Little Patuxent Watershed Assessment

Comprehensive Summary Report








June 2016

Prepared by:
Anne Arundel County
Department of Public Works
Bureau of Engineering
Watershed Protection and
Restoration Program (WPRP)

In association with:
LimnoTech
Versar

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Under:
NPDES Section II. F – Watershed Assessment and Planning

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1. INTRODUCTION

1.1 PURPOSE AND SCOPE

The Anne Arundel County, Maryland, Watershed Protection and Restoration Program (WPRP) initiated a comprehensive assessment of the Little Patuxent Watershed in the spring of 2012. See Map 1.1 for the location of this watershed. This systematic assessment documents current water quality conditions in the watershed to support and prioritize watershed management and planning decisions and develop a detailed restoration plan for this study watershed. Assessing current conditions helps the County determine where to focus resources for maintaining those water bodies in good condition and for mitigating problems to improve the overall watershed health and quality. The study also fulfills requirements of National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit issued to the County by the Maryland Department of the Environment (MDE). Watershed studies have been completed previously for six of the County's twelve major watersheds.

The scope of the Little Patuxent watershed study included collection of field and stream assessment data and supporting Geographic Information System (GIS) data, followed by analysis and modeling using the County's customized watershed assessment and modeling tools. The data collected as part of this watershed assessment were compiled and stored in the County's GIS-interfaced Watershed Management Tool (WMT). Assessment data stored in the WMT are available for review via the County's Watershed Mapping Application (http://gis-world2.aacounty.org/HTML5Viewer/index.html?viewer=WPRPH5).

The WMT and other analysis tools were used to synthesize the assessment data for further evaluation with:

- Engineering models to evaluate existing and future hydrologic, hydraulic and water quality conditions;
- Statistical models to explore possible correlations between watershed stressors and select watershed health indicators; and
- Rating and prioritization activities to determine ranked stream reaches and subwatersheds for restoration and preservation.

Assessment and modeling efforts were performed collaboratively by County staff, with assistance from their consultants. A Professional Management Team (PMT) comprised of County staff and LimnoTech and Versar project staff and technical advisors provided peer review and input on the County assessments and modeling efforts. Specific watershed goals and recommendations for implementation derived from the PMT meetings are provided in this report.

The County's assessment and modeling efforts and findings are detailed in Sections 2, 3, and 4. Recommended watershed management goals and implementation strategies are described in Section 5. The remainder of this section presents the regulatory context for the assessment and describes the physical setting of the Little Patuxent Watershed.

1.2 REGULATORY AND PLANNING CONTEXT

The regulatory and planning context for the watershed assessment includes state regulatory activities, legislative requirements, County actions, and programs aimed at restoration and preservation of water quality in the Little Patuxent Watershed as well as the Chesapeake Bay watershed.

1.2.1 Total Maximum Daily Load

Section 303(d) of the Clean Water Act requires states to establish water quality standards (WQS), identify water bodies for inclusion on the state "303(d) list" that don't meet these standards, and establish the maximum allowable pollutant load (the total maximum daily load [TMDL]) that would allow the listed water body to meet WQS. The Environmental Protection Agency (EPA) has designated MDE as the regulatory authority in Maryland responsible for this process.

In addition to the TMDLs Maryland has developed, EPA has also published the Chesapeake Bay TMDL. This TMDL identifies the necessary pollution reductions of nitrogen, phosphorus and sediment across Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia and sets pollution limits necessary to meet applicable water quality standards in the Bay and its tidal waters. Discussion associated with the Chesapeake Bay TMDL and "local" TMDLs is presented in the following sub-sections. Map 1.2 identifies each watershed in Anne Arundel County and displays the impairments that have prompted the inclusion of waters on the state 303(d)-listing or an approved TMDL (MDE, 2016).

1.2.1.1 Chesapeake Bay

On December 29, 2010, EPA finalized the Chesapeake Bay TMDL, establishing pollutant reduction goals for nitrogen, phosphorus, and suspended solids for the 92 segments (52 of which are in Maryland) that make up the Chesapeake Bay watershed. The County was given nutrient and sediment allocations for regulated (MS4) and unregulated stormwater discharges, wastewater discharges, and septic systems. Although multiple Bay segments are located within Anne Arundel County (see Map 1.3), stormwater pollutant allocations for nitrogen and phosphorus were provided at the County scale rather than at the watershed scale. For planning purposes at the watershed level, the County is applying the same percent load reduction required for urban stormwater at the County level to each of its watersheds. For total nitrogen, this amounts to a 23% total reduction from the existing conditions load by the 2017 interim target and a 38% load reduction by 2025. For total phosphorus, the interim target load reduction is 39% and the 2025 target load reduction is 65%. For total suspended solids, load allocations have not yet been provided.

To ensure the goals of the TMDL are met, EPA has requested a Watershed Implementation Plan (WIP) be developed along with two-year incremental milestones that allow close tracking and assessment of implementation progress. Anne Arundel County's National Pollutant Discharge Elimination System (NPDES) MS4 permit, become the regulatory mechanism to ensure tracking, verifying, and reporting of progress and compliance with the assigned stormwater or wastewater allocations. Anne Arundel County's WIP was included within the broader State wide plan and has been approved by the EPA. The County's WIP includes strategies and milestones associated with stream restoration, stormwater BMP retrofits, and other programmatic efforts.

1.2.1.2 Sediment TMDL

In the Little Patuxent River watershed, aquatic life assessment scores consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) indicate that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions based on Maryland's biocriteria listing methodology (MDE, 2011). The biocriteria listing methodology assesses the condition of Maryland's 8-digit (MD 8- digit) watersheds by measuring the percentage of sites, translated into watershed stream miles, that are assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5), and then calculating whether this percentage differs significantly from reference conditions (i.e., unimpaired watershed <10% stream miles differ from reference conditions).

To determine whether aquatic life is impacted by elevated sediment loads, MDE's Biological Stressor Identification (BSID) methodology was applied. The BSID analysis for the Little Patuxent River watershed concludes that biological communities are likely impaired due to flow/sediment related stressors. Individual stressors within the sediment parameter grouping that are associated with sediment related impacts and an altered hydrologic regime were identified as being probable causes of the biological impairment. Furthermore, the degradation of biological communities in the watershed is strongly associated with urban land use and its concomitant effects. Implementation of best management practices (BMPs) is expected to take place primarily via MS4 permitting process. MDE has published a stormwater waste load allocation (WLA) for storm sewer systems in Anne Arundel County amounting to a reduction goal of 20.5% of the average annual sediment load to the Little Patuxent River (MDE, 2015).

1.2.2 NPDES

The Anne Arundel County NPDES MS4 permit issued in February 2014 by MDE (MD0068306 (11-DP-3316)) covers all stormwater discharges to and from the MS4 owned and operated by the County. Assessments of the Little Patuxent Watershed have been conducted in fulfillment of these MS4 permit requirements.

- Section III.C.2 – Source Identification. Collecting and verifying urban best management practice facility data including locations and delineated drainage areas.
- Section III.E.3 – Illicit Discharge Detection and Elimination. Reporting illicit discharges and connections to the County during the Physical Habitat Condition Assessment.
- Section III.F – Watershed Assessment and Planning. Developing watershed management plans for all watersheds in Anne Arundel County that:
  - Determine current water quality conditions;
  - Identify and rank water quality problems;
  - Identify all structural and non-structural water quality improvement opportunities;
  - Include the results of visual watershed inspection;
  - Specify how the restoration efforts will be monitored; and
  - Provide an estimated cost and a detailed implementation schedule for the improvement opportunities identified above.
- Section IV.E.2 Watershed Restoration Planning. Implementing restoration efforts to treat 20% of the County's impervious area that is not already treated to the maximum extent practical (MEP) within the five-year permit cycle.
  - Watershed plans developed in conjunction with these requirements will:
    - Include the final date for meeting applicable WLAs and provide a detailed schedule for implementing structural and nonstructural water quality projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;
    - Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;
    - Evaluate and track the implementation of restoration plans through monitoring or modeling to document progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and
    - Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA-approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments.

The current generation of MS4 permits in Maryland include greater emphasis on making progress towards meeting both local and Chesapeake Bay wide TMDL WLAs in association with Watershed Assessment and Planning efforts. This is addressed by the requirement to develop Watershed Restoration Plans that include pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater TMDL WLAs.

Anne Arundel County's current NPDES MS4 permit required an impervious area assessment to be submitted to MDE within one year of permit issuance. The impervious area assessment identified 30,950 impervious acres under the County's MS4 jurisdiction. Of these acres, 1,639 were identified as managed to the maximum extent practical (MEP, i.e., the baseline of managed impervious area) and 29,311 acres identified as either having no stormwater management or only partial management (i.e., the baseline of unmanaged impervious area). This resulted in 20% restoration acreage of 5,862 acres (restoration goal), to be completed by the County on or before February 2019.

The Permit requires the County to perform watershed assessments and to develop restoration plans to meet stormwater WLAs in EPA-approved TMDLs. These restoration plans are also required to address restoration of 20% of the County's impervious area that has little or no stormwater management.

1.3 PHYSICAL SETTING

The Little Patuxent Watershed is one of the twelve major watersheds in Anne Arundel County, Maryland. The watershed is a northern branch of the larger Patuxent River watershed, which is located in the western portion of the County (see Map 1.1). There are a variety of jurisdictions in the watershed, including Fort Meade, the Patuxent Wildlife Refuge, and the US Naval Academy Dairy Farm.

1.3.1 Physiography

The Little Patuxent Watershed is in the Atlantic Coastal Plain Physiographic Province. Approximately 62% of the Little Patuxent Watershed is in the Glen Burnie Rolling Upland District. This landform is an undulating upland with slopes typically less than eight degrees (Maryland Geological Survey, 2008). The remaining portion of the watershed is located in the Crownsville Upland District. The Crownsville Upland District is similar to the Glen Burnie Rolling Upland District, but is somewhat more dissected (Maryland Geological Survey, 2008).

As seen in Maps 1.4 and 1.5, the majority of steep slopes in the Little Patuxent Watershed are in the upstream portion of the watershed and along the main stem of the Little Patuxent.

1.3.2 Soils and Geology

A mix of soils from the four hydrologic groups is present in the Little Patuxent Watershed (see Map 1.6 and Table 1.1) (NRCS, 2012). Approximately 38% of the soils in the Little Patuxent Watershed are classified as hydrologic soil group (HSG) C. These soils have a moderately high runoff potential when thoroughly wet and water transmission through the soil is somewhat restricted.

Table 1.1 - Hydrologic Soil Group

Hydrologic Soil Group	Little Patuxent
A	11%
B	34%
C	38%
D	17%

Hydrologic soil group B accounts for 34% of the soils in the Little Patuxent Watershed. These soils have a moderately low runoff potential when thoroughly wet and water transfer through the soil is unimpeded. HSG A (11%) and D (17%) are also found in the Little Patuxent Watershed. HSG A soils have a low runoff potential when wet and water is transmitted freely through the soil. HSG D soils have a high runoff potential when wet and water movement is very restricted.

The most common soil erodibility class present in the Little Patuxent Watershed is potentially highly erodible land, which can be found in 47% of the watershed (NRCS, 2012). See Table 1.2. Map 1.6 illustrates how these soils are interspersed throughout the watersheds. Soils classified as highly erodible lands are also found throughout the watersheds. These soils represent 27% of the soil in the Little Patuxent Watershed. Not highly erodible land soils are found in 26% of the Little Patuxent Watershed.

Table 1.2 -Soil Erodibility

Soil Erodibility	Little Patuxent
Highly erodible land	27%
Not highly erodible land	26%
Potentially highly erodible land	47%

1.3.3 Surface Water

The Little Patuxent Watershed contains approximately 45 miles of perennial stream reaches and 17 miles of intermittent stream reaches, draining 21 subwatersheds. The 21 subwatersheds range in size from approximately 480 acres to 2,675 acres (see Table 1.3). A map of the subwatersheds including the subwatershed three-digit code and name is presented as Map 1.7.

Table 1.3 - Subwatersheds

Subwatershed Code	Subwatershed Name	Area (acres)
LITTLE PATUXENT		
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1,334
LP4	Rogue Harbor 1	1,902
LP5	Little Patuxent 1	1,158
LP6	Towsers Branch 2	1,013
LP7	Little Patuxent 5	1,701
LP8	Little Patuxent 4	1,096
LP9	Rogue Harbor 2	2,287
LPA	Oak Hill	1,031
LPB	Dorsey Run 6	1,732
LPC	Towsers Branch 3	1,954
LPD	Dorsey Run 4	1,592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1,503
LPG	Crofton Golf	1,690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594
--	TOTAL	27,752

1.3.4 Environmental Features

Environmental features in the Little Patuxent Watershed are presented in Map 1.8. As seen in this map, many sensitive environmental features are found throughout the watershed. The majority of wetlands are located along the Little Patuxent River. Greenways are located throughout the watershed with Ft. Meade as an exception.

1.3.5 Land Cover and Land Ownership

The distribution of land cover in the Little Patuxent Watershed is summarized in Table 1.4. Land covered with woods (approximately 45.9 %) makes up the greatest portion of the Little Patuxent Watershed. Apart from woods, the other large land use/land cover category is open space at 11.8% of the watershed. Map 1.9 represents land cover in the watershed.

Table 1.4 - Land Cover

Land Cover	Little Patuxent Watershed	
	Acres	Percent of Watershed
Airport	66.5	0.2%
Commercial	2,322.9	8.4%
Forested Wetland	52.4	0.2%
Industrial	755.7	2.7%
Open Space	3,273.8	11.8%
Open Wetland	100.2	0.4%
Pasture/Hay	454.0	1.6%
Residential 1/2-acre	154.1	0.6%
Residential 1/4-acre	1,723.0	6.2%
Residential 1/8-acre	2,835.5	10.2%
Residential 1-acre	169.1	0.6%
Residential 2-acre	567.6	2.0%
Row Crops	471.3	1.7%
Transportation	1,178.8	4.2%
Utility	384.1	1.4%
Water	503.5	1.8%
Woods	12,739.5	45.9%
TOTAL	*27,752*	--

The land use and ownership along with their impervious areas are summarized in Table 1.5. The largest ownership types are US Government, Natural Lands within County jurisdiction, and US Fish and Wildlife Service. Of the property owned by the County, the private high density residential and County roads and facilities comprise the largest impervious areas. Map 1.10 depicts impervious surfaces and non-private land ownership.

Table 1.5 - Impervious, Land Use, and WIP Sector Ownership

Land Use and WIP Sector Ownership	Area (acres)	Impervious Cover (acres	Impervious % of Land Cover	% of Total Impervious Cover
LITTLE PATUXENT				
County – Private Commercial	826.4	532.9	64%	12%
County – Private Industrial	535.5	218.7	41%	5%
County – Private Agriculture Lands	222.2	1.3	< 1%	< 1%
County – Private Natural Lands	5,835.7	50.8	< 1%	1%
County – Private High Density Residential	1,883.7	713.1	38%	16%
County – Private Medium Density Residential	1,422.7	354.4	25%	8%
County – Private Low Density Residential	675.4	75.3	11%	2%
County – Private Utility/Transportation	457.3	58.5	13%	1%
County Board of Education	436.0	54.7	13%	1%
County Roads and Facilities	2,928.5	711.0	24%	16%
Maryland State Highway Administration	387.9	159.5	41%	4%
Maryland State Institutional Lands	657.6	88.8	14%	2%
US Fish and Wildlife Service	4,846.1	36.0	< 1%	1%
US Park Service	346.4	58.3	17%	1%
US Government	6,290.9	1,234.0	20%	28%
TOTAL	27,752	4,347.4	16%	-

The Little Patuxent watershed was initially developed in the 1780s. Since then, the watershed has developed at varying level of intensities. Table 1.6 is presented as a “heat map” that displays the rate of new impervious surfaces over each time period. Based on this heat map, it is possible to see that the fastest development in the watershed occurred in the Crofton Golf watershed (LPG) during the 1960-1979 period. In the 2000-2015 time period, Towsers Branch 3 (LPC) has had the highest rate of new development. The development rates in individual subwatersheds have peaked at varying times. In the Towsers Branch 1 (LPC) and Crofton Golf (LPG) subwatersheds, the rates of development reached their maximum in the 1960s and 1970s. Overall, the 1980s and 1990s have the greatest new development rates when compared to other time periods. Land development age and current zoning within the watersheds are shown on Maps 1.11 and 1.12, respectively.

Table 1.6 - Rate of New Development

Subshed	1780 - 1899	1900 - 1919	1920 - 1939	1940 - 1959	1960 - 1979	1980 - 1999	2000 - 2011
LITTLE PATUXENT							
LP0	0	0	0	0	0.157	0	0
LP1	0.005	0.030	0.016	0.159	0.088	0.010	0.006
LP2	0	0.012	0.019	0.064	0.027	2.036	3.038
LP3	0.001	0.012	0.017	1.489	4.615	1.380	0.264
LP4	0.002	0.008	0.004	0.054	0.276	1.101	0
LP5	0	0	0	0.046	0.048	0.007	0
LP6	0.001	0.006	0.133	0.305	0.318	0.828	0.537
LP7	0.001	0	0.083	0.119	0.232	0.979	0.433
LP8	0.002	0.023	0.085	0.038	0.034	0.658	0.638
LP9	0.001	0.011	0.083	0.181	0.535	2.703	1.661
LPA	0	0	0.038	0.041	0.211	0.717	0.179
LPB	0	0	0	0	0	0	0
LPC	0	0.002	0.008	0.087	2.162	5.543	6.432
LPD	0.001	0.014	0.050	0.265	0.393	7.479	2.673
LPE	0	0.021	0.017	0.015	0.068	1.907	4.467
LPF	0	0.005	0.043	0.168	2.662	3.066	1.165
LPG	0	0	0.667	0.041	8.448	2.727	0.552
LPH	0	0	0	0	0	0	0
LPI	0	0	0.051	0.005	2.511	0	0
LPJ	0.015	0	0.001	0.092	0.066	0.295	2.226
LPK	0.008	0.022	0.005	0.850	0.535	0.170	0.113

1. Values represent the number of new impervious acres divided by the number of years in the time period

2. Impervious areas in the right of way were removed from this analysis

2. DATA COLLECTION AND COMPILATION

Field data were collected and compiled to support the County's stream reach and subwatershed condition assessment and rating efforts and to assist in development of the County's Chesapeake Bay TMDL WIP strategy. Field crews verified and classified the Little Patuxent tributary stream network, assessed physical habitat conditions, and collected data on infrastructure, environmental features, road crossing flood potential, and channel geomorphology. This data collection field work was performed from April 2012 to June 2012. Additional existing data were also used to support the County's assessment efforts: bioassessment monitoring results, land use cover, impervious areas, BMP characteristics, septic system impacts, soil characteristics, and various other aquatic and landscape indicators. Each of these data components is discussed in more detail in this section. The discussion is organized by pertinent ecosystem zone, including the tributary streams and their associated riparian areas (Section 2.1) and upland areas (Section 2.2).

2.1 STREAM DATA COLLECTION AND COMPILATION

The following subsections present and summarize the collected and compiled data within the Little Patuxent tributary streams and the adjacent riparian areas. Stream classifications and verification, physical habitat condition assessment, inventory of infrastructure and environmental features, habitat scores, channel geomorphology, road crossing flood potential, bioassessments, and aquatic resource indicators are all reported in detail. This information is crucial for determining the conditions within the tributary streams and for subsequently identifying, formulating, and prioritizing restoration activities and land management decisions to improve stream conditions.

2.1.1 Stream Classification and Verification

A watershed assessment is predicated on an accurate understanding of stream location and character (e.g., perennial, intermittent, ephemeral, underground, wetland, etc.). The actual position, alignment, and character of all tributary streams in the Little Patuxent Watershed were field verified. A stream planimetric dataset based on aerial photography, drainage lines derived from a digital elevation model (DEM), and a geodatabase of storm drain outfalls was used as a guide for directing field assessment and verification efforts. Based on field verification activities, a stream reach GIS layer was constructed representing all of the tributary streams that contribute flow to Little Patuxent River.

Field teams confirmed the location of the stream channel and determined the stream character. Additions to and deletions from the existing stream planimetric dataset were recorded and updated as necessary to match observed field conditions. Modifications to the channel alignment in the dataset were made only when significant inconsistencies were noted. Field teams used best professional judgment to evaluate field indicators of perenniality, including hydrologic indicators (e.g., seeps, leaf litter presence, sediment deposition), geomorphic indicators (e.g., riffle pool sequence, substrate sorting, sinuosity, bankfull bench presence), soil indicators (e.g., redox-morphic features, chroma), and biological indicators (e.g., vegetation, benthic macroinvertebrates).

Collectively in the Little Patuxent Watershed, approximately 181 miles of streams were verified and characterized. Not all stream segments were characterized because of limitations relating to private and federally owned access restrictions, physical barriers, and unsafe site conditions. Of all characterized streams, perennial streams were the most common (45 miles assessed). Ephemeral streams were also widespread (33.9 miles assessed). During the field verification efforts, streams were segmented into individual stream reaches to facilitate subsequent assessment and analysis efforts. Stream reaches were identified and segmented in the field as distinct habitat or geomorphic conditions were encountered. Physical features, such as stream confluences, bridges, and culverts, were also used to sub-divide reaches. A total of 1,169 individual reaches were identified within the Little Patuxent Watershed. The average reach length was approximately 820 feet.

A summary of stream miles and number of reaches by type is presented in Table 2.1. Stream classifications encountered throughout the watersheds are depicted in Map 2.1.

Table 2.1 - Stream Character Types

Type	Little Patuxent Watershed: Number of Reaches	Stream Miles	Percent of Total Stream Miles
Ditch	13	1.4	0.8%
Ephemeral	309	33.9	18.7%
Floodway	5	0.6	0.3%
Intermittent	138	15.4	8.5%
Main Stem	25	20.0	11.1%
Not Assessed	218	48.4	26.7%
Perennial	332	45.0	24.9%
Pipe	22	2.6	1.4%
Pond/Lake	33	4.2	2.3%
SWM	13	1.2	0.7%
Wetland/Marsh	61	8.4	4.6%
TOTAL	**1,169**	**181.1**	**---**

Stream segments were assigned a stream order according to a modified Strahler stream order hierarchy. In this hierarchy, ephemeral and intermittent channels as well as other non-perennial headwater reaches are assigned as zero-order streams. First order streams then generally begin with the first headwater perennial stream encountered. A summary of the stream ordering per subwatershed is presented in Table 2.2. A map of the stream ordering is presented in Map 2.2.

Table 2.2 - Strahler Stream Order Per Subwatershed

Subwatershed	Stream Order Miles						
	0	1st	2nd	3rd	4th	5th	Total
LITTLE PATUXENT WATERSHED							
LP0	33	6	4	0	0	0	43
LP1	19	3	0	0	0	0	22
LP2	48	1	0	8	0	0	57
LP3	26	16	12	0	0	0	54
LP4	52	8	0	0	0	0	60
LP5	29	0	0	0	0	0	29
LP6	14	0	0	0	0	0	14
LP7	16	18	12	2	0	5	53
LP8	28	14	2	0	0	3	47
LP9	47	13	4	6	0	0	70
LPA	35	20	13	0	0	0	68
LPB	67	19	4	0	0	1	91
LPC	43	22	13	0	0	0	78
LPD	30	14	13	0	0	3	60
LPE	24	19	11	4	0	0	58
LPF	48	22	4	1	0	8	83
LPG	42	26	13	16	0	0	97
LPH	15	5	4	0	0	0	24
LPI	87	5	0	0	0	5	97
LPJ	21	10	7	7	0	0	45
LPK	5	14	0	0	0	0	19
TOTAL	**729**	**255**	**116**	**44**	**0**	**25**	**1169**

2.1.2 Physical Habitat Condition Assessment

Physical habitat condition is a widely used measure of the overall health of a stream and its ability to support aquatic life. Healthy physical habitat for aquatic organisms is typically comprised of stable channels and substrates, diverse flow characteristics, and abundant cover and food sources. Natural streams are typically in a state of dynamic equilibrium. However, this equilibrium can be disrupted. Habitat parameters common in healthy streams begin to deteriorate when increased urban and agricultural stressors are introduced. Examples of assessed stream reaches are depicted in Figure 2-1.

A field assessment of in-stream physical habitat conditions was performed for perennial streams by observing and measuring various physical attributes. This work was completed in accordance with the 2003 *Physical Habitat Index for Freshwater Wadeable Streams in Maryland* report developed by Maryland Department of Natural Resources (MDNR) (Paul et al, 2003). Collected habitat assessment parameters included qualitative observations of in-stream and riparian conditions (*i.e.*, fish presence, bacteria or algae presence, aquatic vegetation presence, water clarity and odor, and riparian vegetation character) as well as quantified assessment parameters used to calculate a Maryland Physical Habitat Index (MPHI) score. Data used to support the calculation of the scaled MPHI score for each perennial stream reach included individual scores for remoteness, shading, epifaunal substrate, in-stream habitat,

Figure 2-1 - Examples of Assessed Stream Reaches

Stream Reach in the Crofton Golf Subwatershed (LPG) with Minimally Degraded Habitat Condition

Stream Reach in the Dorsey Run 3 Subwatershed (LP2) with Partially Degraded Habitat Condition

Stream Reach in Towsers Branch 1 Subwatershed (LP3) with Degraded Habitat Condition woody debris and rootwads, and bank stability.

Physical habitat condition assessment reaches were created based on observed changes in habitat conditions along a stream. In the Little Patuxent Watershed, approximately 1.2 miles of perennial stream reaches were not assessed due to access issues or due to individual reach lengths being less than the minimum assessment size requirement (75 meters). For the Little Patuxent Watershed, approximately 44 of the 45 miles of perennial streams were assessed and scored. The aggregate assessed perennial stream length is comprised of 304 individual reaches with an average assessed stream reach length of approximately 760 feet.

Based on the calculated MPHI score, each stream reach is assigned a condition category of "Severely Degraded", "Degraded," "Partially Degraded," or "Minimally Degraded". Standard MPHI category breakpoints used by MDNR are as follows:

- 0 to 50.9 – Severely Degraded
- 51.0 to 65.9 – Degraded
- 66.0 to 80.9 – Partially Degraded
- 81.0 to 100 – Minimally Degraded

For this and previous watershed studies, the County uses a modified breakpoint of 59.9 to 60.0 between the "Degraded" and "Severely Degraded" categories. The result is an effectively more conservative approach that identifies additional reaches for restoration. This modified scoring is carried through in the calculation of MPHI scores per watershed and the calculation of Final Habitat Scores (FHS) for reaches and subwatersheds described in Section 2.1.4.

The average stream-weighted MPHI score for the Little Patuxent Watershed is 79.3, which corresponds to a "Partially Degraded" condition. Approximately 40% of perennial stream miles in the watershed were rated as "Partially Degraded." "Minimally Degraded" streams comprised roughly 48% of the perennial streams, followed by "Degraded" streams at 8%, and "Severely Degraded" at 4%.

A summary of MPHI condition categories by stream mile and number of reaches is provided in Table 2.3. A map of the MPHI conditions throughout the watershed is presented as Map 2.3.

Table 2.3 - Physical Habitat Condition Results, MPHI

MPHI Category	Little Patuxent Watershed		
	Number of Reaches	Stream Miles	Percent of Total Stream Miles
Minimally Degraded	139	21.1	48.2%
Partially Degraded	124	17.4	39.7%
Degraded	25	3.7	8.4%
Severely Degraded	16	1.6	3.7%
TOTAL	304	43.8	---

2.1.3 Inventory of Infrastructure and Environmental Features

Accurately documenting infrastructure and other environmental features observed along streams is very important for the assessment of current conditions. For this reason, fieldwork included an inventory of infrastructure and significant environmental features that were compiled within each perennial reach and associated riparian area. These features included riparian buffer deficiencies, excessive in-stream erosion, stream obstructions, stream crossings, utilities, dump sites, head cuts, and tributary pipes and drainage ditches. Depending on the inventory feature type, the associated impact was scored in the field as “Minor”, “Moderate”, “Severe”, or “Extreme” based on its potential impact on the integrity or health of the stream reach. These impacts were translated to a 0-10 point scale depending on the feature type according to the County’s protocol. Impact scores increase with the level of impact. A full description of the scores and ratings are found in *Field Data Collection Guide for Watershed Studies, Anne Arundel County Department of Public Works* (Anne Arundel County, 2012a). In addition to the impact scores, other quantitative and qualitative data, such as dimension, relative location, composition, and restoration potential were collected for each feature.

These infrastructure and environmental features can be critical to the health of the tributary streams in the watersheds for different reasons discussed below. Examples of environmental and infrastructure features encountered in the study watersheds are depicted in Figure 2-2.

- Intact natural vegetated **stream buffers** provide important terrestrial habitat and shading and also serve to dampen runoff velocities and filter runoff pollutants before they enter a stream. These functions are lost or significantly diminished when stream buffers are removed or compromised by land management decisions.
- Stream **crossings** can vary from a foot bridge with only minor impact on channel stability to a large road crossing that forces a stream into a culvert. Culverted stream

crossings tend to be the most problematic because they can become blocked or clogged by accumulated debris, and because they can act to accelerate stream flow. Stream crossing impacts can include flooding, local bed and bank erosion upstream and downstream of the culvert, and fish passage impediments.

- **Dump sites** are typically comprised of trash or debris dumped in the stream channel or in the riparian area. Toxic pollutants from dumpsites can impact water quality and bulk trash and debris can alter stream hydrodynamics.
- Although channel bed and bank **erosion** occurs naturally as streams work to maintain a state of dynamic equilibrium, excessive erosion can occur due to increased stream velocities associated with development activities that increase imperviousness within the watershed. Channel erosion can deliver excessive pollutants such as sediment and phosphorus downstream, where water quality can be impacted and important habitat for fish spawning and benthic invertebrates can be smothered. Excessive erosion can also threaten the stability of other nearby built infrastructure.
- A **head cut** is an abrupt change or drop in stream channel elevation. Head cuts are often indicators of active channel incision or downcutting. The movement of upstream bed material fills in the low points associated with the head cut, and as a result the head cut migrates upstream until a new grade is established for the entire channel.
- Channel **obstructions** can include natural features like fallen trees as well as man-made features like concrete dams or riprap. These obstructions can partially or completely obscure water flow, which can cause flooding and localized erosion and can impede the passage of fish.
- **Pipes and drainage ditches** are typically associated with stormwater conveyance. Depending on their placement and flow characteristics, pipes and drainage ditches can contribute to water quality impairments and erosion in the receiving streams.
- **Utilities** can include sanitary sewers, storm sewers, water lines, gas lines, and electrical transmission lines (buried or overhead). Impacts from utilities are the most severe when they intersect the stream channel where they can alter stream hydraulics and cause localized erosion.

A summary of the impacts for each infrastructure or environmental feature is presented in Table 2.4 and Table 2.5. The distribution of these features throughout the watershed is presented in Map 2.4. For the Little Patuxent Watershed, riparian buffer impacts and erosion impacts had the highest total cumulative impact score of all the inventory features identified. Riparian buffer impacts were most often associated with encroachment from residential lawns. Erosion impacts were attributed mostly to increases in flow associated with development in the watershed. In some cases, erosion impacts may have been due to local hydraulic modifications (e.g., constrictions from a debris dam or fallen tree). Pipes and drainage ditches that contribute flow and erosive forces to the watersheds' streams were the most numerous of all the features, but had relatively lower cumulative impact scores. The relative abundance of these infrastructure features (i.e., erosion, crossings, deficient buffers, and pipes and ditches) is consistent with more urbanized watersheds like the Little Patuxent. The remaining features (i.e., dump sites, obstructions, utilities, and head cuts) were encountered less frequently, but certainly contributed locally to areas of stream degradation throughout the watershed.

Table 2.4 - Infrastructure and Environmental Feature Impact Scores

Type	Number of Features with Impact Score:				Total Cumulative Impact Score
	Minor	Moderate	Severe	Extreme	
LITTLE PATUXENT WATERSHED					
Buffers	0	135	33	1	916
Crossings	223	29	7	1	636
Dump sites	31	15	0	3	138
Erosion	0	306	107	18	2,459
Obstructions	135	71	0	8	705
Pipes/Ditches	327	42	0	11	332
Utilities	29	5	0	6	143
Head Cuts	---	---	---	---	518.15*
TOTAL	**745**	**603**	**147**	**48**	**5,847.15**

* Head cut impact score corresponds to cumulative height of head cuts
--- Not considered as an impact score for associated feature

Figure 2-2 - Examples of Environmental and Infrastructure Features

Crossing in the Oak Hill Subwatershed (LPA) with Moderate Impact Score

Deficient Buffer in the Crofton Golf Subwatershed (LPG) with Moderate Impact Score

Bank Erosion in the Towsers Branch 2 Subwatershed (LP6) with Moderate Impact Score

Outfall in the Towsers Branch 1 Subwatershed (LP3) with Moderate Impact Score

Washdown from Dumpsite in the Oak Hill Subwatershed (LPA)

Exposed Utility in the Little Patuxent 2 Subwatershed (LP0) with Moderate Impact Score

Table 2.5 - Infrastructure and Environmental Features Per Stream Mile Assessed

Subwatershed	Stream Miles	Number of Inventory Points	Number of Inventory Points Per Stream Mile	Total Cumulative Impact Score	Total Cumulative Impact Score Per Stream Mile
LITTLE PATUXENT WATERSHED					
LP0	1.2	41	33.6	83.5	69.6
LP1	1.0	1	1.0	2	2.0
LP2	4.0	42	10.5	137	34.3
LP3	5.8	192	33.1	490.1	84.5
LP4	2.3	51	22.4	61	26.5
LP5	2.2	42	19.2	0	0.0
LP6	7.2	125	17.4	101	14.0
LP7	6.9	134	19.4	307.9	44.6
LP8	6.8	100	14.8	265.2	39.0
LP9	6.6	225	33.9	199.5	30.2
LPA	6.6	70	10.5	596.25	90.3
LPB	6.6	233	35.1	146	22.1
LPC	8.6	298	34.5	532	61.9
LPD	5.4	182	33.5	547.5	101.4
LPE	8.3	224	27.0	455.7	54.9
LPF	8.5	294	34.7	317	37.3
LPG	3.7	74	20.2	649	175.4
LPH	7.5	89	11.8	186	24.8
LPI	4.0	141	35.4	176.5	44.1
LPJ	2.1	119	55.4	334.5	159.3
LPK	1.2	138	55.2	259.5	216.3
TOTAL	**108**	**2815**	**26.1**	**5847.2**	**54.1**

2.1.4 Final Habitat Score

A Final Habitat Score for each perennial stream reach was calculated using the MPHI scores generated from the physical habitat condition assessment (Section 2.1.2) and the sum of the impact scores generated from the inventory of infrastructure and environmental features (Section 2.1.3). The Final Habitat Score is calculated as follows (Anne Arundel Co., 2006):

$$Final\ Habitat\ Score = MPHI\ Score - 0.5\left(\sum Total\ impact\ scores\right)$$

The Final Habitat Score is utilized in the County's subwatershed prioritization assessments, which are discussed in more detail in Section 4. Final Habitat Scores for individual reaches are combined using a reach length-weighted average to assess the physical habitat conditions of perennial streams at the subwatershed level. Similar to the MPHI scoring, each weighted stream reach and consequently each subwatershed is assigned a condition category of "Minimally Degraded," "Partially Degraded," "Degraded," or "Severely Degraded." A breakdown of Final Habitat Scores for the subwatersheds that contain perennial streams is presented in Table 2.6. The Final Habitat Scores found throughout the watershed are presented in Map 2.5. Approximately 74% of the subwatersheds (14) in the Little Patuxent Watershed were considered "Partially Degraded." Two subwatersheds were rated as "Minimally Degraded", one subwatershed (5%) was rated "Degraded", and one subwatershed (5%) was rated "Severely Degraded."

Table 2.6 - Final Habitat Scores at Subwatershed Level

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
Minimally Degraded	2	10.5%
Partially Degraded	14	73.7%
Degraded	1	5.3%
Severely Degraded	1	5.3%
N/A	1	5.3%
TOTAL	**19**	**---**

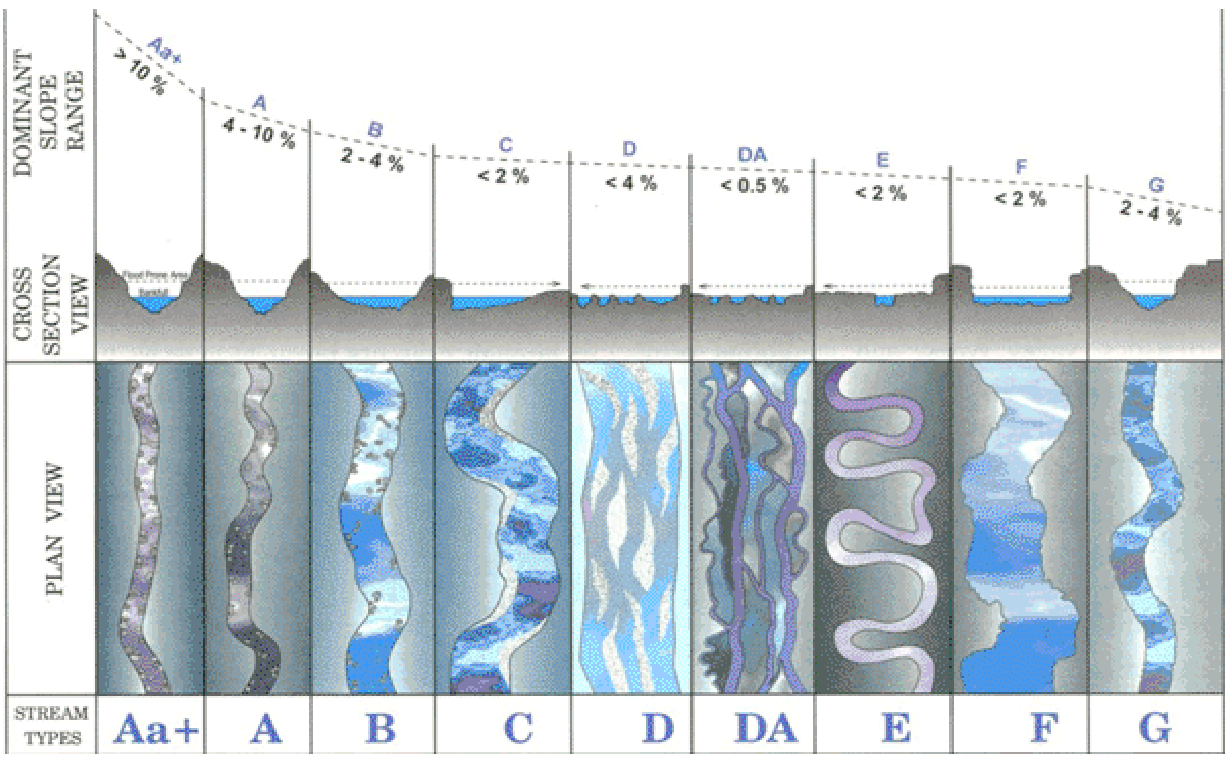
2.1.5 Channel Geomorphology

Over time, a stable natural stream channel will seek and achieve a state of dynamic equilibrium with its contributing watershed. In such a state, the stream will generally maintain its form and function and will undergo lateral adjustments over long periods of time in response to the range of hydrologic conditions to which it is exposed. During periods of normal flow, the stream can safely and efficiently convey the water and sediment that is directed through it. During periods of high flow, the stream can accommodate large volumes of water effectively by allowing it to overtop the stream banks and flow with dissipated energy through the floodplain. Upstream development patterns, however, can alter the volumes and peak flows conveyed through the stream and upset this dynamic equilibrium.

This phenomenon causes the stream to actively erode down its channel bed and banks and eventually lose access to its existing floodplain. This can lead to loss of aquatic and terrestrial habitat, decreased water quality, and greater risk of flood-related damage (including loss of property), as the stream seeks out a new state of equilibrium.

An assessment of channel geomorphology is useful to better understand the stability of a stream and its associated behaviors. The Rosgen classification system is one such assessment method. It provides measurable benchmarks for determining stream stability and for comparing the stream with similar streams in an undisturbed state regardless of their location. The Rosgen classification system has four levels. The Level I classification is a geomorphic characterization that groups streams as Types A through G based on aspects of channel geometry, including water surface slope, entrenchment, width/depth ratio, and sinuosity. A simplification of the longitudinal, cross-sectional, and plan views of the major stream types under the Rosgen Level I classification scheme is presented in Figure 2-3.

Figure 2-3 - Representation of Rosgen Level I Classifications of Major Stream Types



Rosgen, David L. "A classification of natural rivers." Catena 22 (1994): 179. www.wildlandhydrology.com

The County utilizes Rosgen Level I geomorphic classifications in its watershed modeling and analysis as indicators of stream stability and channel entrenchment. In the Little Patuxent Watershed, field data were collected to support the Rosgen Level I geomorphic classification of each single-threaded reach, regardless of perenniality. This is a change from previous watershed studies where only perennial channels were assessed.

The field data were also used to support calculation of a Manning's roughness number for each eligible reach using the Cowan method (Cowan, 1956). These calculated Manning's roughness values were used with DEM-derived longitudinal profiles, channel cross-sections, and bankfull discharge calculations to perform the actual Rosgen Level I classification. A County-developed spreadsheet tool was used to facilitate the classifications.

Table 2.7 - Rosgen Level I Classifications

Classification	Little Patuxent Watershed		
	Number of Reaches	Stream Miles	Percent of Total Stream Miles
A	59	1.1	2.6%
B	220	9.4	21.6%
C	256	23.7	54.6%
D	8	0.5	1.1%
DA	0	0	0%
E	16	1.6	3.6%
F	38	3.2	7.4%
G	67	4.0	9.1%
TOTAL	664	43.4	---

The distribution of Rosgen Level I classifications across the watershed is summarized in Table 2.7 and depicted in Map 2.6. As shown, approximately 55% of single-threaded stream miles were classified as Type "C" channels for the Little Patuxent Watershed. Type "C" channels are typically characterized as moderately stable, with a moderate to high width/depth ratio and sinuosity. Approximately 22% of single-threaded stream miles were classified as Type "B" channels for the Little Patuxent Watershed. Type "B" channels are typically characterized as predominantly stable, moderate gradient channels, with low sinuosity and low erosion rates. Approximately 17% of stream miles in the Little Patuxent Watershed were classified as Type "F" and "G" channels, which are incised channels with high erosion rates. It is important to note that not all "C" and "B" stream types are stable. Over time, changes in the watershed can transform these relatively stable channels to less stable stream systems such as an "F or a "G" type channels.

2.1.6 Road Crossing Flood Potential

Flooding where streams and roadways cross can be a safety hazard to residents due to high water levels and the potential to isolate properties from emergency vehicle access. Roadway stream crossings throughout the Little Patuxent Watershed were analyzed to assess the potential for flooding and the need for replacement or modification. An initial subset of stream crossings with the potential for overtopping was identified during fieldwork activities. This subset of crossings included those roads owned by the County that were within 20 vertical feet of the stream bed, older than five-years in age, and classified as a "Freeway," "Principal Arterial," "Minor Arterial," "Collector," or "Local." These crossings were analyzed further to determine whether flooding or overtopping of a single crossing or two crossings concurrently could result in a community or business area being cut off from emergency services. Seven crossings were identified that met all of the County's criteria. A technical memorandum with a more detailed description of the road crossing selection process is included in Appendix A. The locations of the analyzed road crossings are presented in Map 2.7.

Field surveys were performed on these seven road crossings to obtain data on stream channel and roadway geometry. The 1-year, 2-year, 10-year, and 100-year discharges from each associated drainage area were calculated using the Natural Resource Conservation Service's (NRCS) TR-20 single event runoff and routing model (NRCS, 1992). The culverts associated with each crossing were modeled using the survey data and the Federal Highway Administration's HY8 model to determine the water level height and associated discharge required to overtop each of the crossings. This overtopping discharge was then compared to the range of return period discharges to determine the expected frequency that the road crossing would flood.

A summary of the discharge and flooding frequency data is presented in Table 2.8. In the Little Patuxent Watershed, crossing LP7015.C001 was found to have an overtopping return frequency of less than two years. Overtopping return periods between two and ten years were calculated for one of the crossings (LPC041.C001). Of less concern were the crossings with calculated overtopping return periods of 10 to 100 years (LPE045.C001, LPF048.C001, and LPG088.C001) and greater than 100 years (LP7020.C001 and LPG069.C001).

Table 2.8 - Flooding Potential of Selected Road Crossings

Crossing ID	Drainage Area (sq mi)	Discharge (cfs)				Overtopping Discharge (cfs)	Overtopping Return Period
		1 year	2 year	10 year	100 year		
Conway Rd (LP7015.C001)	0.356	21	43	146	432	23	Less than 2 years
Meyers Station Rd (LP7020.C001)	0.051	1	1	3	7	55	More than 100 years
Evergreen Rd (LPC041.C001)	5.337	385	591	1349	1949	1109	Between 2 and 10 years
Washington, Baltimore, and Annapolis Trail (LPE045.C001)	0.050	31	45	94	200	101	Between 10 and 100 years
Meyers Station Rd (LPF048.C001)	0.164	3	9	41	148	131	Between 10 and 100 years
Harewood Ln (LPG069.C001)	0.209	41	67	165	402	529	More than 100 years
Kingsgate Dr (LPG088.C001)	0.266	215	287	507	975	899	Between 10 and 100 years

2.1.7 Bioassessment

Anne Arundel County has conducted targeted biological monitoring of streams in the Little Patuxent Watershed in 2011 (KCI, 2011). The full 2011 targeted sampling summary report is included as Appendix B.

Benthic monitoring was conducted during the MBSS spring index period (March 1 – April 30) and employed the stream sampling methods specified in the County's Quality Assurance Project Plan (QAPP; Anne Arundel County, 2010), which follows the MBSS protocols (DNR, 2007). At each 75-m sample site, benthic macroinvertebrates were collected using a D-net to collect organisms from a combination of habitats that support the most diverse macroinvertebrate community within a sample segment as per MBSS protocols. At each site, 20 "jabs" of the net totaling 20 square feet of substrate were distributed among available habitats, including submerged vegetation, overhanging bank vegetation, leaf packs, organic mats, stream bed substrate, submerged woody debris, and rocks. The 20 jabs were composited into a single macroinvertebrate sample per site, which were preserved in the field for laboratory identification.

In the lab, benthic samples were subsampled and sorted, and oligochaetes and chironomids were permanent slide-mounted to allow identification to genus level (family level for oligochaetes) according to the County's QAPP (Anne Arundel County, 2010) and accompanying Standard Operating Procedures. Benthic macroinvertebrate taxonomic identifications and counts recorded on bench sheets were entered into an Excel spreadsheet. Final data were imported to a MS Access database.

Benthic macroinvertebrate data were analyzed using the Coastal Plain version of the MBSS Benthic Index of Biotic Integrity (Southerland et al., 2007). Metrics included in this IBI are detailed in Table 2.9.

Table 2.9 - MBSS Coastal Plain BIBI Metrics and Description

Metric	Description
Total Number of Taxa	Measures the overall variety of the macroinvertebrate assemblage
Number of EPT Taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
Number of Ephemeroptera Taxa	Number of mayfly taxa
Percent Intolerant Urban	Percent of sample considered intolerant to urbanization (tolerance values 0-3)
Percent Ephemeroptera	Percent mayfly nymphs
Number Scraper Taxa	Number of taxa that scrape food from substrate
Percent Climbers	Percent of sample that primarily lives on stem type surfaces

MBSS attributes for each identified taxa, including functional feeding group, habitat preference, and tolerance values, were used to compute BIBI metrics. For each BIBI metric at each site, raw values were assigned a score of 1, 3, or 5 based on ranges of values developed for each metric (Table 2.10).

Table 2.10 - Scoring Criteria for Metrics in the MBSS Coastal Plain BIBI

Metric	Score 5	Score 3	Score 1
Total Number of Taxa	≥ 22	14 - 21	< 14
Number of EPT Taxa	≥ 5	2 - 4	< 2
Number of Ephemeroptera Taxa	≥ 2.0	1 - 1	< 1
Percent Intolerant Urban	≥ 28	10 - 27	< 10.0
Percent Ephemeroptera	≥ 11	0.8 – 10.9	< 0.8
Number Scraper Taxa	≥ 2	1 - 1	< 1
Percent Climbers	≥ 8.0	0.9 – 7.9	< 0.9

Scores for each metric were averaged to give a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating (Table 2.11).

Table 2.11 - BIBI Scoring and Narrative Rating

BIBI Score	Narrative Rating
4.0 to 5.0	Good
3.0 to 3.9	Fair
2.0 to 2.9	Poor
1.0 to 1.9	Very Poor

In the Little Patuxent Watershed, BIBI scores ranged from a low of 1.29 (Very Poor) to a high of 4.43 (Good) (Table 2.12). Combining the BIBI results from the targeted sampling events, the greatest number of sites (20 out of 44, or 45.5%) rated “Poor.” An additional 9 sites (20.5%) rated “Very Poor,” while 11 sites (25%) rated “Fair.” Only four sites (9%) rated “Good.” Overall, BIBI results indicated that benthic macroinvertebrate communities have degraded to a great degree in many areas across the Little Patuxent Watershed. The overwhelming majority of sites sampled in the watershed were rated either “Poor” or “Very Poor.” Bioassessment sampling locations and results are presented in Map 2.8.

Table 2.12 - Summary of Bioassessment Data in the Little Patuxent Watershed

Site	Shed Code	Subwatershed	Survey, Year	BIBI Score	BIBI Narrative Rating
LPAX-01-2011	LPG	Crofton Golf	Targeted, 2011	2.71	Poor
LPAX-02-2011	LPG	Crofton Golf	Targeted, 2011	3.29	Fair
LPAX-03-2011	LPA	Oak Hill	Targeted, 2011	3.00	Fair
LPAX-04-2011	LPA	Oak Hill	Targeted, 2011	1.57	Very Poor
LPAX-05-2011	LPC	Towsers Branch 3	Targeted, 2011	2.43	Poor
LPAX-06-2011	LPC	Towsers Branch 3	Targeted, 2011	2.43	Poor

Table 2.12 - Summary of Bioassessment Data in the Little Patuxent Watershed

Site	Shed Code	Subwatershed	Survey, Year	BIBI Score	BIBI Narrative Rating
LPAX-07-2011	LPF	Little Patuxent 6	Targeted, 2011	2.71	Poor
LPAX-08-2011	LPF	Little Patuxent 6	Targeted, 2011	3.29	Fair
LPAX-09-2011	LP6	Towsers Branch 2	Targeted, 2011	1.29	Very Poor
LPAX-11-2011	LP7	Little Patuxent 5	Targeted, 2011	2.14	Poor
LPAX-12-2011	LP7	Little Patuxent 5	Targeted, 2011	2.14	Poor
LPAX-13-2011	LP8	Little Patuxent 4	Targeted, 2011	2.71	Poor
LPAX-14-2011	LP8	Little Patuxent 4	Targeted, 2011	1.86	Very Poor
LPAX-15-2011	LPE	Piney Orchard	Targeted, 2011	3.29	Fair
LPAX-16-2011	LPE	Piney Orchard	Targeted, 2011	2.71	Poor
LPAX-17-2011	LP3	Towsers Branch 1	Targeted, 2011	2.71	Poor
LPAX-18-2011	LP3	Towsers Branch 1	Targeted, 2011	2.71	Poor
LPAX-19-2011	LP9	Rogue Harbor 2	Targeted, 2011	4.14	Good
LPAX-20-2011	LP9	Rogue Harbor 2	Targeted, 2011	4.14	Good
LPAX-23-2011	LPI	Little Patuxent 3	Targeted, 2011	2.71	Poor
LPAX-24-2011	LPH	Little Patuxent 3	Targeted, 2011	2.43	Poor
LPAX-25-2011	LPH	Little Patuxent 3	Targeted, 2011	4.43	Good
LPAX-26-2011	LPH	Little Patuxent 3	Targeted, 2011	3	Fair
LPAX-28-2011	LPI	Dorsey Run 2	Targeted, 2011	1.57	Very Poor
LPAX-29-2011	LP0	Little Patuxent 2	Targeted, 2011	2.14	Poor
LPAX-30-2011	LP0	Little Patuxent 2	Targeted, 2011	2.71	Poor
LPAX-31-2011	LP4	Rogue Harbor 1	Targeted, 2011	3	Fair
LPAX-32-2011	LP4	Rogue Harbor 1	Targeted, 2011	3	Fair
LPAX-33-2011	LP5	Little Patuxent 1	Targeted, 2011	3.57	Fair
LPAX-34-2011	LP5	Little Patuxent 1	Targeted, 2011	2.71	Poor
LPAX-35-2011	LPD	Dorsey Run 4	Targeted, 2011	1.86	Very Poor
LPAX-36-2011	LPD	Dorsey Run 4	Targeted, 2011	1.57	Very Poor
LPAX-37-2011	LP2	Dorsey Run 5	Targeted, 2011	4.14	Good
LPAX-38-2011	LP2	Dorsey Run 5	Targeted, 2011	3.86	Fair
LPAX-39-2011	LPJ	Dorsey Run 2	Targeted, 2011	3	Fair
LPAX-40-2011	LPJ	Dorsey Run 2	Targeted, 2011	3.57	Fair
LPAX-41-2011	LP1	Dorsey Run 1	Targeted, 2011	2.43	Poor
LPAX-42-2011	LP1	Dorsey Run 1	Targeted, 2011	2.71	Poor
LPAX-43-2011	LPK	Jessup	Targeted, 2011	1.86	Very Poor
LPAX-46-2011	LPB	Dorsey Run 6	Targeted, 2011	1.86	Very Poor

Table 2.12 - Summary of Bioassessment Data in the Little Patuxent Watershed

Site	Shed Code	Subwatershed	Survey, Year	BIBI Score	BIBI Narrative Rating
Duplicate Sites for QC					
LPAX-05-2011QC	LPC	Towsers Branch 3	Targeted, 2011	2.14	Poor
LPAX-18-2011QC	LP3	Towsers Branch 1	Targeted, 2011	2.71	Poor
LPAX-24-2011QC	LPH	Little Patuxent 3	Targeted, 2011	2.14	Poor
LPAX-36-2011QC	LPD	Dorsey Run 4	Targeted, 2011	1.57	Very Poor

2.1.8 Aquatic Resource Indicators

Areas that support trout spawning, anadromous fish spawning, and threatened and endangered species are all considered high-quality sensitive habitat that should be preserved. The locations of each of these sensitive habitat types in the Little Patuxent watershed were provided by MDNR and supplemented with additional information from the County. The threatened and endangered species habitat was represented by the Natural Heritage Program's Sensitive Species Project Review Areas (SSPRA). The County overlaid GIS data with locations of these sensitive habitat areas to obtain a single representative GIS layer of all three aquatic resource indicators.

The Little Patuxent Watershed has no subwatersheds with aquatic resource indicators rated as "High" or "Medium High." A total of 9%, or 2 of the subwatersheds, are rated in the "Low" category of aquatic resource indicators. The majority of subwatersheds (19) have been rated as "Medium" for aquatic resource indicators. A summary of aquatic resource ratings is provided in Table 2.13. Subwatershed ratings for aquatic resource indicators are presented in Map 2.9.

Table 2.13 - Aquatic Resource Indicator Ratings

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
High	0	0 %
Medium High	0	0 %
Medium	19	91%
Low	2	9%
TOTAL	21	---

2.2 UPLAND DATA COLLECTION AND COMPILATION

The following subsections on impervious cover, urban stormwater BMPs, onsite sewage disposal systems (OSDSs), soil indicators, and landscape indicators summarize the collected and compiled data in the upland areas associated with the Little Patuxent Watershed. This information is crucial for determining the land use conditions that influence the health of the tributary streams of Little Patuxent River. As with the data presented in the previous section, the following upland data are used to identify and formulate restoration activities and land management decisions to improve conditions throughout the watershed.

2.2.1 Contributory Impervious Cover to Streams

Links have been well-established between the level of impervious cover within a drainage area and the overall health of downgradient water bodies. The Center for Watershed Protection (CWP) suggested that streams with greater than 25% impervious cover are typically considered impaired or non-supporting; streams with 10 to 25% impervious cover are typically considered stressed or impacted, and streams with less than 10% imperviousness can support sensitive habitat and are typically relatively unimpaired (Schueler, 1992). The County utilized its impervious cover GIS layer based on 2011 aerial photography to calculate the impervious percent cover within the drainage area of all assessed perennial reaches. Based on the guidance discussed above from CWP, each perennial reach was assigned a rating of “Sensitive,” “Impacted,” or “Non-supporting” related to its percent impervious cover. Approximately 35% of the stream reaches in the Little Patuxent Watershed were rated “Non-supporting.” A summary of impervious cover ratings is provided in Table 2.14. As described earlier, a map depicting impervious cover throughout the watershed is presented in Map 1.10.

Table 2.14 - Impervious Cover Ratings

CWP Rating Category (% impervious cover)	Little Patuxent Watershed	
	Number of Reaches	Percent of Reaches
Sensitive (0-10%)	110	33%
Impacted (10-19%)	74	22%
Impacted (19-25%)	31	9%
Non-supporting (>25%)	117	35%
TOTAL	332	---

2.2.2 Urban Stormwater Best Management Practices

Urban stormwater BMPs are utilized throughout the County to intercept, detain, retain, and/or treat stormwater runoff before it reaches receiving water bodies. The installation of structural or nonstructural BMPs is required in all new development areas and on certain individual lot developments. The level of requisite stormwater management (e.g., recharge volume, water quality volume, channel protection volume, etc.) is dependent on development size, proximity to Critical Areas, and downstream conditions among other considerations. Redevelopment sites also have stormwater management requirements, which can be met by actual reductions in impervious cover or effective reductions in impervious cover through BMP implementation, BMP upgrades, or other restoration activities (Anne Arundel County OPZ, 2006). In addition to these BMPs triggered by development or redevelopment, the County also regularly implements BMP retrofits of publicly owned property as part of its capital improvement program and its watershed management planning activities.

To facilitate understanding of the level of stormwater management provided by BMPs in the study watershed, a spatially-accurate GIS inventory dataset was developed for all existing public and private stormwater BMPs. This analysis is critical for identifying areas within the watershed that are under-managed and for guiding future retrofit and BMP implementation efforts. The BMP inventory dataset contained accurate and up-to-date information on the locations, type, drainage area, and ownership of stormwater BMPs. BMPs located on federal land were excluded from the investigation. The effort to develop the dataset entailed compiling existing data from multiple County and State sources, narrowing the dataset to eliminate those BMPs outside of the study watershed, confirming or updating the spatial locations of the remaining BMPs, removing duplicate records, and performing research to fill any data gaps. In order to properly account for load reductions associated with BMPs in the County's modeling efforts, drainage areas were delineated for all BMPs. Drainage area delineations were handled differently depending on the BMP structure type, the original data source, and the accuracy of the BMP's spatial location. A technical memorandum with a more detailed description of this work is presented in Appendix C.

BMPs in the Little Patuxent Watershed are grouped by the County into six major categories according to their primary mechanism of action. These categories include "Dry Detention," "Dry Extended Detention," "Filtration," "Infiltration," "Wet Structures," and "Other." A list of general BMP types that fall under each of these categories is included in Table 3.4 in Section 3. A total of 486 BMPs were confirmed to be located within the Little Patuxent Watershed as part of the compilation and research process. The sum of the drainage areas for these BMPs is 3,923.6 acres. A breakdown of BMP types and their drainage areas is presented in Table 2.15. A map of BMPs located throughout the watershed is presented as Map 2.10.

Approximately 3,924 acres or 14% of the area of the Little Patuxent Watershed receives water quantity management (storage and attenuation of runoff) or water quality treatment (pollutant removal) through a BMP. Some of this area is receiving treatment by a series of BMPs because there is some overlap of BMP drainage areas. The BMP drainage areas range in size from 0.01 to 685.5 acres, with an average drainage area of 8.1 acres, and a median drainage area of 1 acre. This indicates that many of the BMPs are small in size.

Table 2.15 - Summary of BMPs by Type

Category	Quantity	Percent by Quantity	Total Managed Drainage Area (acres)	Percent by Drainage Area	Average Drainage Area (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)
Alternative Credits	1	0.2%	0	0%	0	0.0	0.0
Detention Dry	34	7.0%	231.9	5.9%	6.8	0.5	81.0
Environmental Site Design	35	7.2%	25.04	0.6%	0.7	0.01	12.0
Exempt	1	0.2%	5.0	0.1%	5.0	5.0	5.0
Extended Detention Dry	65	13.4%	795.6	20.3%	12.3	1.0	89.0
Filtration	44	9.1%	91.9	2.3%	2.1	0.3	15.0
Infiltration	191	39.3%	257.5	6.6%	1.3	0.05	42.0
Other	3	0.6%	15.4	0.4%	5.1	1.0	10.4
Stream Restoration	4	0.8%	1,061.6	27.1%	265.4	18.0	685.5
Wet Ponds	104	21.4%	1,371.5	35.0%	13.2	1.0	100
Wetlands	4	0.8%	68.2	1.7%	17.1	7.0	35.2
TOTAL/AVERAGE	**486**	**100%**	**3,923.6**	**100%**	**8.1**	**0.01**	**685.5**

The stormwater BMPs in the Little Patuxent Watershed are typically owned by private land owners, the County, or other State agencies, such as the Maryland State Highway Administration. A breakdown of BMP types and ownership is presented in Table 2.16. The majority of the BMPs in the watershed (87%) are privately owned. Publicly owned BMPs comprise another 12% of the BMPs. However, when evaluated by the percent of the drainage area that they manage or treat in the watershed, private BMPs cover 55% and public BMPs cover 27% of the managed area. The Maryland State Highway Administration and other state agencies account for the remaining 18% of the managed land. Many of the privately owned BMPs are dry wells, small bioretention cells, and small environmental site design facilities (e.g. rain gardens) that serve to manage runoff from single rooftops or other impervious areas associated with residential properties.

