**	**F4/5**



R2-16-09 Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0620109226 **Longitude:** -76.7873252399

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		203.8
Cover	**Acres**	**% Area**
Developed Land	**8.5**	**4.2**
Airport	0	0
Commercial	0.4	0.2
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	8.1	4
Utility	0	0
Forest Land	**194**	**95.2**
Forested Wetland	0	0
Residential Woods	0	0
Woods	194	95.2
Open Land	**1.2**	**0.6**
Open Space	1.2	0.6
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2.7	1.3

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- Psectrocladius (midge) and Caecidotea (intolerant isopod) dominated the sample. Scored high for intolerant percent.
- Measured below COMAR standards for pH.
- Sub-optimal instream habitat and epibenthic substrate with abundant rootwads/woody debris providing stable habitat. Very stable banks with excellent vegetative protection and riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is comparable to reference and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-16-09 Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	10
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	31.3
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	1

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Caecidotea	31
Ceratopogonidae	1
Crangonyctidae	5
Crangonyx	1
Eukiefferiella	1
Libellulidae	1
Orthocladiinae	2
Paratendipes	1
Psectrocladius	42
Ptilostomis	1
Simulium	3
Thienemannimyia_group	10
TOTAL:	**99**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	10	Pool Variability	10
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	16
Channel Sinuosity	14	Vegetative Protection - Left Bank	10
Epifaunal Substrate/Available Cover	13	Vegetative Protection - Right Bank	10
Pool Substrate Characterization	14		
RBP Habitat Score			**167**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	19	100	Instream Wood Debris	7	82.23
Shading	95	99.94	Instream Habitat	12	92.86
Epifaunal Substrate	13	97.1	Bank Stability	20	100
PHI Score					**95.35**
PHI Narrative Rating					**Minimally Degraded**

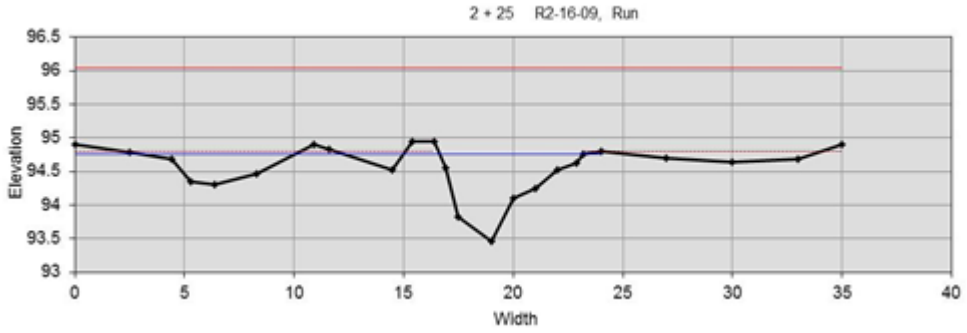
Water Chemistry

Dissolved Oxygen (mg/L)	7.5	pH (SU)	4.2
Turbidity (NTU)	2.42	Specific Conductivity (µS/cm)	57
Temperature (°C)	14.53		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.32	Cross Sectional Area (ft^2)	4.1
Bankfull Width (ft)	6.56	Water Surface Slope (%)	0.61
Mean Bankfull Depth (ft)	0.63	Sinuosity	1.17
Floodprone Width (ft)	132	D50 (mm)	0.15
Entrenchment Ratio	20.13	Adjustments?	None
Width to Depth Ratio	10.48	**Rosgen Stream Type**	**E5**



R2-16-11A Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0767777897 **Longitude:** -76.8034434742

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**132.9**
Cover	**Acres**	**% Area**
Developed Land	**4.5**	**3.4**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	4.5	3.4
Utility	0	0
Forest Land	**123.7**	**93.1**
Forested Wetland	0	0
Residential Woods	0	0
Woods	123.7	93.1
Open Land	**4.6**	**3.5**
Open Space	4.6	3.5
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	1.5	1.2

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Stegopterna (intolerant black fly) and Leuctra (intolerant isopod) dominated the sample. Scored high for intolerant percent.
- Measured below COMAR standards for pH.
- Marginal to sub-optimal habitat diversity with moderately stable banks. Good vegetative protection and excellent riparian width.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-16-11A Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	10
EPT Taxa	4
Ephemeroptera Taxa	0
%Intolerant Urban	90.8
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	0