Table 2.16 - Summary of BMPs by Owner

Ownership	Quantity	Percent by Quantity	Total Managed Drainage Area (acres)	Percent by Drainage Area	Average Drainage Area (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)
Private	424	87%	2,157.8	55%	5.1	0.01	100.0
Public (DPW)	52	10%	1,024.4	26%	19.7	1.0	190.2
Public (non-DPW)	8	2%	20.7	1%	2.6	0.05	18.0
Unknown	2	1%	720.6	18%	360.3	35.2	685.5
TOTAL/ AVERAGE	**486**	**100%**	**3,923.6**	**100%**	**8.1**	**0.01**	**685.5**

2.2.3 Onsite Sewage Disposal Systems

OSDSs or septic systems can contribute high levels of nutrients, particularly nitrogen and bacteria to downgradient water bodies via subsurface migration. This is especially true for older or poorly maintained OSDSs. In 2008, the County conducted a study to evaluate service options for properties with OSDSs and to develop a cost-effective approach to reducing pollutant loads from OSDSs (Anne Arundel County, 2008). As part of this study, the locations and basic characteristics of OSDSs throughout the County were identified. This information was used with data on per capita loading to quantify aggregate pollutant loads from OSDSs across the Little Patuxent Watersheds.

The 2008 OSDS study noted that the Little Patuxent Watershed has approximately 793 OSDSs, which represents approximately 2% of the OSDS County-wide. These systems contribute approximately 25,000 lbs of total nitrogen annually to streams within the Little Patuxent Watershed. The study also identified the most cost-effective approaches to reducing nitrogen loads from OSDSs. Treatment alternatives examined included sewer extension to an existing water reclamation facility (WRF) (both in areas of no public service and areas with an existing sewer system), clustering of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action. In the Little Patuxent Watershed, approximately 63% of OSDSs are recommended for connection to a sewer extension, 1% is recommended for cluster treatment, and 18% are recommended for enhanced nitrogen removal upgrades at individual OSDS. The implementation of all treatment options would be expected to reduce total nitrogen from OSDSs by approximately 67% or 17,000 pounds per year. A map of OSDS locations and the areas associated with treatment recommendations is presented in Map 2.11.

Table 2.17 - Total Annual Nitrogen Load Rating from OSDS

Rating	Little Patuxent	
	Number of Subwatersheds	Percent of Subwatersheds
Very Poor	1	5%
Poor	4	21%
Fair	6	32%
Good	8	42%
TOTAL	**19**	**-**

Since nitrogen is generally the most mobile of the typical pollutants associated with OSDSs, it is used in the County's prioritization assessments as an indicator of septic system impacts to streams within the watershed. Subwatersheds are categorized as "Very Poor," "Poor," "Fair," or "Good" based on the natural breaks (a systematic method for classification) in the cumulative annual total nitrogen loading (in pounds) within the subwatershed. A breakdown of ratings for total nitrogen loading from OSDSs for the Little Patuxent Watershed is presented in Table 2.17 and in Map 2.11. Two subwatersheds, LP1 and LP5, were not assessed due to access restrictions. LP1 is occupied by a Maryland correctional facility, while LP5 is occupied entirely by federally owned land. Approximately 26% of the assessed subwatersheds within the Little Patuxent Watershed are rated "Very Poor" or "Poor." Collectively, the estimated annual total nitrogen contribution from these two categories of subwatersheds is 10,862 lbs/year, which is approximately 44% of the watershed-wide total nitrogen contribution from OSDSs.

Milestones for the reduction of total nitrogen from OSDSs in Anne Arundel County have been published in a Watershed Implementation Plan to comply with the Chesapeake Bay TMDL (Anne Arundel County, 2012b).

2.2.4 Soil Indicators

Native soils vary in their susceptibility to erosive forces. Clay soils, for instance, are less susceptible to erosion than are coarse sandy soils. The soil erodibility factor, K, is a measure of the susceptibility of soil to detachment and transport by precipitation and runoff. Soil erodibility factors for Anne Arundel County were obtained from NRCS datasets (NRCS 2012). The County uses these soil erodibility factors to identify areas susceptible to soil erosion as part of its subwatershed preservation assessment.

Subwatersheds are prioritized "Good," "Fair," "Poor," or "Very Poor" based on natural breaks in soil erodibility factor data across subwatersheds. A summary of subwatershed ratings for soil erodibility is presented in Table 2.18 and depicted in Map 2.12. LP1 and LP5 were not included in this analysis due to access restrictions.

For the Little Patuxent Watershed, 37% of the assessed subwatersheds are rated as "Low" for soil erodibility. Subwatersheds with "Medium" ratings are the second most prevalent in the watershed. A “Medium High” soil erodibility rating occurs in 21% of the subwatersheds, and only 10% of the subwatersheds fall into the “High” category for soil erodibility.

Table 2.18 - Subwatershed Ratings for Soil Erodibility

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
Low	7	37%
Medium	6	32%
Medium High	4	21%
High	2	10%
TOTAL	**19**	**---**

2.2.5 Landscape Indicators

The County employs a variety of landscape-based indicators for restoration and preservation assessments. Percent impervious cover, percent forest within the 100-foot stream buffer, ratio of existing wetlands to potential wetlands, and acres of developable land within the Critical Area are used as indicators of the potential need for restoration activities. Percent forest cover, percent wetland cover, density of headwater streams, percent of land within the Greenway Master Plan, the presence of bog wetlands, acres of Resource Conservation Area (RCA) lands within Critical Area, percent of protected lands, and presence of Wellhead Protection Areas are used as indicators of the potential need for preservation.

GIS datasets were used by the County to quantify the extent of the landscape indicators within each subwatershed in the Little Patuxent Watershed. The GIS analyses related to impervious area, forest cover, bog wetland locations, Critical Areas, protected lands, land associated with the Greenway Master Plan, and density of headwater streams were performed using the County’s existing geodatabase of land use and land features. The GIS analyses associated with wetland cover were performed using GIS datasets obtained from MDNR.

As with previous indicator categories, subwatersheds are prioritized “Very Poor,” “Poor,” “Fair,” or “Good” for restoration, and “High”, “Medium High”, “Medium”, and “Low” for preservation. These categories are based on natural breaks in the data. LP1 and LP5 were not prioritized due to access restrictions. Summaries of these ratings for the Little Patuxent Watershed are presented in Table 2.19 and Table 2.20 and depicted on Maps 2.13, 2.14, and 2.15.

In the Little Patuxent Watershed, the impervious cover indicator had a majority of subwatersheds rated as either “Fair” or “Poor”. The ratings were fairly evenly distributed for the percent of forest within the 100-foot stream buffer indicator, with the "Very Poor" category being the only category assigned to less than 25% of the assessed subwatersheds. The ratio of existing wetlands to potential wetlands was classified as "Good" for 56% of subwatersheds, while only one subwatershed was classified as "Very Poor." The entire Little Patuxent Watershed was rated as "Good" in terms of the acres of developable lands within the Critical Area.

Subwatersheds ratings for preservation in the Little Patuxent Watershed vary across the landscape indicators. Presence of bog wetlands and acres of RCA lands within the Critical Area are rated as "Low" for all subwatersheds. Only two indicators, percent of land within the Greenway Master Plan and percentage of protected lands, have the majority of subwatersheds rated in the "High" and "Medium High" categories. The remaining indicators, percent forest cover, percent wetland cover, density of headwater streams, and presence of wellhead protection areas, are all fairly evenly distributed, but at least 10 of the 19 subwatersheds fall into either the "Low" or "Medium" categories.

Table 2.19 - Landscape Indicator Ratings (Subwatershed Restoration)

Rating	Little Patuxent Watershed Number of Subwatersheds	Percent of Subwatersheds
Percent Impervious Cover		
Good	5	26%
Fair	6	32%
Poor	6	32%
Very Poor	2	10%
Percent Forest within the 100-foot Stream Buffer		
Good	5	26%
Fair	5	26%
Poor	6	32%
Very Poor	3	16%
Ratio of Existing to Potential Wetlands		
Good	3	53%
Fair	4	16%
Poor	4	26%
Very Poor	8	5%
Acres of Developable Critical Area		
Good	19	100%
Fair	0	0%
Poor	0	0%
Very Poor	0	0%

Table 2.20 - Landscape Indicator Ratings (Subwatershed Preservation)

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
Percent Forest Cover		
High	4	21%
Medium High	5	26%
Medium	7	37%
Low	3	16%
Percent Wetland Cover		
High	2	10%
Medium High	5	26%
Medium	5	26%
Low	7	37%
Density of Headwater Streams		
High	3	16%
Medium High	6	32%
Medium	7	37%
Low	3	16%
Percent of Land within the Greenway Master Plan		
High	4	21%
Medium High	7	37%
Medium	3	16%
Low	5	26%
Presence of Bog Wetlands		
High	0	0%
Low	19	100%
Acres of RCA lands with the Critical Area		
High	0	0%
Medium High	0	0%
Medium	0	0%
Low	19	19%
Percent of Protected Lands		
High	6	32%
Medium High	6	32%
Medium	4	21%
Low	3	16%
Presence of Wellhead Protection Areas		
High	9	47%
Low	10	53%

3. HYDROLOGIC AND POLLUTANT LOAD MODELING

The data collection efforts described in Section 2 provide a solid basis for assessing the current status of the Little Patuxent watershed and identifying potential stressors that may contribute to observed impairments. Modeling, the computer simulation of natural processes, serves to extend the utility of the collected data by allowing extrapolation from existing conditions to alternative future conditions (scenarios) that reflect differing assumptions about the course of land development and the implementation of pollutant controls.

Land development is typically associated with increased imperviousness and decreased capacity for managing precipitation. As watersheds become more developed, runoff volumes and peak flow rates increase and stream base flows decrease. This often results in destabilized streams, increased pollutant loading, and adverse impacts to physical habitat. Nutrients and suspended solids are two of the leading causes of water quality impairment in sensitive water bodies, including the Chesapeake Bay and its tributaries. Nutrients, such as nitrogen and phosphorus, can cause excessive algae growth and eutrophication. Suspended solids can limit growth of aquatic vegetation and destroy physical habitat.

The County's hydrologic and pollutant load modeling provides quantification of watershed processes and allows for the comparison of different scenarios used to prioritize restoration and mitigation projects. The County performed hydrologic and pollutant load modeling to help assess existing conditions as well as future development and pollutant control scenarios within the Little Patuxent watershed. The results were used to understand the extent of potential water quality improvements necessary to satisfy MS4 permit and TMDL requirements.

This section presents and discusses the methods and inputs used in the hydrologic and water quality modeling of current and future build-out conditions (Section 3.1) and the results of that modeling (Section 3.2). Discussions of future scenario modeling to support development of the implementation plan for the study watershed are presented in Section 5.

3.1 METHODS

This subsection describes two types of modeling performed in the watershed characterization to help evaluate and prioritize areas and projects for action. Hydrologic modeling, which involves simulation of the runoff and conveyance of rain falling on the watershed, was done to improve understanding of reach and subwatershed sensitivity to erosion and to development. Pollutant load modeling of current conditions, which entails the simulation of the generation, transport, and delivery of solids, nutrients, and pathogens, provides the basis for assessment of current and future condition pollutant loading. Model results enable comparison and prioritization of restoration strategies and projects as discussed in Section 5. The methods and inputs for each model are discussed below.

3.1.1 Hydrologic Modeling

Hydrologic modeling is used to represent rainfall-induced runoff conditions and the conveyance of streamflow in the watershed. The County applies the NRCS TR-20 for hydrologic modeling. This NRCS model is a single event watershed scale runoff and routing model that was used to evaluate runoff volumes and peak flow for various return period storm events. Model inputs include rainfall, curve numbers, and time of concentration. Table 3.1 presents the 24-hour rainfall depths and recurrence intervals for Anne Arundel County. Area-weighted curve numbers, which represent the runoff response to a rain event, are derived from soil types and land cover. Table 3.2 presents the base curve numbers that the County uses to develop the weighted curve numbers.

Time of concentration is the time required for runoff to travel from the hydraulically most distant point in the watershed to the most downstream point or outlet. The County uses a modified version of the NRCS lag equation as a means of calculating the travel time for each subwatershed. The NRCS lag equation relates time of concentration to flow length, average slope, and curve number (NRCS 2010). Since this equation was developed for rural watersheds, the County also applies an urban correction factor (Impervious Area Factor), to account for the more urban nature of the study watersheds (US DOT 1984). The Impervious Area Factor accounts for higher amounts of impervious area that accelerate the rate of overland flow in the watershed.

The TR-20 model results, presented as peak flow rate normalized to area (cfs/acre) and surface runoff yield (inches), are used to evaluate the likely sensitivity of the Little Patuxent watershed to gullying and stream erosion. Areas with higher normalized peak flow rates and/or surface runoff yields are more likely to suffer from erosion in-stream or on the land surface, and therefore could be prioritized higher for restoration versus areas with lower normalized peak flow rates or surface runoff yields. Higher rates and yields are often expected in urbanized areas with more extensive impervious surface area.

Table 3.1 - Rain Frequency

Event Frequency	Rain (in)
1 year	2.7
2 year	3.3
10 year	5.2
100 year	7.4

Table 3.2 - Runoff Curve Numbers for Urban Areas

Land Cover Type and Condition	Hydrologic Soil Group			
	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):				
Poor condition (grass cover < 50%)	Not Used			
Fair condition (grass cover 50% to 75%)	Not Used			
Good condition (grass cover > 75%)	39	61	74	80
Paved parking lots, roofs, driveways, etc.(excluding right-of-way)	98	98	98	98
Streets and roads:				
Paved; curbs and storm drains (excluding right-of-way)	98	98	98	98
Paved; open ditches (including right-of-way)	Not Used			
Gravel (including right-of-way)	Not Used			
Dirt (including right-of-way)	Not Used			
Urban districts:				
Commercial and business	89	92	94	95
Industrial	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses)	77	85	90	92
1/4 acre	61	75	83	87
1/3 acre	57	72	81	86
1/2 acre	54	70	80	85
1 acre	51	68	79	84
2 acres	46	65	77	82
Newly graded areas (pervious areas only, no vegetation)	77	86	91	94

3.1.2 Water Quality Modeling

Water quality modeling is used to represent the generation of pollutant loads and their potential control by BMPs. The County's water quality model for the Little Patuxent watershed is based on EPA's Simple Method (Schueler, 1987) and PLOAD models (EPA, 2001). The water quality model calculates annual loadings for total nitrogen, total phosphorus, total suspended solids, fecal coliforms, and metals from stormwater under pristine, current, and ultimate build-out or future conditions. Given the focus of the Chesapeake Bay TMDL, only total nitrogen, total phosphorus, and total suspended solids are discussed in this report. The water quality model is also used to tabulate annual load reductions or credits that are achieved with existing BMPs within the watershed.

The model's basic elements are polygons determined in GIS by the geometric intersection of the County's 2007 land use dataset, land ownership, impervious cover, and subwatershed boundaries. The polygon GIS attribute information is imported into the County's spreadsheet model to perform the loading calculations. The Simple Method calculates annual runoff as a product of annual rainfall (42.9 inches in Anne Arundel County), the fraction of annual rainfall events that produce runoff (assumed to be 90%), and a runoff coefficient based on the impervious fraction in the drainage area. In one modification to the Simple Method, the County's model uses an actual impervious cover delineation to explicitly represent impervious surface runoff instead of the standard impervious rating approach. The pollutant loads are the product of the annual runoff, the drainage area, and the event mean concentrations (EMCs) for each land use category. A delivery ratio is further applied to the loading estimates depending on its proximity to non-tidal and tidal waters. For the study watershed, the delivery ratio is assumed to be equal to one.

A summary of EMC values and associated land use types are presented in Table 3.3 below. These EMC values have been compiled from a number of literature sources or calculated directly from export coefficients used by the Chesapeake Bay Program (CBP). Individually, the County's EMC values are conservatively set to be equal to or greater than the values used by the CBP.

Table 3.3 - Water Quality Modeling Event Mean Concentrations

TMDL Source Sector	Land Use Code	Land Use Name	Average Impervious Percent	TN (mg/L)	TP (mg/L)	TSS (mg/L)
Urban	AIR	Airport	85	2.24	0.30	99
	COM	Commercial	85	2.24	0.30	43
	IND	Industrial	72	2.22	0.19	77
	OPS	Open Space	1	1.15	0.15	34
	R11	Residential - 1 acre lot	13	2.74	0.32	43
	R12	Residential - 1/2 acre lot	18	2.74	0.32	43
	R14	Residential - 1/4 acre lot	20	2.74	0.32	43
	R18	Residential - 1/8 acre lot	34	2.74	0.32	43
	R21	Residential - 2 acre lot	13	2.74	0.32	43
	R20	Residential - 20 acre lot	2	2.20	0.15	51
	RWD	Residential Woods	6	2.00	0.19	51
	TRN	Transportation	75	2.59	0.43	99
	UTL	Utility	75	1.15	0.15	34
Agriculture	PAS	Pasture and Hay	0	7.83	2.09	341
	SRC	Single Row Crop	1	16.06	2.63	1,046
Other	FRW	Forested Wetland	0	1.00	0.11	34

Table 3.3 - Water Quality Modeling Event Mean Concentrations

TMDL Source Sector	Land Use Code	Land Use Name	Average Impervious Percent	TN (mg/L)	TP (mg/L)	TSS (mg/L)
	OPW	Open Wetland	0	1.00	0.11	34
	WAT	Water	0	1.20	0.03	43
	WDS	Woods	0	1.00	0.11	34

To account for pollutant removal associated with existing BMPs or those implemented in the future, the County utilizes pollutant removal efficiencies. These efficiencies are largely derived from MDE's guidance document *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2011)[1] and conservatively set to be equal to or less than the values used by the CBP. A summary of the BMP pollutant removal efficiencies used by the County are provided in Table 3.4. To facilitate assignment of a pollutant removal efficiency to each BMP type, the County has organized its BMP types into nine BMP category groups.

Table 3.4 - Water Quality Modeling BMP Pollutant Removal Efficiencies

BMP Category Group	County BMP Code	MDE Code	BMP Name	Percent Removal		
				TN	TP	TSS
Detention Dry	DP	DP	Detention Structure (Dry Pond)	5	10	10
	UGVAULT	UGS	Underground Storage	5	10	10
	BS	BS	Bay Saver	5	10	10
	OGS	OGS	Oil Grit Separator	5	10	10
	WQINLET	OGS	Water Quality Inlet	5	10	10
	STMCEPTOR	SC	Stormceptor	5	10	10
	Pretreatment	SC	Pretreatment	5	10	10
	UGS	UGS	Underground Storage	5	10	10
Extended Detention Dry	ED	ED	Extended Detention	20	20	60
	EDSD	EDSD	Extended Detention Structure Dry	20	20	60
	MB	EDSD	Microbasin - Extended Detention Structure Dry	20	20	60
Filtration	O-1	SW	Dry Swale	40	60	80
	O-2	SW	Wet Swale	40	60	80
	ASCD	CD	Attenuation Swale/Check Dam	40	60	80
	F-1	SF	Surface sand filter	40	60	80

[1] During the development of this report and watershed assessment, the 2014 MDE Guidance on BMP removal has been released. This guidance utilizes BMP removal rate adjustor curves (Schueler and Lane, 2012) and alternative BMP credits; these will be applied to future studies.

Table 3.4 - Water Quality Modeling BMP Pollutant Removal Efficiencies

BMP Category Group	County BMP Code	MDE Code	BMP Name	Percent Removal		
				TN	TP	TSS
Filtration	F-2	SF	Underground sand filter	40	60	80
	F-3	SF	Perimeter sand filter	40	60	80
	F-4	BIO	Organic filter	40	60	80
	F-5	SF	Pocket Sand Filter	40	60	80
	F-6	BIO	Bioretention Facility	40	60	80
	SF	SF	Sand Filter	40	60	80
	ATTENSWA	SW	Attenuation Swale	40	60	80
	AS	SW	Attenuation Swale	40	60	80
	POSAND	SF	Pocket Sand Filter	40	60	80
	VB	VB	Vegetated Buffer	40	60	80
	BIO	BIO	Bioretention Facility	40	60	80
	SPSC	SPSC	Regenerative Step Pool Storm Conveyance	40	60	80
	GBMP	BIO	Bioretention Facility	40	60	80
Infiltration	ATTTRENCH	DW	Attenuation Trench	80	85	95
	DW	DW	Dry Well	80	85	95
	DWIT	DW	Dry Well - Infiltration Trench	80	85	95
	DWITCE	DW	Dry Well - Infiltration Trench with Complete Exfiltration	80	85	95
	DWITCE-2	DW	Dry Well - Infiltration Trench with Complete Exfiltration	80	85	95
	C-2/drywells	DW	Dry Well	80	85	95
	DWITCW	DW	Dry Well - Infiltration Trench with Complete Exfiltration	80	85	95
	DWITPE	DW	Dry Well - Infiltration Trench with Partial Exfiltration	80	85	95
	DWITWQE	ITCE	Dry Well - Infiltration Trench with Water Quality Exfiltration	80	85	95
	EDSDITCE	ITCE	Extended Detention Structure Dry, Infiltration Trench with Complete Exfiltration	80	85	95
	IB	IB	Infiltration Basin	80	85	95
	IITCE	ITCE	Infiltration Trench with Complete Exfiltration	80	85	95
	INPOND	IB	Infiltration Basin No Outfall	80	85	95
	IT	IT	Infiltration Trench	80	85	95

Table 3.4 - Water Quality Modeling BMP Pollutant Removal Efficiencies

BMP Category Group	County BMP Code	MDE Code	BMP Name	Percent Removal		
				TN	TP	TSS
Infiltration	ITVSW	IT	Infiltration Trench, Extended Detention	80	85	95
	ITCE	ITCE	Infiltration Trench with Complete Exfiltration	80	85	95
	ITCEMB	ITCE	Infiltration Trench with Complete Exfiltration, Microbasin	80	85	95
	ITPE	ITPE	Infiltration Trench with Partial Exfiltration	80	85	95
	ITWQE	ITWQE	Infiltration Trench with Water Quality Exfiltration	80	85	95
	OGSITCE	ITCE	Oil Grit Separator Infiltration Trench with Complete Exfiltration	80	85	95
	PNDTR	IB	Same as infiltration basin	80	85	95
	PP	PP	Porous Pavement	80	85	95
	SB	IB	Infiltration Basin	80	85	95
	WQITPE	ITWQE	Water Quality Infiltration Trench with Partial Exfiltration	80	85	95
	WQP	ITWQE	Water Quality Trench	80	85	95
Wet Ponds	EDSW	EDSW	Extended Detention Structure Wet	20	45	60
	MP	MP	Micro Pool	20	45	60
	P-3	EDSW	Extended Detention Structure Wet	20	45	60
	EXPOND	WP	Wet Pond	20	45	60
	P-2	WP	Wet Pond	20	45	60
	SW	WP	Wet Structure	20	45	60
	P-1	MP	Micro Pool	20	45	60
	WP	WP	Retention Structure (Wet Pond)	20	45	60
	P-4	WP	Multiple pond system	20	45	60
	P-5	WP	Pocket pond	20	45	60
Wetlands	SM	SM	Shallow Marsh	20	45	60
	W-1	SM	Shallow Wetland	20	45	60
	RSC	SM	Regenerative Wetland Seepage	50	60	90
	W-2	SM	ED shallow wetland	20	45	60
	W-3	SM	pond/wetland system	20	45	60
	W-4	SM	pocket wetland	20	45	60
Stream Restoration	Stream Conventional	STRE	In-stream Riffles/Stabilization	NA	NA	NA

Table 3.4 - Water Quality Modeling BMP Pollutant Removal Efficiencies

BMP Category Group	County BMP Code	MDE Code	BMP Name	Percent Removal		
				TN	TP	TSS
ESD or Stormwater to the MEP	A1	ESDGR	Green Roofs	50	60	90
	A2	ESDPERMP	Permeable Pavement	50	60	90
	A3	ESDRTRF	Reinforced Turf	50	60	90
	C2	ESDRTD	ESD rooftop disconnect	50	60	90
	C2/ Raingardens	ESDRG	ESD rain gardens	50	60	90
	C3	ESDNRTD	ESD non roof top disconnect	50	60	90
	C4	ESDSFNAC	Sheetflow to Conservation Areas	50	60	90
	N1	ESDRTD	Disconnection of Roof-top	50	60	90
	N2	ESDNRTD	Disconnection of Non Roof-top	50	60	90
	N3	ESDSFNAC	Sheetflow to Conservation Areas	50	60	90
	M1	ESDRH	Rainwater Harvesting	50	60	90
	M2	ESDSGW	Submerged Gravel Wetlands	50	60	90
	M3	ESDIL	Landscape Infiltration	50	60	90
	M4	ESDIB	Infiltration Berms	50	60	90
	M5	ESDDW	Dry Wells	50	60	90
	M6	ESDMB	Micro-Bioretention	50	60	90
	M7	ESDRG	Rain Gardens	50	60	90
	M8	ESDSW	Swales	50	60	90
	M9	ESDEF	Enhanced Filters	50	60	90
Alternative Credits	Street Sweeping	VSS	Regenerative Vacuum Street Sweeping	5	6	25
	Inlet Cleaning	CBC	Stormdrain Vacuuming	5	6	25
	Planting pervious	FPU	Forestation on pervious urban	66	77	57
	Impervious to Pervious	IMPP	Impervious Area Elimination and conversion to pervious	13	72	84
	Impervious to Forest	IMPF	Impervious Area Elimination and conversion to forest	71	94	93

With the exception of stream restoration, pollutant removal efficiencies are reported in Table 3.4 for BMPs as percent of a constituent removed. For stream restoration, pollutant removal is determined on the basis of linear foot of stream restored. New removal efficiencies were recently adopted by the CBP (Schueler and Stack, 2014), however since this watershed study was initiated prior to the adoption of the 2014, the previous rates from 2011 which are listed below, are used:

- Total nitrogen – 0.2 lb per linear foot

- Total phosphorus – 0.068 lb per linear foot
- Total suspended solids – 310 lb per linear foot

As previously discussed, the County's water quality model is applied to various scenarios that represent real and hypothetical watershed conditions. A summary of the modeled scenarios is presented in Table 3.5.

Table 3.5 - Modeled Water Quality Scenarios

Modeled Scenario	Purpose
A. Pristine Conditions	Baseline, all-forested condition representing pre-development state
B. Existing Conditions with no SWM	Current land use without accounting for any existing BMPs or disconnected impervious surfaces
C. Credits from existing SWM	Credits based on performance of public and private BMPs and disconnected impervious surfaces
D. Existing Conditions with SWM	Current land use accounting for existing BMPs and disconnected impervious surfaces
E. Future Conditions with Stormwater to the MEP	Expected future land use with development informed by future stormwater regulations and stormwater management retrofits to the MEP

Pristine or pre-development conditions (Scenario A) were modeled for contextual purposes only and assumed that the watershed was entirely forested prior to development. Existing conditions (Scenario B) were based on high resolution 2007 land cover and impervious surface data collected by the County. Existing condition pollutant loads do not account for existing stormwater management (SWM) (i.e., BMPs in the ground or disconnected impervious surfaces).

Existing stormwater management credit modeling (Scenario C) calculates pollutant load reductions for existing stormwater BMPs and disconnection credits. This scenario incorporates into the model all existing publicly and privately owned BMPs, all restoration projects performed as part of the County's Capital Improvement Program (CIP), and all disconnected impervious surfaces (including a subset of rooftops and open section roads with swales). This calculation relies on delineated drainage areas for each BMP or credit and the pollutant removal efficiency. As described in Section 2.2.2, the drainage areas for each BMP were delineated from the County's DEM. Drainage areas for disconnection credits were obtained from the appropriate land cover polygon (i.e., rooftops or road segment). For each polygon representing a BMP or disconnection credit, the resulting baseline pollutant load reduction was calculated using pollutant removal efficiencies summarized in Table 3.4.

In a number of cases, drainage areas from individual BMPs were found to partially or wholly overlap. In reality, it is not unusual for BMPs to treat stormwater pollutants in series (e.g., as part of a treatment train). Nonetheless, in these cases, the County used a conservative accounting approach to avoid double counting of credits. In those areas with overlapping drainage areas, best professional judgment was used to determine which BMP was predominantly managing a particular intersected drainage area. Overlapping drainage area segments were assigned to the closest BMP with the assumption that the closer a segment was to a particular BMP, the more likely the area was to be treated by that facility. The drainage area polygon was then assigned to the predominant BMP. This was performed to ensure that only a single BMP managed a particular area and that the appropriate BMP was receiving the management credit.

Existing conditions with BMP credit accounting (Scenario D) represents actual existing watershed conditions. It combines the results of Scenario B existing conditions modeling and the Scenario C BMP credits for existing BMPs and disconnected impervious surfaces.

The future conditions modeling (Scenario E) relies on realistic estimates of future development. Future watershed conditions were determined in two steps. First, areas in the watershed were identified where future development is legally constrained or not physically possible. These areas, which are shown on Map 3.2, include:

- steep slopes (greater than 25%) derived from the DEM,
- Federal Emergency Management Agency (FEMA) 100-year floodplains,
- jurisdictional wetlands,
- 100-foot regulatory stream buffers,
- schools and parks,
- cemetery lots,
- DNR protected lands, including Maryland Environmental Trust Lands, and
- Utility and storm water management easements.

Second, outside of these areas where development is not possible, existing land use was examined to determine where future development or re-development could occur and what form it would likely take. This analysis was informed by a holding capacity or development capacity study conducted by the County's Office of Planning and Zoning. For those areas where future land use is anticipated to change from the existing condition land use, the County estimated a future impervious cover percentage based on the average impervious values presented in Table 3.3. Future development is subject to the Maryland stormwater regulations discussed in Section 1.2.3, where ESD is to be implemented to the maximum extent practicable. As such, for both future development and redevelopment, the calculated pollutant loads were reduced by the pollutant removal efficiency associated with ESD practices (see Table 3.4). MDE refers to stormwater management retrofits using ESD practices as Stormwater to the MEP. For areas where new development is expected to occur, 100% of the new impervious area was assumed to be managed by Stormwater to the MEP.

For those areas where redevelopment is expected to occur, 50% of the existing impervious area and 100% of new impervious area is managed with Stormwater to the MEP.

3.2 MODELING RESULTS

This subsection presents and discusses results from application of the hydrological and water quality models to the Little Patuxent watershed.

3.2.1 Hydrologic Modeling

The hydrologic model results are primarily utilized in the subwatershed assessments discussed in Section 4. In these assessments, four hydrologic indicators are evaluated for each subwatershed:

- Area-normalized peak flow (cfs/acre) for a 2.7” (one-year storm)
- Area-normalized peak flow (cfs/acre) for a 3.3” (two-year storm)
- Surface runoff yield (inches) for a 2.7” (one-year storm)
- Surface runoff yield (inches) for a 3.3” (two-year storm)

The one-year and two-year events were selected because bankfull conditions for streamflow, which are generally considered to be the most critical condition for delivery of sediment and associated pollutants, typically occur about once every one to two years in the Chesapeake Bay region. The results of the hydrologic model run for the 1, 2, 10, and 100-year storm events are presented below in Table 3.6.

Table 3.6 - Hydrologic Model Results

Subwatershed		1 year	2 year	10 year	100 year
LP0	Runoff Yield (in)	0.67	1.02	2.29	5.37
	Peak Discharge (cfs)	131.0	211.0	511.0	1231.0
LP1	Runoff Yield (in)	0.84	1.23	2.60	5.70
	Peak Discharge (cfs)	112.0	169.0	376.0	852.0
LP2	Runoff Yield (in)	0.69	1.04	2.31	5.32
	Peak Discharge (cfs)	108.0	171.0	410.0	983.0
LP3	Runoff Yield (in)	0.72	1.07	2.36	5.38
	Peak Discharge (cfs)	174.0	274.0	646.0	1532.0
LP4	Runoff Yield (in)	0.40	0.66	1.70	4.31
	Peak Discharge (cfs)	79.0	138.0	389.0	1072.0
LP5	Runoff Yield (in)	0.51	0.81	1.96	4.81
	Peak Discharge (cfs)	87.0	148.0	394.0	1026.0
LP6	Runoff Yield (in)	0.90	1.29	2.68	5.77
	Peak Discharge (cfs)	178.0	265.0	574.0	1278.0
LP7	Runoff Yield (in)	0.42	0.69	1.70	4.10

Table 3.6 - Hydrologic Model Results

Subwatershed		1 year	2 year	10 year	100 year
	Peak Discharge (cfs)	65	109	291.0	775.0
LP8	Runoff Yield (in)	0.57	0.89	2.06	4.83
	Peak Discharge (cfs)	73.0	118.0	296.0	742.0
LP9	Runoff Yield (in)	0.30	0.52	1.46	3.88
	Peak Discharge (cfs)	62	115	350.0	1022.0
LPA	Runoff Yield (in)	0.53	0.84	1.99	4.77
	Peak Discharge (cfs)	66.0	110.0	284.0	727.0
LPB	Runoff Yield (in)	0.40	0.63	1.45	3.07
	Peak Discharge (cfs)	57	91	225.0	568.0
LPC	Runoff Yield (in)	0.81	1.19	2.53	5.58
	Peak Discharge (cfs)	289.0	440.0	989.0	2267.0
LPD	Runoff Yield (in)	0.60	0.84	1.57	2.81
	Peak Discharge (cfs)	81	119	256.0	578.0
LPE	Runoff Yield (in)	0.72	1.08	2.39	5.49
	Peak Discharge (cfs)	177.0	279.0	658.0	1554.0
LPF	Runoff Yield (in)	0.68	1.01	2.18	4.75
	Peak Discharge (cfs)	103	159	369.0	877.0
LPG	Runoff Yield (in)	0.69	1.03	2.31	5.32
	Peak Discharge (cfs)	214.0	339.0	811.0	1947.0
LPH	Runoff Yield (in)	0.52	0.82	1.98	4.87
	Peak Discharge (cfs)	42.0	72.0	193.0	501.0
LPI	Runoff Yield (in)	0.45	0.68	1.48	2.92
	Peak Discharge (cfs)	98	153	362.0	883.0
LPJ	Runoff Yield (in)	0.56	0.88	2.07	4.97
	Peak Discharge (cfs)	79.0	131.0	336.0	851.0
LPK	Runoff Yield (in)	0.76	1.12	2.45	5.53
	Peak Discharge (cfs)	97.0	151.0	349.0	814.0

Subwatersheds were prioritized and rated “High,” “Medium High,” “Medium,” or “Low” based on the natural breaks for each of the four hydrologic indicators. A summary of these ratings for the watershed is presented in Table 3.7. For the majority of the subwatersheds in the Little Patuxent watershed, the one-year peak flow scores were similar to the two-year peak flow scores, and also the one-year yield scores were similar to the two-year yield scores. As shown in Map 3.1, most of the subwatersheds have a similar distribution of low, medium high, and medium area-normalized event peak flow values that translate to lower priorities. Approximately 60% of the subwatersheds within the watershed are rated “Low” or “Medium” for the two peak flow indicators. The hydrologic indicator ratings for surface runoff yield were similarly distributed with 53% and 60% of the rated as “Low” or Medium” for the one-year and two-year yield, respectively. For peak flow and surface runoff yield, the percentage of the watershed rated “High” is 12% and 11% for peak flow and runoff yield, respectively.

Table 3.7 - Hydrologic Indicator Ratings

Rating	Number of Subwatersheds	Percent of Subwatersheds
Peak Flow (one-year storm)		
High	3	12.4%
Medium High	7	33.5%
Medium	4	23.3%
Low	5	30.9%
Peak Flow (two-year storm)		
High	3	12.4%
Medium High	6	27.7%
Medium	5	29.0%
Low	5	30.9%
Surface Runoff Yield (one-year storm)		
High	2	11.1%
Medium High	7	35.8%
Medium	5	23.8%
Low	5	29.3%
Surface Runoff Yield (two-year storm)		
High	2	11.1%
Medium High	5	29.3%
Medium	6	34.0%
Low	6	25.6%

3.2.2 Water Quality Modeling Results

Existing condition water quality modeling results are summarized at the watershed scale in Table 3.8. Additional water quality modeling results are summarized at the subwatershed scale in Table 3.9. These tables show the model-predicted annual loadings of total phosphorus, total nitrogen, and total suspended solids for pristine, current, and future scenarios and for the existing conditions credits. Except where noted, these results are presented for all County jurisdictional lands that fall under the urban stormwater (or urban NPS) sector. Pollutant loading results for existing conditions and future conditions are also depicted in Map 3.3 and Map 3.4, respectively.

Table 3.8 - Annual Loads for Various Scenarios

Scenario	Total Nitrogen (lb/yr)	Total Phosphorus (lb/yr)	Total Suspended Solids (tons/yr)
LITTLE PATUXENT WATERSHED			
A. Pristine Conditions	12,144	1,336	206
B. Existing with no SWM Credits	67,470	8,342	724
C. Credits from Existing SWM	4,208	821	97
D. Existing with SWM Credits	63,261	7,521	627
E. Future with Stormwater to the MEP	67,894	7771	585

Table 3.9 - Annual Loads at Subwatershed Level for Modeled Scenarios

Shed Code	SCENARIO A			SCENARIO B						SCENARIO C			SCENARIO D			SCENARIO E		
	Pristine Condition Loads			Existing Condition Load without existing SWM credit (All lands)			Existing Condition Load without existing SWM credit (County Urban NPS)			SWM Credits (County Urban NPS)			Existing Condition Load with existing SWM credit (County Urban NPS)			Future Condition Load with Existing SWM Credits (County Urban NPS)		
	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)	TN (lbs/yr)	TP (lbs/yr)	TSS (tons/yr)
LP0	293	32	5	4,256	594	53	74	10	1	0	0	0	74	10	1	74	10	1
LP1	272	30	5	2,023	269	23	485	66	6	17	4	0	469	62	6	817	87	6
LP2	383	42	7	3,840	526	54	2,417	305	30	69	14	2	2,348	291	28	2941	321	28
LP3	584	64	10	7,644	971	76	7,118	861	62	211	35	4	6,907	826	58	6897	815	56
LP4	832	92	14	9,105	1,214	100	1,087	164	14	28	6	0	1,059	158	14	1412	170	11
LP5	507	56	9	6,076	823	69	53	7	1	0	0	0	53	7	1	36	5	0
LP6	443	49	8	5,964	892	143	2,521	291	43	166	35	6	2,356	256	37	2397	250	32
LP7	744	82	13	2,450	295	36	2,450	295	36	125	26	4	2,325	269	32	2893	317	30
LP8	479	53	8	1,677	208	22	1,530	189	19	40	9	1	1,490	181	18	1595	193	19
LP9	1,001	110	17	8,280	1,153	114	4,587	587	52	178	28	5	4,409	559	48	4469	554	43
LPA	451	50	8	1,849	244	25	1,129	138	12	66	10	1	1,062	128	11	2937	326	13
LPB	758	83	13	920	107	16	60	10	1	0	0	0	60	10	1	60	10	1
LPC	855	94	15	10,341	1,279	108	9,837	1,198	99	885	200	19	8,952	997	80	8919	970	72
LPD	697	77	12	8,072	1,014	82	7,710	960	76	956	161	20	6,754	798	56	6972	805	55
LPE	408	45	7	5,241	637	49	5,241	637	49	601	123	15	4,641	513	33	4595	503	32
LPF	658	72	11	6,464	806	81	5,896	717	71	246	51	6	5,650	666	65	5751	651	60
LPG	739	81	13	11,083	1,365	108	10,700	1,303	101	511	102	11	10,189	1,201	90	9956	1161	83
LPH	212	23	4	234	27	4	3	0	0	0	0	0	3	0	0	3	0	0
LPI	1,164	128	20	7,543	1,016	93	1,249	169	14	0	0	0	1,249	169	14	1376	182	14
LPJ	402	44	7	2,670	371	33	1,613	218	17	99	15	1	1,514	204	16	1891	220	15
LPK	260	29	4	2,156	282	24	1,711	217	18	11	1	0	1,700	215	18	1905	222	15
Total	**12,144**	**1,336**	**206**	**107,890**	**14,094**	**1,315**	**67,470**	**8,342**	**724**	**4,208**	**821**	**97**	**63,261**	**7,521**	**627**	**67,894**	**7771**	**585**

Pollutant loading was considered in the assessments of both subwatershed restoration and subwatershed preservation that are discussed in more detail in Section 4. For the subwatershed restoration assessment, the County evaluated two water quality indicators based on existing conditions: total nitrogen load from runoff (lbs/acre/yr) and total phosphorus load from runoff (lbs/acre/yr). For the subwatershed preservation assessment, the County evaluated water quality indicators based on the percent future departure of loading conditions for total nitrogen and total phosphorus in terms of pounds per acre per year.

Subwatersheds were prioritized and rated "High," "Medium High," "Medium," or "Low" for each of the water quality indicators related to the subwatershed restoration analysis. A summary of these ratings for Little Patuxent watershed is presented in Table 3.10. A visual representation of the existing condition pollutant loads within the study subwatershed is depicted in Map 3.5. In the watershed, the largest percentage (30%) of subwatersheds were rated "Low" when evaluating total nitrogen or total phosphorus loading. Between 13 and 22% of the subwatershed were rated "High" for the two indicator categories.

Table 3.10 - Water Quality Indicator Ratings (Subwatershed Restoration)

Rating	Number of Subwatersheds	Percent of Subwatersheds
Total Nitrogen Load from Runoff		
High	5	21.7%
Medium High	5	23.3%
Medium	4	24.9%
Low	5	30.1%
Total Phosphorus Load from Runoff		
High	3	13.0%
Medium High	5	23.3%
Medium	5	30.7%
Low	6	33.1%

For the subwatershed preservation assessment, subwatersheds are rated and prioritized "High," "Medium High," "Medium," or "Low" based on their relative need for preservation. A summary of these ratings for the Little Patuxent watershed is presented in Table 3.11 and is shown visually on Map 3.5. In the watershed, for the percent future departure of total nitrogen loading, 79% of the subwatersheds were rated as "Medium High" and "High" priorities. For the percent future departure of total phosphorus loads, 73% of the subwatersheds were rated as “Medium High” and High” priorities. Less than 16% of the watershed area was rated as “Low” priorities for both nitrogen and phosphorus.

Table 3.11 - Water Quality Indicator Ratings (Subwatershed Preservation)

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
Percent Future Departure of Total Nitrogen Load		
High	1	6.6%
Medium High	13	72.1%
Medium	2	5.7%
Low	3	15.7%
Percent Future Departure of Total Phosphorus Load		
High	1	6.6%
Medium High	13	66.6%
Medium	2	11.1%
Low	3	15.7%

4. RATING AND PRIORITIZATION

The County performs three detailed prioritization assessments in order to characterize current conditions within the watershed, guide decisions that impact waterways, and assist with land use management planning. The three assessments (stream restoration, subwatershed restoration, and subwatershed preservation) are presented in more detail in the following subsections. Each prioritization assessment relies on indicators derived from the data collected and compiled in Section 2 and the model results generated in Section 3.

4.1 STREAM RESTORATION ASSESSMENT AND RATING

The County's stream restoration assessment is intended to identify and rate the impaired stream reaches in the Little Patuxent watershed to prioritize future stream restoration and capital improvement projects and to guide future land use management and development decisions. Methods and findings for the stream restoration assessment and rating are presented in this subsection.

4.1.1 Methods

The stream restoration assessment uses a suite of indicator scores or ratings that are weighted and then combined to obtain a single stream restoration rating for each perennial reach. The indicators are grouped into one of five categories: stream habitat; stream morphology; land cover; infrastructure; and hydrology and hydraulics. As shown in Table 4.1, each category is comprised of one to six different indicators, and each indicator has a relative weight assigned by the County.

Table 4.1 - Stream Restoration Assessment Indicators

Category	Indicator	Weight
Stream Habitat	MPHI score	31.6%
Stream Morphology	Rosgen Level I classifications	5.3%
Land Cover	Imperviousness (%)	5.3%
Infrastructure	Stream buffer impacts	5.3%
	Channel erosion impacts	10.5%
	Head cut impacts	5.3%
	Dumpsite impacts	5.3%
	Other infrastructure impacts (pipes, ditches, stream crossings, and obstructions)	15.8%
Hydrology and Hydraulics	Crossing flooding likelihood	15.8%

Among the indicators for stream restoration, the MPHI score is utilized to represent the quality of physical stream habitat characteristics. Rosgen Level I classifications are used as an indicator of the degree of stability and entrenchment of each stream reach. The percentage of imperviousness contributes to increased stormwater volumes and thermal and chemical pollutant loading. The presence and impacts associated with stream buffers, channel erosion, head cuts, dumpsites, and other indicators (i.e., pipes, ditches, stream crossings, and obstructions) are a sign of potential channel degradation, excessive pollution and sedimentation, and habitat impairment. Flooding and overtopping of road stream crossings pose an inconvenience and safety hazard to nearby residents.

Although all stream channel types (e.g., perennial, intermittent, ephemeral, etc.) were assessed as part of the physical habitat condition assessment described in Section 2.1.2, several of the metrics used to calculate the MPHI are only applicable for perennial channels. Since the MPHI score is a critical indicator and weighted so heavily in the County's stream restoration prioritization, only perennial streams are considered.

4.1.2 Results

Of the 304 assessed perennial stream reaches in the Little Patuxent watershed, 7 were rated as "High" priorities for restoration. 109 were rated as "Medium High" priority for restoration. Of the 18 subwatersheds with assessed perennial streams, 11 had more than one-third of their perennial streams rated as "High" or "Medium High":

- Rogue Harbor 1 (LP4) had the greatest percentage (75%) of assessed streams ranked in the "High" and "Medium High" categories. Only 4 streams were assessed in LP4
- Dorsey Run 5 (LPD) had the second highest percentage (62%) of assessed streams ranked in the "High" and Medium High" Categories. Crofton Gulf (LPG) and Piney Orchard (LPE) had the highest number of streams in the "High" and "Medium High" category with 17 and 15, respectively.

The remaining 188 reaches were assessed in the "Medium" and "Low" categories (59 and 129 respectively). A breakdown of the results by subwatershed is presented in Table 4.2. See Map 4.1 for a map of the stream restoration assessment results.

Table 4.2 - Stream Restoration Assessment Results

Subwatershed Code	Subwatershed Name	Number of Reaches with Rating				
		High	Medium High	Medium	Low	Total
LP0	Little Patuxent 2	0	3	1	5	9
LP2	Dorsey Run 3	0	1	3	4	8
LP3	Towsers Branch 1	2	8	9	4	23
LP4	Rogue Harbor 1	0	0	3	1	4
LP7	Little Patuxent 5	0	0	4	13	17
LP8	Little Patuxent 4	0	2	4	5	11
LP9	Rogue Harbor 2	0	0	9	8	17
LPA	Oak Hill	0	1	9	17	27
LPB	Dorsey Run 6	0	0	1	11	12
LPC	Towsers Branch 3	3	7	7	5	22
LPD	Dorsey Run 4	0	2	13	6	21
LPE	Piney Orchard	1	12	14	5	32
LPF	Little Patuxent 6	0	0	6	10	16
LPG	Crofton Gulf	1	13	16	15	45
LPH	Little Patuxent 3	0	0	1	8	9
LPI	Dorsey Run 5	0	0	1	4	5
LPJ	Dorsey Run 2	0	5	5	7	17
LPK	Jessup	0	5	3	1	9
Total		**7**	**59**	**109**	**129**	**304**

4.2 SUBWATERSHED RESTORATION ASSESSMENT AND RATING

The County's subwatershed restoration assessment is intended to identify and rate those subwatersheds where conditions warrant priority consideration for restoration activities. Methods and findings for the subwatershed restoration assessment and rating are presented in this subsection.

4.2.1 Methods

Like the stream restoration assessment, the subwatershed restoration assessment uses a suite of indicator ratings that are weighted and combined to obtain a single restoration rating for each subwatershed. The indicators are grouped into one of seven categories: stream ecology; 303(d) list; septics; BMPs; H&H; water quality; and landscape. Each category is comprised of one to four different indicators. A summary of the indicators and their relative weighting assigned by the County are presented in Table 4.3.

Table 4.3 - Subwatershed Restoration Assessment Indicators

Category	Indicator	Weight
Stream Ecology	Final habitat score	8.1%
	Bioassessment score	8.1%
303(d) List	Number of TMDL impairments	8.1%
Septics	Total nitrogen load from septics (lbs)	2.0%
BMPs	Impervious area treated by BMPs (%)	6.4%
H&H (Land and Soils Only)	Peak flow from 1-year storm (cfs/ac)	4.4%
	Peak flow from 2-year storm (cfs/ac)	4.4%
	Runoff volume from 1-year storm (in)	5.6%
	Runoff volume from 2-year storm (in)	5.6%
Water Quality (Land Only)	Total nitrogen load from runoff (lbs/acre/yr)	6.7%
	Total phosphorus load from runoff (lbs/acre/yr)	6.7%
Landscape	% Impervious cover	9.3%
	% Forest within the 100 ft stream buffer	10.1%
	% of existing wetlands to potential wetlands	9.3%
	Acres of developable Critical Area	5.2%

Among the indicators for the subwatershed restoration assessment, the final habitat and bioassessment scores are used as indicators of the quality of the physical and biological characteristics of stream reaches in the subwatershed. The relative magnitude of total nitrogen loading from septics and total nitrogen and total phosphorus loading from runoff are indicative of potential water quality degradation in each subwatershed. Peak flow and runoff volume are indicators of hydrology changes due to increased development and urbanization. BMP and landscape indicators including percent imperviousness, percent BMP treatment, and percent forested buffer influence stormwater volumes, peak flows, and pollutant loading. The presence of potential wetland areas and acres of developable Critical Area serve as indicators of restoration potential.

4.2.2 Results

The subwatersheds in the Lower Patuxent Watershed were assessed to identify restoration needs. As seen in Table 4.4, of the 19 subwatersheds assessed, five were rated “High”, which makes them priorities for restoration. These five subwatersheds represent 22.8%, of the subwatershed area assessed in the Little Patuxent watershed. The remaining watershed area was broken out between Medium High (25.6%), Medium (25.4%), and Low (26.2%) priority. The breakdown of rating results by subwatershed is presented in Table 4.5. See Map 4.2 for a map of the subwatershed restoration assessment results.

Table 4.4 - Subwatershed Priority Ranking for Restoration

Subwatershed Code	Subwatershed Name	Priority for Restoration
LP0	Little Patuxent 2	High
LP6	Towsers Branch 2	High
LPK	Jessup	High
LPG	Crofton Golf	High
LPC	Towsers Branch 3	Medium High
LP3	Towsers Branch 1	Medium High
LP4	Rogue Harbor 1	Medium High
LPE	Piney Orchard	Medium High
LPD	Dorsey Run 4	Medium High
LP2	Dorsey Run 3	Medium High
LPF	Little Patuxent 6	Medium
LPJ	Dorsey Run 2	Medium
LPI	Dorsey Run 5	Medium
LPH	Little Patuxent 3	Medium
LPA	Oak Hill	Medium
LP9	Rogue Harbor 2	Low
LPB	Dorsey Run 6	Low
LP8	Little Patuxent 4	Low
LP7	Little Patuxent 5	Low

Table 4.5 - Subwatershed Restoration Assessment Results

Rating	Number of Subwatersheds	Percent of Subwatersheds
High	5	26.3%
Medium High	5	26.3%
Medium	5	26.3%
Low	4	21.1%
TOTAL	**19**	---

4.3 SUBWATERSHED PRESERVATION ASSESSMENT AND RATING

The County's subwatershed preservation assessment is intended to identify and rate those subwatersheds where conditions warrant consideration for preservation activities. Methods and findings for the subwatershed preservation assessment and rating are presented below.

4.3.1 Methods

The subwatershed preservation assessment uses a suite of indicator ratings that are weighted and combined to obtain a single preservation rating for each subwatershed. The indicators are grouped into one of five categories: stream ecology, future departure of water quality conditions, soils, landscape, and aquatic living resources. Each category is comprised of one to eight different indicators. A summary of the indicators and the relative weighting assigned by the County are provided in Table 4.6.

Table 4.6 - Subwatershed Preservation Assessment Indicators

Category	Indicator	Weight
Stream Ecology	Final habitat score	7.4%
	Bioassessment score	7.4%
Future Departure of Water Quality Conditions	Percent future departure of total nitrogen	11.1%
	Percent future departure of total phosphorus	11.1%
Soils	NRCS soil erodibility factor	7.4%
Landscape	Percent forest cover	11.1%
	Percent wetland cover	11.1%
	Density of headwater streams (ft/ac)	7.4%
	Percent of land within the Greenway Master Plan	3.7%
	Presence of bog wetlands	3.7%
	Acres of RCA lands within Critical Area	3.7%
	Percent of protected lands	3.7%
	Presence of Wellhead Protection Areas	3.7%
Aquatic Living Resources	Presence of trout spawning, anadromous spawning, and SSPRA	7.4%

4.3.2 Results

A total of 11 subwatersheds in the Lower Patuxent Watershed were assessed to be "High" and "Medium High" priorities on the preservation rating scale. Of these, five were rated as being a "High" priority. "Medium" ratings for preservation make up 26.2% of the subwatersheds. The remaining two subwatersheds were assessed to be a "Low" priority for preservation. The full breakdown for ranking is presented in Table 4.7 and Table 4.8. See Map 4.3 for a map of the subwatershed preservation assessment results for the Lower Patuxent watershed.

Table 4.7 - Subwatershed Priority Rating for Preservation

Subwatershed Code	Subwatershed Name	Priority for Preservation
LP8	Little Patuxent 4	High
LP7	Little Patuxent 5	High
LPA	Oak Hill	High
LPH	Little Patuxent 3	High
LPB	Dorsey Run 6	High
LPC	Towsers Branch 3	Medium High
LP9	Rogue Harbor 2	Medium High
LPJ	Dorsey Run 2	Medium High
LPI	Dorsey Run 5	Medium High
LPF	Little Patuxent 6	Medium High
LP2	Dorsey Run 3	Medium High
LPE	Piney Orchard	Medium
LPD	Dorsey Run 4	Medium
LP0	Little Patuxent 2	Medium
LPK	Jessup	Medium
LP3	Towsers Branch 1	Medium
LPG	Crofton Golf	Medium
LP4	Rogue Harbor 1	Low
LP6	Towsers Branch 2	Low

Table 4.8 - Subwatershed Preservation Assessment Results

Rating	Little Patuxent Watershed	
	Number of Subwatersheds	Percent of Subwatersheds
High	5	23.3%
Medium High	6	11.2%
Medium	6	26.2%
Low	2	39.3%
TOTAL	**19**	---

5. RESTORATION AND PRESERVATION IMPLEMENTATION PLAN

As discussed in detail in the previous sections, the County collected and compiled extensive data on water resource and land use characteristics and conditions (Section 2); conducted hydrologic and water quality modeling for both current and future conditions (Section 3); and prioritized stream reaches and subwatersheds based on the need for restoration and preservation (Section 4). These steps were critical for developing a better understanding of watershed conditions and identifying priorities in the watershed. This section uses the results of these previous steps to identify and describe a specific restoration and preservation implementation plan for the Little Patuxent watershed.

This implementation plan hinges on a gap analysis evaluating load reduction goals, the development of potential restoration activities, and a cost-benefit analysis of restoration scenarios to identify the appropriate mix of restoration activities to meet those load reduction goals. These components are discussed in detail in this section along with a set of specific recommendations for implementation. In addition, concept design plans for a subset of prioritized restoration activities within the Little Patuxent watershed are also presented.

5.1 GAP ANALYSIS

A gap analysis in the context of watershed planning is an approach that compares a baseline of existing and/or future conditions with watershed targets or goals. The “gap” then informs the County on what needs to be done to meet its goals. As discussed in Section 1.2, watershed goals in the Little Patuxent watershed are driven primarily by load allocations associated with the Chesapeake Bay TMDL and the Baltimore Harbor TMDL and permit requirements in the County’s NPDES MS4 permit. Because of this, it has been assumed for the purposes of this report that employing a strategy to satisfy load reduction goals of the Chesapeake Bay TMDL would simultaneously satisfy the Baltimore Harbor TMDL and the NPDES permit impervious treatment requirements.

The focus of this study and this gap analysis is on developing solutions and strategies for addressing urban non-point sources in the watershed. As such, the current pollutant loads, existing credits, and proposed restoration activities are derived from only those associated with urban development. Urban lands, as defined in this plan, include lands coded as industrial, transportation, commercial, residential (all densities), utility, open space, airport, and residential woods. Lands not included as urban are those coded as pasture/hay, row crops, woods, water, and wetland. County urban lands can further be broken down by the contribution from public and private lands.

As discussed in Section 1.2.2.1, the nutrient load allocations assigned from the Chesapeake Bay TMDL are provided for the urban MS4 sector at the County-scale and are not further divided by County watersheds. For planning purposes at the watershed level, the County is applying the same percent load reduction required at the County level to each of its watersheds. For total nitrogen, this amounts to a 21% reduction from an existing conditions annual load without credits by the 2017 interim target, and a 35% annual load reduction by 2025. For total phosphorus, the interim target load reduction is 38% and the 2025 target load reduction is 63%. For total suspended solids, load allocations have not yet been provided by EPA.

Table 5.1 provides a summary of existing and future pollutant loads for the County's urban stormwater sector, the estimated TMDL allocation for urban stormwater for the study watersheds, and the required reduction (gap) to meet the estimated TMDL allocation. The modeling methods to derive the existing and future loads are described in more detail in Section 3.

Table 5.1 - Summary of Loads and Allocations

Scenario	TN (lbs/year)	TP (lbs/year)	TSS (tons/year)
LITTLE PATUXENT WATERSHED			
2010 Load (No BMPs)	67,470	8,342	724
2011 Progress Load (With BMPs)*	61,829	7,827	665
Future Conditions Load (With Credits)	67,894	7,771	585
Estimated 2025 TMDL Allocation	41,673	3,035	NA
Required Reduction from 2011 Progress Load (With BMPs)	20,156	4,792	NA

* Note that the 2011 Progress Load includes credits for existing BMPs, but does not include credit for impervious surface disconnections.

5.2 DEVELOPMENT OF POTENTIAL RESTORATION STRATEGIES

A variety of potential restoration activities are available to improve instream and riparian habitat conditions, to improve management and treatment of stormwater runoff, and to meet nutrient load reduction targets. For the County, a key consideration is that restoration activities must be cost effective relative to the quantity of pollutant removed. Other selection criteria include maintenance, life expectancy, and public acceptance of the proposed measure. For these reasons, prioritizing the planning and implementation of these activities is of great importance. The County has selected a range of restoration activities that are summarized in the sections that follow. These activities have been implemented successfully by the County in other watershed restoration efforts and it is expected that they will translate well to the conditions encountered in the Little Patuxent watershed.

These strategies mirror those presented in the County's approved Phase II WIP for meeting the Chesapeake Bay TMDL. The WIP strategy is broken down into three primary categories:

- **Core Strategies** – These are generally large capital improvement projects that represent the bulk of the load reductions and capital expenditures in the plan. The goals of the Core Strategies are to restore stream stability, restore connectivity with floodplains and streams, restore biological health of streams, and obtain compliance with water quality standards. The locations of these strategies are presented on Map 5.1.

- **Core Tier II Strategies –** These are generally smaller scale capital projects or programmatic strategies that are collectively intended to close the gap to achieve the final 2025 required nutrient load reductions. The locations of these strategies are presented on Map 5.2.
- **Potential Load Reductions Outside of the Core Strategy WIP Areas –** These are credits that may be achieved from installation of stormwater management practices on private property as a result of potential future implementation of a County stormwater utility fee and associated credit program. The locations of these strategies are presented on Map 5.3.

A description of the individual components of each of these strategies is presented in the sections that follow. The locations of all of the TMDL WIP strategies for the Little Patuxent watershed are presented in Map 5.4.

5.2.1 WIP Core Strategies

The following represent the Core Strategies that will be employed in the Little Patuxent watershed.

- **Outfall Retrofits –** This strategy targets all major outfalls characterized by the Infrastructure Management Division (IMD) as impaired with scores of C and lower, outfalls identified through the Illicit Discharge Detection Elimination (IDDE) survey to be unstable, and other major outfalls located in subwatersheds with the highest priority for restoration (see Section 4.2). Major outfalls are defined as stormwater pipes at the end of the collection system that are larger than 36 inches or larger than 18 inches within commercial areas. Outfalls are proposed to be retrofitted with regenerative step pool storm conveyance (SPSC) systems, as allowed by design and site conditions. These outfall retrofits increase infiltration and dampen flow velocities, which enhances removal of suspended particles and associated nutrients and decreases downstream bed and bank erosion in receiving water bodies.
- **Stormwater Pond Retrofits –** This strategy focuses on retrofitting both public and private wet and dry stormwater ponds built prior to 2002 and with a drainage area greater than 10 acres. Based on MDE's analysis of BMP performance by era (MDE 2009), it is assumed that stormwater ponds built prior to 2002 were not designed to comply with currently accepted criteria for management of water quality. As such, these ponds were deemed to be prime candidates for retrofits to more efficient BMPs that are designed for water quality management, like shallow wetland marshes, regenerative SPSCs, or constructed wetland systems. All dry and wet ponds approved before 2002 were selected for retrofitting regardless of subwatershed or stream condition.

- **Stream Restoration –** This strategy targets degraded and severely degraded ephemeral, intermittent, and perennial stream reaches identified by the County's stream restoration assessment and rating (see Section 4.1) to be in the greatest need for restoration. Lower order, ephemeral and intermittent streams are proposed as SPSC Systems and higher ordered perennial streams are proposed as stream restoration. These measures for perennial streams include but not limited to installation of low head rock weirs for grade control and floodplain connection, sand seepage berms for additional nutrient filtration, wetland creation, oxbow ponds, bio-engineering, and riparian stream plantings.
- **Programmed Projects –** This strategy accounts for programmed environmental restoration projects to be implemented by the County. These projects include outfall retrofits, stream restorations, and BMP retrofits.

5.2.2 WIP Core Tier II Strategies

The following represent the Core Tier II Strategies that will be employed in the Little Patuxent watershed.

- **Street Sweeping –** Starting Fiscal Year 2015, Anne Arundel County has enhanced their street sweeping program which now includes sweeping curb-miles and parking lots within the Little Patuxent. This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, and other pollutants. For full credit by MDE, street sweeping should occur twice a month or 26 times a year on urban streets. This frequent sweeping of the same street will reduce nitrogen and phosphorus as well as sediment. Under the enhanced street sweeping program Anne Arundel County is sweeping arterial streets within the Little Patuxent watershed on a bi-weekly basis (26 times a year) and collector and local streets on a monthly basis (12 times a year). In order to quantify sediment load reductions from monthly sweeping efforts, the removal rate of 22% for vacuum- assisted monthly sweeping was applied to total sediment collected from collector and local streets (CWP, 2008).
- **Inlet Cleaning –** Storm drain cleanout practice ranks among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with NPDES stormwater permits. Inlet cleaning will occur at a frequency established by Bureau of Highways at the selected inlets.
- **Public Land Reforestation –** This strategy entails reforesting public open space parcels that have been identified by the Anne Arundel County Forestry Program to be potential forestation sites. This direct conversion of open space to forested land.
- **Stormwater to the MEP –** This strategy includes retrofitting existing impervious surfaces to the maximum extent practical with stormwater management practices, including but not limited to green roofs, permeable pavement, bioretention, and

disconnection. These retrofits will be limited to County-owned properties including Board of Education facilities and Recreation and Park facilities.

5.2.3 Potential Load Reductions Outside of the Core Strategy WIP Areas

The Stormwater fee is a local government fee established in response to federal stormwater management requirements. The federal requirements are designed to prevent local sources of pollution from reaching local waterways. The stormwater utility had to include a stormwater remediation fee to be collected annually from property owners within the County. The County has a stormwater fee credit program to encourage practices that proactively and sustainably manage runoff on private property. It is expected that this program could be a driver for a subset of private property owners to retrofit their properties with Stormwater treatment, outside of the normal course of development and redevelopment.

For planning and accounting purposes, the County assumes that these credits are limited to areas outside of existing areas covered by the Core Strategies and Core Tier II Strategies. The following broad categories of restoration activities are considered:

- **Private Commercial/Industrial Stormwater Management –** This credit accounts for stormwater management retrofits to private commercial and industrial properties.
- **Private Residential Stormwater Management –** This credit accounts for retrofitting rooftops in high density residential areas with practices such as, rain water harvesting or rain gardens.

In 2015, the State of Maryland made changes to the stormwater utility and remediation fee legislation. The new legislation allows Phase I counties to repeal or reduce stormwater fees before July 1, 2016, but affected counties must still identify dedicated revenues to supply local watershed protection funds to meet stormwater permit requirements. The legislation also requires the submission of Anne Arundel County's Financial Assurance Plan (FAP), as well as the submission of the Watershed Protection and Restoration Program (WPRP) annual report, for compliance with Maryland Environment Article §4-202.1. The FAP is to show that the County has the financial means to achieve the permit requirements.

5.3 COST-BENEFIT ANALYSES OF RESTORATION SCENARIOS

The County performed a cost-benefit analysis of the restoration strategies to determine the level of implementation of each restoration activity and associated costs required to meet the load reductions summarized in Section 5.1. The County applied its hydrologic and water quality modeling (discussed in Section 3) to evaluate the potential for the restoration activities to reduce pollutant loading. The County estimated costs for each strategy based on unit costs developed from previous restoration experiences in the County. This analysis was performed in an iterative manner, where assumptions about specific restoration activities, implementation levels, and performance were adjusted to optimize the overall costs and benefits. The results of this analysis highlight the relative effectiveness of each restoration type and provide a useful tool for setting implementation priorities. In addition, the results indicate, at a planning level, the total magnitude of resources necessary to meet the goals for the watershed. The methods and results of this analysis are discussed below.

5.3.1 Load Reduction Calculations

The benefits (in terms of pollutant load reductions) for the restoration activities associated with each strategy were calculated using the water quality model described in Section 3.1.2. Similar to the baseline modeling, the basic elements of the load reduction model are polygons created in GIS. The County generated polygons for the load reduction modeling primarily from the geospatial Identity of GIS layers representing land use, land ownership, and the drainage area of each restoration activity. Drainage areas for each restoration activity were delineated from the County's Digital Elevation Model (DEM) or were obtained from the appropriate land use or land cover polygon. See Table 5.2 for a summary of the drainage area delineation assumptions.

For each polygon representing an individual restoration activity, the baseline pollutant load was calculated and reduced in the model using pollutant removal efficiencies summarized in Table 5.2. As described in Section 3.1.2, these efficiencies were largely derived from MDE's guidance document *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2011). Resultant pollutant loads reductions were calculated for each restoration activity for total nitrogen, total phosphorus, and total suspended solids.

In a number of cases, drainage areas from individual restoration activities were found to overlap either wholly or in part. In reality, it is not unusual for restoration activities to treat stormwater pollutants in series (e.g., as part of a treatment train). Nonetheless, in these cases, the County used a conservative accounting approach to avoid double counting of credits. The exception to this is for the street sweeping Core Tier II Strategy, which has relatively low pollutant removal efficiencies and is widely applied across the watersheds.

The County's water quality model avoided double counting load reduction credits by counting the number of overlapping or nested restoration activities associated with a particular GIS polygon and equally apportioning the existing condition load to each activity. Then the pollutant removal efficiencies for overlapping activities were applied to each distinct portion of the existing condition load assigned to that restoration activity. For example, if a particular polygon was being treated by three distinct restoration activities, then one-third of the existing condition pollutant load would be assigned to each of the three activities. For each activity, this partial load would be reduced based on the pollutant removal efficiency of the practice. The result is effectively a weighted load reduction for situations where overlapping occurs.

Table 5.2 - Summary of Load Reduction Calculation Assumptions

Restoration Type	Drainage Area Delineation	Overlap Allowed?	Removal Efficiency		
			TN	TP	TSS
CORE STRATEGIES					
Outfall Retrofit - SPSC	From DEM, at outfall	No	40%	60%	80%
Stormwater Pond Retrofit	From DEM, at outfall	No	25%	35%	65%
Stream Restoration (Intermittent/ Ephemeral) - SPSC	From DEM, based on reach centroid	No	40%	60%	80%
Stream Restoration (Perennial)	From DEM, based on reach centroid	No	0.2 lb/ft/yr	0.068 lb/ft/yr	310 lb/ft/yr
CORE TIER II STRATEGIES					
Street Sweeping	Road polygons	Yes	4%	4%	10%
Inlet Cleaning	Road polygons	No	5%	6%	25%
Public Land Reforestation	Public open space polygons	No	66%	77%	57%
Stormwater to the MEP	Land use polygons	No	50%	60%	90%

5.3.2 Cost Development

The methods used to derive cost for each treatment type are based on a combination of data and vary by restoration type. The goal is to derive an average unit cost that would apply to most implementation situations. Municipalities across the mid-Atlantic region can have varying design and construction standards in terms of the level of detail, the permits and review agencies required, the type of construction materials allowed for, the type of contracting mechanisms in place, and the type of bidding procedures. All of which can affect a project's cost. With these factors in mind, and because the County has implemented all of these types of projects recently, the use of County-specific recent historical information was determined to be the most effective tool to derive costs[2].

For the Core Strategies, cost data were compiled for each activity from comparable historical County projects and normalized by the contributory drainage area. A statistical analysis of this data showed a very poor correlation. This is largely due to the fact that these data do not take into account treatment design standards and performance efficiencies of the restoration activities. When this same cost data were normalized by nested impervious drainage areas treated and pounds of TN removed, the statistical analysis showed a much stronger correlation. From this analysis, the County developed average unit costs that can then be applied to the proposed restoration activities to develop a planning level cost estimate. See Table 5.3 below for the unit costs used for estimating the cost of the Core Strategies. It should be noted that these unit costs represent only the upfront capital expenditure (survey,

[2] In the past year, actual bid prices for construction have been above estimated costs. This recent inflation of costs may be associated with an increased demand for ecological construction practitioners and materials. If rates continue to increase, the existing rate model used in this study will need to be adjusted to better reflect true costs in future planning.

design, permitting, construction, easements), and generally do not include internal County operations and program/project management costs, and do not include system maintenance or monitoring.

Table 5.3 - Annual Cost Basis for Core Strategies

Restoration Type	Cost ($ per lb TN removed)
Outfall Retrofits	$6,496
Stormwater Pond Retrofits	$8,065
Stream Restoration (Intermittent/Ephemeral)	$7,751
Stream Restoration (Perennial)	$3,009

For the Core Tier II Strategies, the cost development methods were more widely varied. The unit costs for each of the Core Tier II Strategy activities are explained below and summarized in Table 5.4:

- **Street Sweeping –** The County's contracted street sweeping program currently relies on regenerative air vacuum street sweepers to accommodate the street sweeping requirements laid out in the Core Tier II Strategy. The County contracted street sweeping services in early FY15 to augment the existing County street sweeping program, utilizing funding appropriated via the Watershed Protection and Restoration Fund (WPRF). On the County-scale, there are 770 miles of closed/curbed section roadways (1,540 lane miles to account for both directions) that will require sweeping. The monthly productivity of a vehicle is 17,280 miles per year (8 hours/day x 20 days/month x 9 miles/hour x 12 months). In order to cover the estimated 1,541 lane miles on a monthly basis, two vehicles, each manned by one driver and one operator, would be needed. Weather conditions may not allow sweeping every day, so a 100 day/year operation was assumed. The capital cost of purchasing new street sweeping equipment is $194,500 with an anticipated operational life of 6 years. On an annual basis, the cost for two vehicles is $64,833. The operational cost is approximately $576,000 (4 operators x 8 hours/day x 9 miles/hour x 100 days/year x $20/hour). The sum of equipment cost and operational cost is approximately $640,833 per year. The cost over a thirty year period without accounting for inflation would be $12,475 per lane mile.
- **Inlet Cleaning –** Using historic County information for inlet cleaning, it was determined that $200 per inlet would be a suitable unit cost assumption for inlet clean out.
- **Public Land Reforestation –** For a single acre of reforested land, the Anne Arundel County Forestry Program recommends planting 500 seedlings (at a cost of $2/seedling), 100 1.5-inch caliber trees (at a cost of $85/tree), and 55 2.5-inch caliber trees at a cost of $175/tree. The public land reforestation cost was estimated at

$38,250 per acre, which includes a 100% contingency to account for planting costs. When this per acre cost is related to pollutant removal rates, the unit cost becomes $9,430 per pound of TN removed.

- **Stormwater to the MEP –** Unit costs for stormwater management retrofits were taken from a pilot concept plan in the Patapsco Non-Tidal Watershed Master Plan to restore the neighborhood of Brooklyn Park. This plan proposed the use of green alleyways, porous pavement, and rain gardens within the established community of Brooklyn Park along the County's northern border with Baltimore City. Cost estimates from the Brooklyn Park concept were used to estimate the anticipated cost for installing similar types of stormwater management on Board of Education and Department of Recreation and Park lands. The average cost for retrofits from this concept is estimated at $90,876/acre. A 30% contingency was added to accommodate varying site conditions, right of way needs, etc. This results in approximately $120,000 per impervious acre treated. When this per acre cost is related to pollutant removal rates, the unit cost becomes $12,000 per pound of TN removed.

Table 5.4 - Annual Cost Basis for Core Tier II Strategies

Restoration Type	Cost	Unit
Street Sweeping	$12,475	per lane mile
Inlet Cleaning	$200	per inlet
Public Land Reforestation	$9,430	per lb TN removed
Stormwater to the MEP	$12,000	per lb TN removed

5.3.3 Specific Recommended Restoration and Preservation Activities

The results of the cost-benefit analysis yielded a comprehensive list of restoration projects and activities in each watershed. These are summarized in Table 5.5 and 5.6 below.

If fully implemented, these restoration projects and activities will meet the Chesapeake Bay TMDL allocations for the Little Patuxent Watershed. See Figures 5.1 through 5.4.

Table 5.5 - WIP Phase II Strategy for Little Patuxent Watershed

Retrofit Type	Description	Design Efficiency Basis[3]	Nested Drainage Acres[4]	Pollutant Reduction[5]			TN Cost($)/lb[6]	TP Cost($)/lb	TSS Cost($) /Tons
				TN (lbs/ year)	TP (lbs/ year)	TSS (Tons/ year)			
Severely Degraded Streams	Regenerative SPSCs or wetland seepage systems	MDE (2011) Guidance Document Efficiencies	141	1,772	340	28.3	$7,751	$40,407	$484,670
Degraded Streams			138	8,025	1,613	139.7	$7,751	$38,568	$445,141
Severely Degraded Streams	Stream Restoration	MDE (2011) Guidance Document Efficiencies	1,190	1,017	346	788.4	$3,009	$8,850	$3,883
Degraded Streams			1,174	2,408	819	1,866.2	$3,009	$8,850	$3,883
Public Pond Retrofits	Retrofit pre-2002 SWM facilities	Retrofit to enhance WQ treatment. MDE (2011) Guidance Document Efficiencies.	150	250	42	5.8	$8,065	$47,730	$347,291
Private Pond Retrofits			408	921	161	23.7	$8,065	$46,091	$313,170
Severely Degraded Outfalls	Retrofit Outfalls with SPSC system	Project designed to filter ESD volume or portion there of	993	3,419	625	66.4	$6,496	$35,562	$334,622
Degraded Outfalls			0	0	0	0.0	-	-	-
Programmed Projects	Programmed and Budgeted Projects	Retrofit to enhance WQ treatment. MDE (2011) Guidance Document Efficiencies.	26	18	6	0.7	$6,993	$22,583	$196,733
CORE STRATEGY SUBTOTALS			4,219	17,832	5,540	2,919.2	**N/A**		
Street Sweeping	Street Sweeping	MDE (2011) Guidance Document Efficiencies- based on contributing acres	253	350	46	9.8	$6,182	$47,170	$221,142
Inlet Cleaning	Stormdrain and inlet cleaning		1,696	656	97	31.0	$488	$3,291	$10,316

[3] During the development of this report and watershed assessment, the 2014 MDE Guidance on BMP removal has been released. This guidance utilizes BMP removal rate adjustor curves (Schueler and Lane, 2012) and alternative BMP credits; these will be applied to future studies.
[4] Nested acreage is the drainage area to a restoration practice remaining after subtracting the duplicate portions of overlapping drainage areas from other types of restoration practices within the drainage area. The nested acreage is not same as the equivalent impervious area credit or impervious area to the practice.
[5] Load reductions correspond to the EMC values and BMP efficiencies used in County's approved WIP.
[6] Costs represent only the upfront capital expenditure (e.g., survey, design, permitting, construction, easements, etc.), and do not include County operations and program/project management costs, and system maintenance or monitoring costs.

Retrofit Type	Description	Design Efficiency Basis[3]	Nested Drainage Acres[4]	Pollutant Reduction[5]			TN Cost($)/lb[6]	TP Cost($)/lb	TSS Cost($) /Tons
Reforestation	Reforestation of Public Open Space	MDE (2011) Guidance Document Efficiencies	62	28	4	0.3	$9,430	$66,539	$778,474
County Rec and Parks	Implement ESD Practices to MEP	Retrofit to enhance WQ treatment. MDE (2011) Guidance Document Efficiencies.	15	91	13	2.3	$12,000	$81,543	$486,479
County Schools			27	201	33	3.9	$12,000	$73,020	$614,896
County Facilities			69	553	85	11.0	$12,000	$77,907	$600,903
CORE TIER II STRATEGY SUBTOTALS			2,121	1,879	279	58.4	$52,100	$349,471	$2,712,211
Private Commercial and Industrial Properties	Implement ESD Practices to MEP	Retrofit to enhance WQ treatment. MDE (2011) Guidance Document Efficiencies.	163	1,128	162	25.3	-	-	-
POTENTIAL LOAD REDUCTIONS OUTSIDE OF CORE STRATEGY WIP AREAS SUBTOTALS			163	1,128	162	25.3			
LITTLE PATUXENT WATERSHED WIP TOTALS			8,958	23,766	6,545	3,065			

Figure 5-1 - Annual Progress of WIP Strategy towards Meeting Total Nitrogen Load Allocations – Little Patuxent Watershed

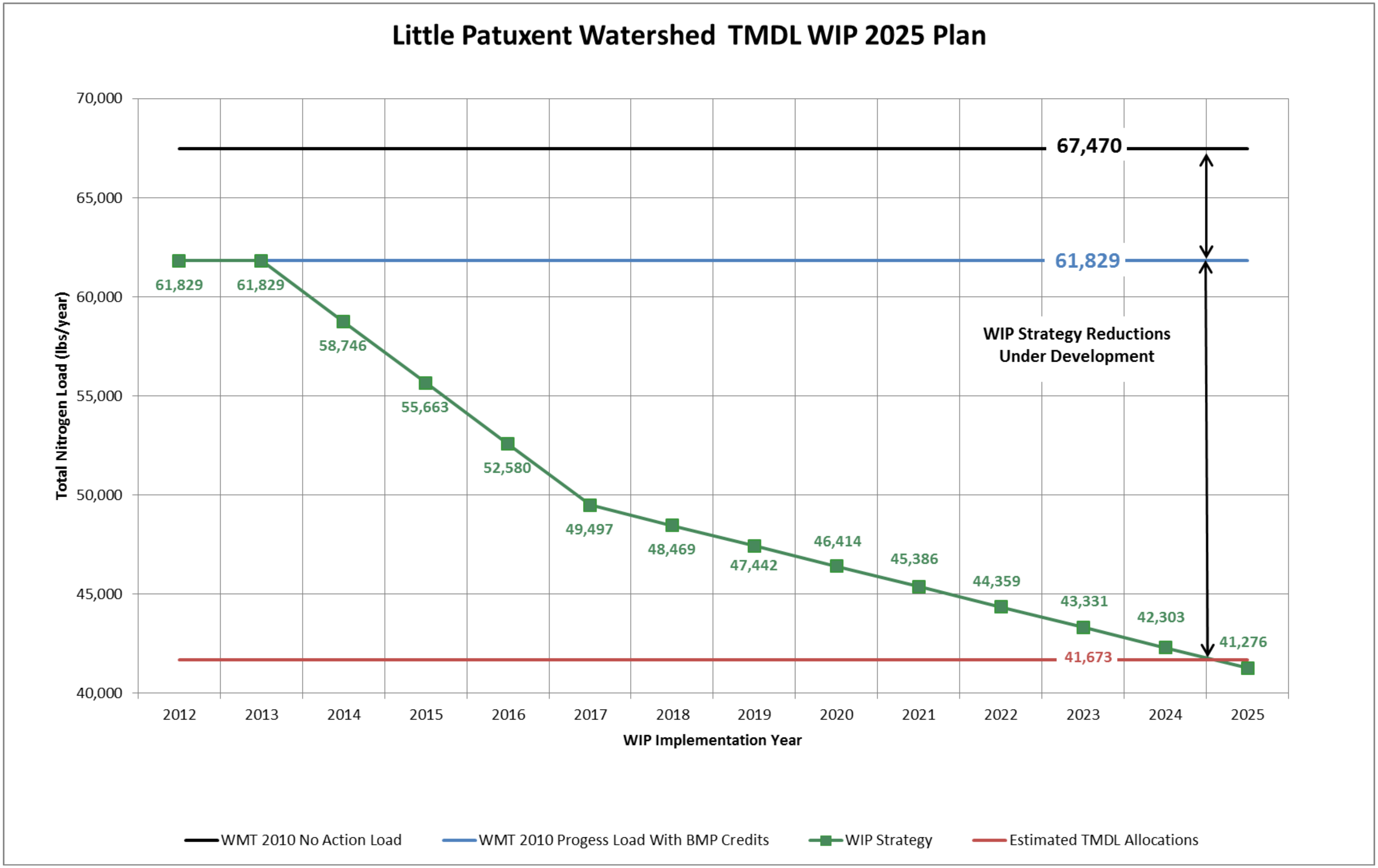
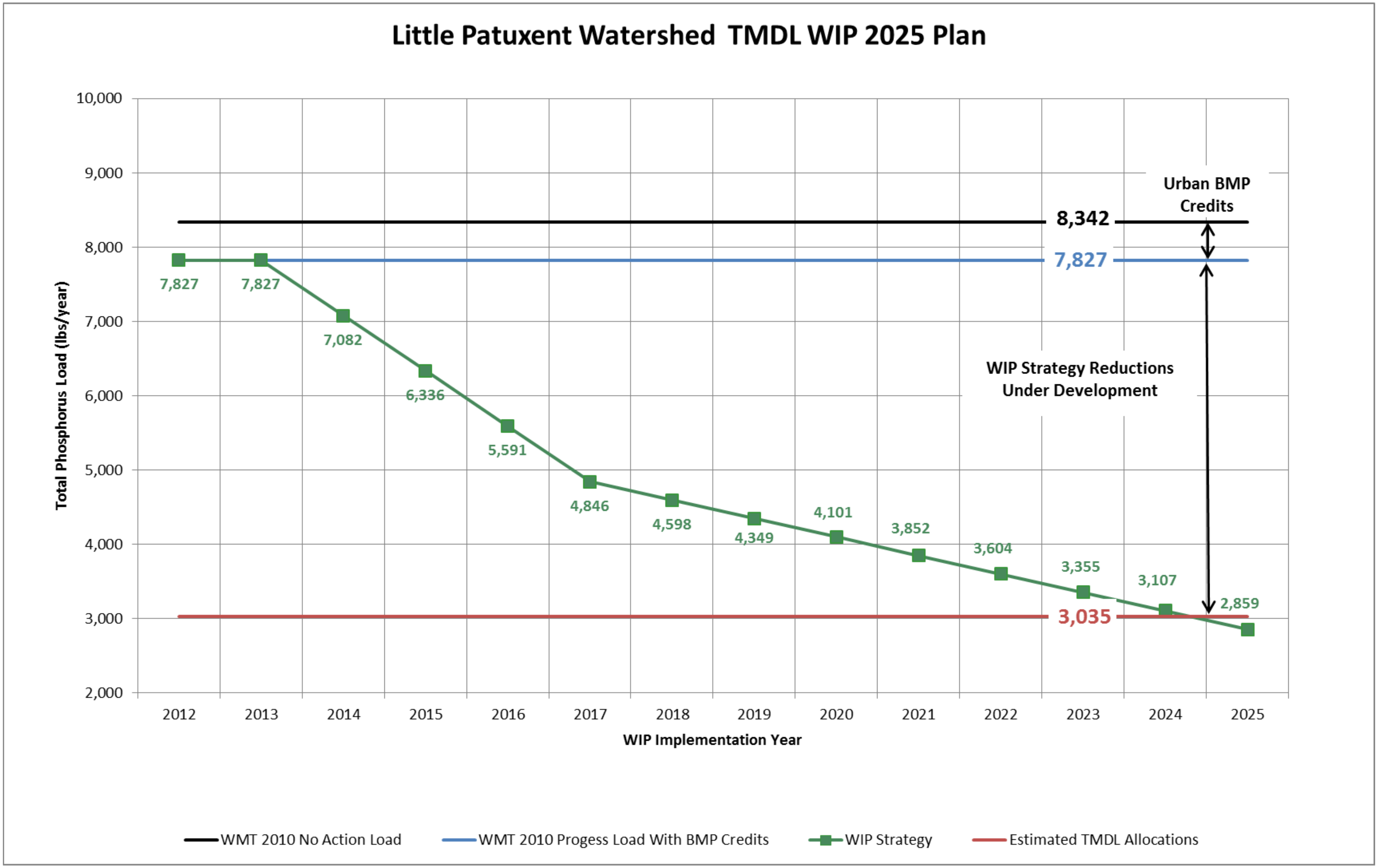


Figure 5-2 - Annual Progress of WIP Strategy towards Meeting Total Phosphorus Load Allocations – Little Patuxent Watershed



5.4 IMPLEMENTATION PLAN

5.4.1 Tracking and Reporting Protocols

The Chesapeake Bay TMDL allocations for urban stormwater will ultimately be regulated through NPDES permitting. As such, the Anne Arundel County NPDES MS4 permit will serve as the regulatory mechanism to track, verify, and report progress and compliance with the assigned stormwater wasteload allocation. Under the County's current permit, annual progress reports are provided to MDE. These annual reports document watershed restoration activities that include those described in the WIP Strategy discussed above. Projects such as stream restoration, outfall retrofits, pond retrofits, and implementation of stormwater management in those areas currently undermanaged or not managed are captured in a watershed restoration database. Additionally, the County collects and reports projects implemented by entities outside of the County government (e.g., watershed association projects, RiverKeeper projects, Watershed Stewards Academy projects). Pollutant load reductions and impervious surface credits associated with this assemblage of projects are calculated and reported back to MDE. These same tracking and reporting efforts will be used to determine compliance with the Chesapeake Bay TMDL urban stormwater allocation assigned to the County.

5.4.2 Implementation Contingencies

The County has identified a number of contingencies to fall back on should the WIP strategy for urban stormwater not be fully realized. First, other source sectors under the County's control are currently exceeding their required reduction goals. This provides some cushion for implementation of the urban stormwater WIP strategy. Second, the County has employed a number of conservative accounting assumptions in the water quality modeling used to develop the WIP strategy. These conservative assumptions result in lower load reduction estimates then what may actually be achieved in reality. This is demonstrated by the fact that the Maryland Assessment and Scenario Tool (MAST) used by the State of Maryland for TMDL accounting predicts higher load reductions from the County's WIP strategy than the County's modeling. Foremost amongst these conservative assumptions is the County's approach of using nested drainage areas for determining BMP credits. This approach does not account for the additive load reductions of BMPs in series. Other conservative assumptions include not taking credit for certain landscape components that remove pollutants (e.g., existing tree canopy and functioning wetlands) and for non-structural urban nutrient management BMPs (e.g., neighborhoods that forbid fertilizer application).

5.4.3 Detailed Targets and Schedule

As shown in Figure 5-1 through 5.4, the pace of annual load reductions necessary to meet the 2017 and 2025 targets is significant. The implementation of the full set of proposed projects and activities in the WIP strategy hinges primarily on the availability of funding. Funding is available for the future CIP projects identified through 2016. These future CIP projects are expected to be implemented, but beyond this horizon, funding details for the remaining WIP strategy projects are less clear. The new stormwater utility discussed in Section 1.2.3 will provide a new dedicated funding source, but the specific mechanisms and financial details of this utility have not yet been determined.

5.4.4 Development of Concept Plans

- Eroded streams with moderate to severe erosion near Jessup Elementary School
- Eroded streams and undermined outfalls near Crofton Country Club
- ESD to the MEP retrofit for Jessup MARC station parking lot
- Degraded Streams in Little Patuxent Watershed
- Undermined outfall structure in Little Patuxent Watershed near Samantha Lane
- Outfall pipe separation in Dorsey Watershed

As a first step toward implementation, the County developed concept design plans for two of the proposed restoration projects discussed in Section 5.3.3. Each concept plan contained a narrative description of the issue to be addressed, the purpose of the restoration activity, a site location map, hydrologic and hydraulic volumes, a plan view of the conceptual design, existing condition photos, design and construction cost estimates, and a feasibility assessment.

The concept plans were developed following a rigorous analysis of existing site conditions. For each of the key projects, field crews conducted site visits to assess the full suitability and feasibility of the selected restoration activity and to collect any necessary field measurements and photos. GIS and modeling data were used to identify project area characteristics, determine project drainage areas, and calculate hydraulic and pollutant load benefits. County-approved design specifications were used to site and size each of the project elements. Standard construction cost guides were used in tandem with County-specific unit costs to develop preliminary design and construction cost estimates. An assessment was also undertaken to identify and address conceptually important constructability issues such as land ownership, construction access, erosion and sediment controls, and potential utility conflicts.

The two projects and a brief description of each are provided below. The full concept design plans are included in Appendix D.

- <u>Crofton Neighborhood Stormwater Retrofit</u> – This project is located in a residential neighborhood in Crofton adjacent to the Crofton Country Club. This project was chosen because the runoff from this residential area is contributing to severe erosion downstream of the stormwater collection system outfall. The design calls for applying Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP). The design consists of bioretention cells, permeable pavement for streets and sidewalks, bio-swales, and rain barrels. The ESD practices will be installed along the existing flow baths and overflows excess runoff from the practices will be conveyed to the existing catch basins. The plantings associated with the bioretention cells and bio-swales will provide aesthetic improvements to the neighborhood.

- Nantucket Elementary School Stormwater Retrofit – This project is located at the Nantucket Elementary School on Nantucket Drive in the Towsers Branch 3 watershed. This project was chosen because there are no stormwater controls on-site and runoff from school is contributing to severe erosion downstream of the stormwater collection system outfall. The design calls for applying Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP). The design consists of bioretention cells, permeable pavement for parking lots and sidewalks, a bio-swale, and a cistern. The parking lot and building roof areas are the prime opportunities for stormwater retrofits. Along with the aesthetic benefits, the ESD design will provide educational opportunities for the school to teach environmental and watershed science.

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7. APPENDICES

APPENDIX A – FLOODING POTENTIAL TECHNICAL MEMORANDUM

APPENDIX B – BIOASSESSMENT REPORT

APPENDIX C – URBAN BMP TECHNICAL MEMORANDUM

APPENDIX D – CONCEPT DESIGN PLANS

APPENDIX A

FLOODING POTENTIAL TECHNICAL MEMORANDUM

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SITE SELECTION OF STREAM CROSSINGS TO BE ANALYZED FOR FLOOD OVERTOPPING

TECHNICAL MEMORANDUM

Subtask 2.1.5
Little Patuxent
Watershed Study

October 2012

Prepared For:
Anne Arundel County Department of Public Works
Watershed Management Program
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Water | Environment | Scientists | Engineers

Introduction

Under Subtask 2.1.5 of the Little Patuxent watershed study, LimnoTech worked with the Anne Arundel County Department of Public Works to identify stream crossings with the potential for flooding within Little Patuxent watershed. These selected stream crossings will be surveyed, modeled using an HY8 hydraulic model, and potentially considered at a later date for replacement or modification. This Technical Memorandum documents the procedures LimnoTech performed to complete this task.

Crossings Selection Procedure

Identification and selection of the sites with flood overtopping potential was performed using the criteria outlined by the County along with County-provided GIS data and crossing information collected during field activities. A more detailed description of the selection criteria and the data sources are discussed below.

Selection Criteria

The County's selection criteria included the following:

- Stream crossing must be owned by the County;
- Road must be classified as Freeway, Principal Arterial, Minor Arterial, Collector, or Local in the County's Master Transportation Plan;
- Overtopping is likely, given field conditions;
- Crossings must be older than 5 years and not scheduled for replacement; and
- Flooding would completely cut off an area from emergency services.

Data Sources

Site selection was conducted using GIS data provided by the County and data collected during field activities associated with the physical habitat condition assessment task (Task 3). Data utilized included:

- Stream reaches ("Streams" ***LimnoTech***)
- Roadway types ("Streets" ***County***)
- Little Patuxent subwatershed boundaries ("Subwatersheds" ***County***)
- Aerial photography (***County***)

- Crossings (“LittlePatuxent_Crossings” ***LimnoTech***)

Crossing Selection Results

The selection process used a stepwise procedure that incorporated one of the County selection criteria into each step. The results of each step are captured in fields added to the “LittlePatuxent_Crossings” GIS layer. The original set of 258 crossings identified during the field assessments are depicted in Figure 1. The selection steps were conducted as follows:

1. A subset of crossings inventoried during field activities was selected if the road crossed was classified as Freeway, Principal Arterial, Minor Arterial, Collector, or Local under the County Master Transportation Plan as provided in the “Streets” shapefile, and crossed a perennial stream or channel that became perennial at the downstream side. Crossings on large roads, including Rt. 295, Rt. 32, and Rt. 3 were not included as it is assumed that they are designed for large storm capacity. Foot trail crossings, driveway culverts, and SWM associated culverts were eliminated from consideration. Of 256 crossings assessed during field activities, **86** met these criteria. These crossings were designated with a “Yes” in the TYPE_CROSS field of the “LittlePatuxent_Crossings” GIS layer. These crossings are depicted in Figure 2.

2. Crossings were selected if field conditions indicated that overtopping is likely, determined primarily by the height (less than 20 ft.) of the road surface above the water surface. LimnoTech also assessed pertinent channel and floodplain characteristics, including culvert dimensions, embankment height, surrounding land use, and probable drainage area contribution. Cases where upstream conditions were non-perennial, while downstream conditions were perennial were assessed on an individual basis and included if warranted. Of the 86 remaining crossings, **62** met this criterion. These crossings were designated with a “Yes” in the HEIGHT_CRO field of the “LittlePatuxent_Crossings” GIS layer. These crossings are depicted in Figure 3.

3. Crossings were to be selected only if older than 5 years and not scheduled for replacement. Age data for all crossings were not available. The ***Anne Arundel County, Proposed Capital Budget and Program. Fiscal Year 2012: Volume #2*** was consulted to determine replacement plans. Of the 62 remaining crossings, **0** met this criterion. These crossings were designated with a “Yes” in the AGE_CROSS field of the “LittlePatuxent_Crossings” GIS layer. These crossings are depicted in Figure 4.

4. Crossings were to be selected if there was potential that overtopped roads may completely isolate an area from emergency services. Aerial photography and county roads coverage were used to visually assess alternate routes to both sides of each crossing**.** Of the 62 crossings meeting previous criteria, **9** were found to isolate an area when flooded either singularly or concurrently. These crossings were designated with a “Yes” in the ISO_CROSS field of the “LittlePatuxent_Crossings” GIS layer. The ISO_NOTE field indicates whether the crossing is included due to singular or concurrent flooding. These crossings are depicted in Figure 5.

5. Crossings were cross referenced with a County database to ensure they were located on county owned roads. A total of **8** crossings were identified for further analysis.

Final Recommendations

LimnoTech recommends that 8 stream crossings be surveyed for selected hydraulic design information (as outlined in Subtask 2.1.6) for utilization by the County in HY8 modeling. The crossings are summarized in Table 1 below. Each crossing has been given a crossing identification that corresponds to the finalized stream reach layer and inventory.

TABLE 1 – Recommended Road Crossings for Surveying

CROSSING ID	ROAD NAME	FUNCTION CLASS	ISOLATION
LP7009.C002	Bragers Road	Local	SOLO
LP7015.C001	Conway Road	Collector	SOLO
LPE045.C001	Emerald Way	Local	SOLO
LPC041.C001	Evergreen Road	Local	SOLO
LPG069.C001	Harewood Lane	Local	SOLO
LPG088.C002	Kingsgate Drive	Local	SOLO
LP7020.C001	Meyers Station Road	Collector	SOLO
LPF048.C001	Meyers Station Road	Collector	SOLO

Figure 1: Original Set of Stream Crossings

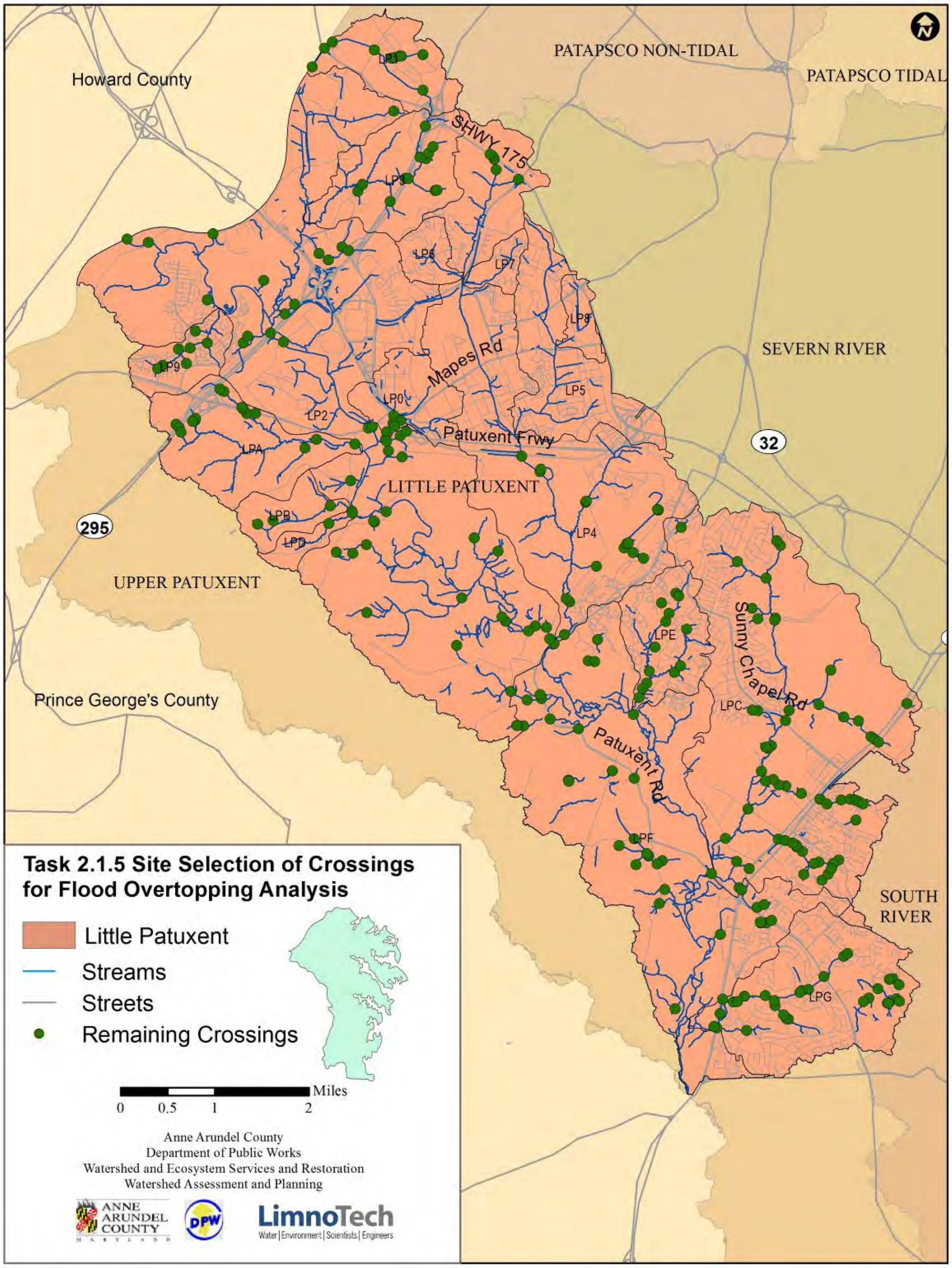


Figure 2: Crossings Meeting the Road Type and Perenniality Criteria

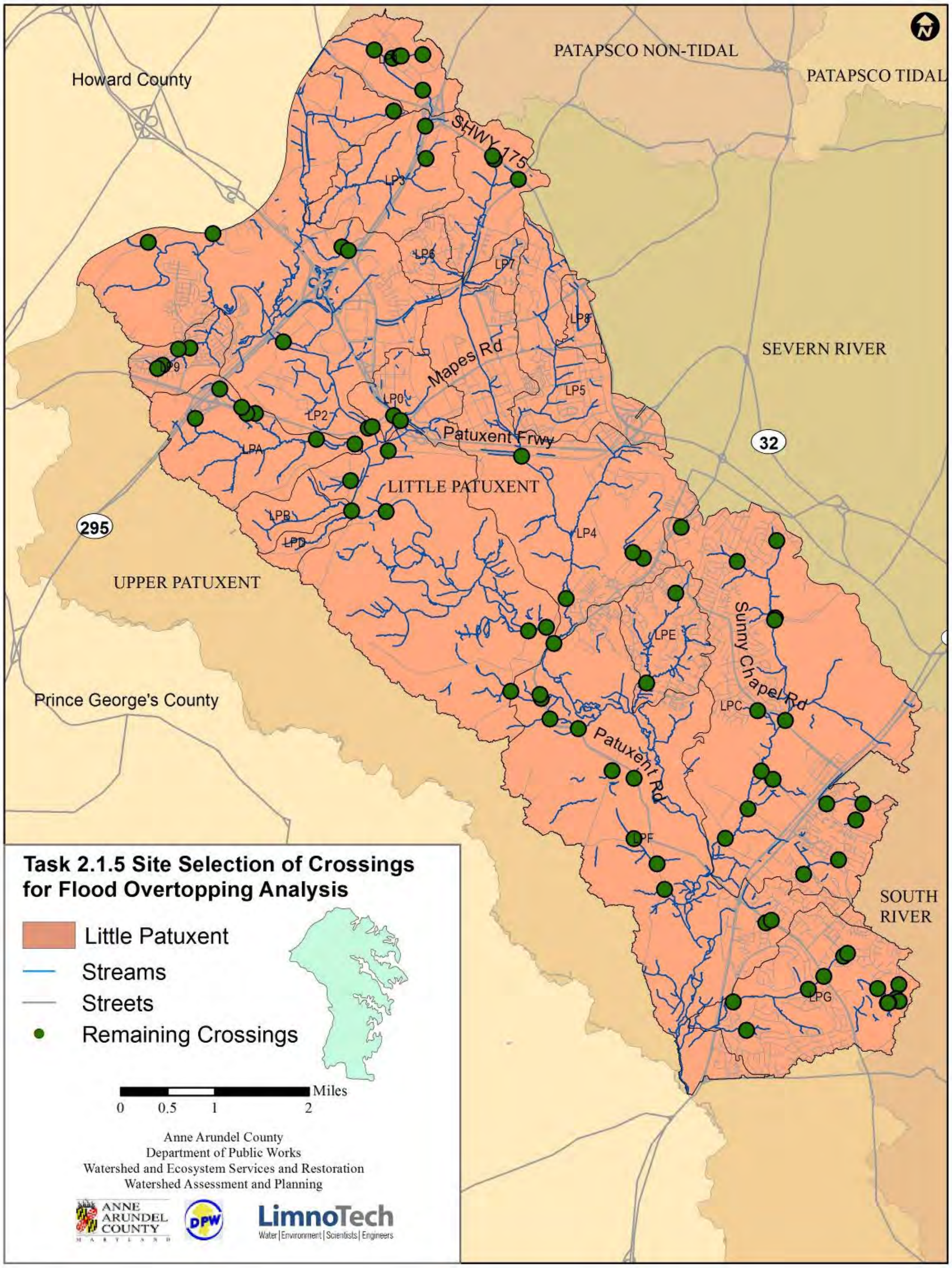


Figure 3: Crossings Meeting Road Type, Perenniality and Field Conditions Criteria

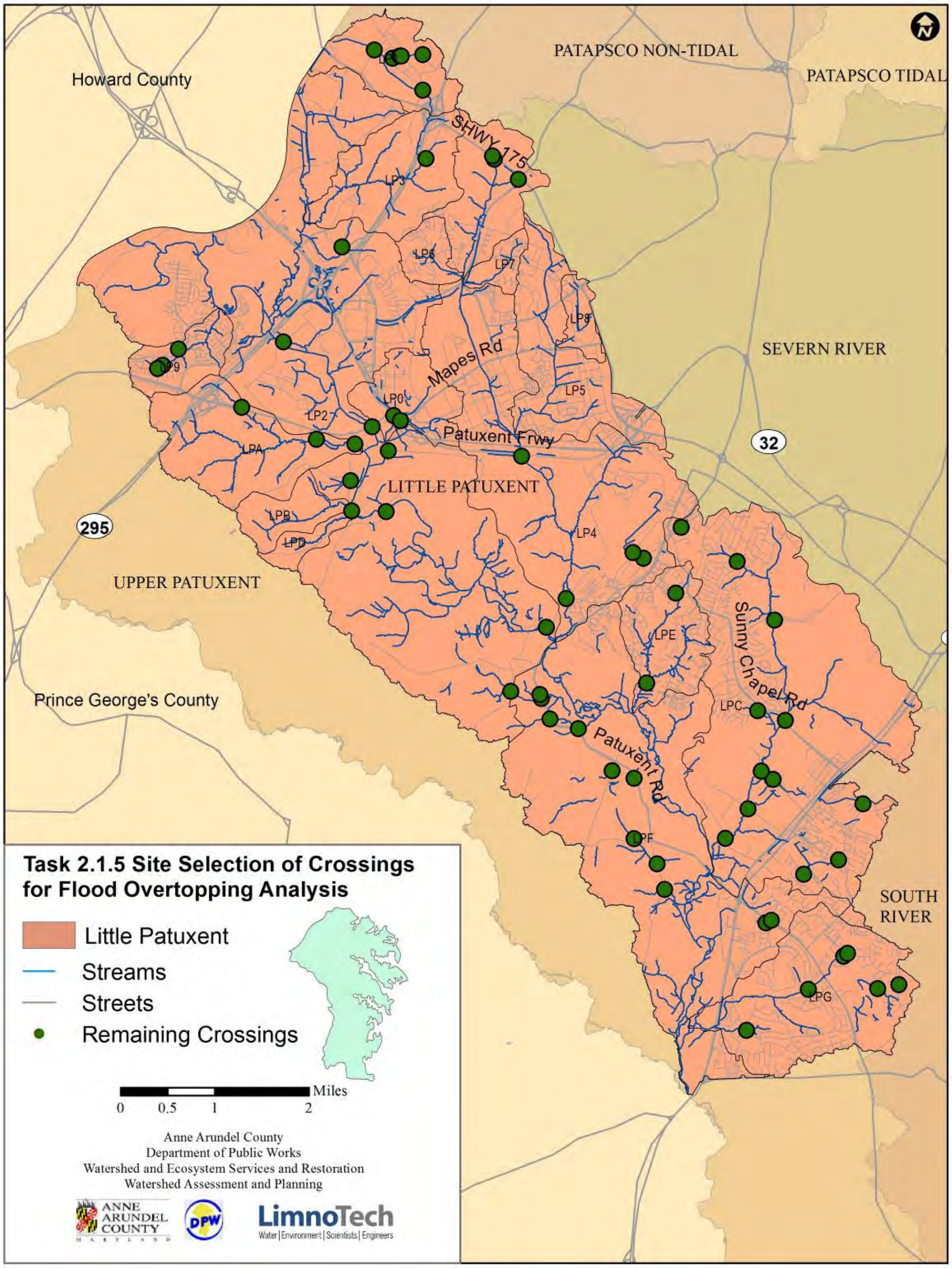


Figure 4: Crossings Meeting Road Type, Perenniality, Field Condition, and Age Criteria

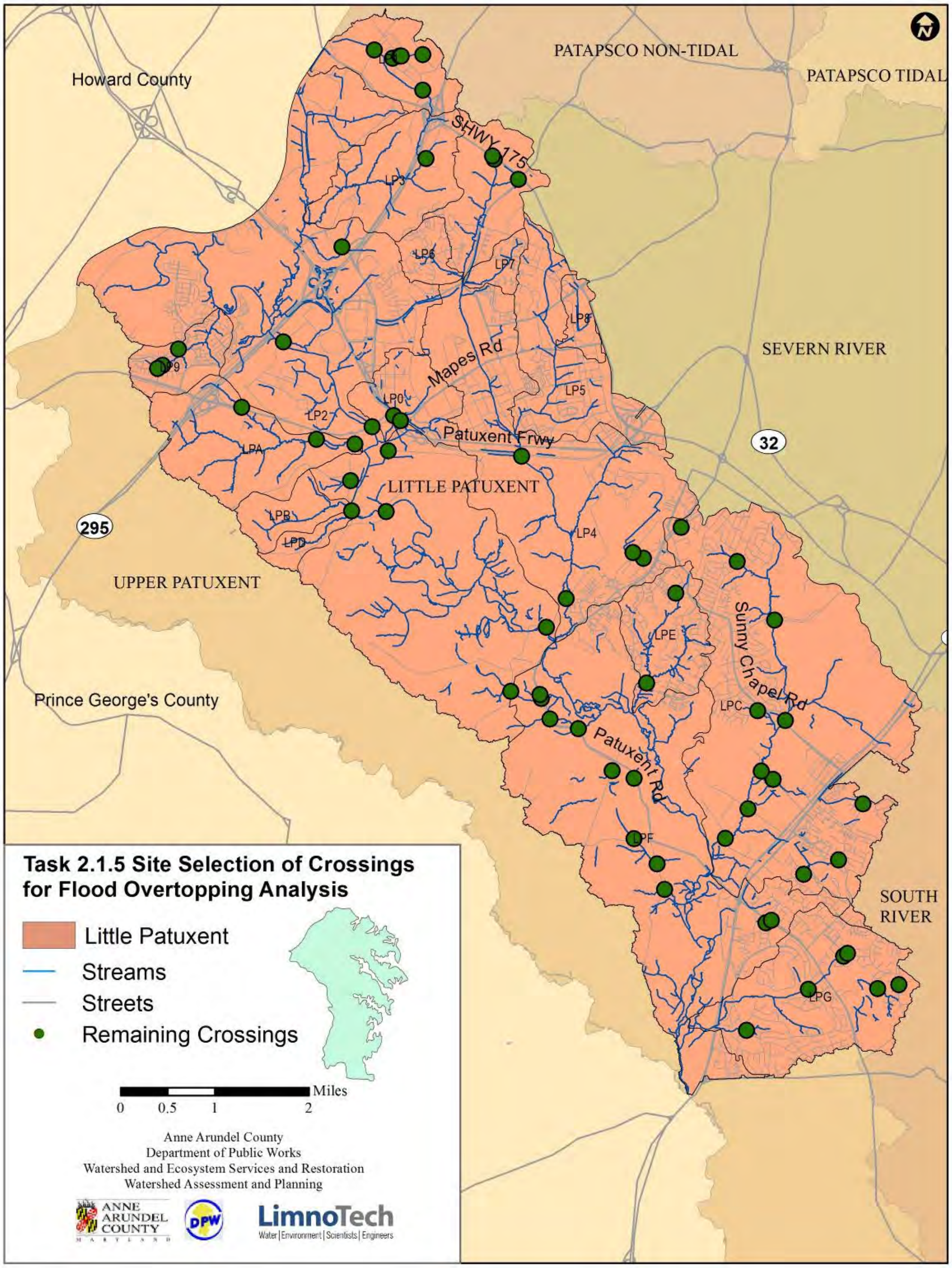
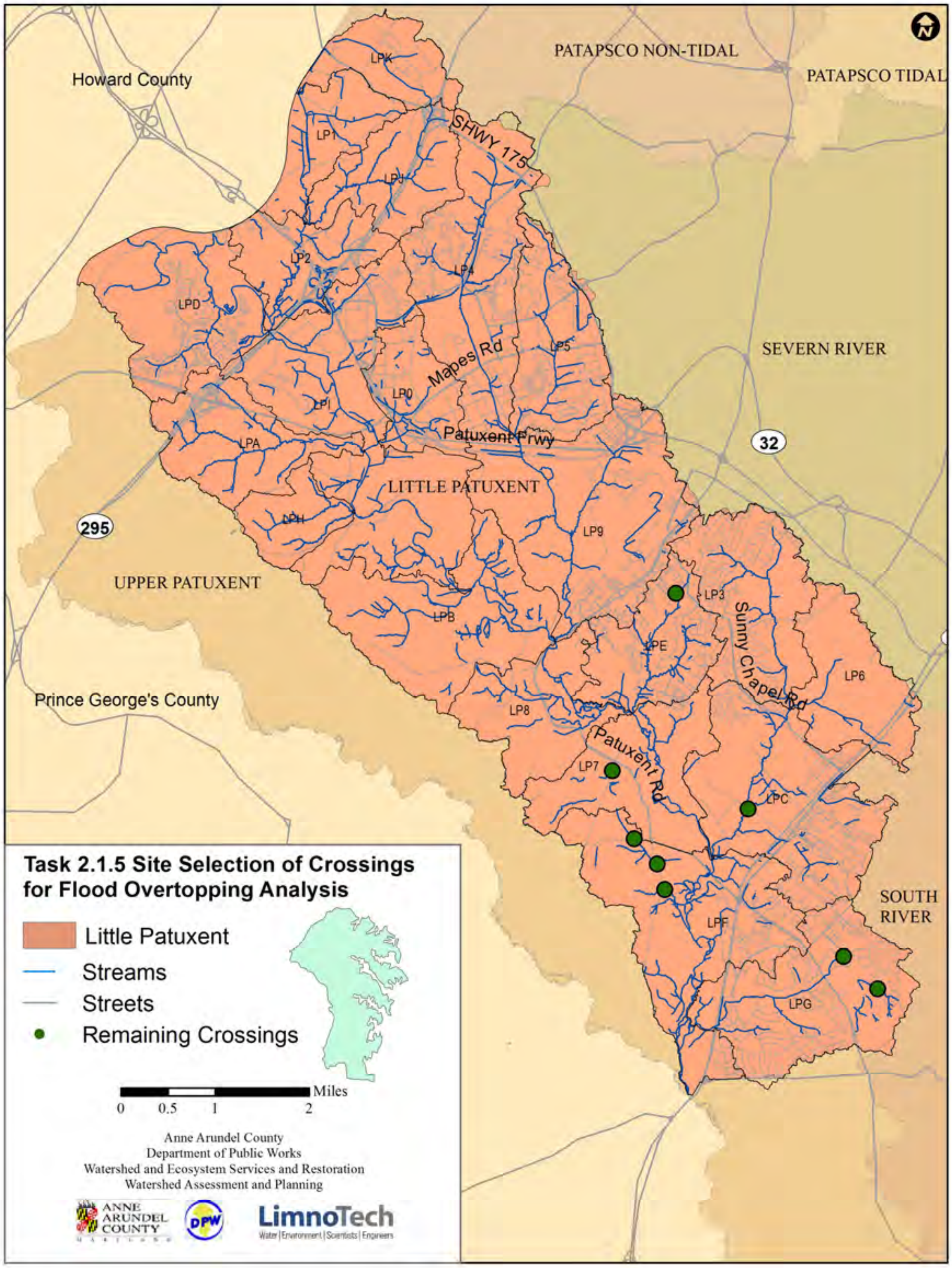


Figure 5: Crossings Recommended for Surveying



APPENDIX B

BIOASSESSMENT REPORT

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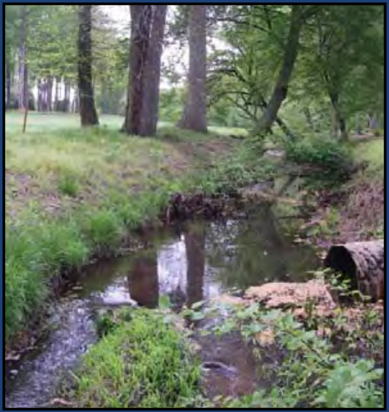

Targeted Biological Assessments of Streams in the Little Patuxent Watershed, Anne Arundel County, Maryland: 2011

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

Targeted Biological Assessment of Streams in the Little Patuxent Watershed, Anne Arundel County, Maryland: 2011

August 2011 - DRAFT

Prepared for:

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Background and Objectives

Anne Arundel County, in an effort to improve its surface water quality and streams, initiated systematic and comprehensive watershed assessments and management plans for restoration and protection across the County. Biological monitoring is a major component of the characterization and prioritization process. Anne Arundel County contracted KCI Technologies, Inc. to conduct a targeted assessment of the biological community and physical habitat in the Little Patuxent watershed during the Spring of 2011. The targeted assessment focuses on *in situ* water quality, sampling and analysis of the benthic macroinvertebrate community, and an assessment of instream and riparian physical habitat conditions.

The data collected and reported herein will be primarily utilized in the County's Watershed Management Tool (WMT), which is developed and maintained by the Department of Public Works, Watershed and Ecosystem Services and Restoration Division (WERS), Watershed Assessment and Planning Program (WAP). Within the WMT, relationships between biological condition, hydrology, water quality, and landuse are developed to support watershed and landuse planning and restoration goal setting. The Little Patuxent watershed targeted biological monitoring and assessment also fulfills part of the County's water quality assessment requirements under their National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit issued by the Maryland Department of the Environment, and assists the County in preparing TMDL implementation plans.

The biological data will also be beneficial for the ongoing County-wide Biological Monitoring and Assessment Program to further develop status, trends and problem identification for the portions of the County sampled. The Anne Arundel County portion of the Little Patuxent watershed (MDE 8-digit watershed 02131105, Little Patuxent River) encompasses 27,975 acres (43.7 square miles) and contains approximately 163 miles of streams based on the County's planimetric GIS stream data. The watershed covers one primary sampling unit (PSU) defined by the County-wide Monitoring and Assessment strategy, Little Patuxent (PSU-17), which was assessed by the County 2007 and 2009 during Rounds 1 and 2.

The Little Patuxent watershed was subdivided into 21 sub-basins by WAP for targeted site selection. Within these sub-basins, 40 targeted sites were selected, at which benthic macroinvertebrate samples were collected, *in situ* water quality was measured, and physical habitat was assessed between April 4 and April 29, 2001.

The Little Patuxent watershed is part of Maryland's Patuxent River basin. The Patuxent River basin drains approximately 900 square miles of land, including portions of Anne Arundel, Baltimore, Calvert, Charles, Howard, Prince George's, Montgomery, and St. Mary's Counties, along the Western Shore of the Chesapeake Bay. The basin originates in the Piedmont physiographic province, but the current study area is located in the central portion of the basin, within the Coastal Plain physiographic province. The Little Patuxent watershed study area is made up of numerous 1st order tributaries draining directly to the Little Patuxent River, as well as three large tributaries: Dorsey Run, which originates in Howard County, Rogue Harbor Branch, and Towsers Branch. Figure 1 – Vicinity Map shows the general location of the watershed as well as drainage areas to each sampling point.

1 Methods

The monitoring program includes chemical, physical and biological assessment conducted throughout the Little Patuxent watershed. The sampling methods used are consistent with the Anne

Arundel County Biological Monitoring and Assessment Program and detailed in the Quality Assurance Project Plan (QAPP; Anne Arundel County, 2011). A summary of these methods and the results of the 2011 monitoring are documented in this report.

Biological assessment methods within Anne Arundel County are designed to be consistent and comparable with the methods used by Maryland Department of Natural Resources (DNR) in their Maryland Biological Stream Survey (MBSS; DNR, 2010). All field crew leaders received recent training in MBSS protocols prior to the sampling. The County has adopted the MBSS methodology to be consistent with statewide monitoring programs and programs adopted by other Maryland counties. The methods have been developed locally and are calibrated specifically to Maryland's physiographic regions and stream types. MBSS physical habitat assessment parameters were collected for the Little Patuxent watershed. Physical habitat was also assessed using the EPA's Rapid Bioassessment Protocol (RBP) (Barbour et al., 1999) habitat assessment for low-gradient streams.

1.1 Selection of Sampling Sites

The sampling design employed a targeted approach with a total of 40 sites distributed throughout the study area on each of the major stream reaches, covering 21 non-tidal subwatersheds, as shown in Figure 2. A complete list of targeted sites along with the corresponding subwatershed code is displayed in Table 1. The primary goal was to establish adequate spatial coverage of the watershed. Additionally, data from the County-wide random sampling program was used in the site selection process. The watershed was sampled for the County-wide program in 2007 and 2009. The targeted sites were generally selected in the downstream most reaches of the Little Patuxent's tributaries and placed to fill gaps not covered by the County-wide assessment. Where two sites could be placed in one subwatershed, the preference for the second site was in the central portion of the subwatershed. Of the 21 subwatersheds, 18 had two sites, one had three sites (LPH), and only two (LPK and LPB) had one site.