Calculated Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	1
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Bezzia_Palpomyia	2
Caecidotea	1
Enchytraeidae	1
Leuctra	29
Lumbricina	2
Nemouridae	5
Rhyacophila	2
Simuliidae	4
Simulium	2
Stegopterna	71
Wormaldia	1
TOTAL:	**120**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	10
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	15	Sediment Deposition	12
Channel Sinuosity	14	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	11		
RBP Habitat Score			**145**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Instream Wood Debris	2	72.28
Shading	90	91.34	Instream Habitat	10	86.14
Epifaunal Substrate	11	88.26	Bank Stability	14	83.67
PHI Score					**83.74**
PHI Narrative Rating					**Minimally Degraded**

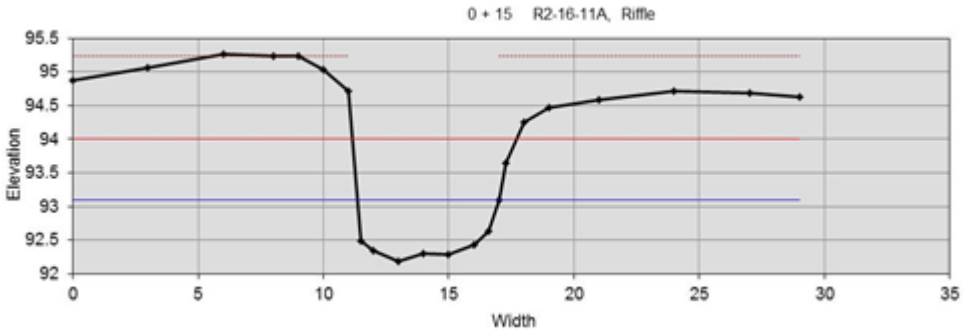
Water Chemistry

Dissolved Oxygen (mg/L)	8.52	pH (SU)	4.43
Turbidity (NTU)	1.16	Specific Conductivity (µS/cm)	70.7
Temperature (°C)	15.1		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.21	Cross Sectional Area (ft^2)	4.02
Bankfull Width (ft)	5.64	Water Surface Slope (%)	0.99
Mean Bankfull Depth (ft)	0.71	Sinuosity	1.32
Floodprone Width (ft)	6.55	D50 (mm)	3.2
Entrenchment Ratio	1.16	Adjustments?	None
Width to Depth Ratio	7.9	**Rosgen Stream Type**	**G4/5c**



R2-16-12A Upper Patuxent Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.0739002174 **Longitude:** -76.8071398371

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**207.4**
Cover	**Acres**	**% Area**
Developed Land	**22.9**	**11.1**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	9	4.3
Utility	14	6.7
Forest Land	**179.8**	**86.7**
Forested Wetland	0	0
Residential Woods	0	0
Woods	179.8	86.7
Open Land	**4.6**	**2.2**
Open Space	4.6	2.2
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2.6	1.2

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Stegopterna and Simulium (black flies) and Leuctra (intolerant stonefly) dominated the sample. Scored high for EPT taxa and intolerant percent.
- Measured below COMAR standards for pH.
- Most habitat parameters received marginal to sub-optimal scores. Over widened channel with moderately unstable banks.
- Bimodal distribution of substrate (sand/gravel).

Recommendations:

- Buffer enhancement.

R2-16-12A Upper Patuxent Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	12
EPT Taxa	5
Ephemeroptera Taxa	0
%Intolerant Urban	69.4
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	1.8

Calculated Metric Scores

Total Taxa	1
EPT Taxa	5
Ephemeroptera Taxa	1
Intolerant Urban %	5
Ephemeroptera %	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**2.71**
BIBI Narrative Rating	**Poor**

Taxa	Count
Calopteryx	1
Diplectrona	1
Leuctra	38
Micropsectra	1
Parachaetocladius	1
Podmosta	2
Rhyacophila	1
Simuliidae	9
Simulium	20
Stegopterna	33
Stenelmis	2
Thienemannimyia_group	1
Wormaldia	1
TOTAL:	**111**

Physical Habitat Assessment

RBP Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	9
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	11	Riparian Vegetative Zone Width- Right Bank	5
Channel Flow Status	14	Sediment Deposition	12
Channel Sinuosity	10	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	9		
RBP Habitat Score			**117**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Instream Wood Debris	7	82.03
Shading	95	99.94	Instream Habitat	10	81.58
Epifaunal Substrate	11	85.36	Bank Stability	12	77.46
PHI Score					**76.45**
PHI Narrative Rating					**Partially Degraded**