Table 1 – Sampling Sites and Corresponding Subwatersheds

	Site ID	Subwatershed Code
Dorsey Run	LPAX-37-2011	LPI
	LPAX-38-2011	LPI
	LPAX-39-2011	LPJ
	LPAX-40-2011	LPJ
	LPAX-41-2011	LPH
	LPAX-42-2011	LPH
	LPAX-43-2011	LPK
Little Patuxent	LPAX-07-2011	LP1
	LPAX-08-2011	LP1
	LPAX-11-2011	LP2
	LPAX-12-2011	LP2
	LPAX-13-2011	LP3
	LPAX-14-2011	LP3
	LPAX-23-2011	LP5
	LPAX-28-2011	LP5
	LPAX-35-2011	LP6
	LPAX-36-2011	LP6
	LPAX-46-2011	LP4

	Site ID	Subwatershed Code
Rogue Harbor	LPAX-19-2011	LPF
	LPAX-20-2011	LPF
	LPAX-31-2011	LPE
	LPAX-32-2011	LPE
	LPAX-33-2011	LPG
	LPAX-34-2011	LPG
Towsers Branch	LPAX-05-2011	LPD
	LPAX-06-2011	LPD
	LPAX-09-2011	LPC
	LPAX-17-2011	LPB
	LPAX-18-2011	LPB
Unnamed Tributary	LPAX-01-2011	LPA
	LPAX-02-2011	LPA
	LPAX-03-2011	LPM
	LPAX-04-2011	LPM
	LPAX-15-2011	LPL
	LPAX-16-2011	LPL
	LPAX-24-2011	LPO
	LPAX-25-2011	LPO
	LPAX-26-2011	LPO
	LPAX-29-2011	LPN
	LPAX-30-2011	LPN

Figure 1 – Study Area Vicinity Map

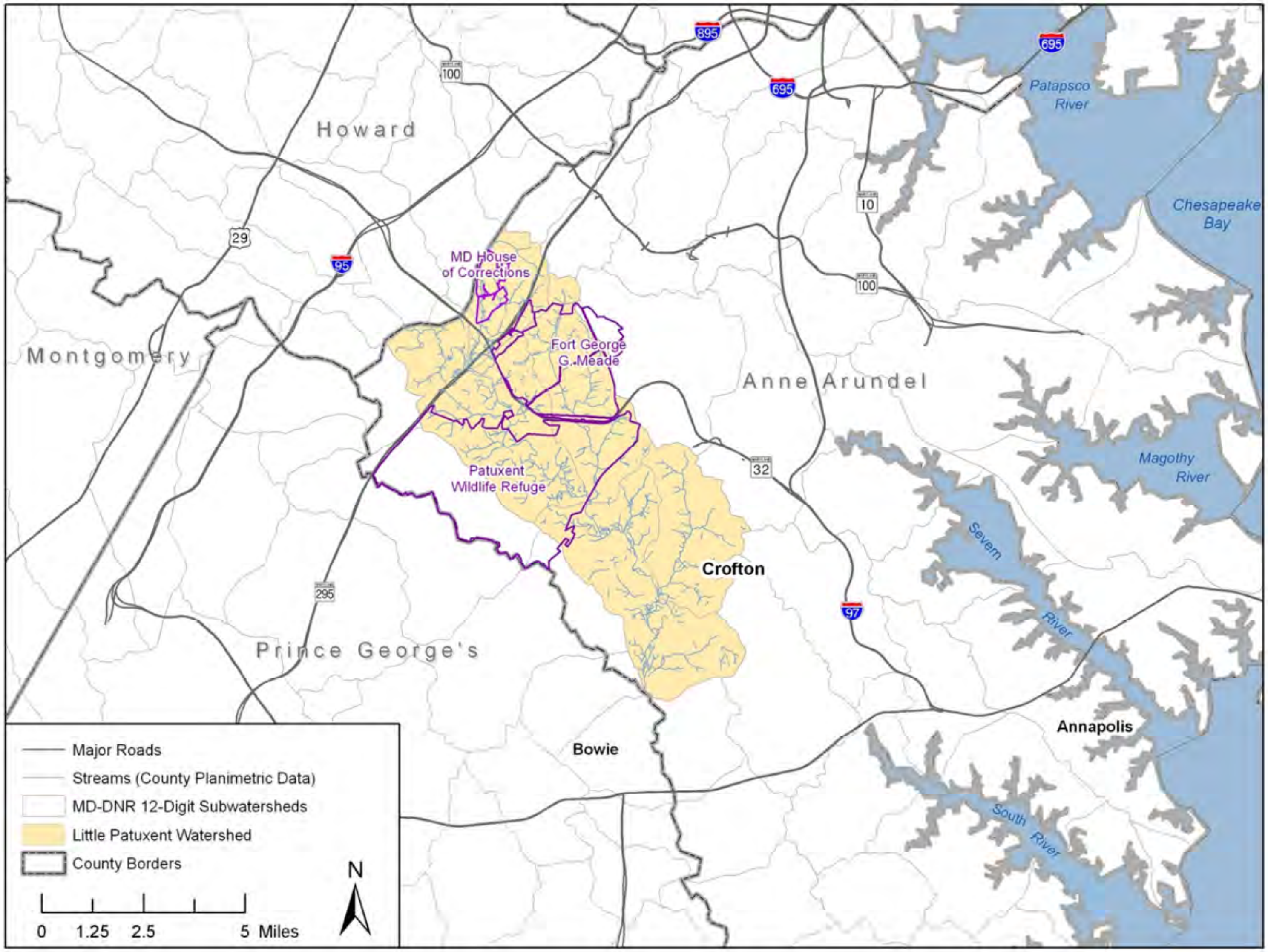
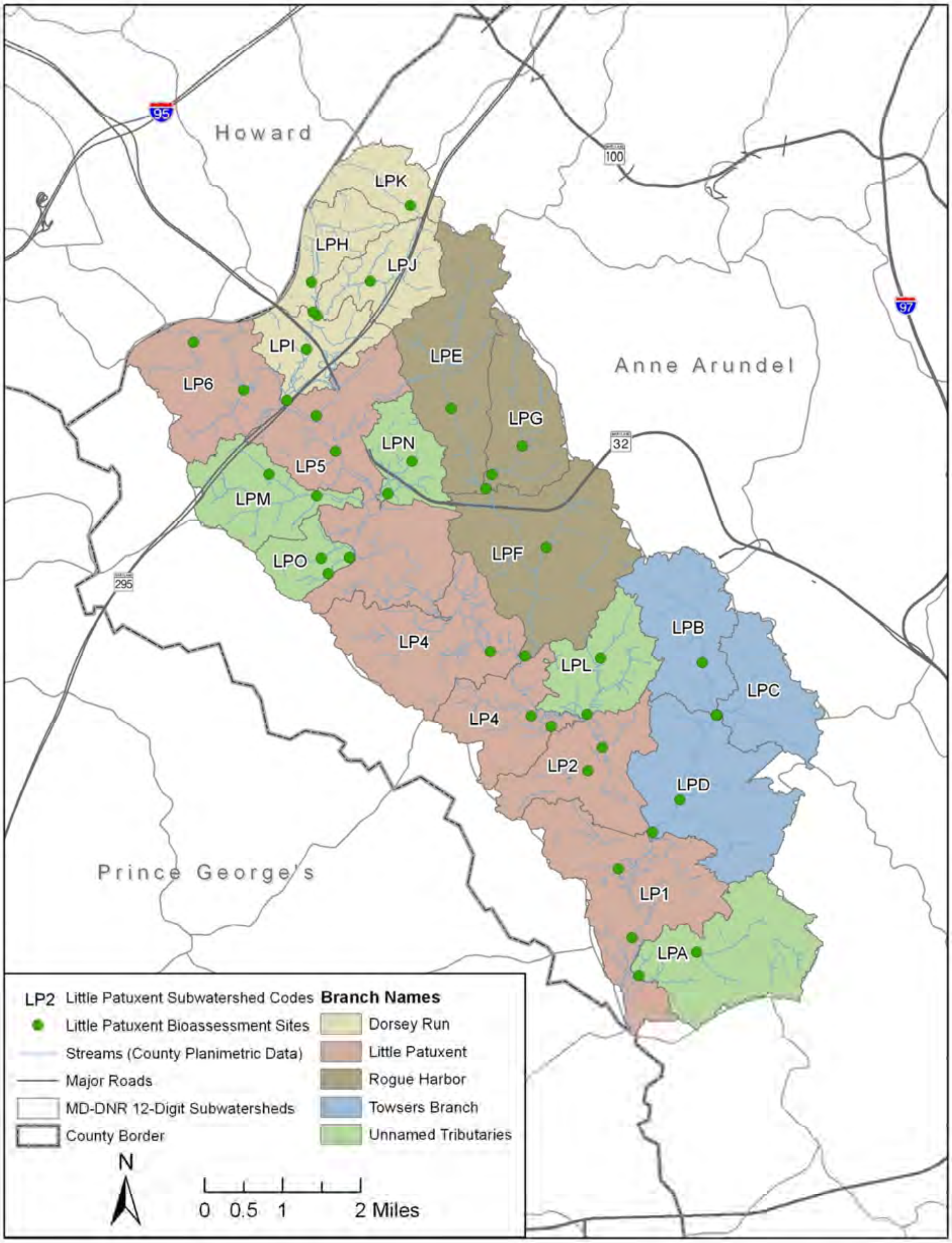


Figure 2 – Little Patuxent Subwatershed Map



If the stream channel at the selected site was found to be unfit for sampling during the field visit, the site was moved to another sampleable reach either on the same stream, or in an adjacent sub-basin, pending approval by the Project Manager and the County. Conditions that would make a site unsampleable include predominant wetland or dry channel conditions, unsafe conditions, and lack of access due to property ownership issues. Desktop reconnaissance resulted in several of the initially selected sites being shifted slightly to facilitate sampling. Once in the field, it was determined that several additional targeted sites were unable to be sampled, and they were relocated accordingly to adhere to the project's objectives.

Field crews used a Trimble® GPS unit and field maps with ortho-photography overlaid with the sites, streams and drainage areas to navigate to the proper site locations. Each sampling site is comprised of a 75-meter stream reach. The position of the reach mid-point was collected with the GPS unit, and the upstream and downstream ends were marked with flagging.

Duplicate biological samples as well as duplicate *in situ* water quality measurements and physical habitat data were collected at ten percent of sites (four total) to serve as Quality Assurance/Quality Control (QA/QC) samples. Each QA/QC sample was collected immediately upstream of the original site in an area where the habitat was very similar to the original sampling site based on visual inspection. Duplicate sites were selected in the field by the field crew at the time of the assessment. This method, as opposed to selecting the sites randomly or by desktop analysis, ensures that the stream type and habitat is similar, that no significant inputs of stormwater or confluences occur in the reach, and that the site is sampleable. A comparison of duplicate site data is included in the Quality Assurance and Quality Control section of this document (Appendix C).

1.2 Impervious Surface/GIS Analysis

Upon arrival at sampling locations, coordinates were recorded using a Trimble® Pathfinder ProXT GPS unit coupled with a field computer at the midpoint of each reach to create a point layer showing sampling locations accurate to within one meter. These sampling points were then snapped to the stream layer on the Digital Elevation Model (DEM) for the watershed using the ArcHydro toolset to delineate drainage areas to each sampling location. The LIDAR derived DEM was generated by the Watershed Management Program based on the 2004 DNR DEM coverage with 1-meter resolution. Before drainage areas were delineated, the DEM was modified with inclusion of County and State Highway Administration stormdrain layers, and streams in areas with low relief. The DEM was reconditioned utilizing terrain preprocessing functionality within the ArcHydro extension toolset.

The impervious surface acreage and percent was calculated for the drainage area to each site using a 2007 vector polygon dataset of impervious land cover, maintained by the DPW, Bureau of Engineering, Watershed Assessment and Planning Program[1]. The GIS impervious layer was developed from 1-m satellite imagery during leaf-off conditions and represents the area of all impervious surfaces (roads, buildings, and parking lots). The results include all of the impervious surfaces and do not distinguish between connected versus disconnected surfaces. Four sampling locations (LPAX-37, 38, 41, and 42) include drainage areas that extend into Howard County. To calculate imperviousness for those four sampling locations, Howard County's vector polygon dataset of impervious land cover from 2006 was used in addition to the Anne Arundel County dataset.

[1] Data custodian: Hala Flores, PWFLOR08@aacounty.org

1.3 Water Quality Sampling

Water quality conditions were measured *in situ* at all monitoring sites, including the duplicate sites, according to methods prescribed in the County's Biological Monitoring and Assessment Program QAPP (Anne Arundel County, 2011). Field measured water chemistry 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, mid-point, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. Most *in situ* parameters (i.e., temperature, pH, specific conductivity, and dissolved oxygen) were measured using a multiparameter sonde (YSI Professional Plus or YSI 650), while turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters were regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

1.4 Physical Habitat Assessment

The biological monitoring sites, including the QC sites, were characterized based on visual observations of physical characteristics and various habitat parameters. The EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2002) were used to assess the physical habitat at each site. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photographs were taken from three locations within each sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health (Table 2). Each parameter is given a numerical score from 0-20 (20 = best, 0 = worst), or 0-10 for individual bank parameters (i.e., bank stability, vegetative protection, and riparian vegetative zone width), and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases.

Table 2 – RBP Low Gradient Habitat Parameters

Low Gradient Stream Parameters	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian Vegetative Zone Width

The RBP habitat parameters for each reach are summed, with a total possible score of 200. The total score is then placed into one of four narrative categories (Table 3) based on the percent comparability to reference conditions. Since adequate reference condition scores do not currently exist for Anne Arundel County, the categories used in this report are based on reference conditions obtained from Prince George's County streams and watersheds (Stribling et al., 1999).

Table 3 – RBP Habitat Score and Ratings

Score	Classification Scoring	Narrative Rating
≥151	≥151	Comparable to Reference
126-150	126-150	Supporting
101-125	101-125	Partially Supporting
≤100	0-100	Non Supporting

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for the coastal plain streams. These parameters are used in calculating the PHI (Table 4). Several of the parameters have been found to be drainage area dependent and are scaled accordingly. The drainage area to each point was calculated using GIS with County digital elevation model (DEM) topography as described in Section 2.2.

Table 4 – PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epibenthic Substrate	Bank Stability

Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count). A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 5 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments performed statewide.

Table 5 – PHI Score and Ratings

PHI Score	Narrative Rating
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

1.5 Benthic Macroinvertebrate Sampling

Biological assessment using benthic macroinvertebrate sampling and analysis was completed at all sites including the QC site. Benthic macroinvertebrate collection follows the QAPP which closely mirrors MBSS procedures (DNR, 2010). The monitoring sites consist of a 75-meter sampling reach, and benthic macroinvertebrate sampling is conducted during the spring index period (March 1st to May 1st). The sampling methods utilize systematic field collections of the benthic macroinvertebrate community. The multi-habitat D-frame net approach is used to sample a range of the most productive habitat types present within the reach. In this sampling approach, a total of twenty jabs are distributed among all available productive habitats within the stream system and combined into a single composite sample. Potential habitats include submerged vegetation, overhanging bank vegetation, leaf packs, stream bed substrate (i.e., cobbles, gravel, sand), and submerged organic matter (i.e., logs, stumps, snags, dead branches, and other debris).

1.5.1 Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and methods described by Caton (1991). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample is spread evenly across a gridded tray (30 total grids), and a minimum of four grids are picked clean of organisms until count of 100 is reached. The 100 (plus 20 percent) organism target is used to allow for specimens that are missing parts or are not mature enough for proper identification. For sites with a final count of greater than 120 organisms identified, a post-processing subsampling procedure was conducted using an Excel spreadsheet application (Tetra Tech, 2006). This post-processing application is designed to randomly subsample all identified organisms within a given sample to a desired target number. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20 percent) but keeps the total number of individuals below the 120 maximum.

Identification of the subsampled specimens is conducted by Environmental Services and Consulting, LLC[2]. Taxa are identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha are identified to the family level while Nematoda is left at phylum. Individuals of early instars or those that may be damaged are identified to the lowest possible level, which could be phylum or order, but in most cases would be family. Chironomidae can be further subsampled depending on the number of individuals in the sample and the numbers in each subfamily or tribe. Most taxa are identified using a stereoscope. Temporary slide mounts are used to identify Oligochaeta to family with a compound scope. Chironomid sorting to subfamily and tribe is also conducted using temporary slide mounts. Permanent slide mounts are then used for final genus level identification. Results are logged on a bench sheet and entered into a spreadsheet for analysis.

1.5.2 Biological Data Analysis

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

Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric as shown in Table 6. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned (Table 7). Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions. These include the coastal plain, piedmont and combined highlands regions, divided by the Fall Line. The current study area is located within the coastal plain region. The following metrics and BIBI scoring were used for the analysis.

[2] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA

Coastal Plain BIBI Metrics *(Modified from Table 2-3 in Southerland et al., 2005a)*

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 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. 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 scraper taxa in the sample, those taxa that scrape food from the substrate. 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.

Information on trophic or functional feeding group and habit were based heavily on information compiled by DNR and from Merritt and Cummins (1996).

Table 6 - Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates

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	≥2.0	1-1	<1.0
Percent Intolerant Urban Taxa	≥28	10-27	<10.0
Percent Ephemeroptera Taxa	≥11	0.8-10.9	<0.8
Number Scraper Taxa	≥2	1-1	<1.0
Percent Climber Taxa	≥8.0	0.9-7.9	<0.9

Table 7 – BIBI Scoring and Rating

BIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

2 Results

Biological monitoring was conducted at a total of 40 sites between April 4 and April 29, 2011. Additionally, four biological duplicate QC samples were collected immediately upstream of sites LPAX-05, LPAX-18, LPAX-24 and LPAX-36. Presented below are the summary results for each assessment site. For site-specific bioassessment data and results, refer to Appendix A. Maps of the Little Patuxent watershed displaying the bioassessment results can be found in Figure 4 and Appendix B.

2.1 Impervious Surface Analysis

The results of the impervious surface analysis are listed below in Table 8 including general information about each sampling site. Drainage areas ranged from 89.3 acres at site LPAX-43, to 8053.5 acres at site LPAX-37, the most downstream site on Dorsey Run. The median watershed size for the study area is 736.7 acres, with 42.5 percent of sites less than 500 acres. Imperviousness ranged from a low of 0.2 percent at LPAX-46, located in the Patuxent Wildlife Refuge, to a high of 46.6 percent at LPAX-35. The average imperviousness for the 40 sites in the study area is 17.9 percent. The distribution of percent imperviousness among sampling sites shows the highest frequency in the ≤10 percent range; however, the frequency remains fairly consistent through 40 percent imperviousness before dropping off at >40 percent (Figure 3).

Table 8 – Drainage Area and Imperviousness

Site	Date Sampled	Drainage Area (acres)	Impervious Area (acres)	Impervious Percent
LPAX-01-2011	4/25/2011	1615.9	534.6	33.1
LPAX-02-2011	4/27/2011	1131.3	355.9	31.5
LPAX-03-2011	4/19/2011	985.2	103.2	10.5
LPAX-04-2011	4/19/2011	176.4	55.0	31.2
LPAX-05-2011	4/25/2011	4247.6	972.9	22.9
LPAX-06-2011	4/29/2011	3431.4	685.1	20.0
LPAX-07-2011	4/27/2011	105.1	1.6	1.5
LPAX-08-2011	4/27/2011	169.5	2.8	1.7
LPAX-09-2011	4/25/2011	1001.1	137.7	13.8
LPAX-11-2011	4/29/2011	365.7	6.5	1.8
LPAX-12-2011	4/29/2011	277.2	15.8	5.7
LPAX-13-2011	4/29/2011	798.2	25.2	3.2
LPAX-14-2011	4/29/2011	385.1	16.1	4.2
LPAX-15-2011	4/29/2011	701.0	208.3	29.7
LPAX-16-2011	4/29/2011	240.7	65.4	27.1
LPAX-17-2011	4/25/2011	1329.9	324.2	24.4
LPAX-18-2011	4/27/2011	969.7	244.3	25.2

Site	Date Sampled	Drainage Area (acres)	Impervious Area (acres)	Impervious Percent
LPAX-19-2011	4/22/2011	5387.6	1062.7	19.7
LPAX-20-2011	4/27/2011	772.7	130.2	16.8
LPAX-23-2011	4/19/2011	117.7	15.9	13.5
LPAX-24-2011	4/22/2011	146.3	2.5	1.7
LPAX-25-2011	4/22/2011	208.3	1.3	0.6
LPAX-26-2011	4/22/2011	101.4	1.4	1.4
LPAX-28-2011	4/19/2011	407.3	147.3	36.2
LPAX-29-2011	4/19/2011	124.2	46.5	37.5
LPAX-30-2011	4/18/2011	123.2	27.4	22.2
LPAX-31-2011	4/18/2011	1905.3	382.7	20.1
LPAX-32-2011	4/18/2011	1380.7	249.1	18.0
LPAX-33-2011	4/18/2011	1082.5	259.6	24.0
LPAX-34-2011	4/18/2011	789.6	173.3	21.9
LPAX-35-2011	4/29/2011	412.8	192.3	46.6
LPAX-36-2011	4/29/2011	374.7	7.4	2.0
LPAX-37-2011	4/27/2011	8053.5	2194.2	27.2
LPAX-38-2011	4/27/2011	7561.8	2136.3	28.3
LPAX-39-2011	4/4/2011	872.9	103.8	11.9
LPAX-40-2011	4/4/2011	535.0	58.7	11.0
LPAX-41-2011	4/4/2011	6320.6	1925.0	30.5
LPAX-42-2011	4/27/2011	5994.4	1811.2	30.2
LPAX-43-2011	4/4/2011	89.3	7.9	8.8
LPAX-46-2011	4/27/2011	595.5	1.0	0.2
Duplicate Sites for QC				
LPAX-05-2011QC	4/25/2011	4246.9	972.9	22.9
LPAX-18-2011QC	4/27/2011	946.3	235.7	24.9
LPAX-24-2011QC	4/22/2011	134.2	1.4	1.1
LPAX-36-2011QC	4/29/2011	372.3	7.4	2.0

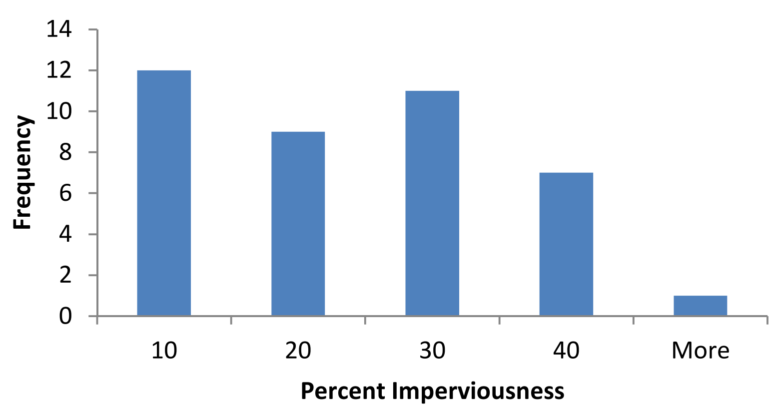
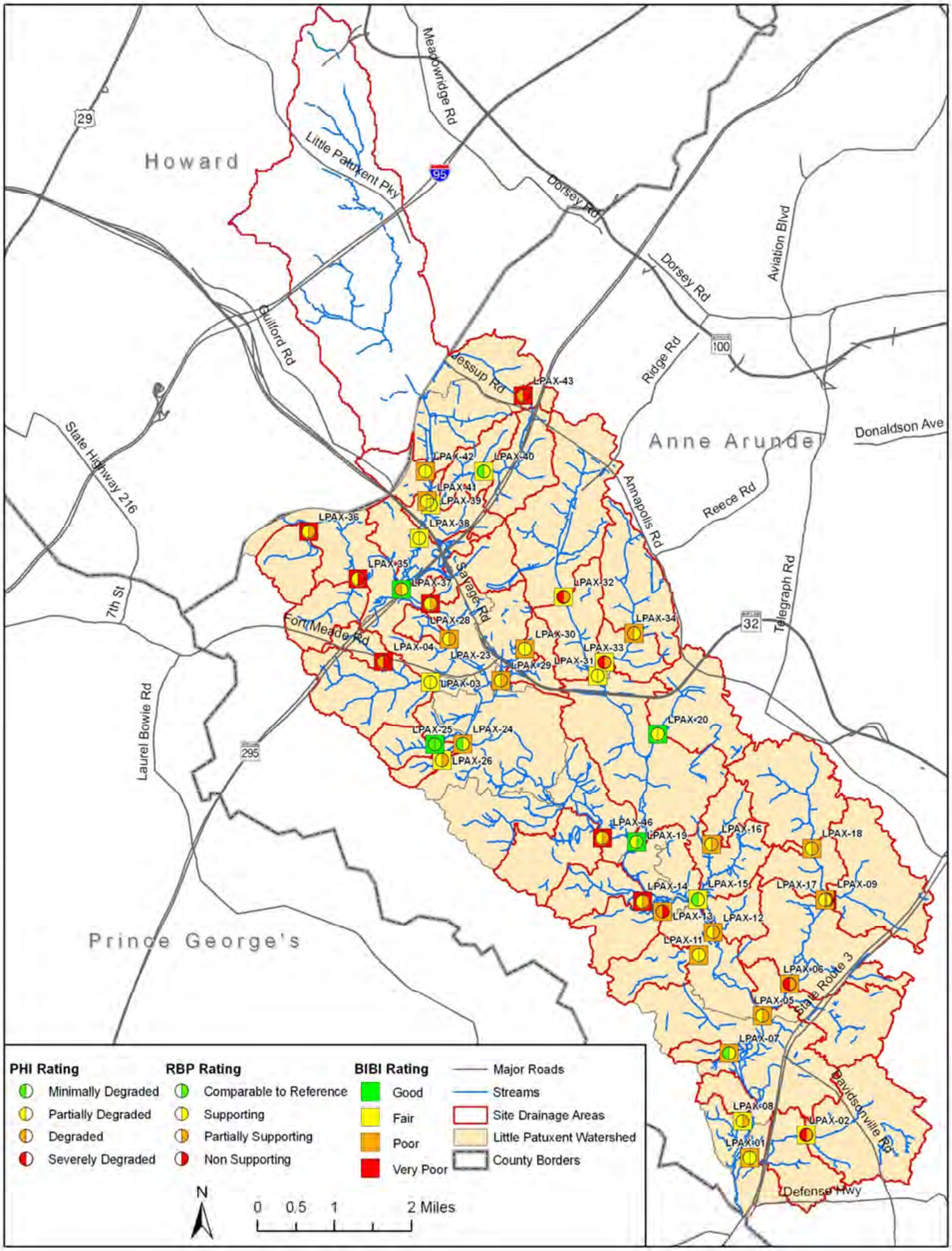


Figure 3 – Histogram showing the distribution of percent imperviousness for 40 targeted sites in the Little Patuxent watershed.

Figure 4 – Bioassessment Results Map



2.2 Water Quality

Instream water quality sampling was conducted in conjunction with macroinvertebrate sampling and occurred between April 4 and April 29, 2011. Water quality data are presented below in Table 9.

The Maryland Department of the Environment (MDE) has established acceptable standards for several of the sampled parameters for each designated Stream Use Classification. Currently, there are no standards available for specific conductivity; however, a threshold for biological impairment in Maryland streams has been established at 247 µS/cm (Morgan et al., 2007). Acceptable standards are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.01-.03 - Water Quality*. The Little Patuxent watershed is listed in *COMAR* in Sub-Basin 02-13-11: Patuxent River Area. The Little Patuxent River and all Tributaries above Old Forge Bridge (1 mile south of MD Route 198) are designated as Use I-P streams. Specific designated uses for Use I-P streams include water contact sports, fishing, the growth and propagation of fish, agricultural water supply, industrial water supply, and public water supply. The remaining portions of the Little Patuxent watershed are designated as Use I streams, which includes uses for water contact sports, fishing, the growth and propagation of fish, agricultural water supply, and industrial water supply. The acceptable standards for Use I and I-P streams are as follows:

- pH - 6.5 to 8.5
- DO - may not be less than 5 mg/l at any time
- Turbidity - maximum of 150 Nephelometer Turbidity Units (NTU's) and maximum monthly average of 50 NTU
- Temperature - maximum of 90°F (32°C) or ambient temperature of the surface water, whichever is greater

Generally, *in situ* water quality parameters fell within COMAR limits for a Use I and I-P streams and are typical of streams in Maryland's coastal plain. All measurements for water temperature and turbidity were within COMAR standards. However, there were 17 sites with pH values recorded below the acceptable limit of 6.5. In addition, there were five sites with dissolved oxygen values recorded below the acceptable limit of 5 mg/l, all of which were noted as being primarily backwatered or having stagnant flow. Although MDE does not have a water quality standard for specific conductivity, Morgan et al. (2007) has reported a biological impairment threshold of 247 µg/l for Maryland streams. A total of 24 sites had specific conductivity values exceeding this threshold.

Table 9 – Instream Water Quality Results

Site	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Conductivity (S/cm)
LPAX-01-2011	6.43	19.17	9.70	7.38	249
LPAX-02-2011	5.40	19.11	6.88	6.97	306
LPAX-03-2011	6.89	12.47	9.97	8.66	190
LPAX-04-2011	7.00	13.40	8.23	19.10	438
LPAX-05-2011	6.12	20.47	9.62	25.50	320
LPAX-06-2011	6.15	14.83	8.76	6.92	297
LPAX-07-2011	6.29	18.60	7.78	6.77	106
LPAX-08-2011	6.65	18.38	0.99	12.30	231
LPAX-09-2011	5.67	24.50	8.33	34.80	174
LPAX-11-2011	5.72	15.02	1.32	9.65	72
LPAX-12-2011	6.18	15.36	9.40	28.70	122
LPAX-13-2011	6.46	16.57	4.69	21.20	142
LPAX-14-2011	6.69	16.87	5.12	12.40	120
LPAX-15-2011	6.64	15.35	8.66	2.76	301
LPAX-16-2011	6.23	15.17	8.94	3.17	394
LPAX-17-2011	5.76	19.42	9.51	11.30	179
LPAX-18-2011	5.77	19.38	6.84	8.04	243
LPAX-19-2011	7.03	12.30	10.50	7.40	425
LPAX-20-2011	7.14	21.37	7.22	8.87	620
LPAX-23-2011	6.68	13.63	5.18	25.00	357
LPAX-24-2011	4.89	10.00	8.93	3.89	50
LPAX-25-2011	5.82	10.07	10.73	3.96	52
LPAX-26-2011	5.20	10.40	4.85	4.52	41
LPAX-28-2011	7.90	14.33	11.03	9.10	614
LPAX-29-2011	6.55	11.57	7.09	7.72	709
LPAX-30-2011	6.44	12.97	8.75	3.84	236
LPAX-31-2011	6.93	11.30	10.06	16.40	335
LPAX-32-2011	6.71	12.90	10.09	13.60	305
LPAX-33-2011	7.15	15.00	8.27	28.90	430
LPAX-34-2011	6.80	12.87	7.81	28.00	322
LPAX-35-2011	7.15	14.97	6.67	4.54	700
LPAX-36-2011	6.68	15.57	2.43	36.00	169
LPAX-37-2011	7.36	20.80	10.31	4.69	540
LPAX-38-2011	7.34	21.10	10.77	6.32	550
LPAX-39-2011	7.16	11.33	10.33	14.60	428
LPAX-40-2011	7.15	13.87	10.69	4.87	363
LPAX-41-2011	7.63	12.93	12.86	4.38	651
LPAX-42-2011	7.39	21.50	10.34	6.97	603
LPAX-43-2011	7.26	8.47	10.21	7.79	758
LPAX-46-2011	5.96	21.00	5.09	9.09	54
Study Mean	*6.56*	*15.61*	*8.12*	*12.15*	*330*
Standard Deviation	*0.69*	*3.88*	*2.70*	*9.25*	*204*
Duplicate Sites for QC					
LPAX-05-2011QC	6.93	21.17	9.65	25.50	318
LPAX-18-2011QC	6.27	19.52	6.34	8.25	242

Site	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Conductivity (S/cm)
LPAX-24-2011QC	4.97	10.05	7.56	4.33	49
LPAX-36-2011QC	6.62	15.77	1.51	45.60	164

2.3 Physical Habitat Assessment

The results of the RBP and PHI habitat assessments are presented in Table 10. The percent comparability to RBP reference scores ranged from 50 percent at site LPAX-43 to a high of 91.7 percent at site LPAX-25. Overall, two sites (5 percent) were classified as 'Comparable to Reference.' Seventeen sites (42.5 percent) were rated as 'Supporting' and sixteen (40 percent) were rated as 'Partially Supporting.' There were also five sites that received the lowest possible rating of 'Non Supporting'. The lowest PHI score of 44.32 was recorded at LPAX-02 while the highest score, 97.69 was recorded at LPAX-25 within the Patuxent Wildlife Refuge. Six sites were rated as 'Degraded' and 25 sites were rated as 'Partially Degraded.' There were five sites in the watershed that received the highest classification of 'Minimally Degraded', and four sites receiving the lowest classification of 'Severely Degraded'.

Distributions of selected RBP metric values were plotted and examined for normality (Figure 5 (a – f)). Two metrics, Pool Variability and Sediment Deposition, Number of Taxa, showed a normal distribution with the majority of sites scoring in the 'Marginal' range (Figure 5 - b and f, respectively). Epifaunal Substrate/Available Cover and Pool Substrate Characterization metrics both have bimodal distributions with peaks in the 'Marginal' and 'Suboptimal' ranges (Figure 5 - a and d, respectively). The remaining two metrics Riparian Vegetative Zone Width, and to a lesser extent Bank Vegetative Protection, had distributions that were skewed towards the 'Optimal' range (Figure 5 - c and e, respectively). For instance, nearly three-quarters all sites (29 sites) received an 'Optimal' rating for Riparian Vegetative Zone Width.

Table 10 – Physical Habitat Assessment Results

Site	Total RBP	Percent Reference	RBP Classification	PHI Score	PHI Narrative Rating
LPAX-01-2011	135	80.36	Supporting	77.80	Partially Degraded
LPAX-02-2011	106	63.10	Partially Supporting	44.32	Severely Degraded
LPAX-03-2011	134	79.76	Supporting	78.84	Partially Degraded
LPAX-04-2011	92	54.76	Non Supporting	57.92	Degraded
LPAX-05-2011	118	70.24	Partially Supporting	66.41	Partially Degraded
LPAX-06-2011	111	66.07	Partially Supporting	47.46	Severely Degraded
LPAX-07-2011	141	83.93	Supporting	88.68	Minimally Degraded
LPAX-08-2011	114	67.86	Partially Supporting	75.05	Partially Degraded
LPAX-09-2011	97	57.74	Non Supporting	53.37	Degraded
LPAX-11-2011	141	83.93	Supporting	66.61	Partially Degraded
LPAX-12-2011	111	66.07	Partially Supporting	67.87	Partially Degraded
LPAX-13-2011	100	59.52	Non Supporting	62.98	Degraded
LPAX-14-2011	124	73.81	Partially Supporting	75.88	Partially Degraded
LPAX-15-2011	132	78.57	Supporting	82.71	Minimally Degraded
LPAX-16-2011	120	71.43	Partially Supporting	79.19	Partially Degraded
LPAX-17-2011	128	76.19	Supporting	67.01	Partially Degraded
LPAX-18-2011	118	70.24	Partially Supporting	77.42	Partially Degraded
LPAX-19-2011	151	89.88	Comparable to Reference	73.63	Partially Degraded
LPAX-20-2011	134	79.76	Supporting	73.57	Partially Degraded
LPAX-23-2011	117	69.64	Partially Supporting	78.12	Partially Degraded
LPAX-24-2011	144	85.71	Supporting	86.01	Minimally Degraded
LPAX-25-2011	154	91.67	Comparable to Reference	97.69	Minimally Degraded
LPAX-26-2011	120	71.43	Partially Supporting	71.92	Partially Degraded
LPAX-28-2011	114	67.86	Partially Supporting	76.59	Partially Degraded
LPAX-29-2011	125	74.40	Partially Supporting	77.96	Partially Degraded
LPAX-30-2011	127	75.60	Supporting	67.50	Partially Degraded
LPAX-31-2011	135	80.36	Supporting	69.29	Partially Degraded
LPAX-32-2011	103	61.31	Partially Supporting	46.98	Severely Degraded
LPAX-33-2011	122	72.62	Partially Supporting	49.74	Severely Degraded
LPAX-34-2011	131	77.98	Supporting	59.79	Degraded
LPAX-35-2011	94	55.95	Non Supporting	66.23	Partially Degraded
LPAX-36-2011	114	67.86	Partially Supporting	71.62	Partially Degraded
LPAX-37-2011	138	82.14	Supporting	64.28	Degraded
LPAX-38-2011	144	85.71	Supporting	68.96	Partially Degraded
LPAX-39-2011	128	76.19	Supporting	75.17	Partially Degraded
LPAX-40-2011	134	79.76	Supporting	81.70	Minimally Degraded
LPAX-41-2011	138	82.14	Supporting	71.97	Partially Degraded
LPAX-42-2011	141	83.93	Supporting	67.54	Partially Degraded
LPAX-43-2011	84	50.00	Non Supporting	59.05	Degraded
LPAX-46-2011	111	66.07	Partially Supporting	67.30	Partially Degraded
Study Mean	*123*	*73.3*	*Partially Supporting*	*69.8*	*Partially Degraded*
Standard Deviation	*17*	*10.0*	--	*11.5*	--
Duplicate Sites for QC					
LPAX-05-2011QC	118	70.24	Partially Supporting	65.32	Degraded
LPAX-18-2011QC	133	79.17	Supporting	79.97	Partially Degraded
LPAX-24-2011QC	138	82.14	Supporting	86.12	Minimally Degraded
LPAX-36-2011QC	123	73.21	Partially Supporting	73.02	Partially Degraded

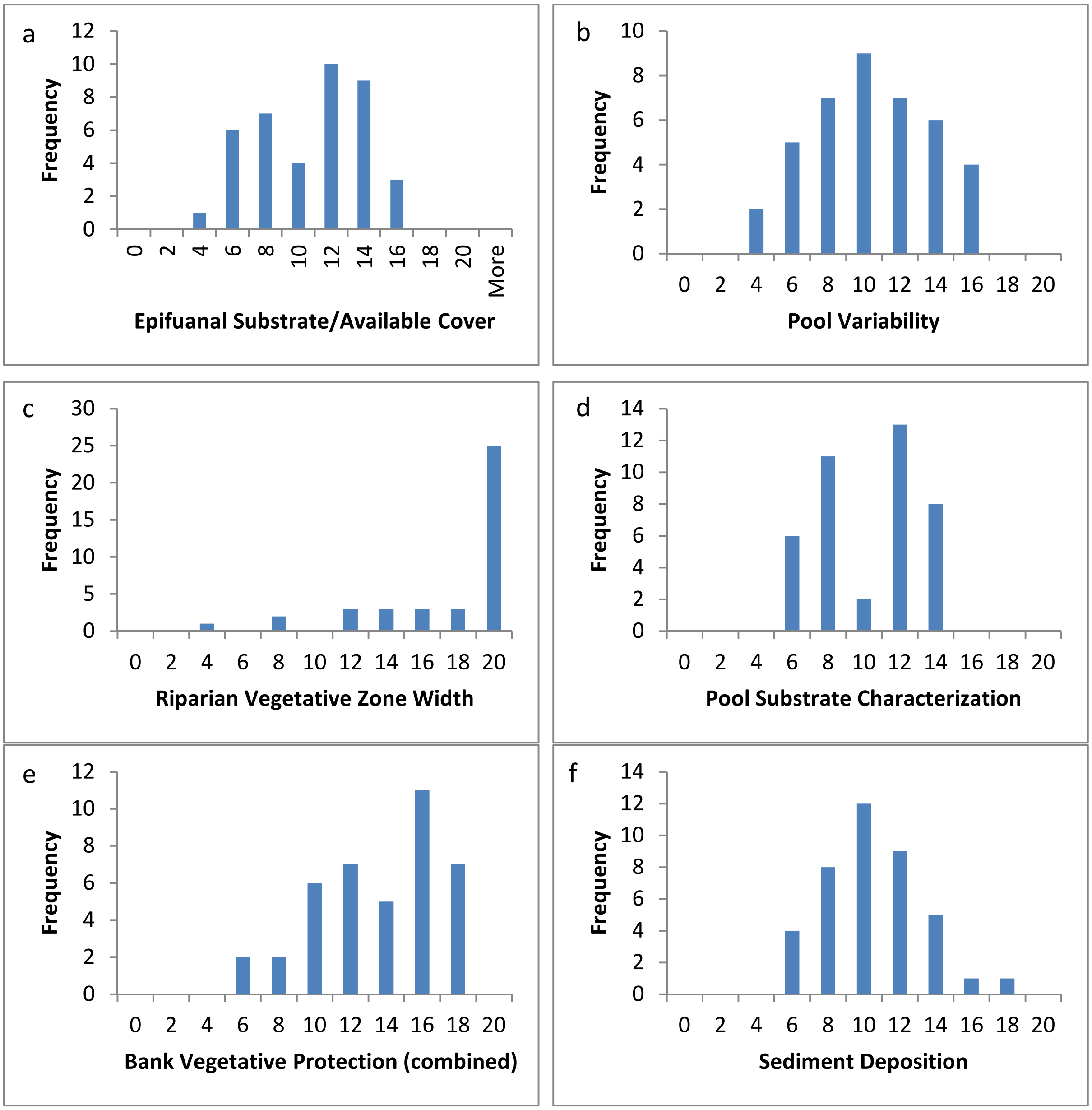


Figure 5 (a-f) – Histograms showing distributions of selected RBP metric values for 40 targeted sites in the Little Patuxent watershed.

2.4 Benthic Macroinvertebrates

The BIBI scores and corresponding narrative ratings for each site are presented in Table 11. Individual BIBI scores ranged from a low of 1.29 and narrative rating of 'Very Poor' at site LPAX-9 to a high of 4.43 and a rating of 'Good' at site LPAX-25. The average BIBI score for the 40 targeted sites was 2.74 ('Poor'), with a standard deviation of 0.77.

Overall, the majority of sites were rated as either 'Poor' (42.5 percent) or 'Fair' (27.5 percent). Additionally, there were eight sites (20 percent) rated as 'Very Poor,' and four sites (10 percent) rated as 'Good.'

Table 11 – Benthic Index of Biotic Integrity (BIBI) Summary Data

Site	BIBI Score	Narrative Rating
LPAX-01-2011	2.71	Poor
LPAX-02-2011	3.29	Fair
LPAX-03-2011	3.00	Fair
LPAX-04-2011	1.57	Very Poor
LPAX-05-2011	2.43	Poor
LPAX-06-2011	2.43	Poor
LPAX-07-2011	2.71	Poor
LPAX-08-2011	3.29	Fair
LPAX-09-2011	1.29	Very Poor
LPAX-11-2011	2.14	Poor
LPAX-12-2011	2.14	Poor
LPAX-13-2011	2.71	Poor
LPAX-14-2011	1.86	Very Poor
LPAX-15-2011	3.29	Fair
LPAX-16-2011	2.71	Poor
LPAX-17-2011	2.71	Poor
LPAX-18-2011	2.71	Poor
LPAX-19-2011	4.14	Good
LPAX-20-2011	4.14	Good
LPAX-23-2011	2.71	Poor
LPAX-24-2011	2.43	Poor
LPAX-25-2011	4.43	Good
LPAX-26-2011	3.00	Fair
LPAX-28-2011	1.57	Very Poor
LPAX-29-2011	2.14	Poor
LPAX-30-2011	2.71	Poor
LPAX-31-2011	3.00	Fair
LPAX-32-2011	3.00	Fair
LPAX-33-2011	3.57	Fair
LPAX-34-2011	2.71	Poor
LPAX-35-2011	1.86	Very Poor
LPAX-36-2011	1.57	Very Poor
LPAX-37-2011	4.14	Good
LPAX-38-2011	3.86	Fair
LPAX-39-2011	3.00	Fair
LPAX-40-2011	3.57	Fair

Site	BIBI Score	Narrative Rating
LPAX-41-2011	2.43	Poor
LPAX-42-2011	2.71	Poor
LPAX-43-2011	1.86	Very Poor
LPAX-46-2011	1.86	Very Poor
Study Mean	2.74	*Poor*
Standard Deviation	0.77	--
Duplicate Sites for QC		
LPAX-05-2011QC	2.14	Poor
LPAX-18-2011QC	2.71	Poor
LPAX-24-2011QC	2.14	Poor
LPAX-36-2011QC	1.57	Very Poor

Distributions of individual BIBI metric values were plotted and examined for normality (Figure 6 (a – g)). Only one metric, Number of Taxa, approximated a normal distribution (Figure 6 (a)). The remaining six metrics had distributions that were skewed towards low values, especially metrics involving sensitive taxa such as Number of Ephemeroptera, Percent Ephemeroptera, and Percent Intolerant Urban (Figure 6 (c - e)).

An analysis of the percent abundance and percent occurrence was completed and the results of the top 30 taxa are shown in Tables Table 12 and Table 13, respectively. *Orthocladius*, a tolerant midge, was the most commonly collected genus making up over 15 percent of the total collected individuals. Of the top 30 taxa by percent abundance, 18 (60 percent) were in the family Chironomidae (midges).

The tolerant chironomids, *Orthocladius* and *Polypedilum* were found at 33 (82.5 percent) and 29 (72.5 percent) of sampling sites, respectively. One intolerant isopod, *Caecidotea* (Tolerance value = 2.6) was found at 13 sites (32.5 percent). By percent occurrence, chironomids (midges) make up over half (60 percent) of the top 30 taxa.

As shown in Table 12 and Table 13, members of the family Chironomidae were dominant throughout the watershed. In general, the relative abundance of chironomids increases with increased perturbation. Table 14 lists all sites sampled and the percentage of identified individuals that were in the Chironomidae family. Site LPAX-28 contained the highest percentage of chironomids (92 percent) followed by LPAX-40 (89 percent) and LPAX-06 (88 percent). The lowest percentage was found at LPAX-11, with only 9 individuals (8 percent).

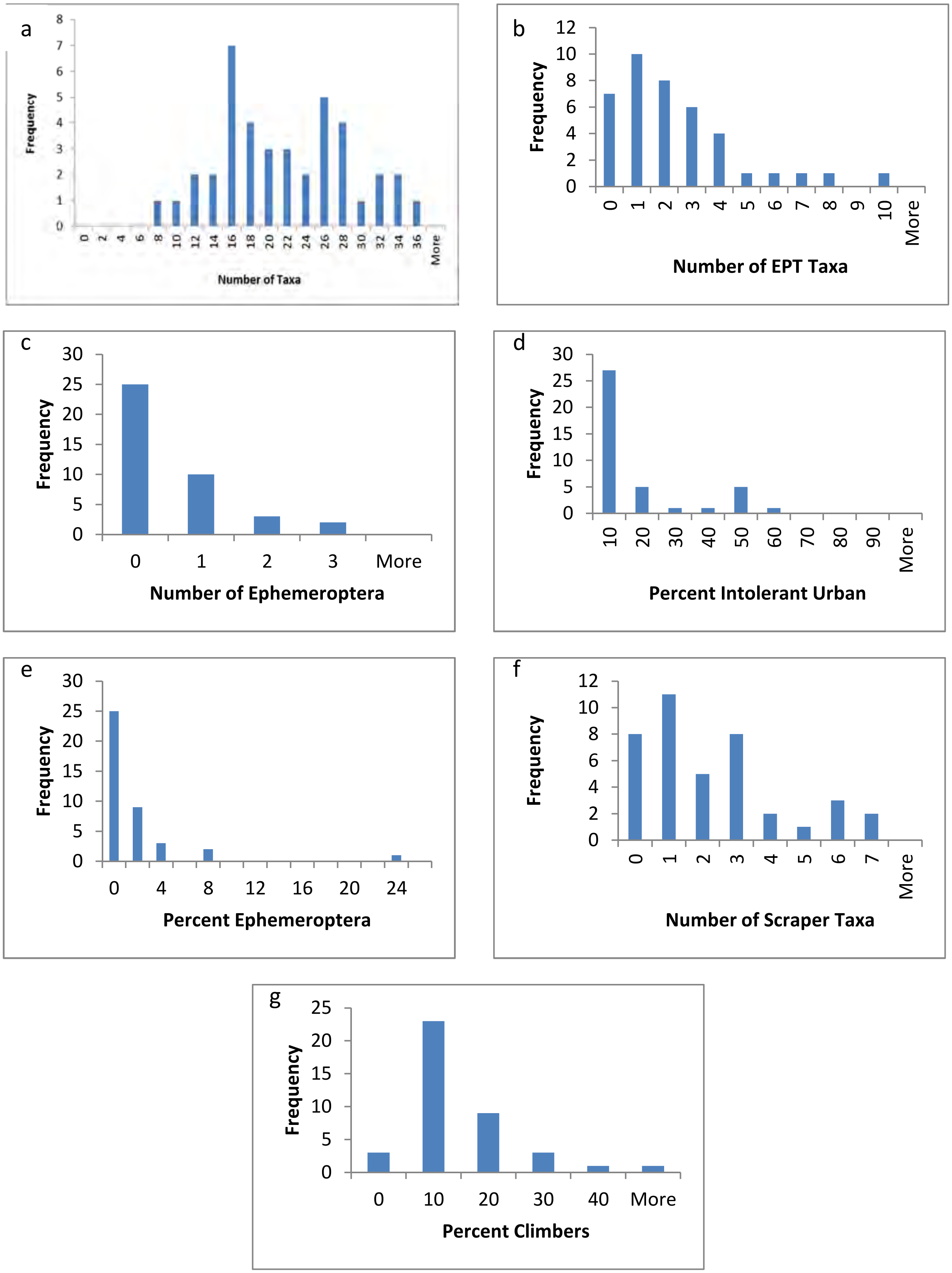


Figure 6 (a-g) – Histograms showing distributions of individual BIBI metric values for 40 targeted sites in the Little Patuxent watershed.

Table 12 – Percent Abundance (by top 30 taxa)

Final Identification	Order	Family	Functional Feeding Group	Habit[1]	Tolerance Value	Total Number of Individuals	Percent of collected individuals
Orthocladius	Diptera	Chironomidae	Collector	sp	9.2	656	15.5
Naididae	Haplotaxida	Naididae	Collector	bu	8.5	272	6.4
Polypedilum	Diptera	Chironomidae	Shredder	cb	6.3	199	4.7
Caecidotea	Isopoda	Asellidae	Collector	sp	2.6	193	4.6
Tubificidae	Haplotaxida	Tubificidae	Collector	cn	8.4	150	3.6
Parametriocnemus	Diptera	Chironomidae	Collector	sp	4.6	140	3.3
Stegopterna	Diptera	Simuliidae	Filterer	cn	2.4	128	3.0
Crangonyx	Amphipoda	Crangonyctidae	Collector	sp	6.7	127	3.0
Chironomus	Diptera	Chironomidae	Collector	bu	4.6	123	2.9
Stenelmis	Coleoptera	Elmidae	Scraper	cn	7.1	118	2.8
Musculium	Veneroida	Sphaeriidae	Filterer	na	5.5	99	2.3
Orthocladiinae	Diptera	Chironomidae	Collector	bu	7.6	98	2.3
Simulium	Diptera	Simuliidae	Filterer	cn	5.7	98	2.3
Cricotopus	Diptera	Chironomidae	Shredder	cn	9.6	87	2.1
Hydrobaenus	Diptera	Chironomidae	Scraper	sp	7.2	80	1.9
Tanytarsus	Diptera	Chironomidae	Filterer	cb	4.9	76	1.8
Tvetenia	Diptera	Chironomidae	Collector	sp	5.1	70	1.7
Rheotanytarsus	Diptera	Chironomidae	Filterer	cn	7.2	68	1.6
Chaetocladius	Diptera	Chironomidae	Collector	sp	7	55	1.3
Chironomini	Diptera	Chironomidae	Collector	bu	5.9	52	1.2
Thienemannimyia group	Diptera	Chironomidae	Predator	sp	8.2	51	1.2
Rheocricotopus	Diptera	Chironomidae	Collector	sp	6.2	48	1.1
Cheumatopsyche	Trichoptera	Hydropsychidae	Filterer	cn	6.5	46	1.1
Ancyronyx	Coleoptera	Elmidae	Scraper	cn	7.8	44	1.0
Amphinemura	Plecoptera	Nemouridae	Shredder	sp	3	41	1.0
Diplocladius	Diptera	Chironomidae	Collector	sp	5.9	38	0.9
Thienemanniella	Diptera	Chironomidae	Collector	sp	5.1	37	0.9
Brillia	Diptera	Chironomidae	Shredder	bu	7.4	36	0.9
Eukiefferiella	Diptera	Chironomidae	Collector	sp	6.1	33	0.8
Caenis	Ephemeroptera	Caenidae	Collector	sp	2.1	32	0.8

1 – Habit abbreviations: bu – burrower, cn – clinger, cb – climber, sp – sprawler, dv – diver, sk – skater.
QC sites were excluded from calculations.

Table 13 – Percent Occurrence (by top 30 taxa)

Final Identification	Order	Family	Functional Feeding Group	Habit[1]	Tolerance Value	Number of sites present	Percent of sites present
Orthocladius	Diptera	Chironomidae	Collector	sp	9.2	33	82.5
Polypedilum	Diptera	Chironomidae	Shredder	cb	6.3	29	72.5
Chironomini	Diptera	Chironomidae	Collector	bu	5.9	23	57.5
Tubificidae	Haplotaxida	Tubificidae	Collector	cn	8.4	23	57.5
Naididae	Haplotaxida	Naididae	Collector	bu	8.5	22	55.0
Cricotopus	Diptera	Chironomidae	Shredder	cn	9.6	20	50.0
Thienemanniella	Diptera	Chironomidae	Collector	sp	5.1	20	50.0
Chironomidae	Diptera	Chironomidae	Collector	na	6.6	19	47.5
Parametriocnemus	Diptera	Chironomidae	Collector	sp	4.6	19	47.5
Thienemannimyia group	Diptera	Chironomidae	Predator	sp	8.2	19	47.5
Hydrobaenus	Diptera	Chironomidae	Scraper	sp	7.2	18	45.0
Simulium	Diptera	Simuliidae	Filterer	cn	5.7	18	45.0
Tanytarsus	Diptera	Chironomidae	Filterer	cb	4.9	18	45.0
Tvetenia	Diptera	Chironomidae	Collector	sp	5.1	18	45.0
Stenelmis	Coleoptera	Elmidae	Scraper	cn	7.1	17	42.5
Chironomus	Diptera	Chironomidae	Collector	bu	4.6	16	40.0
Rheotanytarsus	Diptera	Chironomidae	Filterer	cn	7.2	16	40.0
Cheumatopsyche	Trichoptera	Hydropsychidae	Filterer	cn	6.5	15	37.5
Enchytraeidae	Haplotaxida	Enchytraeidae	Collector	bu	9.1	14	35.0
Bezzia/Palpomyia	Diptera	Ceratopogonidae	Predator	sp	3.6	13	32.5
Caecidotea	Isopoda	Asellidae	Collector	sp	2.6	13	32.5
Chaetocladius	Diptera	Chironomidae	Collector	sp	7.0	13	32.5
Eukiefferiella	Diptera	Chironomidae	Collector	sp	6.1	13	32.5
Brillia	Diptera	Chironomidae	Shredder	bu	7.4	12	30.0
Crangonyx	Amphipoda	Crangonyctidae	Collector	sp	6.7	11	27.5
Rheocricotopus	Diptera	Chironomidae	Collector	sp	6.2	11	27.5
Ancyronyx	Coleoptera	Elmidae	Scraper	cn	7.8	10	25.0
Calopteryx	Odonata	Calopterygidae	Predator	cb	8.3	10	25.0
Ironoquia	Trichoptera	Limnephilidae	Shredder	sp	4.9	10	25.0
Lumbricina	Haplotaxida	not identified	Collector	bu	10.0	10	25.0
Orthocladius	Diptera	Chironomidae	Collector	sp	9.2	33	82.5
Orthocladiinae	Diptera	Chironomidae	Collector	bu	7.6	32	80.0
Polypedilum	Diptera	Chironomidae	Shredder	cb	6.3	29	72.5

1 – Habit abbreviations: bu – burrower, cn – clinger, cb – climber, sp – sprawler, dv – diver, sk – skater.
QC sites were excluded from calculations.

Table 14 – Chironomidae Analysis

Site	Number of Chironomidae	Total Number of Individuals	Percent Chironomidae
LPAX-01-2011	51	73	70
LPAX-02-2011	51	109	47
LPAX-03-2011	47	115	41
LPAX-04-2011	90	109	83
LPAX-05-2011	84	103	82
LPAX-06-2011	99	113	88
LPAX-07-2011	39	101	39
LPAX-08-2011	54	118	46
LPAX-09-2011	81	113	72
LPAX-11-2011	9	110	8
LPAX-12-2011	42	82	51
LPAX-13-2011	24	107	22
LPAX-14-2011	54	117	46
LPAX-15-2011	54	98	55
LPAX-16-2011	54	110	49
LPAX-17-2011	67	108	62
LPAX-18-2011	62	106	58
LPAX-19-2011	42	106	40
LPAX-20-2011	33	110	30
LPAX-23-2011	20	102	20
LPAX-24-2011	28	102	27
LPAX-25-2011	58	112	52
LPAX-26-2011	24	100	24
LPAX-28-2011	109	119	92
LPAX-29-2011	27	64	42
LPAX-30-2011	44	106	42
LPAX-31-2011	61	100	61
LPAX-32-2011	81	105	77
LPAX-33-2011	91	114	80
LPAX-34-2011	89	111	80
LPAX-35-2011	68	104	65
LPAX-36-2011	30	111	27
LPAX-37-2011	18	106	17
LPAX-38-2011	33	103	32
LPAX-39-2011	83	99	84
LPAX-40-2011	104	117	89
LPAX-41-2011	93	110	85
LPAX-42-2011	22	97	23
LPAX-43-2011	45	116	39
LPAX-46-2011	12	113	11

2.5 Quality Assurance/Quality Control

All applicable QA/QC measures were calculated and compared to quantitative measurement quality objectives as presented in Hill and Pieper 2011b. No QA/QC problems were identified with the data collected and presented in this report. Detailed QA/QC results are presented in Appendix C.

3 Discussion

The targeted biological monitoring and assessments of streams in the Little Patuxent watershed provided valuable information regarding the biological, physical, and chemical conditions within the study area, in addition to current land use conditions. This section discusses the comprehensive results and findings of this study as well as some general conclusions regarding the condition of the Little Patuxent watershed.

3.1 Land Use and Impervious Surface

Land use throughout the watershed is diverse, with subwatersheds to the north (Dorsey Run) dominated by industrial/commercial landuse, subwatersheds to the west (Patuxent Wildlife Refuge) dominated by forests, and subwatersheds to the east and south dominated by residential and mixed (commercial/industrial) land uses including the Fort Meade Military Reservation. In addition, the watershed contains several major transportation corridors including the Baltimore-Washington Parkway (I-295) and Maryland Route 32, Route 175 and Route 3 highway corridors, as well as the Maryland Area Rail Commuter (MARC) Penn line and Camden line railway corridors. Half of the sites sampled were dominated by developed land cover, while 17 sites were dominated by forested land cover. The remaining three sites were dominated by open or agricultural land cover.

Impervious surface coverage was relatively high throughout portions of the subwatershed with an average site-specific imperviousness of 17.9 percent. However, there were also several sites in the watershed, such as those located in the Patuxent Wildlife Refuge and Oxbow Natural Area, where imperviousness was very low (≤ 2 percent). Twelve sites had drainage areas with imperviousness below 10 percent, 15 sites ranged between 10 and 25 percent, and 13 sites had impervious drainages greater than 25 percent, which is a general threshold associated with moderate stream degradation (Scheuler, 2008). Not surprisingly, only four sites with greater that 25 percent imperviousness received a biological condition rating of ‘Fair’ or better.

3.2 Water Chemistry

Water quality exceeded COMAR standards at nearly half of all sites sampled, primarily for low pH (<6.5). While the direct cause of low pH is unclear, most instances appear to be on streams draining wetlands with tannic water that could be expected to have naturally low pH levels given the landscape setting. A map of pH and conductivity ranges for each site shows a pattern where sites with low conductivity, typical of minimal anthropogenic disturbance, had low pH values that were outside of COMAR standards; whereas sites with elevated conductivity, typical of increased anthropogenic disturbance, generally had pH values within COMAR standards (Figure 8 and Table 17). While several sites exceeded the standard for low dissolved oxygen, it was noted that these streams exhibited stagnant flow, generally due to backwater conditions at the time of sampling, and may not be typical of average flow conditions at these locations. Furthermore, three of the five sites with low DO had biological conditions that exceeded what the physical habitat condition would indicate, suggesting that the low DO conditions were atypical and not causing significant impairment to the benthic macroinvertebrate assemblages.

Elevated conductivity levels were most prevalent in the more heavily developed, and hence more impervious, northern portion of the watershed. In fact, conductivity values were well correlated to imperviousness (r^2=0.4866; Figure 7), suggesting elevated conductivity levels in this watershed are influenced by runoff from impervious surfaces (i.e., roads, sidewalks, parking lots). This relationship between conductivity and imperviousness is consistent with patterns observed throughout Anne Arundel (Hill & Pieper, 2011). Increased stream inorganic ion concentrations (i.e., conductivity) in urban systems typically results from runoff over impervious surfaces, passage through pipes, and exposure to other anthropogenic infrastructure (Cushman, 2005). While elevated conductivity may not directly affect stream biota, its constituents (e.g., chloride, metals, and nutrients) may be present at levels that can cause considerable biological impairment. Certainly, more detailed water quality sampling would be necessary to identify the nature and extent of chemical stressors throughout the watershed and would aid in locating, and ultimately, mitigating stressor sources impacting the biota.

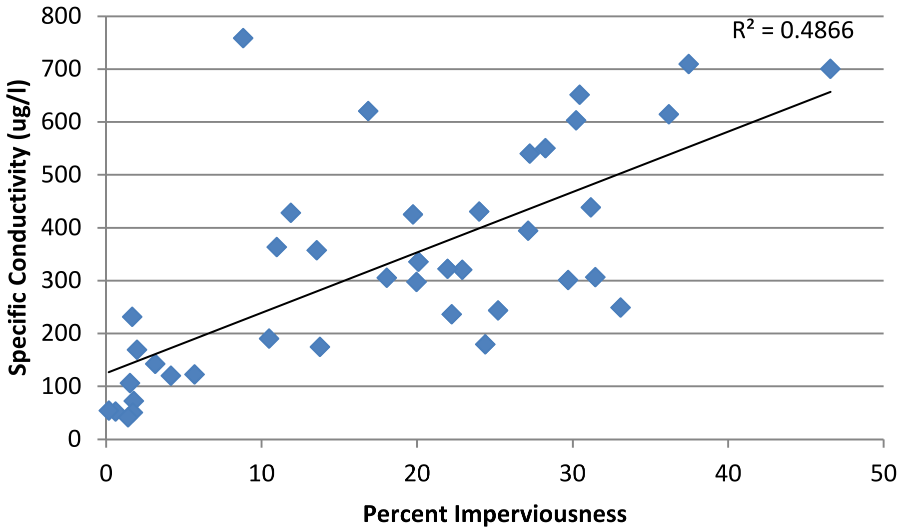
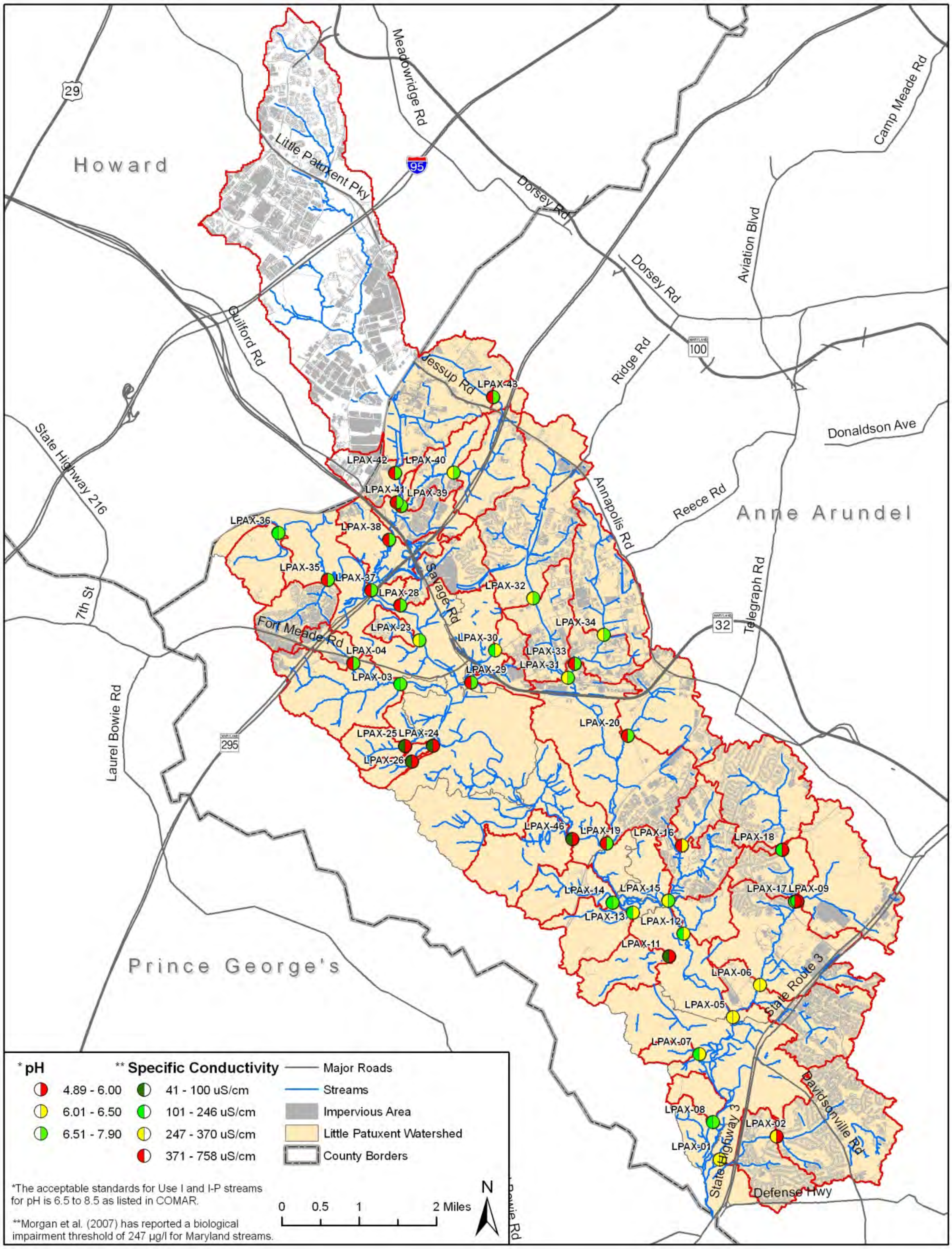


Figure 7 – Relationship between specific conductivity and percent imperviousness for 40 targeted sites in the Little Patuxent watershed.

3.1 Physical Habitat

Physical habitat scores for the RBP and PHI assessments both indicate varying habitat conditions throughout the watershed. The majority of sites assessed were rated as either 'Supporting' (42.5 percent) by the RBP or "Partially Degraded" by the PHI (62.5 percent), which is indicative of moderate stream degradation. On the high end of the scale only two sites were rated as 'Comparable to Reference' (RBP), and five sites received a 'Minimally Degraded' (PHI) rating. In contrast, five sites were rated in the most impaired RBP category of 'Non Supporting' (RBP) and four sites were rated in the most impaired 'Severely Degraded' category for the PHI. Habitat scores for the RBP and PHI assessments were only moderately correlated (r^2 = 0.3421), and often the corresponding narrative categories did not match with respect to the overall level of degradation (Figure 9). For example, four sites were rated as 'Severely Degraded' by the PHI but rated as 'Partially Supporting' by the RBP. However, it is important to note that only two sites (LPAX-19 and LPAX-35) differed by more than one assessment category.

Figure 8 - Conductivity and pH Results Map



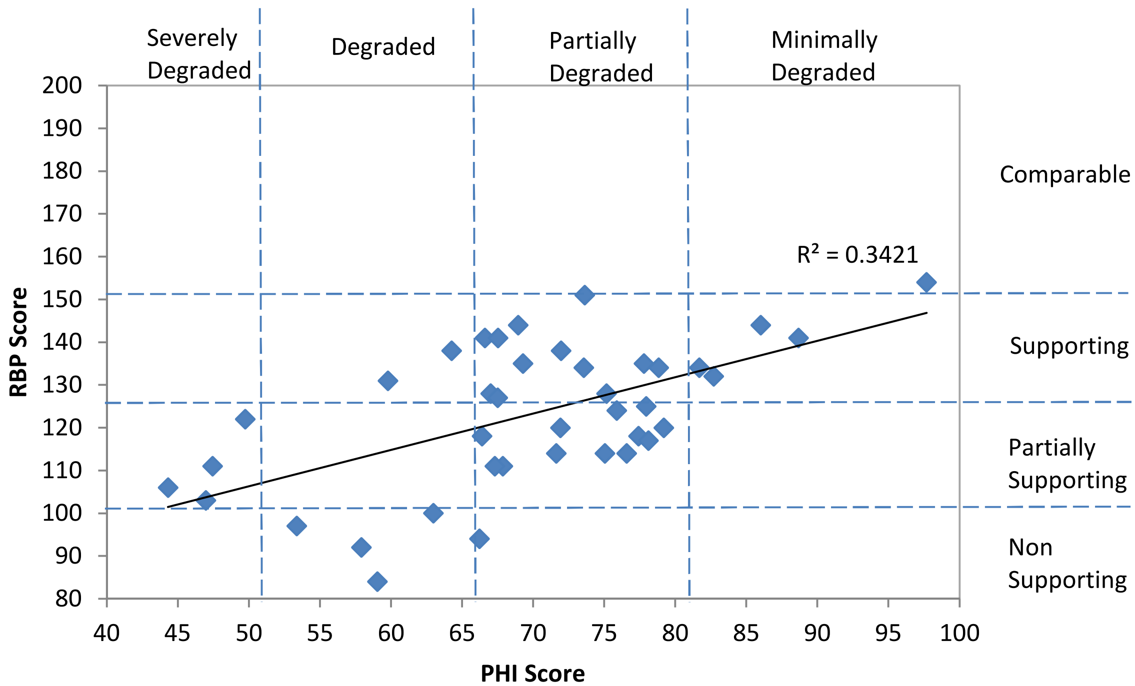


Figure 9 – Comparison of RBP and PHI habitat assessment scores for 40 sites in the Little Patuxent watershed.

3.2 Biological Condition

While the targeted study design does not support assessment results at the overall watershed scale, general statements about the Little Patuxent study area can be made based on site-specific results. Of the 40 sites assessed, 62.5 percent had impaired (i.e., 'Poor' or 'Very Poor') biological conditions and only 10 percent of sites were rated as 'Good'. The biological results indicate a median BIBI score of 2.71, which is in the 'Poor' category. Chironomidae taxa dominated many of the samples and comprised eight of the top ten taxa by percent occurrence. While some chironomid taxa are intolerant to stressors, the relevant abundance of chironomids tends to increase in urbanized drainages. Other prevalent taxa include Tubificidae (Tol. val. = 8.4) and Naididae (Tol. val. = 8.5) both families of tolerant worms. The three most abundant taxa found throughout the study area were either tolerant (i.e., Orthocladius [Tol. val. = 9.2], Naididae) or relatively tolerant (i.e., *Polypedilum* [Tol. val. = 6.3]) to urban stressors, which suggests that urban stressors are prevalent throughout the watershed and are likely influencing biological communities.

3.3 Integrated Assessment

Table 15 contains consolidated assessment results for each site to allow for easier comparisons of site specific conditions. Summary maps displaying biological and physical habitat results are shown in Appendix B.

Table 15 – Consolidated Assessment Results

Site	Sub-watershed Code	Drainage Area (acres)	Impervious Percent	BIBI Score	RBP Score	RBP Percent of Reference	PHI Score
LPAX-01-2011	LPA	1615.9	33.1	2.71	135	80.36	77.80
LPAX-02-2011	LPA	1131.3	31.5	3.29	106	63.10	44.32
LPAX-03-2011	LPM	985.2	10.5	3.00	134	79.76	78.84
LPAX-04-2011	LPM	176.4	31.2	1.57	92	54.76	57.92
LPAX-05-2011	LPD	4247.6	22.9	2.43	118	70.24	66.41
LPAX-06-2011	LPD	3431.4	20.0	2.43	111	66.07	47.46
LPAX-07-2011	LP1	105.1	1.5	2.71	141	83.93	88.68
LPAX-08-2011	LP1	169.5	1.7	3.29	114	67.86	75.05
LPAX-09-2011	LPC	1001.1	13.8	1.29	97	57.74	53.37
LPAX-11-2011	LP2	365.7	1.8	2.14	141	83.93	66.61
LPAX-12-2011	LP2	277.2	5.7	2.14	111	66.07	67.87
LPAX-13-2011	LP3	798.2	3.2	2.71	100	59.52	62.98
LPAX-14-2011	LP3	385.1	4.2	1.86	124	73.81	75.88
LPAX-15-2011	LPL	701.0	29.7	3.29	132	78.57	82.71
LPAX-16-2011	LPL	240.7	27.1	2.71	120	71.43	79.19
LPAX-17-2011	LPB	1329.9	24.4	2.71	128	76.19	67.01
LPAX-18-2011	LPB	969.7	25.2	2.71	118	70.24	77.42
LPAX-19-2011	LPF	5387.6	19.7	4.14	151	89.88	73.63
LPAX-20-2011	LPF	772.7	16.8	4.14	134	79.76	73.57
LPAX-23-2011	LP5	117.7	13.5	2.71	117	69.64	78.12
LPAX-24-2011	LPO	146.3	1.7	2.43	144	85.71	86.01
LPAX-25-2011	LPO	208.3	0.6	4.43	154	91.67	97.69
LPAX-26-2011	LPO	101.4	1.4	3.00	120	71.43	71.92
LPAX-28-2011	LP5	407.3	36.2	1.57	114	67.86	76.59
LPAX-29-2011	LPN	124.2	37.5	2.14	125	74.40	77.96
LPAX-30-2011	LPN	123.2	22.2	2.71	127	75.60	67.50
LPAX-31-2011	LPE	1905.3	20.1	3.00	135	80.36	69.29
LPAX-32-2011	LPE	1380.7	18.0	3.00	103	61.31	46.98
LPAX-33-2011	LPG	1082.5	24.0	3.57	122	72.62	49.74
LPAX-34-2011	LPG	789.6	21.9	2.71	131	77.98	59.79
LPAX-35-2011	LP6	412.8	46.6	1.86	94	55.95	66.23
LPAX-36-2011	LP6	374.7	2.0	1.57	114	67.86	71.62
LPAX-37-2011	LPI	8053.5	27.2	4.14	138	82.14	64.28
LPAX-38-2011	LPI	7561.8	28.3	3.86	144	85.71	68.96
LPAX-39-2011	LPJ	872.9	11.9	3.00	128	76.19	75.17
LPAX-40-2011	LPJ	535.0	11.0	3.57	134	79.76	81.70
LPAX-41-2011	LPH	6320.6	30.5	2.43	138	82.14	71.97
LPAX-42-2011	LPH	5994.4	30.2	2.71	141	83.93	67.54
LPAX-43-2011	LPK	89.3	8.8	1.86	84	50.00	59.05
LPAX-46-2011	LP4	595.5	0.2	1.86	111	66.07	67.30

Biological potential is limited by the quality of the physical habitat, which forms the template upon which biological communities develop (Southwood, 1977). To examine the biological condition in comparison to the site's biological potential as defined by the habitat ratings (both RBP and PHI), a matrix was developed by plotting each station by biological condition rating on one axis and habitat condition rating on the other in order axis to determine whether they exceed, match, or fall short of their expected biological potential. The biological potential matrix for both RBP and PHI habitat ratings is shown in Table 16.

Table 16 – Station Biological Potential Matrix

EPA RBP HABITAT RATING	BIOLOGICAL RATING			
	GOOD	FAIR	POOR	VERY POOR
Comparable	19,25			
Supporting	20,37	03,15, 31,38, 39,40	01,07,11, 17,24,30, 34,41,42	
Partially Supporting		02,08, 26,32, 33	05,06,12, 16,18,23, 29	14,28, 36,46
Non Supporting			13	04,09, 35,43

MBSS PHI HABITAT RATING	BIOLOGICAL RATING			
	GOOD	FAIR	POOR	VERY POOR
Minimally Degraded	25	15,40	**07,24**	
Partially Degraded	19,20,	03,08, 26,31, 38,39	01,05,11, 12,16,17, 18,23,29, 30,41,42	**14,28, 35,36, 46**
Degraded	37		13,34	04,09, 43
Severely Degraded		**02,32, 33**	06	

Green indicates stations where the biological community exceeded the habitat potential
Orange indicates stations where the biological community reached habitat potential
Pink indicates stations where the biological community did not reach the habitat potential
Bolded stations indicate biological conditions that differ by two categories from the corresponding habitat class

BIBI scores were fairly well correlated (r^2 = 0.3649) with RBP scores (Figure 10). PHI scores, on the other hand, were poorly correlated (r^2 = 0.0448) with BIBI scores (Figure 11), suggesting that the parameters included in this index are less predictive of biological conditions in the Little Patuxent watershed. These results are similar to those found throughout Anne Arundel County, which found a stronger correlation between the RBP and BIBI compared to the PHI (Hill and Pieper, 2011a). Nonetheless, it is likely that physical habitat conditions are limiting the potential of biological communities in numerous subwatersheds, especially at sites where the biological conditions match degraded physical habitat conditions. It's also important to note that degraded habitat conditions were also observed in areas with little development and low imperviousness, suggesting that legacy effects of past land use changes (e.g., deforestation, channelization, mill dams) may continue to limit the biological potential in these streams.

While some sites show clear patterns of degraded physical habitat and correspondingly impaired biological communities, indicating physical habitat as the limiting factor, numerous sites show patterns more consistent with water quality impairment (

Table 17). For sites where the biological community did not reach RBP habitat potential, water quality may be a potential limiting or contributing factor. These sites would be good candidates for further investigation of water quality impairment, especially sites with very low DO or excessively high conductivity. However, it should be noted that the water quality parameters measured in this study are limited and are not intended to identify all potential water quality impairments. That said, further investigations may be warranted to identify the nature and extent of water quality impairments, as well as potential sources.

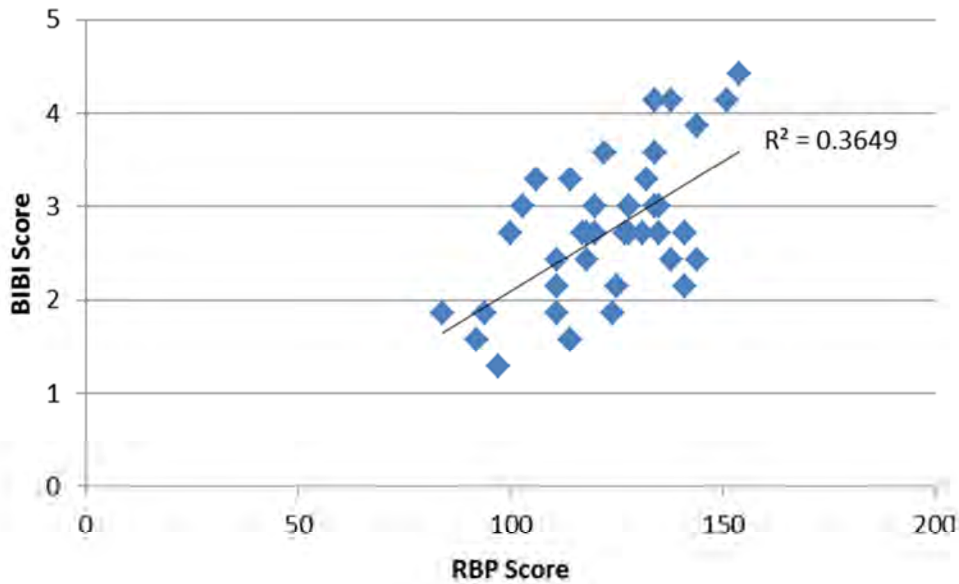


Figure 10 – Relationship between RBP habitat assessment score and BIBI score for 40 targeted sites in the Little Patuxent watershed.

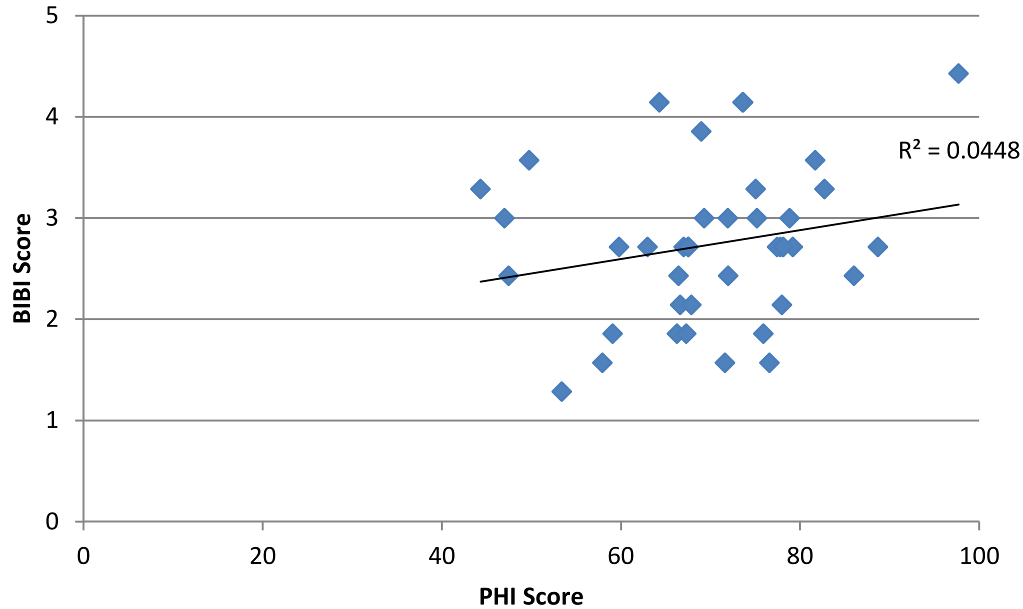


Figure 11 – Relationship between PHI habitat assessment score and BIBI score for 40 targeted sites in the Little Patuxent watershed.

Table 17 - Water quality exceedences by site. Colors correspond with the biological potential matrix in Table 14 using the RBP rating.

Site	Low pH (<6.5)	Low DO (<5.0 mg/l)	Elevated Conductivity (>247 ug/cm)	No Threshold Exceedences
LPAX-02-2011	X		X	
LPAX-13-2011	X	X		
LPAX-26-2011	X	X		
LPAX-08-2011		X		
LPAX-20-2011			X	
LPAX-33-2011			X	
LPAX-37-2011			X	
LPAX-32-2011			X	
LPAX-25-2011	X			
LPAX-09-2011	X			
LPAX-12-2011	X			
LPAX-18-2011	X			
LPAX-06-2011	X		X	
LPAX-05-2011	X		X	
LPAX-16-2011	X		X	
LPAX-19-2011			X	
LPAX-04-2011			X	
LPAX-23-2011			X	
LPAX-29-2011			X	
LPAX-38-2011			X	
LPAX-39-2011			X	
LPAX-40-2011			X	
LPAX-43-2011			X	
LPAX-35-2011			X	
LPAX-15-2011			X	
LPAX-31-2011			X	
LPAX-03-2011				X
LPAX-17-2011	X			
LPAX-07-2011	X			
LPAX-24-2011	X			
LPAX-46-2011	X			
LPAX-01-2011	X		X	
LPAX-30-2011	X			
LPAX-11-2011	X	X		
LPAX-36-2011		X		
LPAX-34-2011			X	
LPAX-28-2011			X	
LPAX-41-2011			X	
LPAX-42-2011			X	
LPAX-14-2011				X

Green indicates stations where the biological community exceeded the RBP habitat potential
Orange indicates stations where the biological community reached RBP habitat potential
Pink indicates stations where the biological community did not reach RBP habitat potential

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Appendix A: Individual Site Summaries

LPAX-01-2011 LPA Subwatershed

Upstream View:

Latitude: 39.0004624677

Downstream View:

Longitude: -76.7040719711

This site is located west of Crain Highway (Rt. 3) approximately 200 meters upstream of the confluence with the Little Patuxent River and is part of the LPA subwatershed. With over 60% as developed land, the drainage area to this site (1,616 acres) contains the entire Crofton Country Club property as well as multiple high density residential communities. This reach was within the floodplain of the Little Patuxent River and as a result was backwatered. Less than 80 organisms were identified in the entire benthic sample, which indicates a poor biological community. Water quality measured below COMAR standards for pH and elevated conductivity, which may impact the biologic community. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage system that cannot be measured through in situ analysis only.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- This sample only contained 73 organisms, the majority of which were midges (Orthocladius and Tvetenia) and worms (Naididae).
- Measured below COMAR standards for pH and conductivity elevated.
- Adequate habitat with high bank stability. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	9.7
Turbidity (NTU)	7.38
Temperature (°C)	19.17
pH (SU)	6.43
Specific Conductivity (µS/cm)	249.1

LPAX-01-2011 LPA Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	2
Ephemeroptera Taxa	1
Intolerant Urban %	4.1
Ephemeroptera %	1.4
Scraper Taxa	1
% Climbers	4.1

Calculated Metric Scores

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

Taxa	Count
Baetidae	1
Brillia	3
Chaetocladius	1
Chironomidae	1
Chironomini	1
Cricotopus	4
Eukiefferiella	3
Lepidoptera	3
Lumbricina	1
Naidinae	7
Orthocladiinae	2
Orthocladius	19
Parametriocnemus	3
Paratendipes	1
Plecoptera	2
Polypedilum	3
Simuliidae	3
Staphylinidae	2
Stenelmis	3
Thienemanniella	5
Tvetenia	5
TOTAL:	**73**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	10
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	12	Sediment Deposition	13
Channel Sinuosity	11	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	10		
EPA Habitat Score			**135**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	16	86.16	Woody Debris/Rootwads	8	61.74
Shading	90	91.34	Instream Habitat	11	66.11
Epifaunal Substrate	11	71.99	Bank Stability	16	89.45
PHI Score					**77.8**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 1615.85

Cover	Acres	%Area
Developed Land	**981.64**	**60.75**
Commercial	75.04	4.64
Industrial	4.58	0.28
Residential 1/8-acre	337.39	20.88
Residential 1/4-acre	472.74	29.26
Residential 1/2-acre	0	0
Residential 1-Acre	5.64	0.35
Residential 2-Acre	18.89	1.17
Transportation	67.36	4.17
Utility	0	0
Forest Land	**459.3**	**28.42**
Forested Wetland	0	0
Residential Woods	163.32	10.11
Woods	295.98	18.32
Open Land	**152.46**	**9.44**
Open Space	147.62	9.14
Open Wetland	0	0
Water	4.85	0.3
Agricultural Land	**22.45**	**1.39**
Pasture/Hay	4.18	0.26
Row Crops	18.27	1.13

Impervious Surface	Acres	% Area
Impervious Land	534.6	33.09

LPAX-02-2011 LPA Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0047573123

Longitude: -76.6903728286

Located east of Crain Highway (State Route 3), this site is part of the LPA subwatershed. With close to 60% as developed land, the drainage area to this site (1,131 acres) contains half of the Crofton Country Club property as well as multiple high density residential communities. This site is located on the Crofton Country Club golf course where a golf cart road runs along the entire right bank of the sampling reach with little to no buffer due to mowed grass and few trees. Low pH and elevated conductivity may be attributed to multiple direct drainage inputs and lack of adequate vegetative protection/buffer. In spite of the partially supporting/severely degraded habitat, high taxa diversity (27 taxa present) including 3 EPT taxa and 2 Ephemeroptera taxa resulted in a biological community that is fair. Since the biological community exceeds the physical habitat potential, nutrient enrichment may be present, especially considering the surrounding golf course land use.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Sample dominated by beetles (Stenelmis), midges (Orthocladius), and worms of the Naididae family.
- Measured below COMAR standards for pH and conductivity elevated.
- Bank stability scored high while instream habitat, epibenthic substrate, and woody debris scored low. Poor riparian width with marginal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	6.88
Turbidity (NTU)	6.97
Temperature (°C)	19.11
pH (SU)	5.4
Specific Conductivity (µS/cm)	306.1

LPAX-02-2011

LPA Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	27
EPT Taxa	3
Ephemeroptera Taxa	2
Intolerant Urban %	0.9
Ephemeroptera %	1.8
Scraper Taxa	1
% Climbers	2.8

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	5
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	3
% Climbers	3
BIBI Score	**3.29**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ablabesmyia	1
Acentrella	1
Argia	1
Baetis	1
Ceratopogonidae	1
Chironomidae	1
Corynoneura	1
Dicrotendipes	4
Enallagma	1
Eukiefferiella	3
Ironoquia	1
Limnophyes	1
Microtendipes	4
Naidinae	14
Orthocladius	13
Parametriocnemus	1
Paratanytarsus	2
Pisidiidae	3
Polypedilum	2
Potthastia	1
Rheotanytarsus	6
Simuliidae	2
Simulium	5
Stenelmis	22
Tanypodinae	1
Thienemanniella	4
Thienemannimyia group	1
Tipula	1
Tubificinae	5
Tvetenia	5
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	9
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	2
Channel Alteration	12	Riparian Vegetative Zone Width- Right Bank	2
Channel Flow Status	18	Sediment Deposition	14
Channel Sinuosity	7	Vegetative Protection - Left Bank	4
Epifaunal Substrate/Available Cover	9	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	12		
EPA Habitat Score			**106**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	3	16.16	Woody Debris/Rootwads	1	45.07
Shading	10	8.55	Instream Habitat	9	58.67
Epifaunal Substrate	8	56.88	Bank Stability	13	80.63
PHI Score					**44.32**
PHI Narrative Rating					**Severely Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 1131.34

Cover	Acres	%Area
Developed Land	**671.07**	**59.32**
Commercial	48.44	4.28
Industrial	4.58	0.4
Residential 1/8-acre	300.31	26.54
Residential 1/4-acre	260.88	23.06
Residential 1/2-acre	0	0
Residential 1-Acre	3.75	0.33
Residential 2-Acre	13.27	1.17
Transportation	39.84	3.52
Utility	0	0
Forest Land	**337.28**	**29.81**
Forested Wetland	0	0
Residential Woods	95.26	8.42
Woods	242.02	21.39
Open Land	**100.54**	**8.89**
Open Space	95.69	8.46
Open Wetland	0	0
Water	4.85	0.43
Agricultural Land	**22.45**	**1.98**
Pasture/Hay	4.18	0.37
Row Crops	18.27	1.62

Impervious Surface	Acres	% Area
Impervious Land	355.9	31.46

LPAX-03-2011 LPM Subwatershed

Upstream View:

Latitude: 39.0900681069

Downstream View:

Longitude: -76.7806637664

Located off of Welchs Court and Waters Road, behind a mobile home park, this site is part of the LPM subwatershed. Of the 985 acre drainage area to this site, over 75% is forested land with approximately 10% total impervious surface. All measured water quality parameters were within COMAR standards. The abundance of good quality cobble and large gravel riffles, good velocity and depth diversity, and overall supporting physical habitat quality resulted in a fair biological community with high taxa diversity (33) and numerous EPT taxa (6) and scraper taxa (4).

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Beetles (Stenelmis) and midges (Orthocladius) dominated the sample.
- Water quality values within COMAR standards.
- Instream habitat and epibenthic substrate scored high. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	9.97
Turbidity (NTU)	8.66
Temperature (°C)	12.47
pH (SU)	6.89
Specific Conductivity (µS/cm)	189.7

LPAX-03-2011

LPM Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	33
EPT Taxa	6
Ephemeroptera Taxa	0
Intolerant Urban %	5.2
Ephemeroptera %	0
Scraper Taxa	4
% Climbers	4.3

Calculated Metric Scores

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

Taxa	Count
Ablabesmyia	2
Ancyronyx	3
Calopteryx	1
Ceratopsyche	1
Chaetocladius	1
Cheumatopsyche	4
Chimarra	1
Chironomini	1
Corduliidae	1
Diplectrona	1
Dubiraphia	3
Hemerodromia	1
Hydrobaenus	1
Leuctra	1
Limnocharidae	1
Lumbricina	1
Nanocladius	1
Nigronia	1
Nilotanypus	1
Orthocladiinae	3
Orthocladius	2
Parametriocnemus	4
Paratendipes	1
Pisidiidae	2
Polycentropus	1
Rheocricotopus	3
Rheotanytarsus	18
Simuliidae	2
Simulium	7
Stegopterna	1
Stenelmis	32
Tanytarsus	4
Thienemannimyia group	2
Tipula	2
Tubificinae	1
Tvetenia	3
TOTAL:	**115**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	12
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	12	Sediment Deposition	8
Channel Sinuosity	9	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	11		
EPA Habitat Score			**134**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Woody Debris/Rootwads	4	55.51
Shading	95	99.94	Instream Habitat	14	87.82
Epifaunal Substrate	15	98.45	Bank Stability	12	77.46
PHI Score					**78.84**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 985.23

Cover	Acres	%Area
Developed Land	**185.59**	**18.84**
Commercial	72.34	7.34
Industrial	5.84	0.59
Residential 1/8-acre	32.03	3.25
Residential 1/4-acre	0.1	0.01
Residential 1/2-acre	0.97	0.1
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	41.17	4.18
Utility	33.14	3.36
Forest Land	**744.74**	**75.59**
Forested Wetland	0	0
Residential Woods	0	0
Woods	744.74	75.59
Open Land	**54.89**	**5.57**
Open Space	49.35	5.01
Open Wetland	3.71	0.38
Water	1.83	0.19
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	103.2	10.48

LPAX-04-2011 LPM Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0939833047

Longitude: -76.7920067774

Located off of Fort Meade Road (Rt. 198), this site is part of the LPM subwatershed. This sampling reach runs adjacent to a parking lot with excessive dumping on the left bank and into the channel. The site is also located immediately downstream of culvert and rip-rap stabilization. As a result, the site has very poor habitat and the channel is deeply incised with areas of severe bank erosion and undercutting. Of the 176 acre drainage area to this site, close to half consists of developed land, 28% of which is commercial property including the Arundel Gateway Business Park as well as portions of Baltimore-Washington Parkway and Rt. 198. The remaining 46% of the drainage area is forested land. Water quality measurements indicated elevated conductivity, which may be attributed to the high percentage of impervious surface (31%) within the drainage area. The lack of EPT, intolerant, or scraper taxa in this sample are indicators of a very poor biological community.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges (Chaetocladius and Orthocladius) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Habitat variables scored poor to marginal. Very poor bank stability and refuse abundant. Poor riparian width on the right bank and marginal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.23
Turbidity (NTU)	19.1
Temperature (°C)	13.4
pH (SU)	7
Specific Conductivity (µS/cm)	438.3

LPAX-04-2011

LPM Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	20
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	1.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	1
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Ablabesmyia	1
Atrichopogon	1
Bezzia/Palpomyia	1
Ceratopogonidae	1
Chaetocladius	34
Cheumatopsyche	1
Chironomidae	1
Dasyhelea	1
Dicrotendipes	1
Diplocladius	9
Enchytraeidae	1
Lumbricina	1
Lumbriculidae	1
Orthocladiinae	3
Orthocladius	30
Polypedilum	1
Prostoma	2
Pseudorthocladius	1
Rheocricotopus	5
Stempellinella	1
Thienemannimyia group	3
Tipula	4
Tubificinae	5
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	3	Pool Variability	8
Bank Stability- Right Bank	2	Riparian Vegetative Zone Width- Left Bank	2
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	6
Channel Sinuosity	10	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	7		
EPA Habitat Score			**92**
EPA Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	2	10.77	Woody Debris/Rootwads	5	77.94
Shading	85	84.56	Instream Habitat	6	61.04
Epifaunal Substrate	7	63.18	Bank Stability	5	50
PHI Score					**57.92**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 176.41

Cover	Acres	%Area
Developed Land	**81.11**	**45.98**
Commercial	49.46	28.04
Industrial	1.09	0.62
Residential 1/8-acre	0.03	0.01
Residential 1/4-acre	0	0
Residential 1/2-acre	0.97	0.55
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	20.36	11.54
Utility	9.19	5.21
Forest Land	**82.6**	**46.82**
Forested Wetland	0	0
Residential Woods	0	0
Woods	82.6	46.82
Open Land	**12.7**	**7.2**
Open Space	12.7	7.2
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	55	31.17

LPAX-05-2011 LPD Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0272114027

Longitude: -76.7008364182

Located on the Towsers Branch mainstem approximately 150 meters upstream of the confluence with the Little Patuxent River and downstream of the crossing at Capitol Raceway Road, this site is part of the LPD subwatershed. Of the 4,248 acre drainage area, over half is developed land with 31% as high density residential. Approximately one-fourth of the drainage area is impervious, which may attribute to the elevated conductivity values measured at the site. This site also fell below COMAR standards for pH; however, this may be due to wetland drainage upstream. The channel is overwidened with actively eroding silt/clay banks indicating an unstable stream. The partially supporting habitat limits the benthic community, resulting in a poor biological rating. No EPT taxa were present in the benthic sample with only 2% intolerant urban taxa.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Midges (Orthocladius) and worms (Naididae) dominated the sample.
- Measured below COMAR standards for pH and conductivity elevated.
- Most habitat variables received sub-optimal scores. Good riparian width but marginal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	9.62
Turbidity (NTU)	25.5
Temperature (°C)	20.47
pH (SU)	6.12
Specific Conductivity (µS/cm)	320.4

LPAX-05-2011 LPD Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	14
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	2
% Climbers	8.7

Calculated Metric Scores

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

Taxa	Count
Brillia	3
Calopteryx	1
Chaetocladius	2
Chironomini	2
Chironomus	1
Cricotopus	3
Enchytraeidae	1
Hydrobaenus	7
Naidinae	14
Orthocladiinae	8
Orthocladius	47
Parametriocnemus	1
Polypedilum	8
Stenelmis	2
Thienemanniella	2
Tubificinae	1
TOTAL:	**103**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	13
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	11	Sediment Deposition	10
Channel Sinuosity	7	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	3
Pool Substrate Characterization	8		
EPA Habitat Score			**118**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Woody Debris/Rootwads	6	44.88
Shading	80	78.67	Instream Habitat	12	61.77
Epifaunal Substrate	11	65.69	Bank Stability	12	77.46
PHI Score					**66.41**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 4247.6

Cover	Acres	%Area
Developed Land	**2236.5**	**52.65**
Commercial	197.22	4.64
Industrial	310.18	7.3
Residential 1/8-acre	629.02	14.81
Residential 1/4-acre	699.61	16.47
Residential 1/2-acre	2.52	0.06
Residential 1-Acre	25.25	0.59
Residential 2-Acre	115.84	2.73
Transportation	129.45	3.05
Utility	127.41	3
Forest Land	**888.84**	**20.93**
Forested Wetland	0	0
Residential Woods	0	0
Woods	888.84	20.93
Open Land	**445.3**	**10.48**
Open Space	429.86	10.12
Open Wetland	0	0
Water	15.44	0.36
Agricultural Land	**676.96**	**15.94**
Pasture/Hay	264	6.22
Row Crops	412.96	9.72

Impervious Surface	Acres	% Area
Impervious Land	972.9	22.9

LPAX-06-2011 LPD Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0332228582

Longitude: -76.6943194916

This site is located on Towsers Branch mainstem immediately downstream of the crossing at Evergreen Road off of Crain Highway and is part of the LPD subwatershed. Abundant woody debris with some riffle habitat and very deep pools are present throughout the stream. Of the 3,431 acre drainage area to this site, half consists of developed land with the remaining 21% as forested, 20% as agriculture, and 10% as open space. Several holding ponds from the adjacent quarry operation appear to drain into the stream just upstream of the sampling reach. A powerline corridor runs the entire length of the left bank of the site which results in poor vegetative protection and riparian buffer. The channel is also incised with actively eroded stream banks indicating an unstable stream type. Insufficient physical habitat and potential water quality impairment, including low pH and elevated conductivity, likely contribute to a poor biological community. Only 4% of the benthic sample consisted of intolerant urban taxa with only one EPT taxa present.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Sample dominated by midges (Orthocladius).
- Measured below COMAR standards for pH and conductivity elevated.
- Extremely low percent shading (5%). Instream habitat, epibenthic substrate and bank stability received sub-optimal scores. Marginal riparian width and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.76
Turbidity (NTU)	6.92
Temperature (°C)	14.83
pH (SU)	6.15
Specific Conductivity (µS/cm)	297

LPAX-06-2011

LPD Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	3.5
Ephemeroptera %	2.7
Scraper Taxa	2
% Climbers	0.9

Calculated Metric Scores

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

Taxa	Count
Acentrella	1
Baetidae	2
Boyeria	1
Brillia	2
Chaetocladius	1
Chironomidae	2
Chironomini	3
Chironomus	1
Cricotopus	7
Macronychus	1
Naidinae	8
Orthocladiinae	2
Orthocladius	75
Parakiefferiella	1
Potthastia	1
Stenelmis	1
Thienemanniella	1
Thienemannimyia group	1
Tvetenia	2
TOTAL:	**113**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	7	Pool Variability	14
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	4
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	4
Channel Flow Status	14	Sediment Deposition	9
Channel Sinuosity	9	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	8		
EPA Habitat Score			**111**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Woody Debris/Rootwads	10	59.13
Shading	5	0	Instream Habitat	13	69.5
Epifaunal Substrate	11	67.08	Bank Stability	14	83.67
PHI Score					**47.46**
PHI Narrative Rating					**Severely Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 3431.37

Cover	Acres	%Area
Developed Land	**1712.36**	**49.9**
Commercial	160.04	4.66
Industrial	309.52	9.02
Residential 1/8-acre	345.77	10.08
Residential 1/4-acre	608.04	17.72
Residential 1/2-acre	2.52	0.07
Residential 1-Acre	24.65	0.72
Residential 2-Acre	71.15	2.07
Transportation	91.72	2.67
Utility	98.94	2.88
Forest Land	**702.35**	**20.47**
Forested Wetland	0	0
Residential Woods	0	0
Woods	702.35	20.47
Open Land	**351.73**	**10.25**
Open Space	344.89	10.05
Open Wetland	0	0
Water	6.84	0.2
Agricultural Land	**664.94**	**19.38**
Pasture/Hay	251.97	7.34
Row Crops	412.96	12.03

Impervious Surface	Acres	% Area
Impervious Land	685.1	19.97

LPAX-07-2011 LP1 Subwatershed

Upstream View:	**Downstream View:**
	
Latitude: 39.0202432886	**Longitude:** -76.708931343

Located behind houses along Meyers Station Road, this site is part of the LP1 subwatershed and drains to the Little Patuxent River. The drainage area to this site (105 acres) is largely forested land (87%) with only 1.5% impervious surface. This site is on a small channel that runs through a wetland and has full floodplain access on both banks. Riffle habitat and woody debris support high scores for physical habitat; however, the lack of Ephemeroptera and scraper taxa in the subsample resulted in a poor biological score. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage area that cannot be measured through in situ analysis only. Measured pH values fell below COMAR standards, but this is likely to be influenced by the surrounding wetland system that drains to the site.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Plecoptera (Amphinemura) and midges (Dicranota, Thienemannimyia group, and Corynoneura) dominated the sample.
- Measured below COMAR standards for pH.
- Bank stability scored high while instream habitat and epibenthic substrate received marginal to sub-optimal scores. Good riparian width and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	7.78
Turbidity (NTU)	6.77
Temperature (°C)	18.6
pH (SU)	6.29
Specific Conductivity (µS/cm)	106

LPAX-07-2011 — LP1 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	47.5
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	6.9

Calculated Metric Scores

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

Taxa	Count
Amphinemura	35
Anchytarsus	2
Bezzia/Palpomyia	5
Caecidotea	1
Chironomidae	1
Conchapelopia	1
Corynoneura	6
Crangonyctidae	1
Cricotopus	1
Diamesa	1
Dicranota	10
Diplectrona	1
Eukiefferiella	1
Naidinae	1
Natarsia	2
Orthocladiinae	2
Orthocladius	1
Parametriocnemus	1
Plecoptera	1
Polypedilum	3
Rheotanytarsus	1
Simulium	4
Stempellina	1
Tanytarsus	3
Thienemanniella	2
Thienemannimyia group	8
Tubificinae	1
Tvetenia	4
TOTAL:	**101**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	10	Pool Variability	7
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	15	Sediment Deposition	11
Channel Sinuosity	12	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	7		
EPA Habitat Score			**141**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Woody Debris/Rootwads	5	83.81
Shading	95	99.94	Instream Habitat	10	88.54
Epifaunal Substrate	11	89.79	Bank Stability	20	100
PHI Score					**88.68**
PHI Narrative Rating					**Minimally Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 105.1

Cover	Acres	%Area
Developed Land	**5.93**	**5.65**
Commercial	0.54	0.51
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	1.52	1.44
Residential 2-Acre	2.01	1.91
Transportation	1.87	1.78
Utility	0	0
Forest Land	**91.15**	**86.73**
Forested Wetland	0	0
Residential Woods	0	0
Woods	91.15	86.73
Open Land	**1.32**	**1.25**
Open Space	1.32	1.25
Open Wetland	0	0
Water	0	0
Agricultural Land	**6.69**	**6.37**
Pasture/Hay	6.69	6.37
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	1.6	1.53

LPAX-08-2011 LP1 Subwatershed

Upstream View:

Latitude: 39.0074618777

Downstream View:

Longitude: -76.7057105108

Located on the Little Patuxent River floodplain between Grays Ford Road and Crain Highway (State Route 3), this site is part of the LP1 subwatershed. Because this site is located approximately 100 meters upstream of the confluence with the Little Patuxent River, the sampling reach was backwatered pool habitat with little observable flow. Low dissolved oxygen levels measured at this site are largely attributed to the stream being backwatered with little mixing occurring in the water column. Few woody debris and fibrous roots along the banks provided only minimal stable habitat for the benthic community. In spite of the partially supporting habitat, 21 taxa were present in the benthic sample with one Ephemeroptera taxa and one scraper taxa present. Of the 169 acre drainage area, 46% is forested land and 30% is developed land with only 1.7% impervious surface. However, it should be noted that the one large developed parcel (classified as industrial land use), appears to never have been fully developed and is more characteristic of open land, hence the low imperviousness in this drainage area.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods (Crangonyx) and midges dominated the sample.
- Measured below COMAR standards for dissolved oxygen.
- Poor habitat diversity but banks are stable. Good riparian width but marginal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	0.99
Turbidity (NTU)	12.3
Temperature (°C)	18.38
pH (SU)	6.65
Specific Conductivity (µS/cm)	231.4

LPAX-08-2011

LP1 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	21
EPT Taxa	2
Ephemeroptera Taxa	1
Intolerant Urban %	11.9
Ephemeroptera %	1.7
Scraper Taxa	1
% Climbers	11.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
Intolerant Urban %	3
Ephemeroptera %	3
Scraper Taxa	3
% Climbers	5
BIBI Score	**3.29**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ablabesmyia	1
Bezzia/Palpomyia	1
Caecidotea	11
Caenis	2
Chironomini	6
Chironomus	21
Crangonyx	25
Cryptotendipes	5
Dubiraphia	3
Gammarus	6
Lumbricina	1
Mallochohelea	3
Microtendipes	1
Neoporus	8
Orthocladiinae	1
Paratendipes	2
Phaenopsectra	1
Polycentropus	1
Polypedilum	7
Tanytarsini	1
Tanytarsus	7
Thienemannimyia group	1
Tubificinae	3
TOTAL:	**118**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	7	Pool Variability	5
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	7
Channel Sinuosity	4	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	6		
EPA Habitat Score			**114**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Woody Debris/Rootwads	4	75.44
Shading	90	91.34	Instream Habitat	6	61.45
Epifaunal Substrate	5	51.82	Bank Stability	16	89.45
PHI Score					**75.05**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 169.47

Cover	Acres	%Area
Developed Land	**50.98**	**30.08**
Commercial	0	0
Industrial	42.55	25.11
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	6.01	3.55
Transportation	2.42	1.43
Utility	0	0
Forest Land	**78.33**	**46.22**
Forested Wetland	0	0
Residential Woods	0	0
Woods	78.33	46.22
Open Land	**10.52**	**6.21**
Open Space	10.52	6.21
Open Wetland	0	0
Water	0	0
Agricultural Land	**29.64**	**17.49**
Pasture/Hay	24.86	14.67
Row Crops	4.77	2.82

Impervious Surface	Acres	% Area
Impervious Land	2.8	1.68

LPAX-09-2011 LPC Subwatershed

Upstream View:

Latitude: 39.0490031808

Downstream View:

Longitude: -76.6852101906

Located at the end of Springhill Court, this site is part of the LPC subwatershed and drains to Towsers Branch. Of the 1,001 acre drainage area to the site, over half consists of agricultural land--the majority of which is the US Naval Academy Dairy Farm, with developed land accounting for 23% of the drainage area. This channel is deeply incised with a severely eroded stream banks, indicating an unstable stream reach. Poor quality riffles and an overall lack of stable substrate resulted in non-supporting physical habitat. No EPT or scraper taxa were present in the benthic sample and only 1% of the sample consisted of intolerant urban taxa. Measured pH values fell below COMAR standards, but this may be due to naturally occurring acidic conditions.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges (Orthocladius) and worms (Naididae) dominated the sample.
- Measured below COMAR standards for pH.
- Very low woody debris score and marginal habitat diversity. Poor vegetative protection on the right bank and marginal riparian width on the left bank.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.33
Turbidity (NTU)	34.8
Temperature (°C)	24.5
pH (SU)	5.67
Specific Conductivity (µS/cm)	173.6

LPAX-09-2011 LPC Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	12
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	0.9
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	1.8

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	1
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**1.29**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Chaetocladius	1
Chironomidae	1
Chironomus	2
Cricotopus	2
Enchytraeidae	1
Lumbricina	2
Lumbriculidae	1
Micropsectra	1
Naidinae	24
Orthocladiinae	1
Orthocladius	67
Peltodytes	1
Rheocricotopus	6
Tubificinae	3
TOTAL:	**113**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	4	Pool Variability	5
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	5
Channel Flow Status	13	Sediment Deposition	10
Channel Sinuosity	8	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	6		
EPA Habitat Score			**97**
EPA Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Woody Debris/Rootwads	0	43.5
Shading	60	58.94	Instream Habitat	7	48.82
Epifaunal Substrate	7	51.87	Bank Stability	8	63.25
PHI Score					**53.37**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 1001.12

Cover	Acres	%Area
Developed Land	**228.44**	**22.82**
Commercial	50.26	5.02
Industrial	85.33	8.52
Residential 1/8-acre	11.52	1.15
Residential 1/4-acre	8.86	0.89
Residential 1/2-acre	2.52	0.25
Residential 1-Acre	8.68	0.87
Residential 2-Acre	19.28	1.93
Transportation	27.2	2.72
Utility	14.78	1.48
Forest Land	**101.63**	**10.15**
Forested Wetland	0	0
Residential Woods	0	0
Woods	101.63	10.15
Open Land	**132.36**	**13.22**
Open Space	130.12	13
Open Wetland	0	0
Water	2.24	0.22
Agricultural Land	**538.7**	**53.81**
Pasture/Hay	149.52	14.93
Row Crops	389.19	38.88

Impervious Surface	Acres	% Area
Impervious Land	137.7	13.75

LPAX-11-2011 LP2 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0386751783

Longitude: -76.7161438723

Located immediately downstream of Patuxent Road, this site is part of the LP2 subwatershed. This site drains a large wetland system upstream of the road crossing and into a large wetland downstream, and as a result the site was slightly backwatered. Low dissolved oxygen and pH values measured at this site are largely attributed to the wetland drainage and subsequent backwatering with little mixing occurring in the water column. Forested land accounts for 73% of the drainage area to this site with developed land accounting for 17%. Of the 366 acre drainage area, only 1.8% is impervious. However, a complete lack of EPT, Ephemeroptera, and scraper taxa resulted in a poor biological community.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Isopods (Caecidotea) and worms (Tubificidae and Naididae) dominated the sample.
- Measured below COMAR standards for pH and dissolved oxygen.
- Bank stability scored high but very little woody debris present. Refuse present in moderate amounts. Good vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	1.32
Turbidity (NTU)	9.65
Temperature (°C)	15.02
pH (SU)	5.72
Specific Conductivity (µS/cm)	72.5

LPAX-11-2011 LP2 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	16
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	47.3
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	2.7

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
Bivalvia	1
Caecidotea	52
Ceratopogonidae	1
Chironomini	4
Chironomus	2
Corethrella	1
Culicoides	1
Curculionidae	1
Larsia	1
Lumbricina	1
Lumbriculidae	3
Naidinae	13
Peltodytes	2
Pisidium	3
Polypedilum	1
Serromyia	1
Synurella	4
Thienemanniella	1
Tubificinae	17
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	10	Pool Variability	7
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	6
Channel Flow Status	20	Sediment Deposition	18
Channel Sinuosity	8	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	12		
EPA Habitat Score			**141**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	2	10.77	Woody Debris/Rootwads	1	57.85
Shading	70	68.32	Instream Habitat	12	86.87
Epifaunal Substrate	10	75.86	Bank Stability	20	100
PHI Score					**66.61**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **365.72**

Cover	Acres	%Area
Developed Land	**62.96**	**17.22**
Commercial	0.18	0.05
Industrial	0.16	0.04
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	2.56	0.7
Residential 2-Acre	36.68	10.03
Transportation	8.01	2.19
Utility	15.36	4.2
Forest Land	**269.16**	**73.6**
Forested Wetland	0	0
Residential Woods	0	0
Woods	269.16	73.6
Open Land	**31.92**	**8.73**
Open Space	20.94	5.72
Open Wetland	3.25	0.89
Water	7.73	2.11
Agricultural Land	**1.68**	**0.46**
Pasture/Hay	1.68	0.46
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	6.5	1.77

LPAX-12-2011 LP2 Subwatershed

Upstream View:

Latitude: 39.042914223

Downstream View:

Longitude: -76.7126820998

Located approximately 0.4 miles northeast of the intersection of Patuxent Road and Bragers Road, this site is part of the LP2 subwatershed. This site is located approximately 50 meters upstream of the confluence with the Little Patuxent River, and consequently the downstream end of the reach was backwatered. Poor quality riffles in a silt/clay substrate and minimal woody debris provide inadequate epifaunal substrate, resulting in a poor biological community. Because the sampling reach is located on the active floodplain of the Little Patuxent River, the local physical habitat is being influenced by backwatering and fine sediment deposition. Of the 277 acre drainage area to the site, only 6% is impervious surface. Half of the drainage area consists of forested land with the remaining 39% as open and 11% as developed land; however, it should be noted that the majority of the land classified as open is an active quarry operation.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Sample dominated by various midges and worms of the family Naididae.
- Measured below COMAR standards for pH.
- Poor bank stability and marginal habitat diversity. Very little woody debris. Good riparian width but marginal vegetative protection on the left bank.

Water Chemistry:

Dissolved Oxygen (mg/L)	9.4
Turbidity (NTU)	28.7
Temperature (°C)	15.36
pH (SU)	6.18
Specific Conductivity (µS/cm)	122.3

LPAX-12-2011 LP2 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	27
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	4.9
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	11

Calculated Metric Scores

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

Taxa	Count
Amphipoda	1
Bezzia/Palpomyia	3
Brillia	4
Chironomini	3
Chironomus	1
Coenagrionidae	1
Crangonyx	2
Cricotopus	1
Dicranota	2
Diplectrona	1
Diptera	9
Enchytraeidae	1
Eukiefferiella	1
Lumbricina	2
Naidinae	10
Nemata	1
Orthocladiinae	5
Orthocladius	2
Parakiefferiella	1
Parametriocnemus	2
Peltodytes	1
Polypedilum	6
Rheocricotopus	8
Rheotanytarsus	2
Simulium	2
Staphylinidae	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia group	4
Tipula	1
Tubificinae	2
TOTAL:	**82**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	5
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	11	Sediment Deposition	8
Channel Sinuosity	14	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	7		
EPA Habitat Score			**111**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	17	91.55	Woody Debris/Rootwads	1	60.99
Shading	80	78.67	Instream Habitat	5	50.87
Epifaunal Substrate	6	54.43	Bank Stability	10	70.71
PHI Score					**67.87**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 277.18

Cover	Acres	%Area
Developed Land	**29.07**	**10.49**
Commercial	4.19	1.51
Industrial	21.96	7.92
Residential 1/8-acre	0	0
Residential 1/4-acre	2.82	1.02
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	0.1	0.04
Utility	0	0
Forest Land	**139.56**	**50.35**
Forested Wetland	0	0
Residential Woods	0	0
Woods	139.56	50.35
Open Land	**108.55**	**39.16**
Open Space	107.26	38.7
Open Wetland	0	0
Water	1.29	0.47
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	15.8	5.69

LPAX-13-2011 LP3 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0469569916

Longitude: -76.7248178859

This site is located approximately 200 meters northeast of Patuxent Road and is part of the LP3 subwatershed. The drainage area to this site (798 acres) is largely forested land (85%) with only 3% impervious surface. However, because the stream is located approximately 200 meters upstream of the confluence with the Little Patuxent River, this site was predominantly backwatered with virtually no visible flow. Low dissolved oxygen levels measured at this site are largely attributed to the stream being backwatered with little mixing occurring in the water column. Poor physical habitat consisted of mostly deep pools with anaerobic silt/muck bottom, insufficient for supporting a robust biological community. Measured pH values fell below COMAR standards, which is likely due to wetland drainage as evidenced by the tannic color of the water.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Sample dominated by midges (Serromyia and Chironomus) and worms (Tubificidae).
- Measured below COMAR standards for pH and dissolved oxygen.
- Marginal habitat diversity but good riparian vegetation. Banks are moderately unstable. Good riparian width but marginal vegetative protection on the left bank.

Water Chemistry:

Dissolved Oxygen (mg/L)	4.69
Turbidity (NTU)	21.2
Temperature (°C)	16.57
pH (SU)	6.46
Specific Conductivity (µS/cm)	142.4

LPAX-13-2011 LP3 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	17
EPT Taxa	1
Ephemeroptera Taxa	1
Intolerant Urban %	13.1
Ephemeroptera %	0.9
Scraper Taxa	1
% Climbers	0.9

Calculated Metric Scores

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

Taxa	Count
Caecidotea	11
Caenis	1
Chironomus	17
Crangonyx	3
Culicoides	1
Ephydridae	1
Gomphidae	1
Hydrobaenus	1
Musculium	2
Orthocladiinae	1
Orthocladius	1
Pisidiidae	1
Pisidium	3
Polypedilum	1
Procladius	1
Rheotanytarsus	1
Serromyia	22
Tubificinae	37
Zavrelimyia	1
TOTAL:	**107**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	6
Bank Stability- Right Bank	2	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	15	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	6
Channel Sinuosity	8	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	5	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	5		
EPA Habitat Score			**100**
EPA Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Woody Debris/Rootwads	7	66.77
Shading	100	100	Instream Habitat	6	45.59
Epifaunal Substrate	5	41.73	Bank Stability	7	59.16
PHI Score					**62.98**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 798.2

Cover	Acres	%Area
Developed Land	**84.25**	**10.56**
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	6.66	0.83
Residential 2-Acre	43.37	5.43
Transportation	34.22	4.29
Utility	0	0
Forest Land	**677.45**	**84.87**
Forested Wetland	0	0
Residential Woods	0	0
Woods	677.45	84.87
Open Land	**36.5**	**4.57**
Open Space	36.5	4.57
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	25.2	3.16

LPAX-14-2011 — LP3 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0488016996

Longitude: -76.7296755061

Located approximately 300 meters east of Patuxent Road, this site is part of the LP3 subwatershed. The drainage area to this site (385 acres) is predominantly forested land (83%), which includes property on the Patuxent Research Refuge. Located on the floodplain of the Little Patuxent River, this site drains an extensive wetland area. With very little flow, the site is an entrenched channel with a silt/sand bottom and an abundance of detrital material. Although the site received a partially supporting habitat score, epifaunal substrate was only marginal, resulting in a poor biological community which contained only one EPT taxa, lacked Ephemeroptera taxa, and consisted of just 6% intolerant taxa in the benthic sample. All measured water quality parameters fell within COMAR standards. Impacts from historical land use (deforestation, channelization, etc.) may continue to limit the stream's ability to support a healthy biota.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods (Crangonyx) and midges dominated the sample.
- Water quality values within COMAR standards.
- Moderately stable banks with marginal habitat diversity. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	5.12
Turbidity (NTU)	12.4
Temperature (°C)	16.87
pH (SU)	6.69
Specific Conductivity (µS/cm)	119.5

LPAX-14-2011

LP3 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	21
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	6
Ephemeroptera %	0
Scraper Taxa	1
% Climbers	3.4

Calculated Metric Scores

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

Taxa	Count
Amphipoda	12
Brillia	1
Caecidotea	2
Chironomini	2
Chironomus	15
Cladotanytarsus	1
Corynoneura	5
Crangonyx	37
Cricotopus	2
Elmidae	1
Hydrobaenus	1
Micropsectra	3
Microtendipes	4
Musculium	5
Oecetis	1
Orthocladiinae	1
Orthocladius	1
Parametriocnemus	2
Polypedilum	1
Potthastia	2
Rheotanytarsus	11
Simuliidae	1
Thienemanniella	2
Trichoptera	1
Tubificinae	3
TOTAL:	**117**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	8
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	13	Sediment Deposition	9
Channel Sinuosity	10	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	7		
EPA Habitat Score			**124**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	18	96.93	Woody Debris/Rootwads	5	69.1
Shading	100	100	Instream Habitat	5	47.5
Epifaunal Substrate	7	58.09	Bank Stability	14	83.67
PHI Score					**75.88**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **385.12**

Cover	Acres	%Area
Developed Land	**48.64**	**12.63**
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	6.66	1.73
Residential 2-Acre	19.68	5.11
Transportation	22.3	5.79
Utility	0	0
Forest Land	**321.21**	**83.4**
Forested Wetland	0	0
Residential Woods	0	0
Woods	321.21	83.4
Open Land	**15.28**	**3.97**
Open Space	15.28	3.97
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	16.1	4.17

LPAX-15-2011 LPL Subwatershed

Upstream View:

Latitude: 39.0491529775

Downstream View:

Longitude: -76.7163012177

Located just off of a hike and bike trail near Strawberry Lake Way, this site is part of the LPL subwatershed. Of the 798 acre drainage area to this site, 30% consists of impervious surface and largely drains high density residential communities (68%). Conductivity values were elevated, likely due to the high imperviousness in the drainage area. Numerous good quality riffles and woody debris/rootwads support a fair biological community with high taxa diversity. Multiple sand and gravel bars throughout the stream indicate a system that is overwidened and actively aggrading.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Worms (Naididae), midges (Orthocladius) and black flies (Simulium) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Scored high for instream habitat, epibenthic substrate, and woody debris.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.66
Turbidity (NTU)	2.76
Temperature (°C)	15.35
pH (SU)	6.64
Specific Conductivity (µS/cm)	301.2

LPAX-15-2011

LPL Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	27
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	1
Ephemeroptera %	1
Scraper Taxa	2
% Climbers	5.1

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	3
BIBI Score	**3.29**
BIBI Narrative Rating	**Fair**

Taxa	Count
Acentrella	1
Boyeria	1
Brillia	3
Chaetocladius	1
Chironomidae	1
Corynoneura	1
Cricotopus	1
Hydrobaenus	2
Hydropsyche	2
Limnophyes	1
Naidinae	15
Nemata	1
Orthocladiinae	1
Orthocladius	19
Parakiefferiella	1
Parametriocnemus	3
Paratanytarsus	2
Paratendipes	1
Physa	1
Polypedilum	1
Rheotanytarsus	5
Simulium	11
Stenochironomus	1
Taeniopteryx	8
Tanytarsini	1
Tanytarsus	2
Thienemanniella	6
Tipula	3
Tubificinae	1
Tvetenia	1
TOTAL:	**98**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	10
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	10	Sediment Deposition	6
Channel Sinuosity	12	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	11		
EPA Habitat Score			**132**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Woody Debris/Rootwads	11	80.07
Shading	95	99.94	Instream Habitat	15	96.86
Epifaunal Substrate	14	94.86	Bank Stability	17	92.2
PHI Score					**82.71**
PHI Narrative Rating					**Minimally Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 700.96

Cover	Acres	%Area
Developed Land	**479.58**	**68.42**
Commercial	4.53	0.65
Industrial	11.43	1.63
Residential 1/8-acre	248.55	35.46
Residential 1/4-acre	177.9	25.38
Residential 1/2-acre	0	0
Residential 1-Acre	0.73	0.1
Residential 2-Acre	4.1	0.59
Transportation	32.33	4.61
Utility	0	0
Forest Land	**190.51**	**27.18**
Forested Wetland	0	0
Residential Woods	0	0
Woods	190.51	27.18
Open Land	**30.87**	**4.4**
Open Space	29.62	4.23
Open Wetland	0	0
Water	1.25	0.18
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	208.3	29.72

LPAX-16-2011 — LPL Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0595530917

Longitude: -76.7129874179

Located behind a retention pond to the east of Streamview Drive, this site is part of the LPL subwatershed. Of the 241 acre drainage area to this site, 27% consists impervious surface and largely drains high density residential communities (64%). Low pH and elevated conductivity values measured at this site may be attributed to an outfall from the retention pond that flows directly into the sampling reach. A mix of riffle and woody debris habitat is only partially supporting of a healthy biological community. Only 2% of the benthic sample accounted for taxa intolerant to urban stressors, and the overall benthic community was rated poor.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Worms of the Naididae family and various midges dominated the sample.
- Measured below COMAR standards for pH and conductivity elevated.
- Most habitat variables received sub-optimal scores. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.94
Turbidity (NTU)	3.17
Temperature (°C)	15.17
pH (SU)	6.23
Specific Conductivity (µS/cm)	393.5

LPAX-16-2011

LPL Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	17
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	1.8
Ephemeroptera %	0.9
Scraper Taxa	1
% Climbers	4.5

Calculated Metric Scores

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

Taxa	Count
Cheumatopsyche	3
Chironomidae	1
Chironomini	1
Diplocladius	2
Eukiefferiella	4
Ironoquia	3
Libellulidae	1
Musculium	1
Naidinae	44
Orthocladiinae	16
Orthocladius	7
Parametriocnemus	10
Physa	1
Plauditus	1
Polypedilum	4
Potthastia	1
Rheotanytarsus	1
Thienemanniella	1
Tubificinae	2
Tvetenia	6
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	10
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	11	Sediment Deposition	9
Channel Sinuosity	14	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	8		
EPA Habitat Score			**120**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	9	48.47	Woody Debris/Rootwads	4	71.46
Shading	95	99.94	Instream Habitat	13	96.7
Epifaunal Substrate	11	84.39	Bank Stability	11	74.16
PHI Score					**79.19**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **240.74**

Cover	Acres	%Area
Developed Land	**153.79**	**63.88**
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	83.23	34.57
Residential 1/4-acre	54.35	22.58
Residential 1/2-acre	0	0
Residential 1-Acre	0.73	0.3
Residential 2-Acre	4.1	1.7
Transportation	11.37	4.72
Utility	0	0
Forest Land	**84.26**	**35**
Forested Wetland	0	0
Residential Woods	0	0
Woods	84.26	35
Open Land	**2.7**	**1.12**
Open Space	2.31	0.96
Open Wetland	0	0
Water	0.39	0.16
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	65.4	27.15

LPAX-17-2011 LPB Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0489726492 **Longitude:** -76.6857378423

Located east of a powerline corridor that runs behind Springhill Court, this site is part of the LPB subwatershed. Of the 1,330 acre drainage area to this site, 64% consists of developed land and 20% as forested land. Impervious surface accounts for 24% of the drainage area. The channel is incised with severe bank erosion indicating an unstable stream type, likely resulting from the high imperviousness upstream. The riparian buffer width was limited due to the powerline corridor along the left bank and pasture along the right bank (US Naval Academy Dairy Farm). Water quality measured below COMAR standards for pH, which is likely due to wetland drainage upstream. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage system that cannot be measured through in situ analysis only. However, the unstable stream type may also be impacting the biota.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Sample dominated by midges (Orthocladius, Polypedilum,and Tvetenia).
- Measured below COMAR standards for pH.
- Marginal bank stability. Instream habitat and epibenthic substrate received sub-optimal scores. Refuse present in moderate amounts.