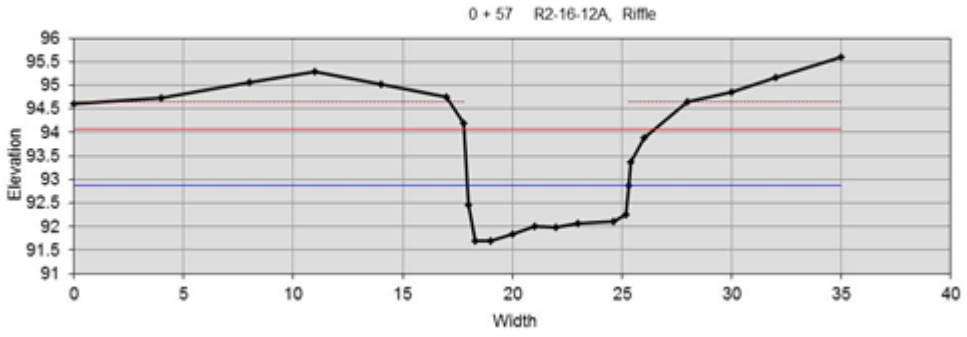
Water Chemistry

Dissolved Oxygen (mg/L)	10.08	pH (SU)	4.61
Turbidity (NTU)	1.56	Specific Conductivity (µS/cm)	51.5
Temperature (°C)	16.7		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.32	Cross Sectional Area (ft^2)	6.61
Bankfull Width (ft)	7.35	Water Surface Slope (%)	0.86
Mean Bankfull Depth (ft)	0.9	Sinuosity	1.15
Floodprone Width (ft)	8.67	D50 (mm)	0.14
Entrenchment Ratio	1.18	Adjustments?	None
Width to Depth Ratio	8.17	**Rosgen Stream Type**	**G5/4c**



Appendix B: Geomorphic Assessment Results

Station	(mi.^{2})	(ft/ft)	(ft.)	(ft.)	(ft/ft)	(ft.^{2})	(%)	(ft/ft)	(ft.)	(mm)	Adj?	Rosgen LI	Rosgen LII
	DA	ER	Wbf	Dbf	W/D	Abf	Slope	Sinuosity	Wfp	D50		Stream Type	Stream Type
R2-16-01	0.33	31.2	6.76	0.74	9.19	4.98	0.23	1.14	211	0.082	None	E	E5/6
R2-16-03	0.49	16.58	8.74	1.03	8.53	8.97	0.77	1.56	145	1.1	None	E	E5/4
R2-16-04	0.08	8.83	5.66	0.36	15.91	2.02	3.3	1.09	50	0.11	None	C	C5b → F5b
R2-16-05	0.59	6.91	12.73	1.13	11.31	14.34	0.92	1.04	88	0.097	None	E	E5
R2-16-06	0.51	19.05	6.82	0.75	9.11	5.11	0.1	1.27	130	0.32	None	E	E5
R2-16-08	0.46	1.19	9.67	0.66	14.68	6.37	0.69	1.47	11.48	2.6	None	F	F4/5
R2-16-09	0.32	20.13	6.56	0.63	10.48	4.1	0.61	1.17	132	0.15	None	E	E5
R2-16-11A	1.58	1.3	14.4	1.1	13	15.9	0.98	1.5	18.6	13	None	F	F4
R2-16-12A	0.32	1.18	7.35	0.90	8.17	6.61	0.86	1.15	8.67	0.14	None	G	G5/4c
R2-17-10	1.0	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Average	**0.57**	**11.82**	**8.74**	**0.81**	**11.15**	**7.60**	**0.94**	**1.27**	**88.31**	**1.96**			
SD	**0.43**	**10.54**	**3.01**	**0.25**	**2.80**	**4.68**	**0.93**	**0.19**	**71.14**	**4.22**			
Var	**0.18**	**111.19**	**9.07**	**0.06**	**7.85**	**21.89**	**0.87**	**0.04**	**5060.76**	**17.84**			

See Rosgen (1996) for any additional explanation needed concerning these data. * = estimated value.
DA = Drainage area.
ER = Entrenchment Ratio.
Wbf = width of the bankfull channel.
Dbf = *Mean* depth of the bankfull channel.
W/D = width to depth ratio of the bankfull channel.
Abf = cross sectional area of the bankfull channel.
Slope = water surface slope of the assessment reach.
Sinuosity = stream channel distance divided by the valley distance.
Wfp = width of the floodprone area
D50 = median particle size determined in pebble count.
Adj? = notes any parameters that required allowed adjustment for classification purposes.
Rosgen LI Stream Type = the basic stream type classification.
Rosgen LII Stream Type = adds particle size to LI classification