Water Chemistry:

Dissolved Oxygen (mg/L)	9.51
Turbidity (NTU)	11.3
Temperature (°C)	19.42
pH (SU)	5.76
Specific Conductivity (µS/cm)	178.7

LPAX-17-2011

LPB Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	16
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	22.2

Calculated Metric Scores

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

Taxa	Count
Amphipoda	1
Ancyronyx	9
Calopteryx	3
Cheumatopsyche	8
Chironomidae	1
Chironomini	2
Crangonyx	1
Dicrotendipes	4
Hydropsyche	6
Macronychus	4
Naidinae	4
Orthocladiinae	1
Orthocladius	20
Parametriocnemus	1
Polypedilum	21
Stenelmis	3
Thienemanniella	2
Thienemannimyia group	1
Tubificinae	2
Tvetenia	14
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	13
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	7
Channel Alteration	15	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	13	Sediment Deposition	12
Channel Sinuosity	9	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	11		
EPA Habitat Score			**128**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Woody Debris/Rootwads	4	52.11
Shading	50	49.95	Instream Habitat	14	84.75
Epifaunal Substrate	14	90.69	Bank Stability	10	70.71
PHI Score					**67.01**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 1329.86

Cover	Acres	%Area
Developed Land	**848.6**	**63.81**
Commercial	36.84	2.77
Industrial	0.37	0.03
Residential 1/8-acre	212.12	15.95
Residential 1/4-acre	503.83	37.89
Residential 1/2-acre	0	0
Residential 1-Acre	13.9	1.05
Residential 2-Acre	21.95	1.65
Transportation	22.66	1.7
Utility	36.93	2.78
Forest Land	**260.23**	**19.57**
Forested Wetland	0	0
Residential Woods	0	0
Woods	260.23	19.57
Open Land	**98.68**	**7.42**
Open Space	98.5	7.41
Open Wetland	0	0
Water	0.18	0.01
Agricultural Land	**122.36**	**9.2**
Pasture/Hay	98.61	7.41
Row Crops	23.75	1.79

Impervious Surface	Acres	% Area
Impervious Land	324.2	24.38

LPAX-18-2011 LPB Subwatershed

Upstream View:

Latitude: 39.0586884382

Downstream View:

Longitude: -76.6888042091

Located behind the end of Autumn Valley Lane and Four Season Drive, this site is part of the LPB subwatershed and drains to Towsers Branch. A quarter of the drainage area to this site is impervious surface as the dominant land cover is developed (68%), followed by forested land (25%). This site has a limited forested riparian buffer due to the powerline corridor along the left bank and pasture along the right bank (US Naval Academy Dairy Farm). Wetlands surround and drain to this reach, which may contribute to the low pH measurements. A mix of riffle and woody debris habitat support a poor biological community that had high taxa diversity yet a lack of both Ephemeroptera and intolerant taxa. The downstream end of the reach is deeply incised; however, armoring around a utility line has prevented the headcut from moving upstream but also backwatered the stream for a good portion of the sampling reach.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Sample dominated by midges (Diplocladius and Orthocladius), worms (Naididae), and beetles (Ancyronyx).
- Measured below COMAR standards for pH.
- Sub-optimal habitat diversity. Moderately unstable banks. Good riparian width but poor vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	6.84
Turbidity (NTU)	8.04
Temperature (°C)	19.38
pH (SU)	5.77
Specific Conductivity (µS/cm)	243.1

LPAX-18-2011

LPB Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	25
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	5
% Climbers	13.2

Calculated Metric Scores

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

Taxa	Count
Ancyronyx	14
Brillia	1
Calopteryx	4
Cheumatopsyche	1
Chironomini	1
Crangonyctidae	1
Cryptochironomus	1
Dicrotendipes	2
Diplocladius	10
Dubiraphia	1
Eukiefferiella	5
Helichus	2
Macronychus	3
Naidinae	11
Nanocladius	1
Nemata	1
Orthocladiinae	5
Orthocladius	13
Parametriocnemus	1
Polypedilum	9
Rheocricotopus	5
Simulium	4
Stenelmis	2
Stenochironomus	1
Tanytarsini	1
Tanytarsus	1
Thienemanniella	1
Tvetenia	4
TOTAL:	**106**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	3	Pool Variability	11
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	11	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	15	Sediment Deposition	15
Channel Sinuosity	10	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	9		
EPA Habitat Score			**118**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Woody Debris/Rootwads	5	58.65
Shading	95	99.94	Instream Habitat	14	87.99
Epifaunal Substrate	15	98.55	Bank Stability	6	54.77
PHI Score					**77.42**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 969.69

Cover	Acres	%Area
Developed Land	**655.53**	**67.6**
Commercial	29.66	3.06
Industrial	0.37	0.04
Residential 1/8-acre	158.84	16.38
Residential 1/4-acre	389.28	40.15
Residential 1/2-acre	0	0
Residential 1-Acre	13.9	1.43
Residential 2-Acre	21.95	2.26
Transportation	15.13	1.56
Utility	26.38	2.72
Forest Land	**247.12**	**25.48**
Forested Wetland	0	0
Residential Woods	0	0
Woods	247.12	25.48
Open Land	**51.16**	**5.28**
Open Space	51.16	5.28
Open Wetland	0	0
Water	0	0
Agricultural Land	**15.88**	**1.64**
Pasture/Hay	15.12	1.56
Row Crops	0.75	0.08

Impervious Surface	Acres	% Area
Impervious Land	244.3	25.2

LPAX-19-2011 LPF Subwatershed

Upstream View:	**Downstream View:**
	
Latitude: 39.0599999506	**Longitude:** -76.7310535605

This site is located on the Rogue Harbor Branch mainstem approximately 150 meters upstream of the confluence with the Little Patuxent River, just west of Piney Orchard Parkway, in the LPF subwatershed. The drainage area to this site (5,388 acres) drains a large section of Fort Meade Military Reservation and part of the Patuxent Research Refuge. The predominant land cover is split between developed and forested land (38% for each) with a large portion of open space (21%), resulting in 19.7% imperviousness. There is an good mix of stable habitat including an abundance of roots and woody debris as well as gravel riffles. Heavy bar formation in the channel indicates some overwidening, but stream banks are mostly stable. Ten EPT taxa, including 3 Ephemeroptera, and 6 scraper taxa were present in the benthic sample; however, only 6% of the sample consisted of taxa intolerant to urban stressors. Elevated levels of conductivity may be a result of the developed land cover upstream and may affect the quantity of intolerant taxa.

Summary Results:

- Biological condition – *"Good"*
- Habitat scores *"Comparable to Reference"* and *"Partially Degraded"*
- Sample dominated by midges (including Polypedilum and Rheotanytarsus) and beetles (Stenelmis).
- Water quality values within COMAR standards but conductivity elevated.
- Instream habitat, epibenthic substrate, and bank stability received sub-optimal scores. Low scores for remoteness and woody debris. Good riparian width and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.5
Turbidity (NTU)	7.4
Temperature (°C)	12.3
pH (SU)	7.03
Specific Conductivity (µS/cm)	425.5

LPAX-19-2011 LPF Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	29
EPT Taxa	10
Ephemeroptera Taxa	3
Intolerant Urban %	8.5
Ephemeroptera %	7.5
Scraper Taxa	6
% Climbers	15.1

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**4.14**
BIBI Narrative Rating	**Good**

Taxa	Count
Acentrella	1
Ancyronyx	2
Baetis	1
Bezzia/Palpomyia	1
Calopteryx	1
Cheumatopsyche	6
Chironomini	5
Cladotanytarsus	1
Coenagrionidae	1
Corynoneura	2
Diamesinae	1
Dubiraphia	3
Helichus	1
Hydropsyche	1
Hydropsychidae	1
Maccaffertium	6
Macronychus	2
Microcylloepus	7
Nectopsyche	1
Orthocladiinae	1
Orthocladius	5
Perlesta	1
Polycentropodidae	1
Polypedilum	9
Potthastia	1
Rheocricotopus	5
Rheotanytarsus	7
Simuliidae	1
Simulium	4
Stenelmis	14
Taeniopteryx	6
Tanytarsus	4
Triaenodes	2
Tvetenia	1
TOTAL:	**106**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	14
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	10
Channel Sinuosity	13	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	15	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	12		
EPA Habitat Score			**151**
EPA Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Woody Debris/Rootwads	12	59.94
Shading	90	91.34	Instream Habitat	15	75.98
Epifaunal Substrate	15	87.38	Bank Stability	16	89.45
PHI Score					**73.63**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 5387.58

Cover	Acres	%Area
Developed Land	**2062.63**	**38.29**
Commercial	622.23	11.55
Industrial	170.53	3.17
Residential 1/8-acre	609.19	11.31
Residential 1/4-acre	216.75	4.02
Residential 1/2-acre	28.13	0.52
Residential 1-Acre	32.69	0.61
Residential 2-Acre	30.01	0.56
Transportation	337.33	6.26
Utility	15.78	0.29
Forest Land	**2032.61**	**37.73**
Forested Wetland	7.9	0.15
Residential Woods	0	0
Woods	2024.71	37.58
Open Land	**1148.44**	**21.32**
Open Space	1096.16	20.35
Open Wetland	21.2	0.39
Water	31.07	0.58
Agricultural Land	**143.89**	**2.67**
Pasture/Hay	143.89	2.67
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	1062.7	19.73

LPAX-20-2011 LPF Subwatershed

Upstream View:

Latitude: 39.0802264645

Downstream View:

Longitude: -76.7259047949

Located in the Patuxent Research Refuge off of Wildlife Loop Road and immediately downstream of a culvert adjacent to a firing range, this site is on a tributary to Rouge Harbor and is part of the LPF subwatershed. The drainage area to this site (773 acres) drains a section of Fort Meade Military Reservation and part of the Patuxent Research Refuge. The predominant land cover is developed (43%), which may explain the elevated conductivity levels, followed closely by forested land (38%). Numerous riffles, while only moderate quality, as well as rootwads support a good biological community. The benthic sample for this site had high taxa diversity (31 taxa) and was dominated by an intolerant mayfly, Caenis (T.V. = 2.1), resulting in a high percentage of Ephemeroptera (24%) and percentage of taxa intolerant to urban stressors (33%).

Summary Results:

- Biological condition – *"Good"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Sample dominated by Caenis(Ephemeroptera) and beetles (Stenelmis).
- Water quality values within COMAR standards but conductivity elevated.
- Bank stability scored high. Sub-optimal habitat diversity. Low scores for remoteness and woody debris. Good vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	7.22
Turbidity (NTU)	8.87
Temperature (°C)	21.37
pH (SU)	7.14
Specific Conductivity (µS/cm)	619.7

LPAX-20-2011

LPF Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	31
EPT Taxa	4
Ephemeroptera Taxa	1
Intolerant Urban %	32.7
Ephemeroptera %	23.6
Scraper Taxa	4
% Climbers	7.3

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
Intolerant Urban %	5
Ephemeroptera %	5
Scraper Taxa	5
% Climbers	3
BIBI Score	**4.14**
BIBI Narrative Rating	**Good**

Taxa	Count
Bezzia/Palpomyia	1
Caenis	26
Chaetocladius	4
Cheumatopsyche	3
Chironomini	1
Chironomus	2
Corynoneura	1
Diplocladius	2
Dubiraphia	1
Helichus	1
Hemerodromia	1
Hydropsychidae	1
Ironoquia	1
Ischnura	3
Micropsectra	1
Musculium	1
Naidinae	2
Nanocladius	1
Nematoda	1
Neoporus	5
Orthocladiinae	3
Parametriocnemus	3
Paratanytarsus	7
Perlesta	8
Physa	1
Polypedilum	2
Potthastia	1
Rheotanytarsus	3
Simulium	1
Sphaerium	1
Stenelmis	15
Tanytarsus	1
Thienemanniella	1
Tubificinae	4
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	13
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	13	Sediment Deposition	12
Channel Sinuosity	6	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	12		
EPA Habitat Score			**134**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Woody Debris/Rootwads	3	55.3
Shading	95	99.94	Instream Habitat	11	73.67
Epifaunal Substrate	12	82.6	Bank Stability	17	92.2
PHI Score					**73.57**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 772.69

Cover	Acres	%Area
Developed Land	**331.97**	**42.96**
Commercial	64.81	8.39
Industrial	109.85	14.22
Residential 1/8-acre	21.37	2.77
Residential 1/4-acre	46.08	5.96
Residential 1/2-acre	5.26	0.68
Residential 1-Acre	11.67	1.51
Residential 2-Acre	1.65	0.21
Transportation	63.19	8.18
Utility	8.1	1.05
Forest Land	**296.17**	**38.33**
Forested Wetland	0	0
Residential Woods	0	0
Woods	296.17	38.33
Open Land	**84.92**	**10.99**
Open Space	77.7	10.06
Open Wetland	1.17	0.15
Water	6.05	0.78
Agricultural Land	**59.62**	**7.72**
Pasture/Hay	59.62	7.72
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	130.2	16.85

LPAX-23-2011 LP5 Subwatershed

Upstream View:

Latitude: 39.0982987741

Downstream View:

Longitude: -76.776099634

Located on the property of the District of Columbia Children's Center and approximately 475 meters east of the end of Forest Haven Avenue, this site is part of the LP5 subwatershed. Of the 118 acre drainage area, 62% is forested with the remaining 27% as developed and 12% as open space, resulting in 13.5% imperviousness. Located approximately 150 meters upstream of the confluence at the Little Patuxent River, the stream drains an extensive wetland network and has very little visible flow. The channel consists of all muck and detritus bottom substrate with very little stable benthic substrate. Some small emergent vegetation is present but mostly young plants. An excellent riparian buffer contributes to a partially supporting habitat. Elevated conductivity levels may be a result of the developed land cover upstream.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Bivalves (Musculium), isopods (Caecidotea), and worms (Tubificidae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Poor habitat diversity but banks are stable. Good riparian width and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	5.18
Turbidity (NTU)	25
Temperature (°C)	13.63
pH (SU)	6.68
Specific Conductivity (µS/cm)	357.4

LPAX-23-2011 LP5 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	16.7
Ephemeroptera %	0
Scraper Taxa	2
% Climbers	15.7

Calculated Metric Scores

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

Taxa	Count
Bezzia/Palpomyia	1
Bivalvia	6
Caecidotea	16
Chaoboridae	1
Chironomini	2
Chironomus	10
Chrysops	1
Crangonyx	4
Dixidae	2
Fossaria	11
Hydroporini	1
Lepidoptera	1
Limnephilidae	1
Musculium	20
Naidinae	1
Orthocladiinae	2
Orthocladius	2
Physa	1
Stratiomyidae	1
Tanytarsus	3
Tubificinae	14
Tvetenia	1
TOTAL:	**102**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	4
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	6	Sediment Deposition	10
Channel Sinuosity	12	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	4	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	5		
EPA Habitat Score			**117**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	20	100	Woody Debris/Rootwads	5	82.52
Shading	95	99.94	Instream Habitat	2	42.98
Epifaunal Substrate	4	48.38	Bank Stability	18	94.87
PHI Score					**78.12**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **117.75**

Cover	Acres	%Area
Developed Land	**31.65**	**26.88**
Commercial	28.18	23.93
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	3.46	2.94
Utility	0	0
Forest Land	**72.48**	**61.55**
Forested Wetland	0	0
Residential Woods	0	0
Woods	72.48	61.55
Open Land	**13.62**	**11.57**
Open Space	13.62	11.57
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	15.9	13.54

LPAX-24-2011 LPO Subwatershed

Upstream View:

Latitude: 39.0784450442

Downstream View:

Longitude: -76.772900715

Located within the Patuxent Research Refuge approximately 100 meters upstream of Bald Eagle Drive near the visitor center, this site is on an unnamed tributary to the Little Patuxent River and is part of the LPO subwatershed. The 146 acre drainage area to this site is predominantly forested land (95%) with only 5% accounting for developed land. Only 1.7% of the drainage area is impervious surface. Even though there is an adequate mix of riffles and woody debris/rootwad habitat, there is a poor biological community due to few EPT taxa and the complete lack of Ephemeroptera taxa and scraper taxa in the benthic sample. Measured pH values fell below COMAR standards; however, the lack of anthropogenic disturbance suggests that it is due to naturally acidic conditions in this drainage area. Evidence of incision, overwidening, and active bank erosion indicate that the channel has not yet reach a stable form, which could also explain why the benthic community is not meeting expectations.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Black flies (Simulium and Stegopterna) dominated the sample.
- Measured below COMAR standards for pH.
- Most habitat variables received sub-optimal scores. Scored high for woody debris. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.93
Turbidity (NTU)	3.89
Temperature (°C)	10
pH (SU)	4.89
Specific Conductivity (µS/cm)	49.6

LPAX-24-2011 LPO Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	20
EPT Taxa	4
Ephemeroptera Taxa	0
Intolerant Urban %	41.2
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	3.9

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	2
Bezzia/Palpomyia	2
Calopteryx	1
Chironomini	1
Cricotopus	1
Enchytraeidae	3
Eukiefferiella	5
Hydroporini	1
Ironoquia	1
Leuctra	2
Lumbricina	4
Naidinae	1
Nemouridae	2
Orthocladiinae	4
Orthocladius	1
Paramerina	1
Parametriocnemus	4
Polypedilum	3
Rheocricotopus	4
Simuliidae	5
Simulium	14
Stegopterna	35
Thienemannimyia group	4
Wormaldia	1
TOTAL:	**102**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	10
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	11
Channel Sinuosity	15	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	11		
EPA Habitat Score			**144**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Woody Debris/Rootwads	8	88.94
Shading	90	91.34	Instream Habitat	11	90.7
Epifaunal Substrate	13	99.26	Bank Stability	15	86.61
PHI Score					**86.01**
PHI Narrative Rating					**Minimally Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 146.29

Cover	Acres	%Area
Developed Land	**7.3**	**4.99**
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	7.3	4.99
Utility	0	0
Forest Land	**137.79**	**94.19**
Forested Wetland	0	0
Residential Woods	0	0
Woods	137.79	94.19
Open Land	**1.21**	**0.83**
Open Space	1.21	0.83
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	2.5	1.73

LPAX-25-2011 LPO Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0783628833

Longitude: -76.7796143343

This site is located within the Patuxent Research Refuge approximately 0.4 miles west of the visitor center on an unnamed tributary that drains to the Little Patuxent River in the LPO subwatershed. The 208 acre drainage area to this site is predominantly forested land (86%) with 13% accounting for open space. Only 0.6% of the drainage area is impervious surface. This site has an optimal mix of stable habitat types with numerous riffles and rootwads providing adequate habitat for a healthy and diverse benthic community. High taxa diversity (35 taxa) including 8 EPT taxa, 2 Ephemeroptera taxa, and 6 scraper taxa were present in this sample. Moderate bar formation and some minor bank erosion is present, but the stream appears to be evolving to a more stable stream type from a previously disturbed and incised state. Measured pH values fell below COMAR standards; however, the lack of anthropogenic disturbance suggests that it is due to naturally acidic conditions in this drainage area.

Summary Results:

- Biological condition – *"Good"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- Various midges and the Trichoptera genus, Diplectrona, dominated the sample.
- Measured below COMAR standards for pH.
- Most habitat variables received sub-optimal to optimal scores. Scored very high for woody debris. Good riparian width and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.73
Turbidity (NTU)	3.96
Temperature (°C)	10.07
pH (SU)	5.82
Specific Conductivity (µS/cm)	51.7

LPAX-25-2011

LPO Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	35
EPT Taxa	8
Ephemeroptera Taxa	2
Intolerant Urban %	26.8
Ephemeroptera %	6.3
Scraper Taxa	6
% Climbers	18.8

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
Intolerant Urban %	3
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**4.43**
BIBI Narrative Rating	**Good**

Taxa	Count
Ablabesmyia	2
Amphinemura	1
Anchytarsus	4
Ancyronyx	1
Bezzia/Palpomyia	1
Calopteryx	1
Chironomini	1
Corynoneura	1
Diamesinae	1
Dineutus	1
Diplectrona	13
Eccoptura	1
Enchytraeidae	1
Eurylophella	5
Habrophlebia	1
Helichus	1
Hydroporini	1
Lepidoptera	2
Leptophlebiidae	1
Leuctra	8
Nigronia	1
Orthocladiinae	1
Oulimnius	1
Parametriocnemus	18
Phaenopsectra	1
Polypedilum	8
Pseudolimnophila	1
Psilotreta	1
Pycnopsyche	1
Simulium	1
Stegopterna	1
Stempellinella	5
Stenelmis	2
Tanytarsus	7
Thienemannimyia group	5
Tipula	1
Tipulidae	1
Tvetenia	3
Zavrelimyia	5
TOTAL:	**112**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	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	14	Sediment Deposition	12
Channel Sinuosity	13	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	15	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	13		
EPA Habitat Score			**154**
EPA Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	19	100	Woody Debris/Rootwads	12	96.77
Shading	95	99.94	Instream Habitat	14	100
Epifaunal Substrate	16	100	Bank Stability	16	89.45
PHI Score					**97.69**
PHI Narrative Rating					**Minimally Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 208.29

Cover	Acres	%Area
Developed Land	**1.72**	**0.83**
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	1.72	0.83
Utility	0	0
Forest Land	**179.96**	**86.4**
Forested Wetland	0	0
Residential Woods	0	0
Woods	179.96	86.4
Open Land	**26.6**	**12.77**
Open Space	26.6	12.77
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	1.3	0.6

LPAX-26-2011 LPO Subwatershed

Upstream View:

Latitude: 39.0754986306

Downstream View:

Longitude: -76.7779495874

Located within the Patuxent Research Refuge just off of Switchboard Road, this site is on an unnamed tributary that drains to the Little Patuxent River and is part of the LPO subwatershed. The 101 acre drainage area to this site consists largely of forested land (94%) with only 5% accounting for developed land, only 1.4% which of is impervious surface. This reach consisted of a series of stagnant, backwatered pools caused by leaf/woody debris jams throughout the reach and exhibited virtually no visible flow. While there were only a few poor quality riffles present, instream woody debris and leaf packs provided habitat to the benthic community. A high percentage of intolerants (50%) and climbers (8%) in the sample led to a fair biological condition rating. Low dissolved oxygen levels measured at this site are largely attributed to the stream being backwatered with little mixing occurring in the water column and the abundance of detrital decomposition. Measured pH values fell below COMAR standards; however, the lack of anthropogenic disturbance suggests that it is due to naturally acidic conditions in this drainage area. Furthermore, the lack of flow and small drainage area suggest that this reach may be intermittent in nature.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Isopods (Caecidotea), worms (Lumbricina and Enchytraeidae), and midges dominated the sample.
- Measured below COMAR standards for pH and dissolved oxygen.
- Marginal habitat diversity and banks are moderately stable. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	4.85
Turbidity (NTU)	4.52
Temperature (°C)	10.4
pH (SU)	5.2
Specific Conductivity (µS/cm)	41

LPAX-26-2011

LPO Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	16
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	50
Ephemeroptera %	0
Scraper Taxa	1
% Climbers	8

Calculated Metric Scores

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

Taxa	Count
Aedes	1
Caecidotea	21
Chironomidae	1
Curculionidae	1
Enchytraeidae	11
Eukiefferiella	1
Hydrobaenus	1
Hydroporini	1
Ironoquia	2
Libellulidae	1
Lumbricina	9
Orthocladiinae	1
Paraphaenocladius	2
Podmosta	8
Pseudorthocladius	2
Stegopterna	21
Tanytarsus	8
Tvetenia	8
TOTAL:	**100**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	7
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	11	Sediment Deposition	11
Channel Sinuosity	12	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	6		
EPA Habitat Score			**120**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	8	43.08	Woody Debris/Rootwads	2	75.33
Shading	95	99.94	Instream Habitat	7	72.25
Epifaunal Substrate	7	66.78	Bank Stability	11	74.16
PHI Score					**71.92**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 101.45

Cover	Acres	%Area
Developed Land	**5.17**	**5.1**
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	5.17	5.1
Utility	0	0
Forest Land	**95.06**	**93.71**
Forested Wetland	0	0
Residential Woods	0	0
Woods	95.06	93.71
Open Land	**1.21**	**1.19**
Open Space	1.21	1.19
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	1.4	1.4

LPAX-28-2011 LP5 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1048558768

Longitude: -76.7806478164

Located south of Oak Hill Drive on a tributary to the Little Patuxent River, this site is part of the LP5 subwatershed. Over half of the 407 acre drainage area is developed land (56%) and includes part of the Fort Meade Military Reservation. The channel is incised and overwidened with some heavily eroded banks and extensive bar formation. Gravel dominated riffles of moderate quality provide limited habitat for a very poor biological community. Only 11 taxa were present in the benthic sample which completely lacked EPT, Ephemeroptera, scraper, and intolerant taxa. Because habitat is partially supporting and biological condition is very poor, there are likely water quality issues, such as elevated conductivity, impacting the biological community.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Orthocladius (midge) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Moderately unstable banks. Refuse present in moderate amounts.

Water Chemistry:

Dissolved Oxygen (mg/L)	11.03
Turbidity (NTU)	9.1
Temperature (°C)	14.33
pH (SU)	7.9
Specific Conductivity (µS/cm)	613.8

LPAX-28-2011

LP5 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	11
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	2
% Climbers	0

Calculated Metric Scores

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

Taxa	Count
Argia	1
Ceratopogonidae	2
Chaetocladius	1
Chironomidae	1
Cricotopus	2
Ephydridae	1
Hydrobaenus	2
Limnophyes	1
Muscidae	1
Nematoda	3
Orthocladiinae	4
Orthocladius	98
Stenelmis	2
TOTAL:	**119**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	9
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	15	Riparian Vegetative Zone Width- Right Bank	7
Channel Flow Status	14	Sediment Deposition	7
Channel Sinuosity	10	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	11		

EPA Habitat Score	**114**
EPA Narrative Rating	**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Woody Debris/Rootwads	3	62.55
Shading	90	91.34	Instream Habitat	11	80.22
Epifaunal Substrate	12	86.78	Bank Stability	8	63.25

PHI Score	**76.59**
PHI Narrative Rating	**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 407.26

Cover	Acres	%Area
Developed Land	**229.3**	**56.3**
Commercial	105.15	25.82
Industrial	0	0
Residential 1/8-acre	94.51	23.21
Residential 1/4-acre	1.46	0.36
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	28.17	6.92
Utility	0	0
Forest Land	**143.2**	**35.16**
Forested Wetland	0	0
Residential Woods	0	0
Woods	143.2	35.16
Open Land	**34.77**	**8.54**
Open Space	34.27	8.42
Open Wetland	0	0
Water	0.5	0.12
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	147.3	36.18

LPAX-29-2011 LPN Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0903630658

Longitude: -76.7636466722

This site is located between Patuxent Freeway (Rt. 32) and General Aviation Drive, this site is on an unnamed tributary to the Little Patuxent River and is part of the LPN subwatershed. Close to half of the 124 acre drainage area to this site is developed land (49%), which includes part of the Fort Meade Military Reservation. Forested and open space account for the remaining 32% and 20% of the drainage area, respectively. Over a third of the drainage area (37%) is impervious surface, which includes several large parking lots and a large stretch of Rt. 32. This site is located on an incised channel with little observed flow. The stream appears to have been historically channelized but is creating meanders and increasing sinuosity, which is leading to actively eroding and undercutting banks. Less than 80 organisms were identified in the entire benthic sample, which indicates a poor biological community likely resulting from the degraded habitat conditions. Elevated levels of conductivity, possibly due to the high imperviousness in the drainage area, may also be impacting biota.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- This sample only contained 64 organisms, the majority of which were midges (Diplocladius) and bivalves (Musculium and Pisidiidae).
- Water quality values within COMAR standards but conductivity elevated.
- Instream habitat and epibenthic substrate received marginal scores. Moderately unstable banks. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	7.09
Turbidity (NTU)	7.72
Temperature (°C)	11.57
pH (SU)	6.55
Specific Conductivity (µS/cm)	709.4

LPAX-29-2011

LPN Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	7.8
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	3.1

Calculated Metric Scores

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

Taxa	Count
Caecidotea	2
Chaetocladius	1
Chironomus	1
Cordulegaster	2
Crangonyx	2
Diplocladius	13
Enchytraeidae	1
Fossaria	1
Hydrobaenus	4
Ironoquia	5
Lepidoptera	2
Musculium	6
Orthocladiinae	4
Orthocladius	3
Physa	1
Pisidiidae	9
Rheocricotopus	1
Sialis	1
Tubificinae	5
TOTAL:	**64**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	7
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	13	Sediment Deposition	11
Channel Sinuosity	12	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	7		
EPA Habitat Score			**125**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Woody Debris/Rootwads	6	84.87
Shading	95	99.94	Instream Habitat	6	64.63
Epifaunal Substrate	7	65.47	Bank Stability	12	77.46
PHI Score					**77.96**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 124.19

Cover	Acres	%Area
Developed Land	**60.29**	**48.55**
Commercial	26.48	21.32
Industrial	8.78	7.07
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	18.99	15.29
Utility	6.03	4.85
Forest Land	**39.48**	**31.79**
Forested Wetland	1.1	0.88
Residential Woods	0	0
Woods	38.39	30.91
Open Land	**24.42**	**19.66**
Open Space	24.42	19.66
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	46.5	37.46

LPAX-30-2011 — LPN Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0963491529

Longitude: -76.7578387815

Located near the intersection of O'Brien Road and Mapes Road immediately downstream of the Fort Meade Golf Course, this site is on an unnamed tributary and is part of the LPN subwatershed. Of the 123 acre drainage area to this site, open space accounts for 41%, developed land accounts for 36%, and forested land accounts for the remaining 24%. Close to one-quarter of the drainage area (22%) is impervious surface. Half of the drainage area to this site drains the Fort Meade Golf Course while the other half drains developed parcels on the Fort Meade Military Reservation. Riparian vegetation along the left bank is mostly cleared due to a utility corridor. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage area that cannot be measured through in situ analysis only. Measured pH values fell below COMAR standards, but it is unclear whether it is due to naturally acidic conditions or anthropogenic disturbance.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Midges, black flies (Simulium), and worms (Naididae and Tubificidae) dominated the sample.
- Measured below COMAR standards for pH.
- Poor remoteness score and marginal habitat diversity.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.75
Turbidity (NTU)	3.84
Temperature (°C)	12.97
pH (SU)	6.44
Specific Conductivity (µS/cm)	236.3

LPAX-30-2011

LPN Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	33
EPT Taxa	4
Ephemeroptera Taxa	0
Intolerant Urban %	13.2
Ephemeroptera %	0
Scraper Taxa	1
% Climbers	0.9

Calculated Metric Scores

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

Taxa	Count
Agabus	1
Amphinemura	1
Bezzia/Palpomyia	2
Chaetocladius	5
Corynoneura	1
Crangonyx	3
Cricotopus	4
Cryptochironomus	1
Culicoides	1
Curculionidae	1
Dicranota	2
Diplectrona	3
Enchytraeidae	1
Eukiefferiella	2
Heterotrissocladius	3
Lepidostoma	1
Microvelia	1
Naidinae	4
Neoporus	1
Nigronia	1
Orthocladiinae	6
Orthocladius	6
Oulimnius	1
Parametriocnemus	1
Pisidiidae	4
Polycentropus	2
Prodiamesa	2
Prostoma	5
Rheocricotopus	9
Simulium	17
Thienemanniella	2
Thienemannimyia group	1
Tubificinae	10
Zavrelimyia	1
TOTAL:	**106**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	10
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	6
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	16	Sediment Deposition	10
Channel Sinuosity	8	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	9	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	13		
EPA Habitat Score			**127**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	3	16.16	Woody Debris/Rootwads	2	73.13
Shading	75	73.32	Instream Habitat	8	75.81
Epifaunal Substrate	9	77.14	Bank Stability	16	89.45
PHI Score					**67.5**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 123.22

Cover	Acres	%Area
Developed Land	**43.79**	**35.54**
Commercial	37.72	30.62
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	6.06	4.92
Utility	0	0
Forest Land	**29.27**	**23.75**
Forested Wetland	0	0
Residential Woods	0	0
Woods	29.27	23.75
Open Land	**50.16**	**40.71**
Open Space	50.16	40.71
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	27.4	22.21

LPAX-31-2011 — LPE Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0911964223 **Longitude:** -76.7403186317

Located near the intersection of Rock Avenue and Leonard Wood Avenue, this site drains a large section of Fort Meade Military Reservation to Rogue Harbor and is part of the LPE subwatershed. An abundance of rootwads and gravel riffles provide stable habitat for a fair biological habitat. There are some areas of active erosion, but the banks are mostly stable. Forty percent of the 1,905 acre drainage area to this site is developed land, with 32% as forested and 25% as open space. One fifth of the drainage area is impervious surface, which may explain the elevated conductivity measured at this site.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Sample dominated by midges (Orthocladius, Polypedilum, and Tanytarsus) and black flies (Stenelmis).
- Water quality values within COMAR standards but conductivity elevated.
- Remoteness scored poorly with sub-optimal scores for most of the remaining habitat variables. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.06
Turbidity (NTU)	16.4
Temperature (°C)	11.3
pH (SU)	6.93
Specific Conductivity (µS/cm)	335.2

LPAX-31-2011 — LPE Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	27
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	8
Ephemeroptera %	0
Scraper Taxa	7
% Climbers	29

Calculated Metric Scores

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

Taxa	Count
Ablabesmyia	1
Ancyronyx	2
Antocha	1
Calopteryx	6
Cheumatopsyche	3
Chironomini	1
Cricotopus	4
Cryptochironomus	1
Dubiraphia	6
Hemerodromia	3
Hydrobaenus	2
Hydroptila	1
Limnocharidae	1
Macronychus	1
Micropsectra	7
Optioservus	1
Orconectes	1
Orthocladiinae	6
Orthocladius	10
Polypedilum	8
Rheocricotopus	1
Rheotanytarsus	6
Simulium	3
Sphaerium	1
Stenelmis	9
Tanytarsus	8
Thienemanniella	1
Thienemannimyia group	3
Tvetenia	2
TOTAL:	**100**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	6	Pool Variability	12
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	15	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	18	Sediment Deposition	13
Channel Sinuosity	6	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	13		
EPA Habitat Score			**135**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Woody Debris/Rootwads	9	62.83
Shading	70	68.32	Instream Habitat	14	81.07
Epifaunal Substrate	14	88.34	Bank Stability	12	77.46
PHI Score					**69.29**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **1905.35**

Cover	Acres	%Area
Developed Land	**764**	**40.1**
Commercial	209.37	10.99
Industrial	2.17	0.11
Residential 1/8-acre	338.33	17.76
Residential 1/4-acre	92.02	4.83
Residential 1/2-acre	0	0
Residential 1-Acre	19.93	1.05
Residential 2-Acre	12.75	0.67
Transportation	89.44	4.69
Utility	0	0
Forest Land	**626.33**	**32.87**
Forested Wetland	0	0
Residential Woods	0	0
Woods	626.33	32.87
Open Land	**470.87**	**24.71**
Open Space	467.94	24.56
Open Wetland	0	0
Water	2.93	0.15
Agricultural Land	**44.15**	**2.32**
Pasture/Hay	44.15	2.32
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	382.7	20.08

LPAX-32-2011 LPE Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1061492851

Longitude: -76.7485572877

Located on the Fort Meade Golf Course directly off of Kenyon Loop, this site drains a large section of Fort Meade Military Reservation to Rogue Harbor and is part of the LPE subwatershed. The riparian buffer is severely lacking due to the golf course and active bank erosion is present throughout the site. Numerous pipe outfalls were observed along the right bank, which likely contributed to the elevated conductivity measured at this site. A relatively high taxa diversity (22 taxa), number of scraper taxa, and a high percentage of climbers present in the benthic sample resulted in a fair biological condition rating. Forty percent of the 1,381 acre drainage area to this site is developed land, with 39% as forested and 17% as open space, resulting in 18% impervious cover.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Orthocladius (midge) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Very low woody debris, percent shading, and remoteness scores. Marginal habitat diversity, riparian width, and vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.09
Turbidity (NTU)	13.6
Temperature (°C)	12.9
pH (SU)	6.71
Specific Conductivity (µS/cm)	305.3

LPAX-32-2011

LPE Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	22
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	1.9
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	15.2

Calculated Metric Scores

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

Taxa	Count
Bezzia/Palpomyia	1
Boyeria	1
Calopteryx	2
Ceratopsyche	2
Chelifera	1
Cheumatopsyche	2
Chironomidae	2
Chironomini	2
Coenagrionidae	1
Cricotopus	1
Dubiraphia	2
Eukiefferiella	2
Hemerodromia	2
Hydrobaenus	2
Orthocladiinae	2
Orthocladius	51
Paratendipes	1
Polypedilum	8
Potthastia	2
Rheocricotopus	1
Simulium	5
Stenelmis	4
Tanytarsus	4
Tubificinae	1
Tvetenia	3
TOTAL:	**105**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	4	Pool Variability	11
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	5
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	2
Channel Flow Status	18	Sediment Deposition	10
Channel Sinuosity	5	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	11		
EPA Habitat Score			**103**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	5	26.93	Woody Debris/Rootwads	1	42.81
Shading	20	21.22	Instream Habitat	9	56.63
Epifaunal Substrate	10	67.2	Bank Stability	9	67.08
PHI Score					**46.98**
PHI Narrative Rating					**Severely Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) **1380.66**

Cover	Acres	%Area
Developed Land	**555.57**	**40.24**
Commercial	86.63	6.27
Industrial	0.15	0.01
Residential 1/8-acre	295.53	21.4
Residential 1/4-acre	92.02	6.66
Residential 1/2-acre	0	0
Residential 1-Acre	19.93	1.44
Residential 2-Acre	12.75	0.92
Transportation	48.57	3.52
Utility	0	0
Forest Land	**542.64**	**39.3**
Forested Wetland	0	0
Residential Woods	0	0
Woods	542.64	39.3
Open Land	**238.3**	**17.26**
Open Space	238.3	17.26
Open Wetland	0	0
Water	0	0
Agricultural Land	**44.15**	**3.2**
Pasture/Hay	44.15	3.2
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	249.1	18.04

LPAX-33-2011 LPG Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0937869212

Longitude: -76.7386858015

This site is located immediately upstream of Redwood Road and drains to Rogue Harbor in the LPG subwatershed. The entire drainage area of this site (1,082 acres) is within the Fort Meade Military Reservation and consists of 42% developed land, 38% open space, and 19% forested land. Nearly one-quarter of the drainage area (24%) is impervious surface. Elevated levels of conductivity may be a result of the developed land cover upstream. This site is backwatered due to a debris jam at the culvert which is located at the downstream portion of the site. A wet retention pond is located 230 meters upstream from the site and may be altering flow. Despite the poor physical habitat quality, a fair biological community attributed to high taxa diversity (26 taxa), number of scraper taxa, and a high percentage of climbers (46%) present in the benthic sample, as well as the presence of Caenis, an intolerant mayfly.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Polypedilum (midge) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Very low woody debris, percent shading, and remoteness scores. Marginal habitat diversity.

Water Chemistry:

Dissolved Oxygen (mg/L)	8.27
Turbidity (NTU)	28.9
Temperature (°C)	15
pH (SU)	7.15
Specific Conductivity (µS/cm)	429.7

LPAX-33-2011

LPG Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	26
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	2.6
Ephemeroptera %	1.8
Scraper Taxa	3
% Climbers	46.5

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.57**
BIBI Narrative Rating	**Fair**

Taxa	Count
Caenis	2
Chaetocladius	2
Cheumatopsyche	1
Chironomidae	1
Chironomini	7
Chironomus	1
Clinotanypus	1
Coenagrionidae	1
Crangonyx	3
Dicrotendipes	2
Enchytraeidae	1
Glyptotendipes	8
Hirudinea	1
Hydrobaenus	1
Ironoquia	1
Ischnura	1
Limnophyes	1
Menetus	1
Naidinae	2
Orthocladiinae	1
Orthocladius	6
Paratanytarsus	1
Physa	1
Polypedilum	49
Potthastia	1
Rheotanytarsus	2
Simulium	8
Tanypodinae	1
Thienemanniella	1
Thienemannimyia group	5
TOTAL:	**114**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	10
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	5
Channel Alteration	12	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	18	Sediment Deposition	14
Channel Sinuosity	4	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	13		
EPA Habitat Score			**122**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Woody Debris/Rootwads	1	45.57
Shading	35	36.34	Instream Habitat	9	59.12
Epifaunal Substrate	8	57.17	Bank Stability	18	94.87
PHI Score					**49.74**
PHI Narrative Rating					**Severely Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 1082.53

Cover	Acres	%Area
Developed Land	**459.22**	**42.42**
Commercial	262.78	24.27
Industrial	0	0
Residential 1/8-acre	90.49	8.36
Residential 1/4-acre	27.69	2.56
Residential 1/2-acre	4.6	0.42
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	73.66	6.8
Utility	0	0
Forest Land	**209.59**	**19.36**
Forested Wetland	0	0
Residential Woods	0	0
Woods	209.59	19.36
Open Land	**413.73**	**38.22**
Open Space	405.31	37.44
Open Wetland	0	0
Water	8.42	0.78
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	259.6	23.98

LPAX-34-2011 LPG Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0992103206

Longitude: -76.7315979907

Located immediately upstream of Llewellyn Avenue, this site drains to Rogue Harbor and is part of the LPG subwatershed. The entire drainage area of this site (790 acres) is within the Fort Meade Military Reservation and consists largely of developed and open space (39% for both) with 23% as forested land. Impervious surface accounts for 22% of the drainage area. This site is backwatered a good distance due to a culvert just downstream of the sampling reach and possible beaver activity. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage system that cannot be measured through in situ analysis only. The depressed biological community may be a result of the backwatered condition in the sampling reach.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Degraded"*
- Midges (Orthocladius, Polypedilum, and Tanytarsus) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Bank stability scored high but habitat diversity received marginal scores. Very poor remoteness score.

Water Chemistry:

Dissolved Oxygen (mg/L)	7.81
Turbidity (NTU)	28
Temperature (°C)	12.87
pH (SU)	6.8
Specific Conductivity (µS/cm)	322.4

LPAX-34-2011 | LPG Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	26
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	2.7
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	35.1

Calculated Metric Scores

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

Taxa	Count
Ablabesmyia	1
Argia	6
Calopteryx	2
Chironomidae	2
Chironomini	1
Dicrotendipes	1
Diplocladius	1
Dubiraphia	1
Enallagma	1
Enchytraeidae	1
Eukiefferiella	2
Hydrobaenus	3
Hydroporini	2
Ironoquia	1
Ischnura	1
Micropsectra	3
Orthocladiinae	2
Orthocladius	28
Parametriocnemus	4
Paratanytarsus	1
Paratendipes	1
Physa	1
Polypedilum	16
Rheotanytarsus	1
Simulium	4
Sphaerium	2
Stictochironomus	1
Tanypodinae	2
Tanytarsus	15
Thienemannimyia group	4
TOTAL:	**111**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	12
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	5
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	7
Channel Flow Status	18	Sediment Deposition	11
Channel Sinuosity	8	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	12		
EPA Habitat Score			**131**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	2	10.77	Woody Debris/Rootwads	5	60.97
Shading	60	58.94	Instream Habitat	9	62.35
Epifaunal Substrate	10	70.84	Bank Stability	18	94.87
PHI Score					**59.79**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		789.64
Cover	**Acres**	**%Area**
Developed Land	**305.45**	**38.68**
Commercial	167.4	21.2
Industrial	0	0
Residential 1/8-acre	74.69	9.46
Residential 1/4-acre	5.89	0.75
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	57.47	7.28
Utility	0	0
Forest Land	**178.26**	**22.58**
Forested Wetland	0	0
Residential Woods	0	0
Woods	178.26	22.58
Open Land	**305.93**	**38.74**
Open Space	305.23	38.65
Open Wetland	0	0
Water	0.7	0.09
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	173.3	21.95

LPAX-35-2011 LP6 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1096682415

Longitude: -76.7980677411

This site is located approximately 150 meters downstream of Russett Green West and approximately 100 meters upstream of the confluence with the Little Patuxent River in the LP6 subwatershed. Of the 413 acre drainage area, 78% is developed land, the majority of which is high density residential. The remaining 21% of the drainage area is forested land. Nearly one-half of the drainage area (47%) is impervious surface. The site is deeply incised and overwidened with severe erosion on both banks and heavy sediment deposition, likely due to the altered flow regime. Woody debris is abundant but primarily dewatered due to low flow in the channel. Riffle habitat is also present but poor quality. A complete lack of EPT, Ephemeroptera, and taxa intolerant to urban stressors characterize a very poor biological community. Elevated conductivity levels are likely the result of a highly-developed, highly-impervious drainage area, and are potentially indicative of water quality impairment.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Partially Degraded"*
- Sample dominated by midges (Chironomus, Cricotopus, and Orthocladius) and worms of the Tubificidae family.
- Water quality values within COMAR standards but conductivity elevated.
- Refuse present in moderate amounts. Poor bank stability with marginal habitat diversity. Good riparian width but poor vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	6.67
Turbidity (NTU)	4.54
Temperature (°C)	14.97
pH (SU)	7.15
Specific Conductivity (µS/cm)	700.4

LPAX-35-2011 LP6 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	14
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	1
% Climbers	3.8

Calculated Metric Scores

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

Taxa	Count
Ancyronyx	4
Chironomidae	1
Chironomus	15
Cricotopus	34
Dicrotendipes	1
Enchytraeidae	2
Eukiefferiella	1
Lumbriculidae	1
Naidinae	3
Nemata	2
Orthocladius	10
Paratanytarsus	1
Polypedilum	4
Thienemanniella	1
Tubificinae	24
TOTAL:	**104**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	1	Pool Variability	10
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	9	Sediment Deposition	6
Channel Sinuosity	10	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	6		
EPA Habitat Score			**94**
EPA Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Woody Debris/Rootwads	10	83.11
Shading	95	99.94	Instream Habitat	6	52.34
Epifaunal Substrate	8	63.45	Bank Stability	4	44.72
PHI Score					**66.23**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 412.79

Cover	Acres	%Area
Developed Land	**323.11**	**78.28**
Commercial	77.68	18.82
Industrial	0	0
Residential 1/8-acre	191.92	46.49
Residential 1/4-acre	24.82	6.01
Residential 1/2-acre	0	0
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	28.7	6.95
Utility	0	0
Forest Land	**87.94**	**21.3**
Forested Wetland	0	0
Residential Woods	0	0
Woods	87.94	21.3
Open Land	**1.74**	**0.42**
Open Space	1.74	0.42
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	192.3	46.58

LPAX-36-2011 — LP6 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1185223756

Longitude: -76.8099706349

Located approximately 100 meters upstream of the confluence with the Little Patuxent River, this site is northwest of the Marsh Crossing Drive and Big Pool Road intersection and adjacent to the Oxbow Natural Area in the LP6 subwatershed. Of the 375 acre drainage area to this site, the majority of the land cover is forested (75%) with the remaining 17% and 9% consisting of open space and developed land, respectively. Only 2% of the drainage area is impervious surface. In spite of the heavily forested drainage area, the channel is incised and overwidened with very little flow and a very poor biological community. It appears that the channel has either been historically channelized or is a relic of the abandoned oxbow channel. The benthic sample completely lacked EPT, Ephemeroptera, scraper, and climber taxa; however, half of the taxa were intolerant to urban stressors.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Caecidotea (isopod) and Chironomus (midge) dominated the sample.
- Measured below COMAR standards for dissolved oxygen.
- Poor instream habitat with marginal epibenthic substrate. Banks are stable with abundant woody debris. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	2.43
Turbidity (NTU)	36
Temperature (°C)	15.57
pH (SU)	6.68
Specific Conductivity (µS/cm)	169.1

LPAX-36-2011

LP6 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	7
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	49.5
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	0

Calculated Metric Scores

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

Taxa	Count
Amphipoda	5
Bivalvia	3
Caecidotea	55
Chironomus	27
Crangonyx	7
Parachironomus	1
Phaenopsectra	1
Pisidium	11
Psectrotanypus	1
TOTAL:	**111**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	8
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	7	Sediment Deposition	9
Channel Sinuosity	9	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	7		
EPA Habitat Score			**114**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Woody Debris/Rootwads	10	84.21
Shading	90	91.34	Instream Habitat	4	42.23
Epifaunal Substrate	6	52.46	Bank Stability	16	89.45
PHI Score					**71.62**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		374.68
Cover	**Acres**	**%Area**
Developed Land	**33.46**	**8.93**
Commercial	0.7	0.19
Industrial	0	0
Residential 1/8-acre	4.91	1.31
Residential 1/4-acre	0	0
Residential 1/2-acre	14.73	3.93
Residential 1-Acre	2.77	0.74
Residential 2-Acre	6.49	1.73
Transportation	3.81	1.02
Utility	0.05	0.01
Forest Land	**279.16**	**74.51**
Forested Wetland	28.02	7.48
Residential Woods	0	0
Woods	251.14	67.03
Open Land	**62.05**	**16.56**
Open Space	4.45	1.19
Open Wetland	53.77	14.35
Water	3.83	1.02
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	7.4	1.98

LPAX-37-2011 LPI Subwatershed

Upstream View:

Latitude: 39.1076948539

Downstream View:

Longitude: -76.7876171728

This site is located on the mainstem of Dorsey Run, approximately 100 meters upstream of the confluence with the Little Patuxent River, just off of the eastbound Route 32 ramp to southbound Baltimore-Washington Parkway (Rt. 295) in the LPI subwatershed. Of the 8,054 acre drainage area to this site, 1,704 acres drains from Howard County. Over one-half of the total drainage area is developed land (56%) with 32% as forested and 11% as open space. More than one-quarter of the drainage area is impervious surface (27%). This site is located on a large, wide channel with a good mix of velocity/depth and stable habitat for benthos; however, large bar formation and active bank erosion is evident, suggesting an unstable stream reach. Gravel riffles of moderate quality and abundant woody debris support a good biological community. The benthic sample for this site had high taxa diversity (31 taxa), 7 EPT, 2 Ephemeroptera, and 7 scraper taxa; but, only 6% of the sample consisted of taxa intolerant to urban stressors. Elevated levels of conductivity, likely resulting from the heavily developed land cover upstream, may be influencing the quantity of intolerant taxa.

Summary Results:

- Biological condition – *"Good"*
- Habitat scores *"Supporting"* and *"Degraded"*
- Snails (Amnicola) and bivavles (Musculium) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Percent shading, remoteness, and woody debris received low scores. Moderately unstable banks with sub-optimal habitat diversity. Good riparian width.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.31
Turbidity (NTU)	4.69
Temperature (°C)	20.8
pH (SU)	7.36
Specific Conductivity (µS/cm)	540.3

LPAX-37-2011

LPI Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	31
EPT Taxa	7
Ephemeroptera Taxa	2
Intolerant Urban %	5.7
Ephemeroptera %	2.8
Scraper Taxa	7
% Climbers	21.7

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**4.14**
BIBI Narrative Rating	**Good**

Taxa	Count
Acentrella	1
Amnicola	21
Amphipoda	4
Ancyronyx	2
Argia	1
Boyeria	1
Brillia	1
Caecidotea	1
Chelifera	1
Cheumatopsyche	2
Chironomidae	1
Cricotopus	4
Curculionidae	1
Heptageniidae	2
Hydrobaenus	1
Hydropsyche	4
Hydropsychidae	1
Lumbriculidae	1
Macronychus	3
Musculium	27
Naidinae	3
Orthocladiinae	1
Orthocladius	6
Perlesta	1
Physa	1
Pisidiidae	5
Polycentropodidae	1
Potthastia	1
Rheotanytarsus	1
Staphylinidae	1
Stenelmis	2
Taeniopteryx	1
Thienemannimyia group	1
Tvetenia	1
TOTAL:	**106**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	4	Pool Variability	15
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	15	Sediment Deposition	12
Channel Sinuosity	10	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	15	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	14		
EPA Habitat Score			**138**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Woody Debris/Rootwads	9	46.51
Shading	65	63.55	Instream Habitat	14	66.32
Epifaunal Substrate	15	84.76	Bank Stability	10	70.71
PHI Score					**64.28**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres) 8053.52

Cover	Acres	%Area
Developed Land	**2236.5**	**56.27**
Commercial	508.94	6.32
Industrial	64.88	0.81
Residential 1/8-acre	11.13	0.14
Residential 1/4-acre	35.82	0.44
Residential 1/2-acre	104.48	1.3
Residential 1-Acre	71.22	0.88
Residential 2-Acre	119.39	1.48
Transportation	175.73	2.18
Utility	13.98	0.17
Forest Land	**888.15**	**31.54**
Forested Wetland	0	0
Residential Woods	0	0
Woods	1434.99	17.82
Open Land	**445.3**	**11.48**
Open Space	453.19	5.63
Open Wetland	11.43	0.14
Water	21.8	0.27
Agricultural Land	**676.96**	**0.54**
Pasture/Hay	19.17	0.24
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	2194.2	27.24

LPAX-38-2011 — LPI Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1172534438

Longitude: -76.7832578219

Located on the Dorsey Run mainstem, just prior of the exit at eastbound Route 32 to southbound Baltimore-Washington Parkway (Rt. 295), this site is part of the LPI subwatershed. Of the 7,562 acre drainage area to this site, 1,704 acres drains from Howard County. Over half of the total drainage area is developed land (58%) with 31% as forested and 10% as open space. More than one-quarter of the drainage area is impervious surface (28%). This site is located on a deep, wide channel with extensive bar formation and heavy bank erosion on the outer meanders, likely due to altered flow regimes caused by high imperviousness. Several very deep pools were observed throughout this site. An abundance of woody debris and rootwads provides adequate habitat for a fair biological community. Elevated levels of conductivity may be a result of the developed land cover upstream and may be influencing the quantity of intolerant taxa--only 5% of the benthic sample consisted of taxa intolerant to urban stressors.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Worms (Naididae) and midges dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Good riparian width with suboptimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.77
Turbidity (NTU)	6.32
Temperature (°C)	21.1
pH (SU)	7.34
Specific Conductivity (µS/cm)	550.3

LPAX-38-2011

LPI Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	25
EPT Taxa	5
Ephemeroptera Taxa	3
Intolerant Urban %	4.9
Ephemeroptera %	2.9
Scraper Taxa	6
% Climbers	7.8

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	3
BIBI Score	**3.86**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amnicola	3
Ancyronyx	5
Argia	2
Baetis	1
Brillia	6
Caecidotea	2
Caenis	1
Cheumatopsyche	3
Chironomidae	1
Chironomini	1
Chironomus	4
Cricotopus	8
Enchytraeidae	1
Hagenius	1
Hydropsyche	5
Lumbriculidae	1
Maccaffertium	1
Macronychus	6
Naidinae	28
Orthocladiinae	1
Orthocladius	9
Physa	4
Polypedilum	1
Simulium	3
Stenelmis	1
Thienemanniella	1
Tubificinae	2
Xylotopus	1
TOTAL:	**103**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	16
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	9
Channel Sinuosity	12	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	13		
EPA Habitat Score			**144**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Woody Debris/Rootwads	12	56.1
Shading	50	49.95	Instream Habitat	14	66.96
Epifaunal Substrate	14	79.36	Bank Stability	13	80.63
PHI Score					**68.96**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**7561.83**
Cover	**Acres**	**%Area**
Developed Land	**635.63**	**58.45**
Commercial	470.73	6.23
Industrial	52.24	0.69
Residential 1/8-acre	11.13	0.15
Residential 1/4-acre	31.55	0.42
Residential 1/2-acre	104.48	1.38
Residential 1-Acre	71.22	0.94
Residential 2-Acre	119.39	1.58
Transportation	132.85	1.76
Utility	0	0
Forest Land	**246.44**	**31.21**
Forested Wetland	0	0
Residential Woods	0	0
Woods	1255.3	16.6
Open Land	**49.16**	**9.58**
Open Space	266.44	3.52
Open Wetland	11.43	0.15
Water	8.57	0.11
Agricultural Land	**15.03**	**0.57**
Pasture/Hay	19.17	0.25
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2136.3	28.25

LPAX-39-2011 LPJ Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1235897278

Longitude: -76.7804216847

Located approximately 100 meters upstream from the confluence with Dorsey Run, just off of the exit of Guilford Road to National Business Parkway, this site is part of the LPJ subwatershed. Over half of the 873 acre drainage area to this site is forested land with 26% as developed land with 12% as impervious surface. The stream channel is overwidened and incised with multiple bars throughout, likely due to altered flow regimes caused by development upstream. Both banks are actively eroding. An abundance of woody debris and rootwads, but poor quality riffle habitat, supports a fair biological community. Elevated levels of conductivity may be a result of the developed land cover upstream and may be influencing the quantity of intolerant taxa--only 6% of the benthic sample consisted of taxa intolerant to urban stressors.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Midges (Hydrobaenus, Orthocladius, and Parametriocnemus) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Moderately unstable banks. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.33
Turbidity (NTU)	14.6
Temperature (°C)	11.33
pH (SU)	7.16
Specific Conductivity (µS/cm)	428.5

LPAX-39-2011 LPJ Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	24
EPT Taxa	3
Ephemeroptera Taxa	0
Intolerant Urban %	6.1
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	13.1

Calculated Metric Scores

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

Taxa	Count
Ablabesmyia	5
Amphinemura	1
Brillia	1
Cheumatopsyche	2
Chironomidae	1
Chironomini	1
Cricotopus	1
Eukiefferiella	3
Gastropoda	1
Helichus	1
Hydrobaenus	16
Ironoquia	1
Microtendipes	3
Orthocladiinae	6
Orthocladius	10
Parametriocnemus	17
Paratanytarsus	1
Paratendipes	1
Polypedilum	9
Rheotanytarsus	1
Simulium	4
Stegopterna	5
Tanytarsus	3
Thienemannimyia group	1
Tipula	1
Tvetenia	2
Xylotopus	1
TOTAL:	**99**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	12
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	10	Sediment Deposition	7
Channel Sinuosity	13	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	12		
EPA Habitat Score			**128**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Woody Debris/Rootwads	6	62.8
Shading	90	91.34	Instream Habitat	12	77.97
Epifaunal Substrate	12	81.81	Bank Stability	9	67.08
PHI Score					**75.17**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 872.95

Cover	Acres	%Area
Developed Land	**229.57**	**26.3**
Commercial	114.98	13.17
Industrial	0	0
Residential 1/8-acre	11.13	1.28
Residential 1/4-acre	31.55	3.61
Residential 1/2-acre	3.41	0.39
Residential 1-Acre	2.47	0.28
Residential 2-Acre	28.89	3.31
Transportation	37.13	4.25
Utility	0	0
Forest Land	**557.07**	**63.81**
Forested Wetland	0	0
Residential Woods	0	0
Woods	557.07	63.81
Open Land	**79.01**	**9.05**
Open Space	79.01	9.05
Open Wetland	0	0
Water	0	0
Agricultural Land	**7.3**	**0.84**
Pasture/Hay	7.3	0.84
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	103.8	11.89

LPAX-40-2011 LPJ Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1298022137

Longitude: -76.7676944484

Located behind the National Business Park located off of the Baltimore Washington Parkway, this site is part of the LPJ subwatershed and drains to Dorsey Run. Of the 535 acre drainage area to this site, over half of the area is forested land (61%) with 24% as developed and 14% as open space. Eleven percent of the drainage area is impervious surface. A trail runs approximately 2 meters from the left bank and multiple bars were observed throughout the site. Good woody debris and rootwad habitat along with some gravel riffles support a fair biological community. Elevated levels of conductivity may be a result of the developed land cover upstream and may be influencing the quantity of intolerant taxa--only 5% of the benthic sample consisted of taxa intolerant to urban stressors.

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Sample dominated by Parametriocnemus (midge).
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Good riparian width with suboptimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.69
Turbidity (NTU)	4.87
Temperature (°C)	13.87
pH (SU)	7.15
Specific Conductivity (µS/cm)	363.2

LPAX-40-2011

LPJ Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	26
EPT Taxa	4
Ephemeroptera Taxa	1
Intolerant Urban %	5.1
Ephemeroptera %	0.9
Scraper Taxa	3
% Climbers	10.3

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
Intolerant Urban %	1
Ephemeroptera %	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.57**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ablabesmyia	1
Amphinemura	1
Baetidae	1
Bezzia/Palpomyia	1
Brillia	2
Chironomini	3
Corynoneura	1
Cricotopus	1
Eriopterini	1
Hydrobaenus	3
Ironoquia	1
Lepidoptera	1
Lepidostoma	1
Microtendipes	7
Neoporus	2
Nigronia	1
Orthocladiinae	1
Orthocladius	1
Oulimnius	1
Parametriocnemus	63
Polypedilum	9
Pseudolimnophila	1
Stenelmis	1
Stenochironomus	1
Tanytarsus	2
Thienemanniella	1
Thienemannimyia group	3
Tvetenia	5
TOTAL:	**117**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	11
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	7
Channel Sinuosity	10	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	13	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	12		
EPA Habitat Score			**134**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Woody Debris/Rootwads	8	74.25
Shading	90	91.34	Instream Habitat	13	88.52
Epifaunal Substrate	13	90.81	Bank Stability	13	80.63
PHI Score					**81.7**
PHI Narrative Rating					**Minimally Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 535.05

Cover	Acres	%Area
Developed Land	**130.1**	**24.32**
Commercial	33.7	6.3
Industrial	0	0
Residential 1/8-acre	11.13	2.08
Residential 1/4-acre	27.92	5.22
Residential 1/2-acre	3.41	0.64
Residential 1-Acre	2.47	0.46
Residential 2-Acre	16.86	3.15
Transportation	34.61	6.47
Utility	0	0
Forest Land	**324.23**	**60.6**
Forested Wetland	0	0
Residential Woods	0	0
Woods	324.23	60.6
Open Land	**74.29**	**13.89**
Open Space	74.29	13.89
Open Wetland	0	0
Water	0	0
Agricultural Land	**6.42**	**1.2**
Pasture/Hay	6.42	1.2
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	58.7	10.98

LPAX-41-2011 LPH Subwatershed

Upstream View:

Latitude: 39.1242488469

Downstream View:

Longitude: -76.7814099186

Located on the Dorsey Run mainstem, just off of the exit of Guilford Road to National Business Parkway, this site is part of the LPH subwatershed. Of the 6,321 acre drainage area to this site, 1,704 acres drains from Howard County. Over half of the total drainage area is developed land (64%) with 26% as forested and 10% as open space. Almost one-third of the drainage area is impervious surface (30%). This channel is overwidened with large mid-channel and point bars, likely due to altered flow regimes caused by high imperviousness. Several deep pools with cover provide good habitat for fish. A good mix of gravel riffles, rootwads, and wood provide diverse habitat for benthic macroinvertebrates. However, the biological community was poor due to the complete lack of Ephemeroptera taxa and taxa intolerant to urban stressors. Elevated levels of conductivity may be a result of the highly-developed land cover upstream and are likely influencing the quantity of intolerant taxa. Because habitat is supporting and biological condition is poor, there may be additional water quality impairments, other than elevated conductivity, in this drainage area that cannot be measured through in situ analysis only.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Orthocladius (midge) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Refuse present in moderate amounts. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	12.86
Turbidity (NTU)	4.38
Temperature (°C)	12.93
pH (SU)	7.63
Specific Conductivity (µS/cm)	651.1

LPAX-41-2011

LPH Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	2
Ephemeroptera Taxa	0
Intolerant Urban %	0
Ephemeroptera %	0
Scraper Taxa	3
% Climbers	4.5

Calculated Metric Scores

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

Taxa	**Count**
Ancyronyx	2
Ceratopsyche	1
Cheumatopsyche	5
Chironomidae	2
Cricotopus	2
Hydrobaenus	2
Naidinae	2
Orthocladius	78
Parametriocnemus	1
Paratanytarsus	1
Pisidiidae	1
Polypedilum	3
Rheotanytarsus	2
Stenelmis	3
Tanytarsus	2
Tubificinae	3
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	15
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	11	Sediment Deposition	9
Channel Sinuosity	10	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	13		
EPA Habitat Score			**138**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Woody Debris/Rootwads	12	58.13
Shading	70	68.32	Instream Habitat	14	68.8
Epifaunal Substrate	14	80.53	Bank Stability	13	80.63
PHI Score					**71.97**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres) 6320.59

Cover	Acres	%Area
Developed Land	**5.17**	**63.59**
Commercial	224.8	3.56
Industrial	51.93	0.82
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	101.07	1.6
Residential 1-Acre	68.75	1.09
Residential 2-Acre	88.91	1.41
Transportation	57.65	0.91
Utility	0	0
Forest Land	**127.81**	**25.79**
Forested Wetland	0	0
Residential Woods	0	0
Woods	525.06	8.31
Open Land	**1.21**	**9.83**
Open Space	163.84	2.59
Open Wetland	11.43	0.18
Water	7.94	0.13
Agricultural Land	**0**	**0.57**
Pasture/Hay	11.88	0.19
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	1925	30.46

LPAX-42-2011 LPH Subwatershed

Upstream View:

Downstream View:

Latitude: 39.1298028977

Longitude: -76.7818087904

Located on the mainstem of Dorsey Run just off of Brock Bridge Road, this site is part of the LPH subwatershed. Of the 5,994 acre drainage area to this site, 1,632 acres drains from Howard County. Over half of the total drainage area is developed land (63%) with 26% as forested and 10% as open space. Nearly one-third of the drainage area is impervious surface (30%). This site is a large, overwidened channel with many mid-channel and point bars, likely due to altered flow regimes caused by high imperviousness. There is a good mix of velocity/depth and an abundance of large woody debris in deep pools provides good habitat for fish. The presence of moderate quality gravel riffles provides some stable habitat for a poor biological community. Elevated conductivity levels may be a result of the highly-developed land cover upstream, much of which is industrial/commercial development, and may be influencing the quantity of intolerant taxa--only 5% of the benthic sample consisted of taxa intolerant to urban stressors. Because habitat is supporting and biological condition is poor, there may be problems with water quality in this drainage system, as indicated by the elevated conductivity readings, which are impacting the biota.

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Worms of the Naididae family dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Most habitat variables received sub-optimal scores. Good riparian width with suboptimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.34
Turbidity (NTU)	6.97
Temperature (°C)	21.5
pH (SU)	7.39
Specific Conductivity (µS/cm)	603

LPAX-42-2011

LPH Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	3
Ephemeroptera Taxa	1
Intolerant Urban %	5.2
Ephemeroptera %	1
Scraper Taxa	1
% Climbers	1

Calculated Metric Scores

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

Taxa	Count
Acentrella	1
Brillia	9
Caecidotea	2
Chaetocladius	1
Cheumatopsyche	2
Corbicula	1
Cricotopus	4
Enchytraeidae	1
Hagenius	1
Hydrobaenus	1
Naidinae	61
Orthocladius	6
Polycentropodidae	2
Polypedilum	1
Tubificinae	4
TOTAL:	**97**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	9	Pool Variability	15
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	8
Channel Sinuosity	11	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	13	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	13		
EPA Habitat Score			**141**
EPA Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Woody Debris/Rootwads	11	55.77
Shading	55	54.42	Instream Habitat	14	69.34
Epifaunal Substrate	13	75.07	Bank Stability	13	80.63
PHI Score					**67.54**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**5994.41**
Cover	**Acres**	**%Area**
Developed Land	**33.46**	**63.22**
Commercial	206.08	3.44
Industrial	16.74	0.28
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	101.07	1.69
Residential 1-Acre	68.75	1.15
Residential 2-Acre	88.91	1.48
Transportation	46.68	0.78
Utility	0	0
Forest Land	**276.82**	**25.95**
Forested Wetland	0	0
Residential Woods	0	0
Woods	450.44	7.51
Open Land	**62.05**	**10.14**
Open Space	151.86	2.53
Open Wetland	11.43	0.19
Water	6.23	0.1
Agricultural Land	**0**	**0.6**
Pasture/Hay	11.88	0.2
Row Crops	0	0

Impervious Surface	**Acres**	**% Area**
Impervious Land	1811.2	30.21

LPAX-43-2011 | LPK Subwatershed

Upstream View:

Latitude: 39.1440169295

Downstream View:

Longitude: -76.7581064463

Located just off of Race Road between Citrus Avenue and Sellner Road, this site is part of the LPK subwatershed. This site is deeply incised most likely due to a road culvert located just upstream. A 2 foot drop below the culvert is causing a severe fish blockage. The reach is overwidened leading to mid-channel bars and areas of active bank erosion, indicating an unstable stream type. Shallow, poor quality riffles provide inadequate habitat leading to a very poor biological community with low taxa diversity. There was a complete lack of Ephemeroptera taxa and climber taxa in the benthic sample; however over half of the sample (59%) consisted of taxa intolerant to urban stressors. The small drainage area to this site (89 acres) is largely forested land (79%) with 17% as developed land. Only 9% of the drainage area is impervious surface. Conductivity levels were elevated considerably, possibly due to highway runoff from Baltimore-Washington Parkway (Rt. 295) and Jessup Road (Rt. 175) or from the corrugated metal culvert pipe immediately upstream of the sampling reach.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges (Hydrobaenus) and black flies (Stegopterna) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Moderately unstable banks, poor instream habitat, and marginal epibenthic substrate. Refuse present in moderate amounts.

Water Chemistry:

Dissolved Oxygen (mg/L)	10.21
Turbidity (NTU)	7.79
Temperature (°C)	8.47
pH (SU)	7.26
Specific Conductivity (µS/cm)	758

LPAX-43-2011 LPK Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	10
EPT Taxa	1
Ephemeroptera Taxa	0
Intolerant Urban %	58.6
Ephemeroptera %	0
Scraper Taxa	1
% Climbers	0

Calculated Metric Scores

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

Taxa	Count
Diamesa	2
Heterotanytarsus	2
Hybomitra	1
Hydrobaenus	30
Nemouridae	1
Neoporus	3
Orthocladius	9
Podmosta	1
Stegopterna	65
Thienemannimyia group	1
Zavrelimyia	1
TOTAL:	**116**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	5	Pool Variability	6
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	10	Riparian Vegetative Zone Width- Right Bank	4
Channel Flow Status	7	Sediment Deposition	7
Channel Sinuosity	9	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	7		
EPA Habitat Score			**84**
EPA Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	2	10.77	Woody Debris/Rootwads	4	82.69
Shading	75	73.32	Instream Habitat	5	62.46
Epifaunal Substrate	6	61.8	Bank Stability	8	63.25
PHI Score					**59.05**
PHI Narrative Rating					**Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 89.3

Cover	Acres	%Area
Developed Land	**15.38**	**17.22**
Commercial	3.37	3.77
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0.17	0.19
Residential 1-Acre	0.88	0.98
Residential 2-Acre	3.23	3.61
Transportation	7.74	8.67
Utility	0	0
Forest Land	**70.65**	**79.11**
Forested Wetland	0	0
Residential Woods	0	0
Woods	70.65	79.11
Open Land	**3.27**	**3.67**
Open Space	3.27	3.67
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	7.9	8.82

LPAX-46-2011 — LP4 Subwatershed

Upstream View:

Downstream View:

Latitude: 39.0608370599

Longitude: -76.7392940294

Located in the Patuxent Research Refuge just west of Wildlife Loop Road, this site is part of the LP4 subwatershed. The majority of the 596 acre drainage area to this site is forested land (94%) with 6% as open space. Less than 1% of the entire drainage area is impervious surface (0.2%). This site is a low gradient stream on the floodplain of the Little Patuxent River with reduced flow due to debris jams just upstream. With an entirely silt/sand bottom, there is very little stable habitat and an abundance of fine particulate organic matter. A complete lack of EPT, Ephemeroptera, and scraper taxa resulted in a very poor biological community. Although habitat is partially supporting, instream habitat and epifaunal substrate were rated in the poor categories, limiting the streams ability to support a diverse biological community. Furthermore, the acidic pH values (below COMAR standards), which appear to be naturally influenced by the surrounding wetland system draining to the site, may further limit the biological potential of this stream.

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods (Crangonyx) and bivalves (Musculium) dominated the sample.
- Measured below COMAR standards for pH.
- Poor habitat diversity but banks are stable. Very little woody debris present. Good riparian width with sub-optimal vegetative protection.

Water Chemistry:

Dissolved Oxygen (mg/L)	5.09
Turbidity (NTU)	9.09
Temperature (°C)	21
pH (SU)	5.96
Specific Conductivity (µS/cm)	54.4

LPAX-46-2011

LP4 Subwatershed

Biological Assessment

Raw Metric Values

Total Taxa	16
EPT Taxa	0
Ephemeroptera Taxa	0
Intolerant Urban %	15
Ephemeroptera %	0
Scraper Taxa	0
% Climbers	1.8

Calculated Metric Scores

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

Taxa	Count
Bezzia/Palpomyia	1
Bivalvia	2
Caecidotea	17
Chironomus	3
Crangonyx	40
Dicrotendipes	1
Diplocladius	1
Lepidoptera	1
Lumbricina	2
Musculium	37
Paratendipes	1
Polypedilum	1
Simulium	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia group	2
Zavrelimyia	1
TOTAL:	**113**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

Bank Stability- Left Bank	8	Pool Variability	3
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	10	Sediment Deposition	14
Channel Sinuosity	6	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	5	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	8		
EPA Habitat Score			**111**
EPA Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Woody Debris/Rootwads	1	52.33
Shading	95	99.94	Instream Habitat	5	43.04
Epifaunal Substrate	5	43.63	Bank Stability	16	89.45
PHI Score					**67.3**
PHI Narrative Rating					**Partially Degraded**

Land Use/Land Cover Analysis:

Total Drainage Area (acres) 595.52

Cover	Acres	%Area
Developed Land	**0.37**	**0.06**
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	0.37	0.06
Utility	0	0
Forest Land	**557.86**	**93.68**
Forested Wetland	7.59	1.27
Residential Woods	0	0
Woods	550.27	92.4
Open Land	**37.28**	**6.26**
Open Space	32.96	5.54
Open Wetland	0	0
Water	4.32	0.73
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0

Impervious Surface	Acres	% Area
Impervious Land	1	0.17

Appendix B: Bioassessment Results Maps

Appendix C: QA/QC Procedures and Results

Appendix C: Quality Assurance/Quality Control Procedures and Results

A quality assurance and quality control analysis was completed for the data collected for the Little Patuxent Watershed Targeted Biological Assessment following the methods described by Hill and Pieper (2011b). This analysis included performance characteristics of precision, accuracy, bias, sensitivity, and completeness, with comparisons to MQOs. Performance measures include:

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

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

Field Sampling

All field crew leaders were recently trained in MBSS Spring Sampling protocols prior to the start of field sampling. All subjective scoring of physical habitat parameters was completed with the input of all team members at the sampling site to reduce individual sampler bias.

Field water quality measurements were collected *in-situ* at all monitoring sites according to methods in the County QAPP. All *in situ* parameters were measured with a multi-parameter sonde (YSI Professional Plus series or YSI 560 series) except turbidity which was measured with a Hach 2100 Turbidimeter. Water quality equipment was regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

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

Replicate (duplicate) samples were taken at ten percent of the overall sites (four sites), one within each sampling unit. QC samples were collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was selected in the field to ensure that the QC sites maintained similar habitat conditions to the original site, and no additional stressors or unusual conditions were present that may affect the biota. Duplicate samples included collection and analysis of the benthic macroinvertebrate community, completion of the RBP and the PHI habitat assessments, and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites. After sampling was completed, a review of physical habitat scores and water quality parameters between the targeted and QC reaches revealed similar physical habitat and water chemistry conditions. Consequently, it is expected that targeted and QC reaches would support similar benthic macroinvertebrate communities, and random variability between duplicate sample pairs would be minimized.

Precision

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

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

Acceptable measurement quality objectives are listed in Table 1. DNR's MBSS protocols were used for the collection and analysis of macroinvertebrate data.

Table 1 – Measurement quality objectives for metric and index scores

Attribute	MQO[1]		
	Median RPD	RMSE	CV
Total Number of Taxa	20	4.3	20
Number of EPT Taxa	30	1.7	50
Number of Ephemeroptera Taxa	30	2.8	100
Percent Intolerant Urban	80	15.9	80
Percent Ephemeroptera	30	0.5	100
Number of Scraper Taxa	30	0.9	100
Percent Climber	30	6.9	70
B-IBI	20	0.96	22

[1]Values derived from Hill and Pieper, 2011b

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

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

Site	Total Taxa	EPT Taxa	% Ephem	Ephem Taxa	% Intol Urban	Scraper Taxa	% Climbers	BIBI	Rating
LPAX-05-2011	14	0	0.0	0	0.0	2	8.7	2.43	Poor
LPAX-05-2011-QC	15	0	0.0	0	2.0	4	6.9	2.14	Poor
LPAX-18-2011	25	1	0.0	0	0.0	5	13.2	2.71	Poor
LPAX-18-2011-QC	24	0	0.0	0	0.0	5	13.0	2.71	Poor
LPAX-24-2011	20	4	0.0	0	41.2	0	3.9	2.43	Poor
LPAX-24-2011-QC	17	3	0.0	0	49.2	0	0.0	2.14	Poor
LPAX-36-2011	7	0	0.0	0	49.5	0	0.0	1.57	Very Poor
LPAX-36-2011-QC	6	0	0.0	0	85.0	0	0.0	1.57	Very Poor
Median RPD	11.1	14.3	0.0	0.0	35.17	0.0	12.47	6.25	-
RMSE	1.99	0.58	0.00	0.00	7.59	**1.10**	2.01	0.20	-
CV	12.4	**57.7**	0.0	0.0	26.77	54.9	35.20	9.12	-

Both metric values and index scores were compared to MQOs to determine exceedances. One metric, EPT Taxa, exceeded the MQO for CV, but did not exceed the MQO for mRPD or RMSE. The high CV was due to the low occurrence of EPT Taxa in all samples (mostly zero) except LPAX-24-2011, which skewed the CV upward. Another metric, Scraper Taxa, exceeded the MQO for RMSE, but passed mRPD. This was primarily due to one outlier sample pair (LPAX-18-2011), which had a large proportion of Scraper Taxa relative to the other samples. All other values were within acceptable ranges.

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, approximately 59 percent (26 samples) underwent quality control procedures for sorting, above the ten percent requirement. Average percent sorting efficiency was 95.9% (n= 26). All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked, while ten percent of samples sorted by experienced laboratory personnel were also checked. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters.

Taxonomic Identification and Enumeration

Four samples (LPAX-02-2011, LPAX-06-2011, LPAX-26-2011, and LPAX-33-2011) were randomly selected for QC identification and enumeration by an independent lab. Original identification was completed by Environmental Services and Consulting, LLC[1] (ESC). Re-identification of the randomly selected sites was done by Aquatic Resources Center[2]. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

Precision

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

The PDE compares the final specimen counts between the two taxonomy labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the QAPP, the PDE for each sample must be equal to or less than 5%, and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD for all four samples are found in Tables 3-7.

The PDE was below the MQO value of 5% for all verification samples. Following re-identification by the secondary laboratory, the initial PTD of one sample (LPAX-26) exceeded the acceptable

[1] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA
[2] Address: 545 Cathy Jo Circle, Nashville, TN

MQO value of 15%. There was a minor discrepancy between laboratories concerning two genera of Orthocladiinae (Midges), *Eukiefferiella* and *Tvetenia,* partially due to some specimens being mounted on their side where key distinguishing features were obscured. The secondary laboratory took a second look at the specimens under oil and verified that the individuals in question had the characteristics of *Tvetenia,* which agreed with the primary identification. There was another minor discrepancy between laboratories concerning two genera of Nemouridae (Stoneflies), *Podmosta* and *Paranemoura,* which was resolved when the secondary taxonomist concurred with the primary identification of *Podmosta.* There was also a hierarchical disagreement between five Simuliidae (Blackfly) pupae, where the primary taxonomist was able to key them to genus, while the secondary taxonomist left them at family level. Upon closer inspection by the secondary laboratory, the five specimens were keyed out to genus level as *Stegopterna,* resulting in a full agreement for those specimens. As a result, there were enough agreements to reduce the PTD for sample LPAX-26 to an acceptable value of 14%.

Summary

A summary of QC results for this sampling period, as compared to established MQOs, for each activity in the biological sampling process is displayed below in Table 3. Results indicate that all MQOs were met for this project, and subsequently, all data are of acceptable quality as specified by the QAPP.

Table 3. Summary comparison of QC results and measurement quality objectives[1].

Activity	Performance Indicator	Measure	MQO	2011 Results
Field Sampling	Precision	mRPD (BIBI)	<20	6.25
		RMSE (BIBI)	<0.6	0.2
Laboratory Sorting/Subsampling	Bias	PSE	>90	95.9
Taxonomic Identification	Precision	PDE	<5	1.1
		PTD	<15	10.2
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	0.33

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

Table 4 - Taxonomic Identification and Enumeration Results: LPAX-02-2011

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
Diptera	Ceratopogonidae	-	-	Ceratopogonidae	1	1	1
	Chironomidae	-	-	Chironomidae	1	0	0
	Chironomidae	Chironominae	Chironomini	Microtendipes	4	4	2
	Chironomidae	Chironominae	Chironomini	Polypedilum	2	2	2
	Chironomidae	Chironominae	Tanytarsini	Paratanytarsus	2	2	2
	Chironomidae	Chironominae	Tanytarsini	Rheotanytarsus	6	6	6
	Chironomidae	Orthocladiinae	-	Corynoneura	1	1	1
	Chironomidae	Orthocladiinae	-	Eukiefferiella	3	3	3
	Chironomidae	Orthocladiinae	-	Limnophyes	1	1	1
	Chironomidae	Orthocladiinae	-	Orthocladius	13	0	13
	Chironomidae	Orthocladiinae		Cricotopus/Orthocladius	0	13	0
	Chironomidae	Orthocladiinae	-	Parametriocnemus	1	1	1
	Chironomidae	Orthocladiinae	-	Thienemanniella	4	5	4
	Chironomidae	Orthocladiinae	-	Tvetenia	5	5	5
	Chironomidae	Tanypodinae	-	Tanypodinae	1	1	1
	Chironomidae	Tanypodinae	Pentaneurini	Ablabesmyia	1	1	1
	Chironomidae	Tanypodinae	Pentaneurini	Thienemannimyia group	1	1	1
	Chironomidae			Dicrotendipes	4	4	4
	Chironomidae			Potthastia	1	1	1
	Simuliidae	-	-	Simuliidae	2	2	2
	Simuliidae	-	-	Simulium	5	5	5
	Tipulidae	-	-	Tipula	1	1	1
Coleoptera	Elmidae	-	-	Stenelmis	22	22	22
	Elmidae			Dubiraphia	0	1	0
Ephemeroptera	Baetidae	-	-	Acentrella	1	0	0
	Baetidae	-	-	Baetis	1	0	0
	Baetidae	-	-	Baetidae	0	1	0
	Baetidae	-	-	Plauditas	0	1	0
Haplotaxida	Naididae	-	-	Naididae	14	0	14

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
	Naididae	-	-	Nais	0	14	0
	Tubificidae	-	-	Tubificidae	5	1	5
	Tubificidae	-	-	Limnodrilus	0	1	0
	Tubificidae	-	-	Bothrioneurum	0	1	0
	Tubificidae	-	-	Aulodrilus	0	1	0
	Tubificidae	-	-	Spirosperma	0	1	0
Odonata	Coenagrionidae	-	-	Argia	1	1	1
	Coenagrionidae	-	-	Enallagma	1	1	1
Trichoptera	Limnephilidae	-	-	Ironoquia	1	1	1
Bivalvia	Pisidiidae	-	-	Pisidiidae	3	3	3
				Total	109	110	104
				PDE			0.46
				PTD			5.45

Table 5 - Taxonomic Identification and Enumeration Results: LPAX-06-2011

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
Diptera	Chironomidae	-	-	Chironomidae	2	0	0
	Chironomidae	Chironominae	Chironomini	Chironomus	1	1	1
	Chironomidae	Chironominae	Chironomini	Chironomini	3	0	0
	Chironomidae	Chironominae	Chironomini	Polypedilum	0	3	0
	Chironomidae	Diamesinae	-	Potthastia	1	1	1
	Chironomidae	Orthocladiinae	-	Brillia	2	2	2
	Chironomidae	Orthocladiinae	-	Chaetocladius	1	0	0
	Chironomidae	Orthocladiinae	-	Cricotopus	7	0	0
	Chironomidae	Orthocladiinae	-	Orthocladius	75	0	0
	Chironomidae	Orthocladiinae	-	Cricotopus/Orthocladius	0	79	79
	Chironomidae	Orthocladiinae	-	Orthocladiinae	2	5	2

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
	Chironomidae	Orthocladiinae	-	Eukiefferiella	0	1	0
	Chironomidae	Orthocladiinae	-	Hydrobaenus	0	1	0
	Chironomidae	Orthocladiinae	-	Zalutschia	0	1	0
	Chironomidae	Orthocladiinae	-	Parakiefferiella	1	1	1
	Chironomidae	Orthocladiinae	-	Thienemanniella	1	0	0
	Chironomidae	Orthocladiinae	-	Tvetenia	2	2	2
	Chironomidae	Tanypodinae	Pentaneurini	Thienemannimyia group	1	1	1
Coleoptera	Elmidae	-	-	Macronychus	1	1	1
	Elmidae	-	-	Stenelmis	1	1	1
Ephemeroptera	Baetidae	-	-	Acentrella	1	0	0
	Baetidae	-	-	Baetidae	2	3	2
Haplotaxida	Naididae	Naidinae	-	Naidinae	8	0	8
	Naididae	-	-	Nais	0	8	0
Odonata	Aeshnidae	-	-	Boyeria	1	1	1
				Total	113	112	102
				PDE			0.44
				PTD			8.93

B Table 6 - Taxonomic Identification and Enumeration Results: LPAX-26-2011

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
Diptera	Chironomidae	-	-	Chironomidae	1	0	0
	Chironomidae	Chironominae	Tanytarsini	Tanytarsus	8	8	8
	Chironomidae	Orthocladiinae	-	Eukiefferiella	1	1	1
	Chironomidae	Orthocladiinae	-	Parakiefferiella	0	1	0
	Chironomidae	Orthocladiinae	-	Hydrobaenus	1	0	0
	Chironomidae	Orthocladiinae	-	Orthocladiinae	1	1	1
	Chironomidae	Orthocladiinae	-	Paraphaenocladius	2	2	2

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
	Chironomidae	Orthocladiinae	-	Pseudorthocladius	2	2	2
	Chironomidae	Orthocladiinae	-	Tvetenia	8	8	8
	Culicidae	-	-	Aedes	1	0	0
	Simuliidae	Simuliinae	Prosimuliini	Stegopterna	16	18	16
	Simuliidae	Simuliinae	Prosimuliini	Stegopterna	5	5	5
Coleoptera	Curculionidae	-	-	Curculionidae	1	0	0
	Dytiscidae	Hydroporinae	Hydroporini	Hydroporini	1	0	1
	Dytiscidae	Hydroporinae	Hydroporini	Hydroporinae	0	1	0
Haplotaxida	Enchytraeidae	-	-	Enchytraeidae	11	20	11
	not identified	-	-	Lumbricina	9	0	0
	Tubificidae	-	-	Tubificidae	0	1	0
Isopoda	Asellidae	-	-	Caecidotea	21	20	20
Odonata	Libellulidae	-	-	Libellulidae	1		0
	Corduliidae	Corduliinae	-	Corduliinae		1	0
Plecoptera	Nemouridae	-	-	Podmosta	8	8	8
Trichoptera	Limnephilidae	-	-	Ironoquia	2	2	2
				Total	110	99	85
				PDE			0.50
				PTD			14.14

Table 7 - Taxonomic Identification and Enumeration Results: LPAX-33-2011

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
Diptera	Chironomidae	-	-	Chironomidae	1	0	0
	Chironomidae	Chironominae	Chironomini	Chironomini	4	0	0
	Chironomidae	Chironominae	Chironomini	Chironomini	3	3	3
	Chironomidae	Chironominae	Chironomini	Chironomus	1	1	1
	Chironomidae	Chironominae	Chironomini	Dicrotendipes	2	0	0

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
	Chironomidae	Chironominae	Chironomini	Glyptotendipes	8	8	8
	Chironomidae	Chironominae	Chironomini	Phaenopsectra	0	2	0
	Chironomidae	Chironominae	Chironomini	Polypedilum	49	51	49
	Chironomidae	Chironominae	Chironomini	Stictochironomus	0	2	0
	Chironomidae	Chironominae	Chironomini	Tribelos	0	1	0
	Chironomidae	Chironominae	Tanytarsini	Paratanytarsus	1	1	1
	Chironomidae	Chironominae	Tanytarsini	Rheotanytarsus	2	2	2
	Chironomidae	Diamesinae	-	Potthastia	1	1	1
	Chironomidae	Orthocladiinae	-	Chaetocladius	2	2	2
	Chironomidae	Orthocladiinae	-	Hydrobaenus	1	0	0
	Chironomidae	Orthocladiinae	-	Limnophyes	1	1	1
	Chironomidae	Orthocladiinae	-	Parakiefferiella	0	1	0
	Chironomidae	Orthocladiinae	-	Orthocladiinae	1	0	0
	Chironomidae	Orthocladiinae	-	Orthocladius	5	0	0
	Chironomidae	Orthocladiinae	-	Orthocladius	1	0	0
	Chironomidae	-	-	Cricotopus/Orthocladius	0	7	6
	Chironomidae	Orthocladiinae	-	Thienemanniella	1	2	1
	Chironomidae	Tanypodinae	-	Tanypodinae	1	0	0
	Chironomidae	Tanypodinae	Pentaneurini	Thienemannimyia group	5	6	5
	Chironomidae	Tanypodinae	Tanypodini	Clinotanypus	1	1	1
	Simuliidae	-	-	Simulium	8	1	1
Ephemeroptera	Caenidae	-	-	Caenis	2	1	1
Haplotaxida	Enchytraeidae	-	-	Enchytraeidae	1	1	1
	Naididae	-	-	Naididae	2	1	1
	not identified	-	-	Hirudinea	1	1	1
Odonata	Coenagrionidae	-	-	Coenagrionidae	1	0	0
	Coenagrionidae	-	-	Enallagma	0	1	0
	Coenagrionidae	-	-	Ischnura	1	1	1
Trichoptera	Hydropsychidae	-	-	Cheumatopsyche	1	1	1
	Limnephilidae	-	-	Ironoquia	1	1	1
Amphipoda	Crangonyctidae	-	-	Crangonyx	3	3	3

Order	Family	Subfamily	Tribe	Final ID	Primary Taxonomist	Secondary Taxonomist	# of agreements
Basommatophora	Physidae	-	-	Physa	1	1	1
	Planorbidae	-	-	Gyraulus	0	1	0
	Planorbidae	-	-	Menetus	1	1	1
				Total	114	107	94
				PDE			3.17
				PTD			12.15

APPENDIX C

URBAN BMP TECHNICAL MEMORANDUM

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URBAN BEST MANAGEMENT PRACTICES TECHNICAL MEMORANDUM

Subtask 2.2
Little Patuxent Watershed Study

November 2013

Prepared For:
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Introduction

Under Subtask 2.2 of the Little Patuxent watershed study, LimnoTech worked with the Anne Arundel County Department of Public Works to develop a complete geospatial dataset of urban stormwater best management practices (BMPs) within the Little Patuxent watershed. In summary, the effort to develop the dataset entailed four primary steps:

- Step 1 - compiling existing data from multiple County sources;
- Step 2 - identifying BMPs inside the study area;
- Step 3 - performing research to fill any data gaps; and
- Step 4 - delineating BMPs drainage areas.

This Technical Memorandum documents the steps and procedures LimnoTech and the County performed to complete this task. These steps and procedures were performed in accordance with discussions with County personnel and protocols established during previous watershed studies in *Urban Best Management Practices Technical Memorandum* dated June 2011, and *Anne Arundel County Comprehensive Watershed Studies, Subtask 2.2 – SWM Facility Maps Technical Memorandum* dated June 2007.

Step 1 - Compiling Existing Data

The first step in the process was to compile all of the existing BMP records associated with the Little Patuxent watershed. Several sources were utilized in this process. A unique ID was employed in the compiled dataset to identify the original BMP record and source. The following is a list and brief description of the data sources:

- **Urban BMP Database:** This dataset exists as a point shapefile that was derived from the Anne Arundel County Inspections and Permit urban stormwater management database. The dataset contains Anne Arundel County permitted public and private urban BMPs. Facilities permitted directly by other entities are not included in this dataset. This dataset was current through June 2013 and contained 12,891 BMP records.

- **Field Verified BMP Dataset:** During the summer of 2012, LimnoTech and Versar collected limited information on BMPs encountered during stream assessment activities in the study area. The collected information included BMP type, a GPS recorded location, condition notes, and a photo. A total of 129 BMPs were included in this dataset.

- **Capital Improvement Program Restoration Project Dataset:** This dataset represents the location and drainage area of all of the County's Capital Improvement Program stream restoration and other watershed restoration projects. A total of 422 records were included in this dataset.

Step 2 - Identifying BMPs Inside the Study Area

With a draft dataset of BMP records compiled from the sources listed above, LimnoTech worked to identify BMPs known or thought to be inside the study area and remove those BMP records known to be outside of the watershed. This also involved updating spatial locations for BMPs with inaccurate or incomplete spatial attributes. LimnoTech followed the protocols for this step as outlined in the County's June 2007 Technical Memo and in conversations with County personnel. As each BMP data source had different degrees of inherent spatial accuracy, the steps for confirming spatial locations varied among the sources. The procedures for each data source are provided below.

- **Urban BMP Database:** The data contained in this dataset is under review by the Department of Public Works' Infrastructure Management Division and the spatial locations for many BMP records are inaccurate or unknown. The following steps were taken to identify BMP locations in reference to the study area boundaries and update as appropriate:
    - The *XY_Source* field describes the source of the location data and was used to determine whether a BMP location was considered spatially accurate. This field was the primary level of screening for BMPs in the Urban BMP Database. Table 1 at right provides the values in the database for the *XY_Source* field and indicates whether a particular value is considered spatially accurate. BMPs with spatially accurate sources were determined to be inside or outside of the study area. All BMPs identified inside the study area and BMPs with *XY_Source* values deemed to have

Table 1. Urban BMP Database XY_Sources

XY_Source	Considered Spatially Accurate (Y/N)
2007_To_MDE	No
Address	No
AsBuilt	Yes
CleanedbyHand	Yes
Converted 27 to 83	No
converted IP 27 to 83	No
corrected KCI	Yes
County Centroid	No
Countyview	Yes
CPF from TaxAcct	Yes
CPF From TaxAcct	Yes
CPF FROM TAXACCT	Yes
CPF_XY	Yes
CV	Yes
CV from Address	Yes
CV from SCD Map	Yes
Hand Moved _2010	Yes
Hand Moved to Address	Yes
Hand placed on street	Yes
HandMovedfromCentroid	Yes
HandPlacedMay09	Yes
I&P_2011	No
IP	No
IP_2010	No
IP_New09	No
IP_New09IP_New09	No
KCI 2008 GPS	Yes
Magothy Study	Yes
moved to subdivision	No
MovetoOrtho	No
New09	No
Plat	No
PNTStudy	Yes
PTBodkin_Study	Yes
SevernStudy	Yes
SouthStudy	Yes
Structure Address	No
Subdivision	No
UpperPax Study	Yes

questionable spatial accuracy were retained for further research and verification.

- The Parcel and the Structure Address GIS layers were used in tandem with tax account numbers and addresses to determine whether the retained BMPs with questionable spatial data were located inside or outside of the study area. All BMP records with spatial locations and matching tax accounts or addresses outside of the study area were removed from the draft dataset. BMP points located outside the study area, but with a tax account or address associated with a parcel inside the study area, were moved to the study area parcel/address only if other identifying information confirmed it. Unmatched BMPs and matched BMPs inside the study area were retained.
- For the records that still remained at this point, additional checks were performed to locate the remaining subset of BMP records. Looking at each BMP record individually, LimnoTech used various County tools to first positively identify a BMP record from the draft dataset and second to confirm or update its location. Specifically, LimnoTech used the Parcel GIS layer, Structure Address GIS layer, As-built records on CountyView, scanned grading and building permits, other archived electronic records, orthophotography, and GoogleMaps to assist in this process. A record was considered positively identified if two pieces of identifying information matched fields in the BMP dataset.

- **Field Verified BMP Dataset**: BMPs in the Field Verified dataset included a subset of BMPs from the Urban BMP Database as well as additional BMPs found during field activities. Any Field Verified BMP that matched a BMP from the Urban BMP Database was used to verify the spatial location of the Urban BMP then flagged for removal due its limited attribute data. All other Field Verified BMPs were retained and considered spatially accurate.

- **Capital Improvement Program Restoration Project Dataset:** This dataset was considered spatially accurate. CIP data were provided as polygons. LimnoTech used the centroids of each polygon for inclusion into the point database. Project drainage areas that fell within the study area boundaries were retained.

Resolving Duplicate Records

Given that data was compiled from multiple datasets, it is inevitable that there were duplicate records. Note that the degree of identifying information available made it very difficult to identify duplicates within an individual data source. As such, an effort to identify and remove duplicates was only rigorously performed between data sources. LimnoTech identified duplicate records by examining attributes and spatial locations. Best professional judgment was used to identify and remove duplicate records only when points were co-located with matching identifying attributes and structure

Step 3 - Performing Research to Fill Data Gaps

LimnoTech researched data gaps concurrently with the step to confirm and update spatial locations at the County offices (see previous section). Looking at each BMP record individually, LimnoTech used County tools including As-builts on CountyView, scanned grading and building permits, and other archived electronic records to fill in data gaps. The following data were researched:

- **Drainage Area:** The design drainage area for the majority of records was found in the existing compiled datasets. For records with null or zero values, the scanned grading and building permits, archived records, and As-builts on CountyView were researched for the information. This data was captured in the final dataset in the field, *Drainage*. Units are in acres.

- **Structure Type:** The structure type was documented using structure codes in accordance with the County BMP master list. For records with missing structure type information, the scanned grading and building permits, archived records, and As-builts on CountyView were researched for that information. This data was captured in the final dataset in the field, *STRUCTYPE*.

- **Approval Date:** When available, the approval date for the majority of records was found in the existing compiled datasets. For records without approval dates, the scanned grading and building permits, archived records, and As-builts on CountyView were researched for the information. This data was captured in the final dataset in the field, *APPRDATE*.

- **Built Date:** When available, the built date for the majority of records was found in the existing compiled datasets. For records without built dates, As-builts on CountyView were researched for the information. This data was captured in the final dataset in the field, *BUILT_DATE*.

- **Ownership:** The BMP owner was only compiled if it existed in the original dataset or if it was revealed during the record research to identify spatial locations, drainage areas, or structure types. This data was captured in the final dataset in the field, *OWNERSHIP*.

Step 4 - Delineating BMP Drainage Areas

To properly account for load reductions associated with BMPs in the County's modeling efforts, LimnoTech and the County worked to delineate drainage areas for all BMPs. Drainage area delineations were handled differently depending on the BMP structure type, the original data source, and the accuracy of the BMP's spatial location. The *Delineate* field in the final dataset was created and populated to categorize the method used to determine the BMP drainage area. The *WMT_DA* field was used to capture the drainage area acreage in the final dataset.

- Drainage area polygons for BMPs associated with the **Urban BMP Database** and **Field Verified BMP Dataset** were delineated as follows:
    - The points for BMPs with typically large drainage areas (*e.g.*, wet ponds, dry ponds, infiltration basins, wetlands) and with accurate spatial locations were snapped to the nearest flow accumulation grid cell that captured the approximate design drainage area. Occasionally, it was necessary to snap two points representing the same BMP. This was only done when the flow accumulation path was split and one point would not allow for appropriate drainage delineations. The drainage area was then delineated using the flow accumulation grid and the ArcHydro Batch Watershed Delineation tool. The *Delineate* field for all of these BMPs was marked as "Snapped."

- The points for BMPs associated with rooftop drainage (***e.g.***, dry wells and dry well infiltration trenches) were placed on the building polygon centroid. The building polygon was then used to represent the BMP drainage area. For the few newer BMPs for which a building polygon did not yet exist in the County GIS layer, a building size was recorded or estimated from available information and an equivalent-sized polygon was created to represent the drainage area. The ***Delineate*** field for all of these BMPs was marked as "Building Footprint."
- The points for the few BMPs that were designed for parcel or lot level stormwater management (***e.g.***, permeable pavement) and that were not delineated using the flow accumulation grid, were placed on the parcel or lot centroid. The associated parcel polygon was used to represent the BMP drainage area. The ***Delineate*** field for these BMPs was marked as "Lot Footprint."
- For the few BMPs where the design drainage area was known, but only the general location of the BMP was known, an artificial circular drainage area polygon was created. This was accomplished by calculating the radius of a circle with an area equivalent to the known drainage area. This radius was then used to draw a buffer around the general location of the BMP. The polygon created from this buffering step was used as the BMP drainage area. The ***Delineate*** field for these BMPs was marked as "Buffer."
- For BMPs with no measurable water quality benefit (***e.g.***, pre-treatment BMPs), drainage areas were not created. The ***Delineate*** field for these BMPs was marked as "No WQ – No DA."
- A small subset of BMPs with limited attributes and/or questionable spatial locations were categorized as "Missing Records" in the ***Delineate*** field. These BMPs will be researched further under another task as additional data becomes available.

- Drainage area polygons for BMPs associated with the **Capital Improvement Program** were previously developed as part of the original dataset development. These drainage area polygons were used as-is with no modifications.

Once the drainage areas were created or compiled for each BMP in the final dataset, the County set up a topology to identify overlapping drainage areas. Where drainage areas overlapped, best professional judgment was used to determine which BMP was predominantly managing a particular intersected drainage area. Overlapping drainage area polygons were assigned to the closest BMP with the assumption that the closer a drainage area polygon was to a particular BMP the more likely it was to be treated by that facility. The drainage area polygon was then assigned to the predominant BMP. This was performed to ensure that only a single BMP managed a particular area and that the appropriate BMP was receiving the management credit.

Final Data Deliverables

In addition to this Technical Memo, the data deliverables for this subtask also included:

- a point shapefile representing all BMP locations with compiled, verified, and researched attributes; and
- a polygon shapefile representing the BMP drainage areas.

Summary of Findings

During the research efforts above, a total of 490[1] BMPs were confirmed to be in the Little Patuxent watershed. These BMPs will be used for additional analyses in the watershed study, including the evaluation of water quality under various current and future development scenarios. An additional 223 BMPs were researched and are either missing information or are non-credit BMP types.

[1] Ten BMPs were split into multiple pour points (30 in total) for delineation purposes. Therefore, a total of 508 features exist in the BMP database.

APPENDIX D

CONCEPT DESIGN PLANS

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Conceptual Design Plan

Project Overview

This conceptual plan consists of retrofitting an existing neighborhood in Crofton adjacent to the Crofton Country Club, by applying Environmental Site Design (ESD) techniques to the Maximum Extent Practicable (MEP) . Stormwater runoff from this residential area is contributing to severe erosion downstream of the stormwater collection system outfall. This plan features the use of bioretention, water quality swales, and permeable surface in the road Rights-of-Way, sidewalk replacement with permeable surface, and rain harvesting system installation to reduce the volume of runoff and improve water quality. A 1" rain event was used to size all ESD practices, with the exception of rain harvesting systems; they are intended to capture a 0.2" rain event.

Project Type: Stormwater retrofit to the Maximum Extent Practicable (MEP)

Watershed: Little Patuxent

Subwatershed: Crofton Golf (Shed Code: LPG)

Location: This Crofton neighborhood is accessible via Crofton Parkway, and is bounded by Harcourt and Harwell Avenues. It is surrounded on three sides by the Crofton Country Club (Figure 1).

Figure 1 - Project Location Map

Project Description

The Crofton neighborhood served by Harcourt and Harwell Avenues is a low/medium density residential area consisting of single-family houses. It is served by 13 catch basins (GIS-verified), 11 of which are street inlets. The stormwater outfall is to a stream on the northwest edge of the neighborhood, on the site of the Crofton Country Club. All houses in the community have driveways and garages in addition to on-street parking. There are tree lawns between the streets and sidewalks. The street areas along the curbs, the tree lawns, and the sidewalks are the prime retrofit opportunities for stormwater treatment to the MEP. Also, the single-family homes in the community all have roof area sufficient to justify rain harvesting systems for each home. The purpose of this concept plan is to incorporate ESD to the MEP.

Figure 2 - Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Low/Medium-Density Residential (93%), Natural Features (7%)

Drainage Area: 18.65 acres

Impermeable Area: 6.02 acres

Surface Soils: 100% Hydrologic Soil Group B (requires field verification)

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	74.82	0.604	9.0	15.0	0.73	1.09

Conceptual Design

The conceptual design for ESD to the MEP in the neighborhood consists of bioretention cells, permeable surface for streets and sidewalks, bio-swales, and rain harvesting systems to treat stormwater runoff. Eight bioretention cells totaling 3,372 square feet, 27 strips of permeable street surface totaling 9,613 square feet, permeable sidewalk throughout the neighborhood totaling 18,742 square feet, and 18 bio-swales totaling 2,664 square feet have been initially identified to address the water quality volume from a one inch rain event. Additionally, rain harvesting systems installed at every house will supplement overall retention by capturing the water quality volume from a 0.2 inch rain event. Table 2 provides a detailed review of the water quality volume calculations associated with these practices. The location of the practices represents the maximum treatment available for feasible areas within the overall drainage area (Figure 3).

Conceptual Design Plan

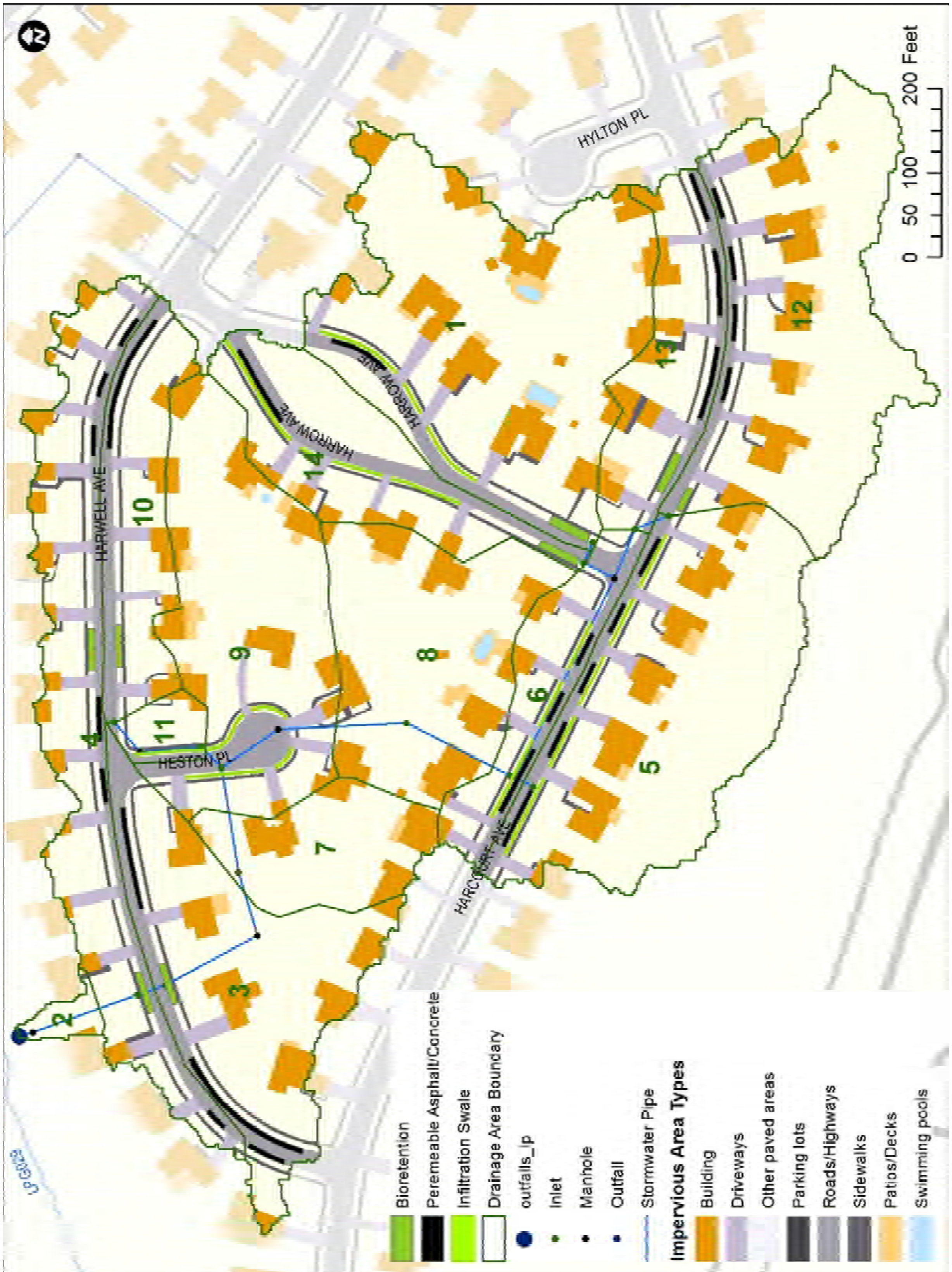

Figure 3 - Plan View of ESD Retrofit

Wherever possible, bioretention cells are located along the existing flow paths. Catch basins that are located nearby the bioretention cells will remain and will collect runoff in excess of that produced by a 1" rain event. The bioretention cells' overflows will empty into existing catch basins. Runoff that is unable to enter the bioretention cell will bypass the cell and flow along the street to the downstream catch basin. Bioretention cells will include enhanced underdrains that allow for sump-type retention in the practice's storage layer, unless further soil investigations prove that the infiltration rates are sufficient to exclude underdrains.

Soil media within the bioretention cells will consist of four different layers of media (Figure 4). The top layer shall include 2 to 3 inches of double shredded hardwood mulch to protect the soil media from erosion, reduce weed growth, retain moisture, and provide some filtration. The second layer shall be an engineered media of approximately 85% sand, 10% soil fines, and 5% organic leaf compost. The soil media shall also have a phosphorus index (P-index) of 10 to ensure that the system is not exporting phosphorus. Maximum infiltration rates need to be between one and six inches per hour and the porosity should be approximately 30%. The third bioretention layer is a choking layer used to prevent downward movement of the engineered media. The choking layer shall be a 4-inch layer of washed sand over a 2-inch layer of washed gravel (ASTM No.8 or No. 89). The choice of choking layer will depend on the head space available. The final layer of the bioretention cell is a stone reservoir layer. This layer provides additional retention capacity for larger storm events. The perforated underdrain pipe will be laid near the top of the reservoir layer to allow for sump-type retention. The stone reservoir layer shall be comprised of washed ASTM No. 57 gravel.

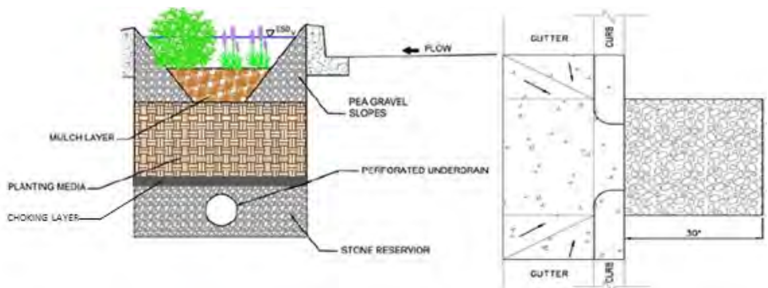

Figure 4 - Typical Cross Section of Bioretention (MDE 2009) and Curb Cut

Permeable surfaces have been selected to provide stormwater retention and treatment beneath the streets and sidewalks. Types of permeable surface could include permeable interlocking concrete pavers (PICP), porous asphalt (PA), and pervious concrete (PC). Other permeable pavements surfaces may include concrete grid pavers and plastic reinforcing grid pavers. A practical benefit of permeable pavement is that it does not reduce the availability of on-street parking. Permeable pavement and porous concrete allows for stormwater runoff to percolate through the permeable surface into the subgrade, given adequate infiltration rates in the underlying soils. The quantity of runoff retention depends upon the depth of gravel substrate beneath the permeable surface. As with the bioretention cells, underdrains for the engineered permeable surfaces may be required, depending on the results of field investigations of soil infiltration rates. Figure 5 shows a typical permeable pavement cross-section.

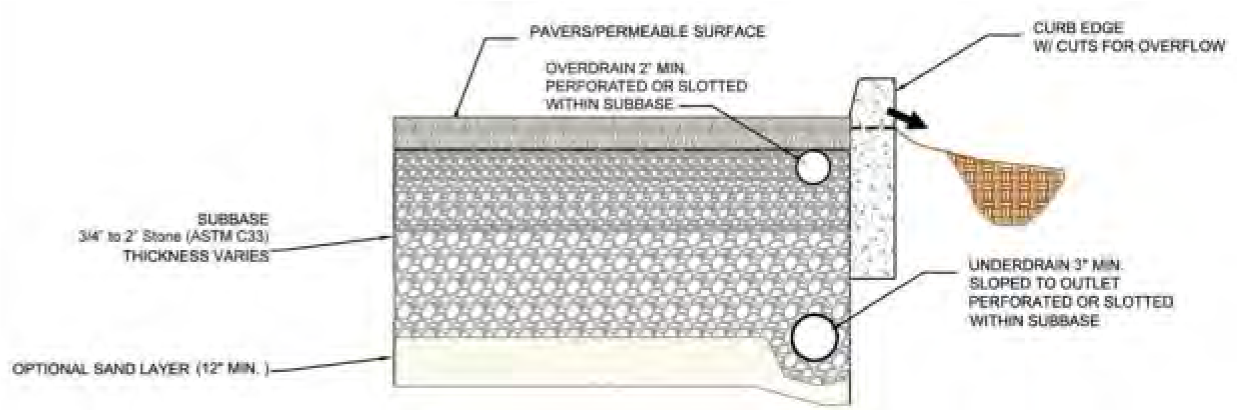

Figure 5 - Typical Cross Section of Permeable Pavement (MDE 2009)

Bio-swales have also been selected to enhance stormwater retention and treatment. Bio-swales provide conveyance, water quality treatment, and the attenuation of stormwater runoff. Bio-swales reduce the pollutant load through vegetative filtering, sedimentation, and biological uptake. The bio-swales proposed for this design have cross-sections identical to those of the bioretention cells, but are narrower so that the can be accommodated by the tree-lawn areas between sidewalk and street. They also feature vertical or near-vertical sides in order to fit within the narrow tree-lawn spaces. As with the bioretention cells, field investigation of soil infiltration rates will determine the need for underdrains.

Rain harvesting systems (Figure 6) have also been identified as another means of intercepting and storing rainfall for future use. The stored water may be used for outdoor landscaping irrigation, washing, and as a source of non-potable water. The concept plan calls for a rain harvesting system consisting of two interconnected rain barrels to be installed at every house in the community. While most houses have roof areas that could accommodate more rain barrels, usage of more than two barrels is unlikely for most residents. The houses' rain leaders will need to be modified so water can be diverted to the rain barrels. The pollutant removal capability of a rain barrel is proportional to the amount of runoff captured, stored, and reused. Rain barrels must be operated and maintained so that storage volume is available. This typically involves taking rain barrels offline during winter months to prevent freezing and damage to the rain barrels.

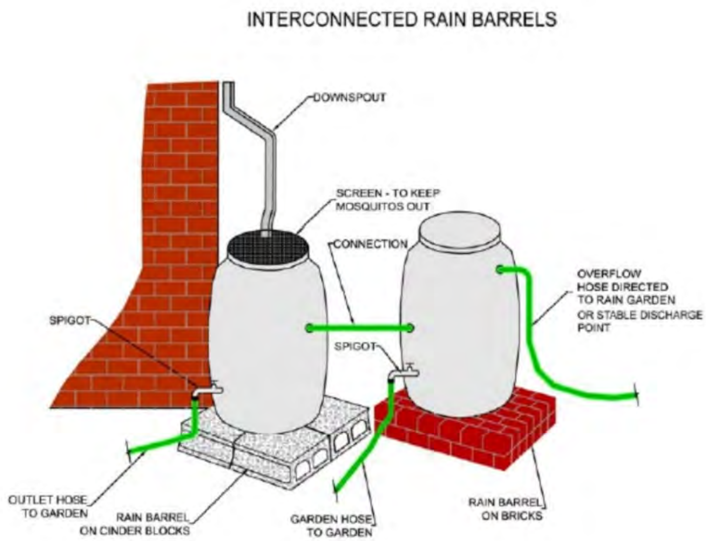

Figure 6 – Rain Harvesting System Example: Interconnected Rain Barrels (MDE 2009)

ESD Practices Summary

Table 1 - Water Quality Volume Calculations

Subshed	Permeable Sidewalk[1] surface area (ft^2)	Bioretention Cell[2] surface area (ft^2)	Permeable Street[1] surface area (ft^2)	Bio-swale[2] surface area (ft^2)	Rain harvesting[3] WQv (ft^3)	Total WQv captured, all practices (ft^3)	Available WQv (ft^3)	Percent WQv Captured
1	1,559	554	432	412	76	2,140	3,144	68%
2	-	-	-	-	-	0	39	0%
3	2,204	402	1,616	-	76	2,730	2,375	115%
4	3,525	831	1,372	-	-	3,686	2,729	135%
5	1,657	-	1,504	617	63	2,514	2,461	102%
6	1,548	-	1,004	408	25	1,923	1,149	167%
7	-	-	-	-	38	38	699	5%
8	-	-	-	-	76	76	1,486	5%
9	1,124	-	-	478	63	1,167	2,228	52%
10	1,750	399	733	-	38	1,887	1,371	138%
11	511	-	-	149	-	441	195	226%
12	1,466	237	983	-	76	1,759	2,336	75%
13	1,553	495	1,376	-	38	2,242	1,442	155%
14	1,846	455	594	600	-	2,414	1,376	175%
Total	**18,743**	**3,373**	**9,614**	**2,664**	**569**	**23,017**	**23,030**	**n/a**

1 : Permeable surface volumes based on assumed porosity of 0.3 and depth of 2 ft.

2 : Bioretention cell and bio-swale volumes based on an assumed porosity of 0.3 and an available reservoir depth of 3 ft.

3: Rain harvesting WQv assumes two 55-gallon rain barrels for each house, with no retention available for 3 months of the year (winter).

Project Cost Estimate

Cost estimates for this concept design are based on unit costs developed by King and Hagan (2011). This source only included costs for new permeable surface installations, and did not provide costs for retrofit installations. The source's costs for bioretention cell retrofits were four times greater than for new bioretention cell construction, so that factor of four was applied to the new permeable surface costs to estimate a retrofit cost. Table 2 shows the costs broken down by drainage and a final estimate of $1,153,391. Costs do not include maintenance.

Table 2 Design Cost Estimate

Practice Type	Impermeable Area Treated (acres)	Pre-construction Cost ($/imp-acre)	Construction Cost ($/imp-acre)	Total Unit Cost ($/imp acre)	Total Cost
Permeable Surfaces (sidewalks and streets)	0.65	$87,120	$871,200	$958,320	$622,908
Bioretention Cells	2.47	$52,500	$131,250	$183,750	$453,863
Bio-swales	1.61	$12,000	$30,000	$42,000	$67,620
Rain Harvesting Systems[1]	0.87	n/a	n/a	n/a	$9,000
				Total Estimated Cost	**$1,153,391**

1 : Cost estimated at $200 per house, 45 houses in neighborhood drainage area (covers two rain barrels and installation/connection hardware)

*LimnoTech's cost estimate is based on experience and best professional judgment. However, LimnoTech cannot not guarantee that proposals, bids, or actual Construction Cost will not vary from the opinions or estimates of potential Construction Cost as presented. Variations in cost estimates may be a result of final designs, the cost of labor, materials, equipment, or services furnished by others, or contractors' methods of determining prices, or competitive bidding or local market conditions.

Project Benefits

Water Volume Reductions: Through a combination of bioretention cells, permeable surfaces, rain harvesting systems, and bio-swales, the quantity of water entering Crofton Golf will be reduced. All practices capture water within the drainage area.

Water Quality Benefits: The installation of the practices in the neighborhood should result in the improvements to water quality that are summarized in Table ***3***.

Table 3. Pollutant Load Reductions

	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	152.1	17.8	1.2
Post-Restoration	76.1	7.1	0.12
% Reduction	50%	60%	90%

Aesthetic Benefits: The plantings associated with the bioretention cells and bio-swales, if properly maintained, will provide aesthetic improvements to the neighborhood.

Education & Outreach: The process of siting, installing, and maintaining ESD practices offers the opportunity to engage the public about these practices and educate them about the local and regional benefits of green infrastructure. Public workshops can help to explain how each ESD practice functions, and can convey property owner responsibilities for proper rain harvesting system operation and maintenance.

Traffic Calming: The bump-outs to accommodate the bioretention cells will provide traffic-calming on the neighborhood's streets.

Project Constraints

Public Property Boundary: All work, with the exception of rain barrel installation, must be completed within the ROW to allow for proper maintenance and ownership rights.

Design/Construction: A topographical survey is necessary prior to further design, to confirm the sub-drainage area delineations. Final design will also require geotechnical investigations. Infiltration testing and borings of the project location soils needs to be completed to better inform design and to determine whether practices require underdrains.

Utilities: There may be underground utilities along the right of way. This has the potential to reduce the depth of the stormwater management practices. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Much of this concept plan will impact the paved portion of neighborhood streets. A tree protection plan is recommended to ensure that tree root systems are properly maintained and avoided during construction. Other environmental impacts are not anticipated for this design.

Community Impacts: The permeable surface installation will reduce street parking temporarily. The bioretention cell bumpouts will reduce available street parking permanently. Rain barrels will need to be actively used and maintained by residents.

Erosion and Sediment Control: Proper erosion and sediment controls are required during construction. It will be necessary to block off some catch basins during retrofits to ensure that excess solids are not entering the stormwater collection system or newly constructed practices.

Maintenance: Proper design and construction of a BMP is essential to its ability to detain runoff and adequately remove pollutants from stormwater. Equally important is the proper operation and upkeep of such a facility. Without proper maintenance, a BMP will not function as it is intended and, in some instances, may cause a host of problems from endangering the public to nuisance odors to reduced property values.

References

King, Dennis and Patrick Hagan. 2011. Costs of Stormwater Management Practices in Maryland Counties. Ref. no. [UMCES] CBL 11-043. Avaialble at: http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Documents/King_Hagan_Stormwater%20Cost%20Report%20to%20MDE_Final%20Draft_12Oct2011.pdf

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Neighborhood Images (From Google Street View)

Figure 3 - Harwell Avenue at Harcourt Avenue

Figure 4 - Harcourt Avenue, Looking East

Figure 5 - Harwell Avenue at Heston Place

Figure 6 - Heston Place cul de sac

Project Overview

This conceptual plan consists of stormwater retrofits by applying Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP) retrofit of the Nantucket Elementary School property. Runoff from this property are contributing to erosion downstream of the stormwater collection system outfall. This plan features the use of bioretention, permeable pavers, bio-swales, and rain-water harvesting utlizing a cistern to reduce the volume of runoff and improve water quality from a 1-inch precipitation event. This 1" rain event was used to size all ESD practices, with the exception of the cistern; it is intended to capture a 1.7" rain event.

Project Type: Stormwater to the Maximum Extent Practicable (MEP) Retrofit

Watershed: Little Patuxent

Subwatershed: Towsers Branch 3 (Shed Code: LPC)

Location: Nantucket Drive is the main street accessing Nantucket Elementary School. Nantucket Drive is accessible from Johns Hopkins Rd and Riedel Rd which both intersect Crain Highway. (Figure 1)

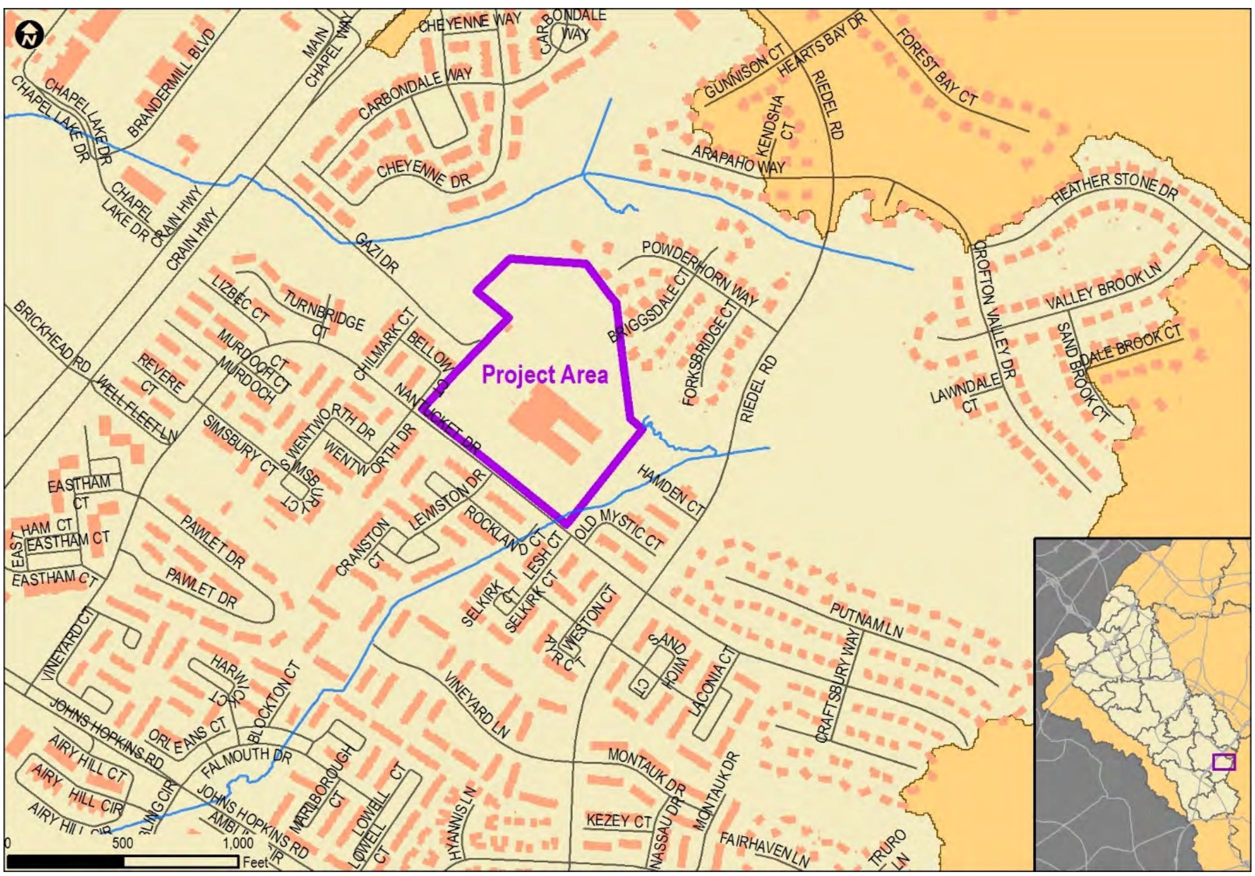

Figure 1 Project Location Map

Project Description

Nantucket Elementary School is owned and maintained by Anne Arundel County Public Schools. The 7 acre school site (total parcel is15 acres) consists of parking lots, sidewalks, a single building, courtyard areas, and multiple recreation areas (Figure 2). Currently, a stormwater collection system with 12 catch basins conveys water to the County's collection system along Nantucket Drive. A small portion of the impervious area flows to the east of the school building. The parking lot and building roof areas are the prime opportunities for retrofits of stormwater management to the MEP. Construction plans were made available by the County for an addition to school which occurred in 2014/2015 (AACPS 2014). The plans showed utilities, topography, and other relevant features. The addition included a bioretention facility to capture the runoff from the addition, while the remaining impervious area remained untreated. The purpose of this concept plan is to incorporate ESD to the MEP.

Figure 2 Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Government/Institution (100%)

Drainage Area: 7.04 acres

Impervious Area: 4.82 acres

Surface Soils: 100% Hydrologic Soil Group C (requires field verification)

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	93.8	0.094	20.0	26.0	1.99	2.50

Conceptual Design

The conceptual design for ESD to the MEP practices at the school focuses on the use of bioretention, permeable pavers, a bio-swale, and a cistern to capture stormwater runoff. eleven bioretention cells totaling (8,311 square feet), 2 strips of pervious pavers totaling (11,364 square feet), 1 bio-swale totaling (2,141 square feet) and a cistern have been initially identified to address the water quality volume from a one inch storm. Detailed water quality volume calculations are provided in Table 1. The location of these practices represents the maximum treatment available for feasible areas within the drainage area (Figure 3).

Conceptual Design Plan

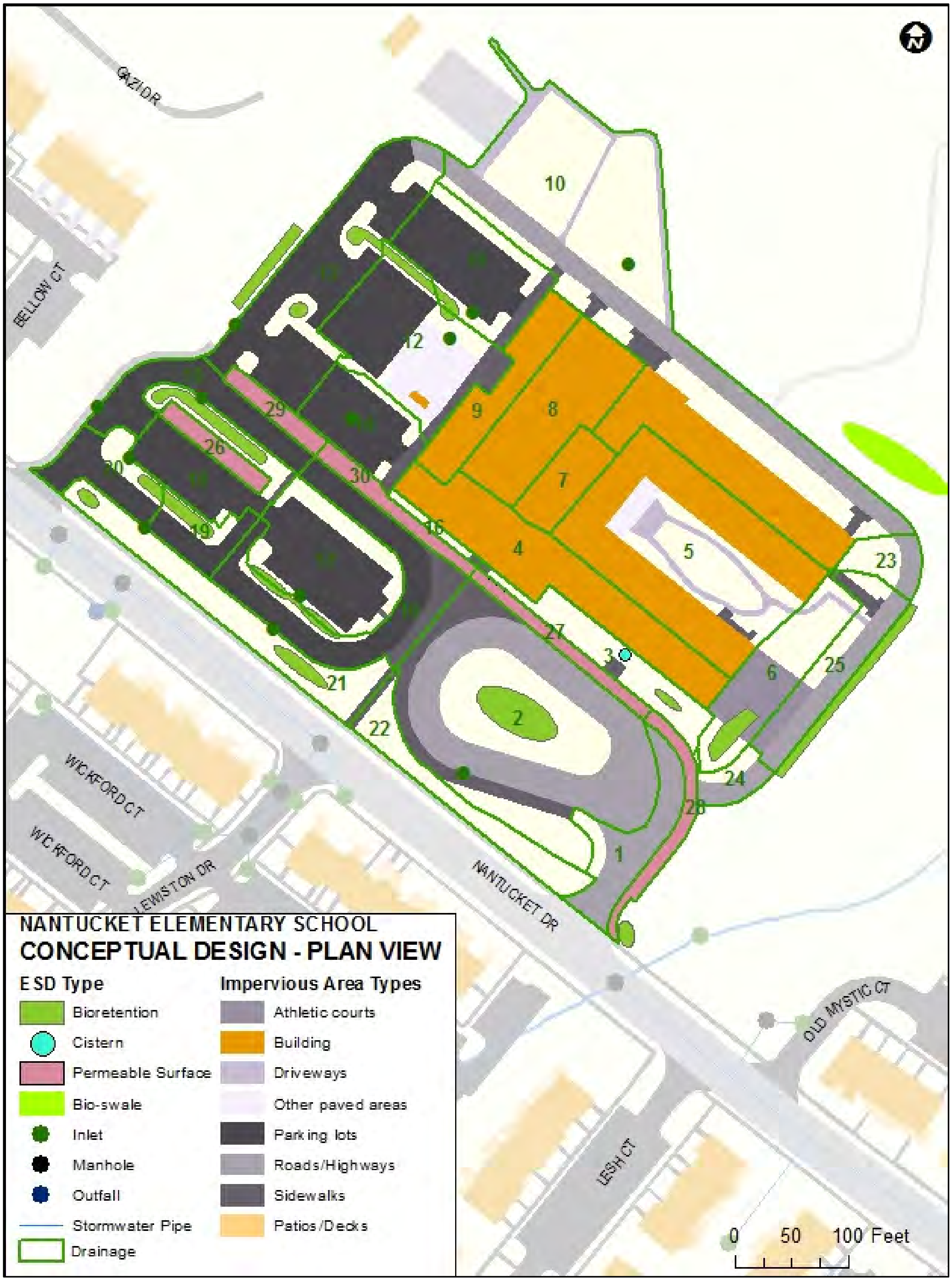

Figure 3 Plan View of ESD Retrofit

Wherever possible, bioretention cells are located along the existing flow paths. Existing catch basins that are located near the bioretention cells will remain and will collect runoff in excess of that produced by a 1-inch rain event. The bioretention underdrain will connect directly to the existing stormwater lateral or manhole depending on the site conditions. Any flows in excess of the ESD practices will flow into catch basins. At proposed ESD locations not coinciding with a current catch basin, a new connection to the stormwater infrastructure will have to be made. Depending on the situation, this will necessitate the creation of a new connection or manhole. All bioretention cells will have underdrains unless further soil investigations prove that the infiltrations rates are sufficient to preclude them.

Soil media within the bioretention cells will consist of four different layers of media (Figure 4). The top layer shall include 2 to 3 inches of double shredded hardwood mulch to protect the soil media from erosion, reduce weed growth, retain moisture, and provide some filtration. The second layer shall be an engineered media of approximately 85% sand, 10% soil fines, and 5% organic leaf compost. The soil media shall also have a phosphorus index (P-index) of 10 to ensure that the system is not exporting phosphorus. Maximum infiltration rates need to be between one and six inches per hour and the porosity should be approximately 30%. The third bioretention layer is a choking layer used to prevent downward movement of the engineered media. The choking layer shall be a 4-inch layer of washed sand over a 2-inch layer of washed gravel (ASTM No.8 or No. 89). The choice of choking layer will depend on the head space available. The final layer of the bioretention cell is a stone reservoir layer. This layer provides additional retention capacity for larger storm events. The perforated underdrain pipe will be laid near the top of the reservoir layer to allow for sump-type retention. The stone reservoir layer shall be comprised of washed ASTM No. 57 gravel.

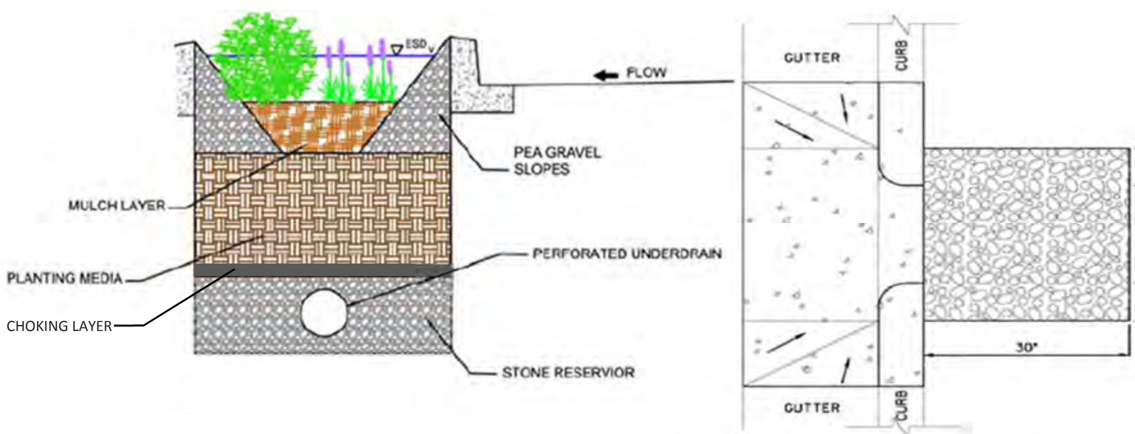

Figure 4 Typical Cross Section of Bioretention (MDE 2009) and Curb Cut

Pervious pavers have been selected to provide temporary stormwater storage and treatment beneath the sidewalks and parking area (Figure 4). A practical benefit of pervious pavers is that it does not reduce the availability of parking space at the school. Pervious pavers allow for stormwater runoff to percolate through the permeable media into the subgrade. The quantity of runoff detention depends upon the depth of gravel substrate beneath the pavers and elevation of the underdrain. An infiltration test must performed by a geotechnical engineer to determine the soil conditions. Pervious paver practices will be connected through the underdrain to the stormwater collection system. The pervious paver materials can be either concrete or brick depending on the County's preference. Pervious pavement may also be considered for the parking lot strip.

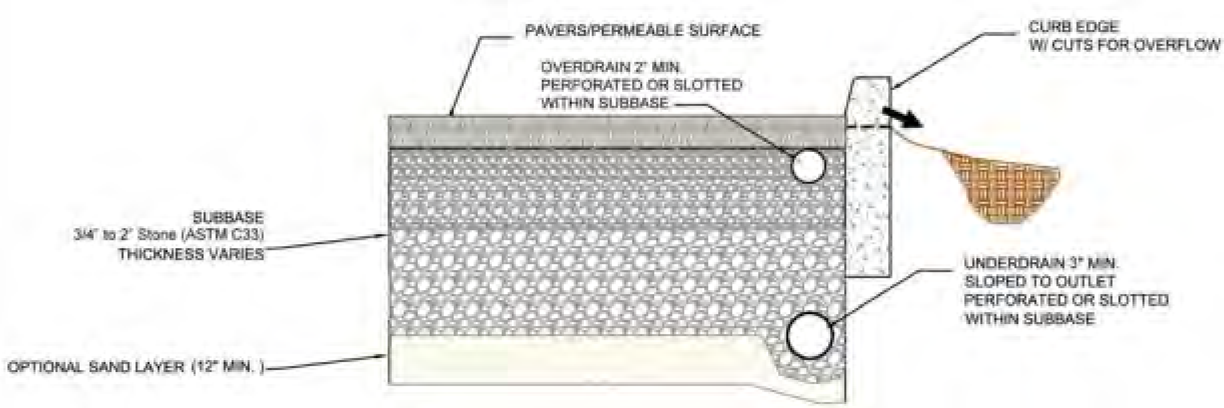

Figure 5 Typical Permeable Paver (MDE 2009)

A bio-swale has been selected to enhance stormwater storage and treatment (Figure 5). Bio-swales provide conveyance, water quality treatment, and the attenuation of stormwater runoff. Bio-swales reduce the pollutant load through vegetative filtering, sedimentation, and biological uptake. Depending on soil conditions and slope an underdrain may be necessary. The swale should be constructed with a 2 to 4-foot soil media depth with planted vegetative cover.

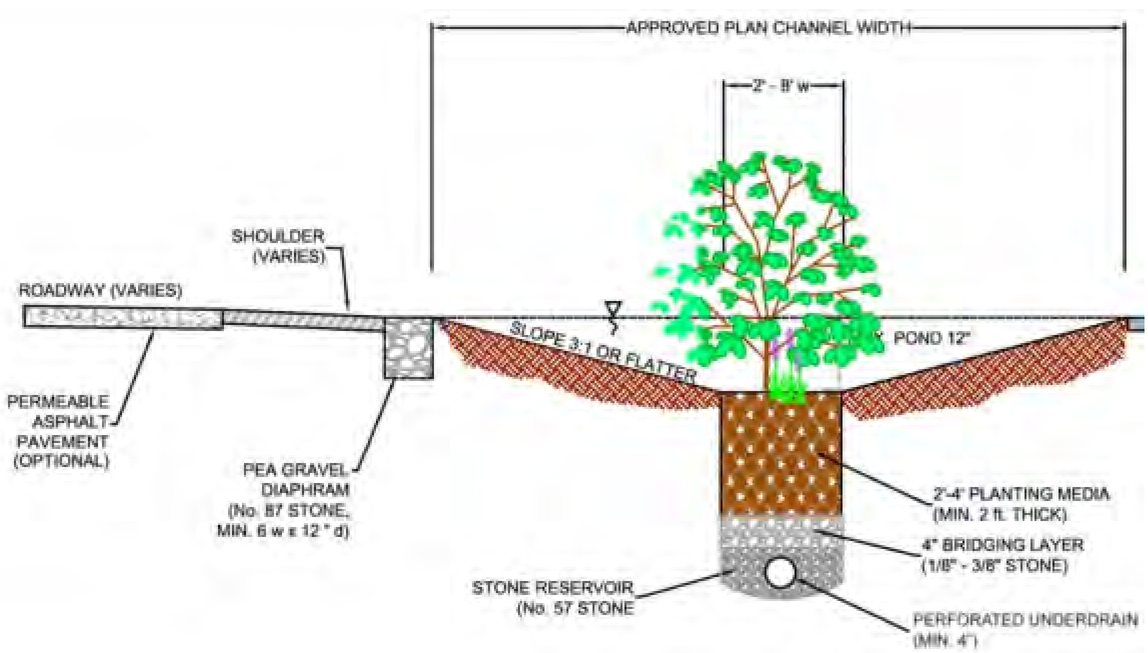

Figure 6 Typical Bio-Swale (MDE 2009)

A cistern has been identified as another feature to intercept and store rainfall for future use (Figure 6). The stored water may be used for outdoor landscaping irrigation, washing, and as a source of non-potable water. The buildings rain leaders will need to be modified so water can be diverted to the cistern. The pollutant removal capability of a cistern is proportional to the amount of runoff captured, stored, and reused. Cisterns must be operated and maintained throughout the year so that storage volume is available. It was assumed the cistern would not be used from November through February. For dewatering between storms, a stable pervious area should be located nearby the cistern.

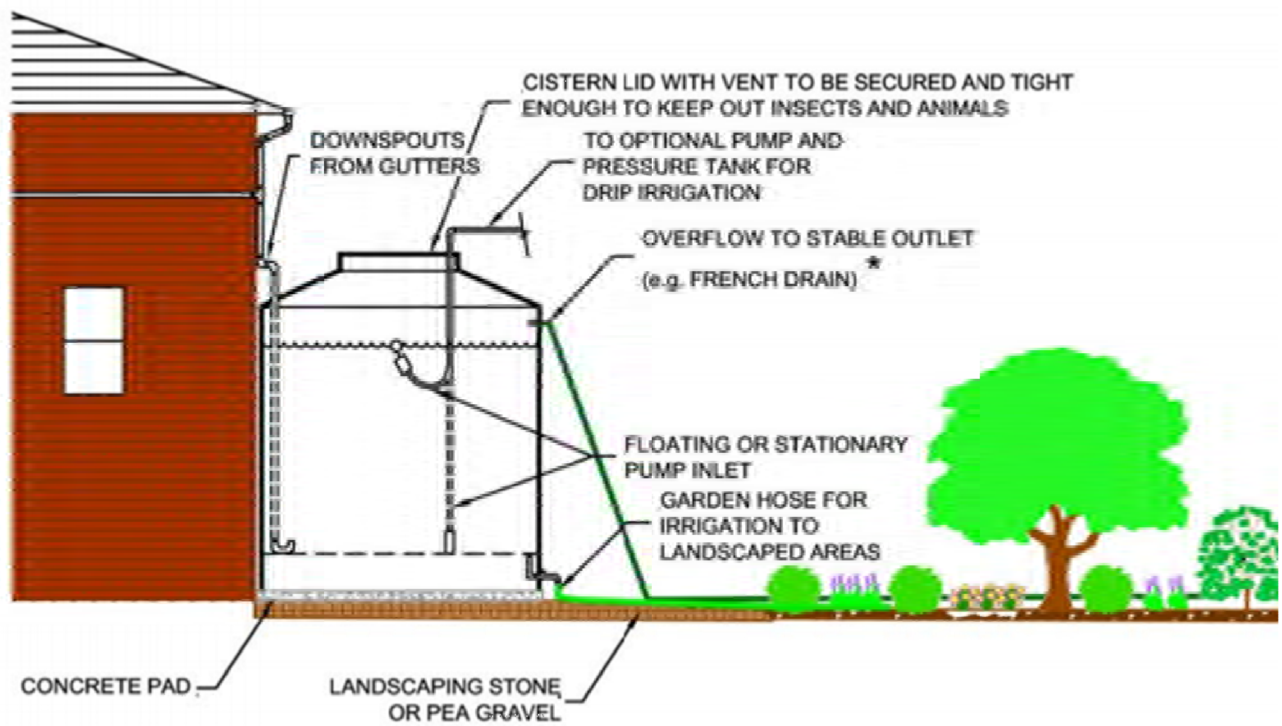

Figure 7 Typical Cistern (MDE 2009)

ESD Practices Summary

Table 1 Water Quality Volume Calculations

Drainage	Permeable Sidewalk[1] surface area (ft^2)	Bioretention Cell[2] surface area (ft^2)	Permeable Paver[1] surface area (ft^2)	Bio-swale[2] surface area (ft^2)	Rain barrel WQv (ft^3)	Total WQv Captured (ft^3)	Available WQv (ft^3)	Max WQv Captured (ft^3) [4]	%WQv Captured
1	-	261	-	-	-	235	436	235	54%
2	-	2,165	-	-	-	1,949	1,728	1,728	>100%
3	-	172	-	-	-	155	51	51	>100%
4	-	-	-	-	57	57	1,128	57	5%
5	-	-	-	-	-	-	1,636	0	0%
6	-	820	-	-	-	738	339	339	>100%[3]
7	-	-	-	-	-	-	317	0	0%
8	-	-	-	-	-	-	911	0	0%
9	-	-	-	-	-	-	505	0	0%
10	-	-	-	2,141	-	1,927	2,125	1,927	91%
11	-	734	-	-	-	661	641	641	>100%
12	-	372	-	-	-	335	936	335	36%
13	-	1,068	-	-	-	961	1,175	961	82%
14	-	-	-	-	-	-	483	0	0%
15	-	1,194	-	-	-	1,075	506	506	>100%
16	-	583	-	-	-	525	921	525	57%
17	-	740	-	-	-	666	631	631	>100%
18	-	520	-	-	-	468	468	468	100%
19	-	301	-	-	-	271	185	185	>100%
20	-	202	-	-	-	182	276	182	66%
21	-	-	-	-	-	-	62	0	0%
22	-	-	-	-	-	-	48	0	0%
23	-	-	-	-	-	-	93	0	0%
24	-	-	-	-	-	-	111	0	0%
25	-	401	-	-	-	427	427	427	100%[3]
26	-	-	1,857	-	-	1,114	148	148	>100%
27	2,391	-	-	-	-	1,435	188	188	>100%
28	2,715	-	-	-	-	1,629	215	215	>100%
29	1,865	-	-	-	-	1,119	148	148	>100%
30	2,535	-	-	-	-	1,521	201	201	>100%
Total	**9,506**	**9,533**	**1,857**	**2,141**	**57**	**17,450**	**17,039**	**10,098**	**59%**

1 : Permeable surface volumes based on assumed porosity of 0.3 and depth of 2 ft.

2 : Bioretention cell and bio-swale volumes based on an assumed porosity of 0.3 and depth of 3 ft.

3 : Bioretention from 2014/2015 construction in drainage 6 and 25 are assumed to treat 100% of runoff

4 : Max WQv captured does not include volume treated in excess of 100%

Project Cost Estimate

Cost estimates for this concept design are based on unit costs developed by King and Hagan (2011). This source only included costs for new permeable surface installations, and did not provide costs for retrofit installations. The source's costs for bioretention cell retrofits were four times greater than for new bioretention cell construction, so that factor of four was applied to the new permeable surface costs to estimate a retrofit cost. Table 2 shows the costs broken down by practice type and a final estimate of $612,454. Costs do not include maintenance.

Table 2 Design Cost Estimates

Practice Type	Impervious surface treated (acres)	Pre-constr. cost ($/imp-acre)	Constr. cost ($/imp-acre)	Total per-imp-acre cost	Total Cost
Permeable Surface	0.261	$87,120	$871,200	$958,320	$250,122
Bioretention Cells	1.83	$52,500	$131,250	$183,750	$336,263
Bio-Swales	0.585	$12,000	$30,000	$42,000	$24,570
Cistern	0.327	-	-	-	$ 1,500
				Total Estimated Cost	$ 612,454

- Retrofit cost for Permeable surfaces derived/estimated by applying same 4X difference between BRC-new and BRC-urban retrofit costs to Permeable Pavement-new
- Rain Harvesting cistern cost is an estimate and only includes cost of cistern
- LimnoTech's cost estimate is based on experience and best professional judgment. However, LimnoTech cannot not guarantee that proposals, bids, or actual Construction Cost will not vary from the opinions or estimates of potential Construction Cost as presented. Variations in cost estimates may be a result of final designs, the cost of labor, materials, equipment, or services furnished by others, or contractors' methods of determining prices, or competitive bidding or local market conditions.

Project Benefits

Water Volume Reductions: Through a combination of bioretention cells, pervious pavers, cisterns, and a bio-swale, the quantity of water entering Towsers Branch will be reduced. All practices capture water within the parcel. To the degree permitted by the underlying soils, water will infiltrate into the ground though underdrains. All other water will be stored in the stormwater MEP practice media and have a delayed discharge into Towsers Branch.

Aesthetic Benefits: The plantings associated with the bioretention cells and bio-swale will provide aesthetic improvements to the school landscape.

Educational Opportunities: The process of siting, installing, and maintaining ESD practices offers the opportunity to engage the public and students about these practices and educate them about the local and regional benefits of green infrastructure.

Water Quality: The installation of the practices at the school should result in a reduction of stormwater loads. This reduction, as shown in Table 3, was calculated with methods described by Schueler and Lane (2012) and MDE (2014).

Table 3 Pollutant Load Reductions

	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	12.9	1.7	0.124
Post-Restoration	9.1	1.1	0.058
% Reduction	29.5%	35.4%	53.1%

Project Constraints

Property Boundary: All work must be completed within the property to allow for proper maintenance and ownership rights. Anne Arundel County Public Schools will need to approve of concepts.

Design/Construction: A topographical survey is necessary prior to further design. The survey needs to include the invert elevations of all retrofitted catch basins and manholes. Additionally, the survey should confirm the sub-drainage area delineations. Final design will also require geotechnical investigations. Infiltration testing and borings of the project location soils needs to be completed to better inform design and to determine whether practices require underdrains.

Utilities: There may be underground utilities within the parcel. This has the potential to reduce the depth of the stormwater management practices. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: A tree protection plan is recommended to ensure that tree root systems are properly maintained and avoided during construction. Other environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Proper erosion and sediment controls are required during construction. It will be necessary to block off some catch basins during retrofits to ensure that excess solids are not entering the stormwater collection system or newly constructed practices.

Maintenance: Proper design and construction of a BMP is essential to its ability to detain runoff and adequately remove pollutants from stormwater. Equally important is the proper operation and upkeep of such a facility. Without proper maintenance, a BMP will not function as it is intended and, in some instances, may cause a host of problems from endangering the public to nuisance odors to reduced property values.

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Project Photos (From Bing Bird's Eye)

OVERSIZED MAPS

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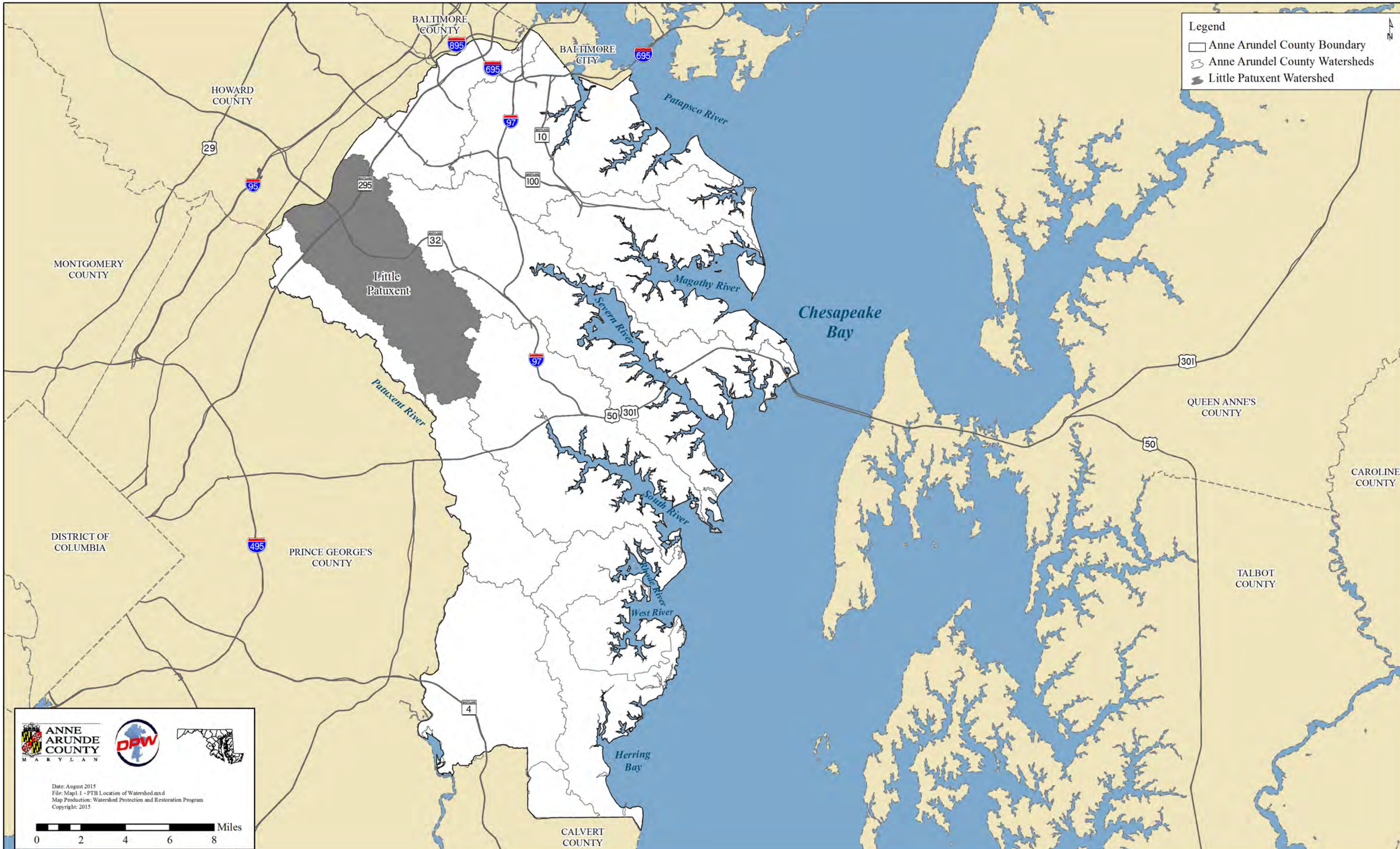
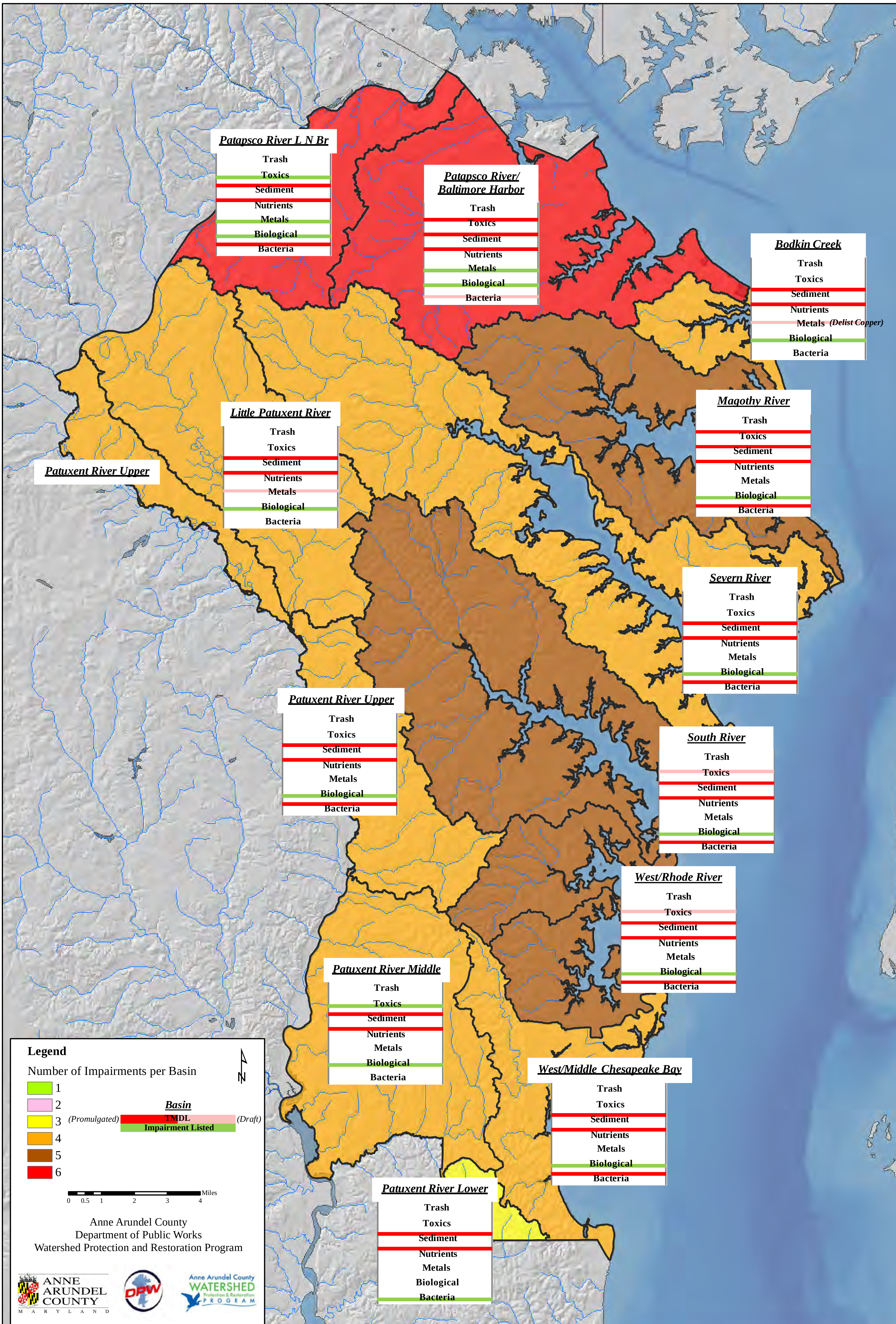
Map 1.1 - Location of Little Patuxent Watershed

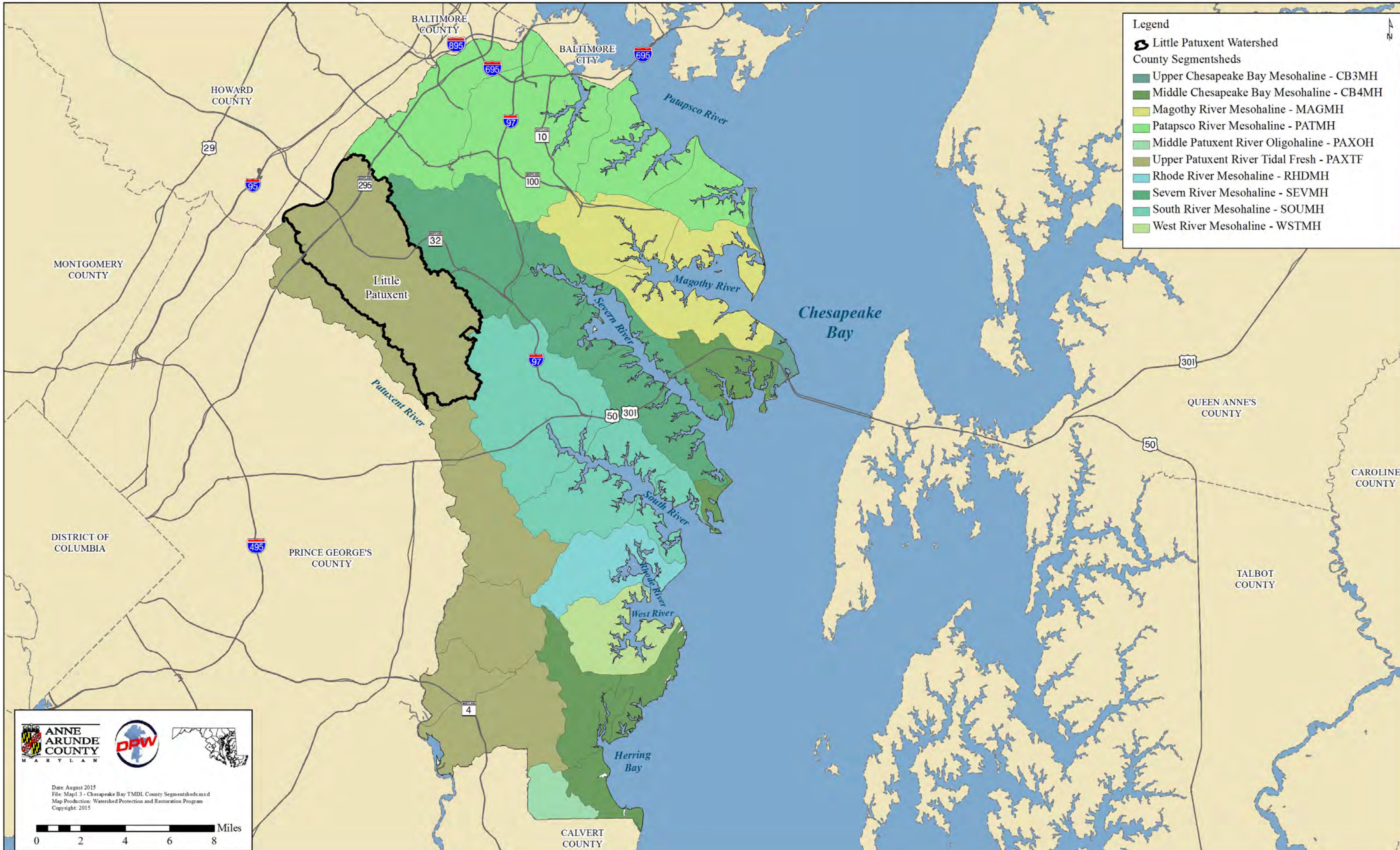


Map 1.2 Category 5 303 (D) Listed Waters and TMDLs

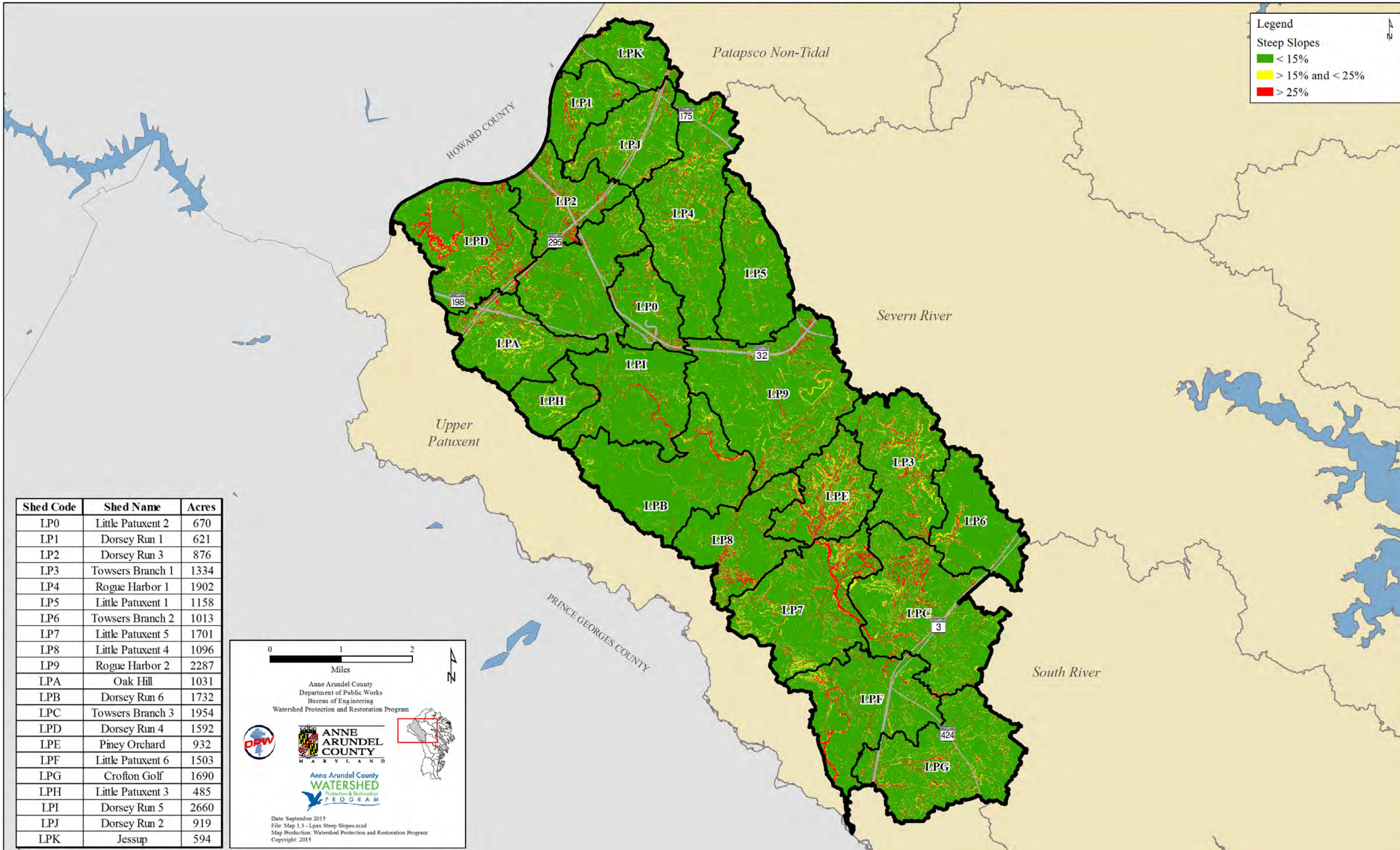


Date: August 20, 2015
File: \\wmtserver\wapshare\Watershed Studies\Little Patuxent\Study Reports\Maps\Map1.2 - Category 5 303 (D) Listed Waters and TMDLs.mxd
Map Production: Watershed Protection and Restoration Program

Map 1.3 - Chesapeake Bay TMDL County Segmentsheds

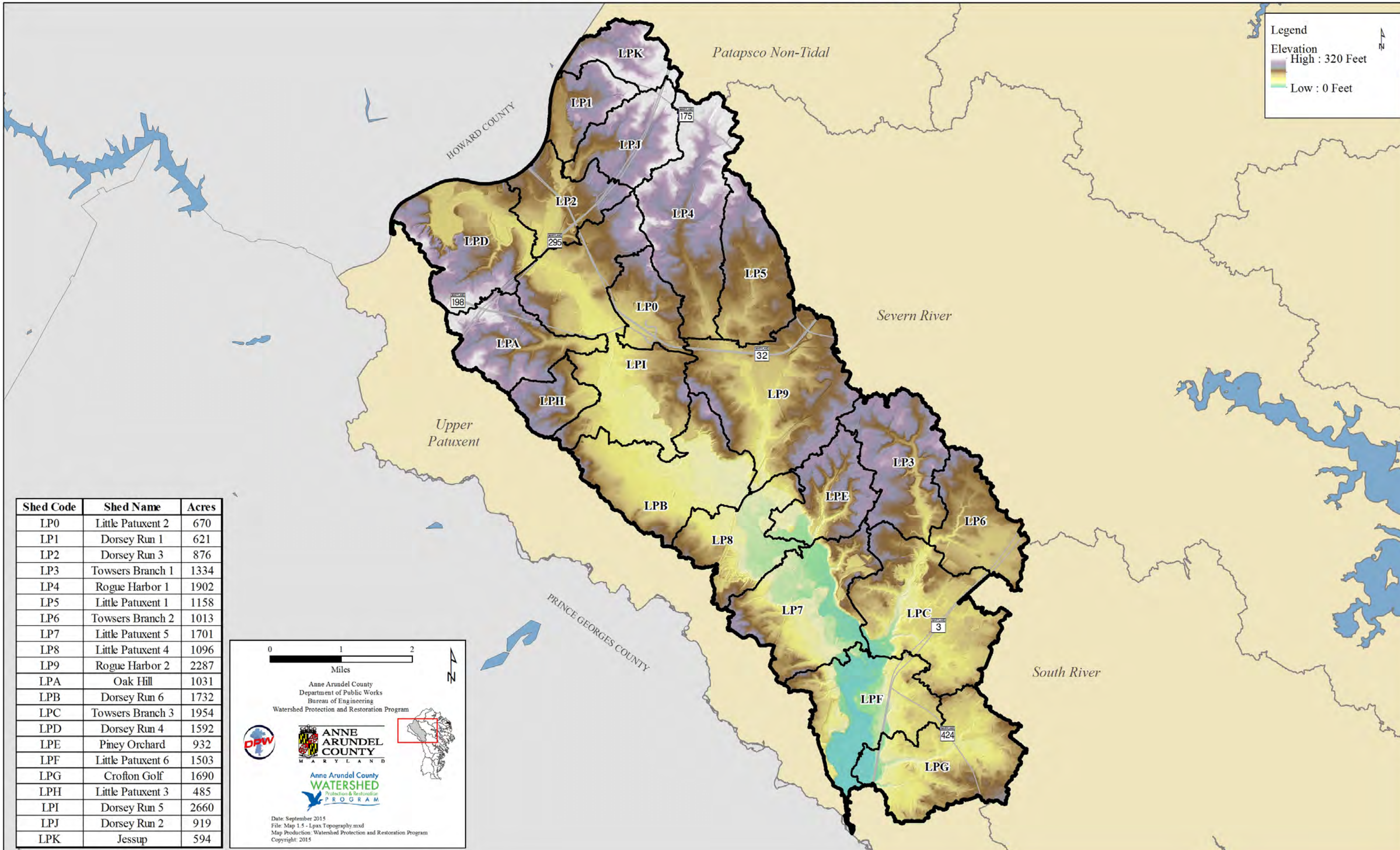


Map 1.4 – Little Patuxent Steep Slopes



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.5 – Little Patuxent Topography



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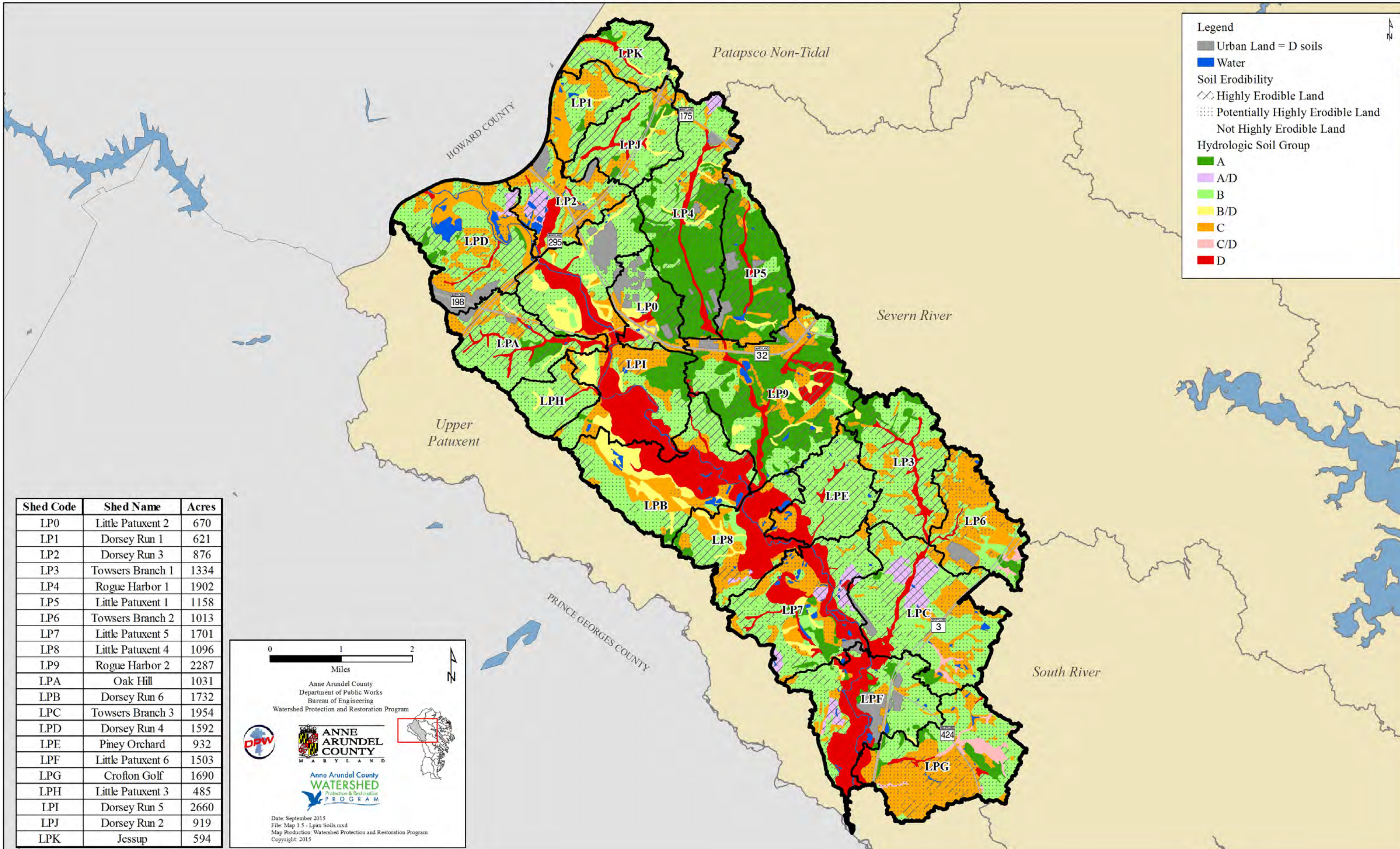
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.6 – Little Patuxent Soils



Shed Code	Shed Name	Acres
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LP9	Rogue Harbor 2	2287
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LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
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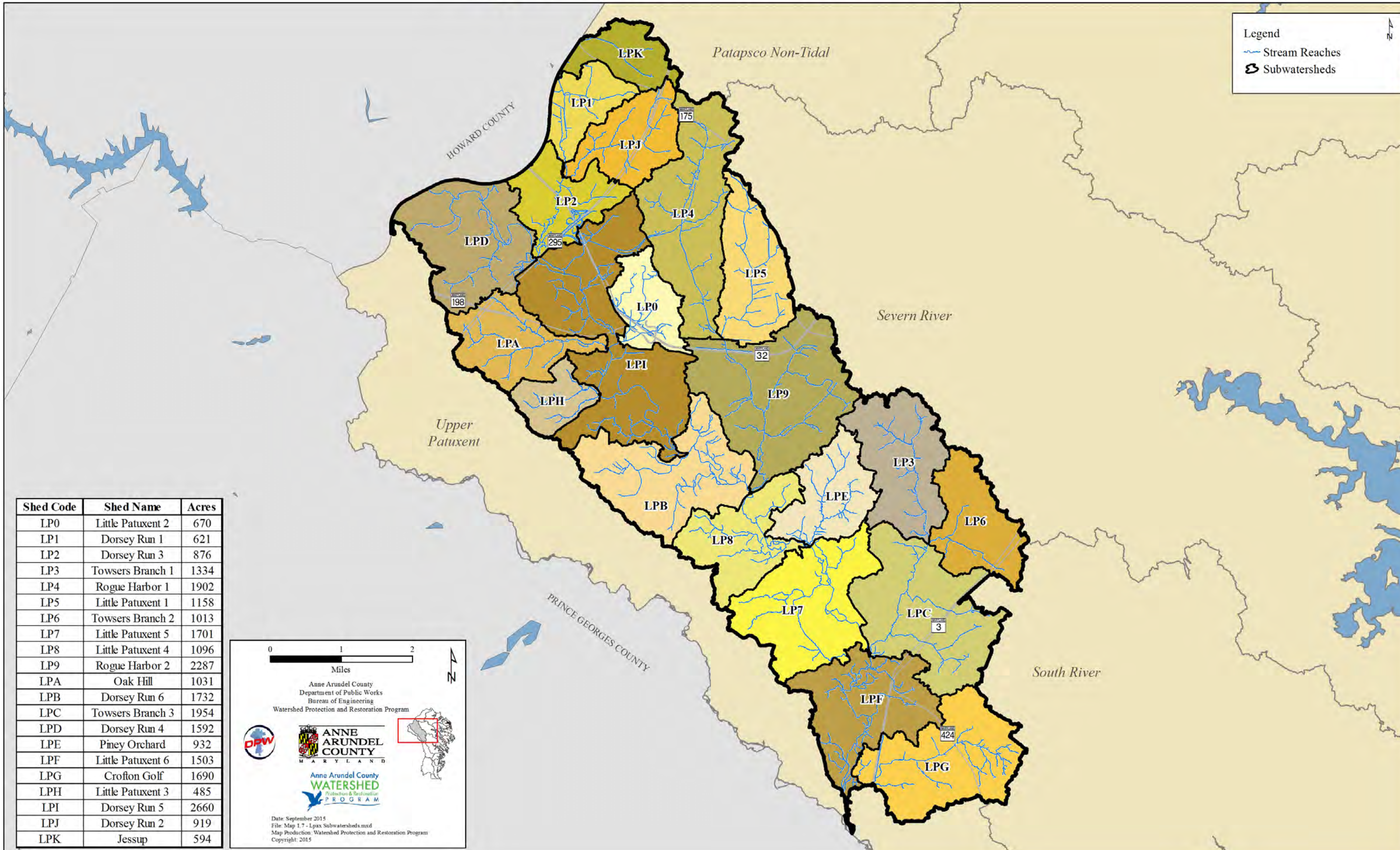
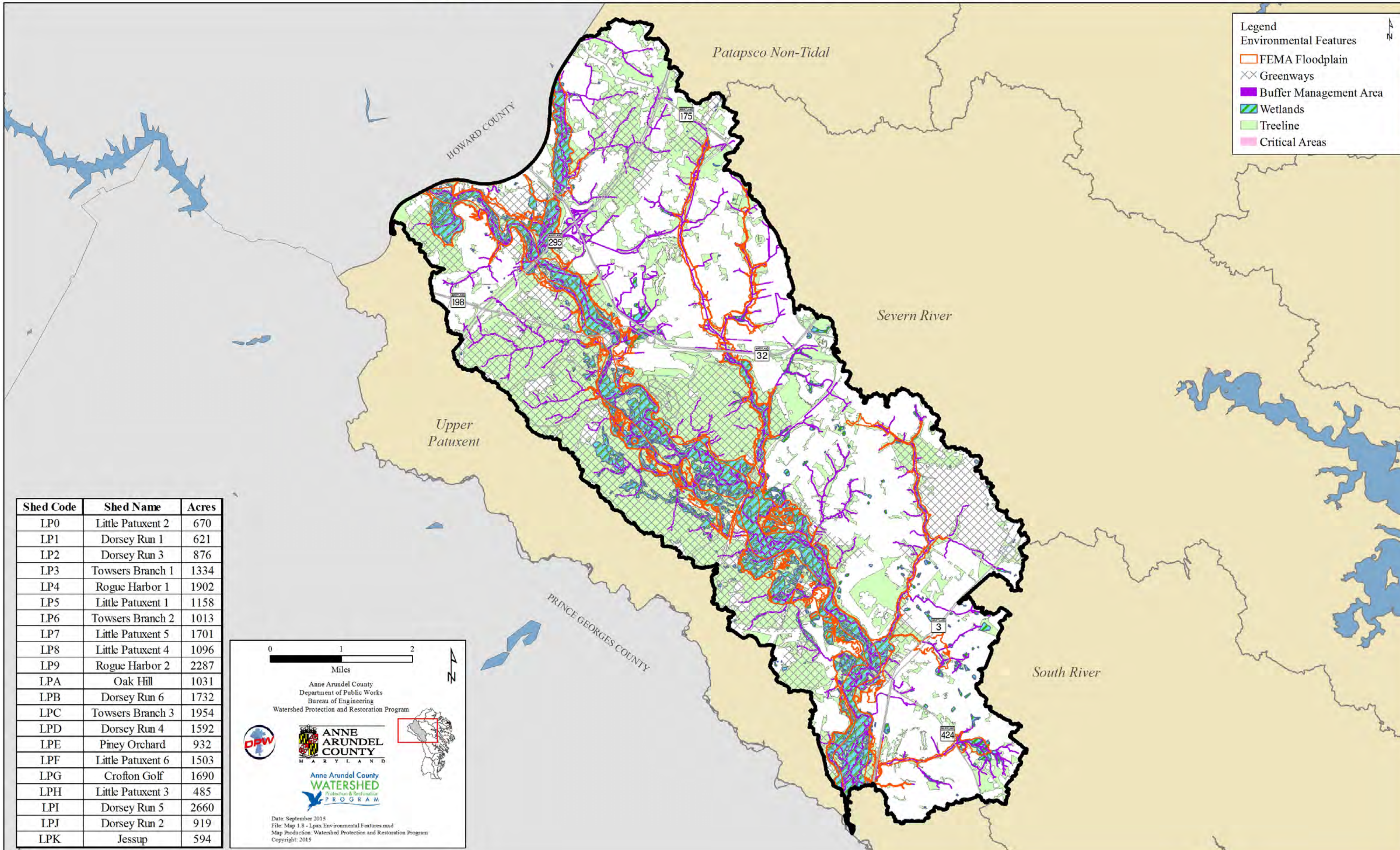
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.7 – Little Patuxent Subwatersheds



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.8 – Little Patuxent Environmental Features



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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LP6	Towsers Branch 2	1013
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LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
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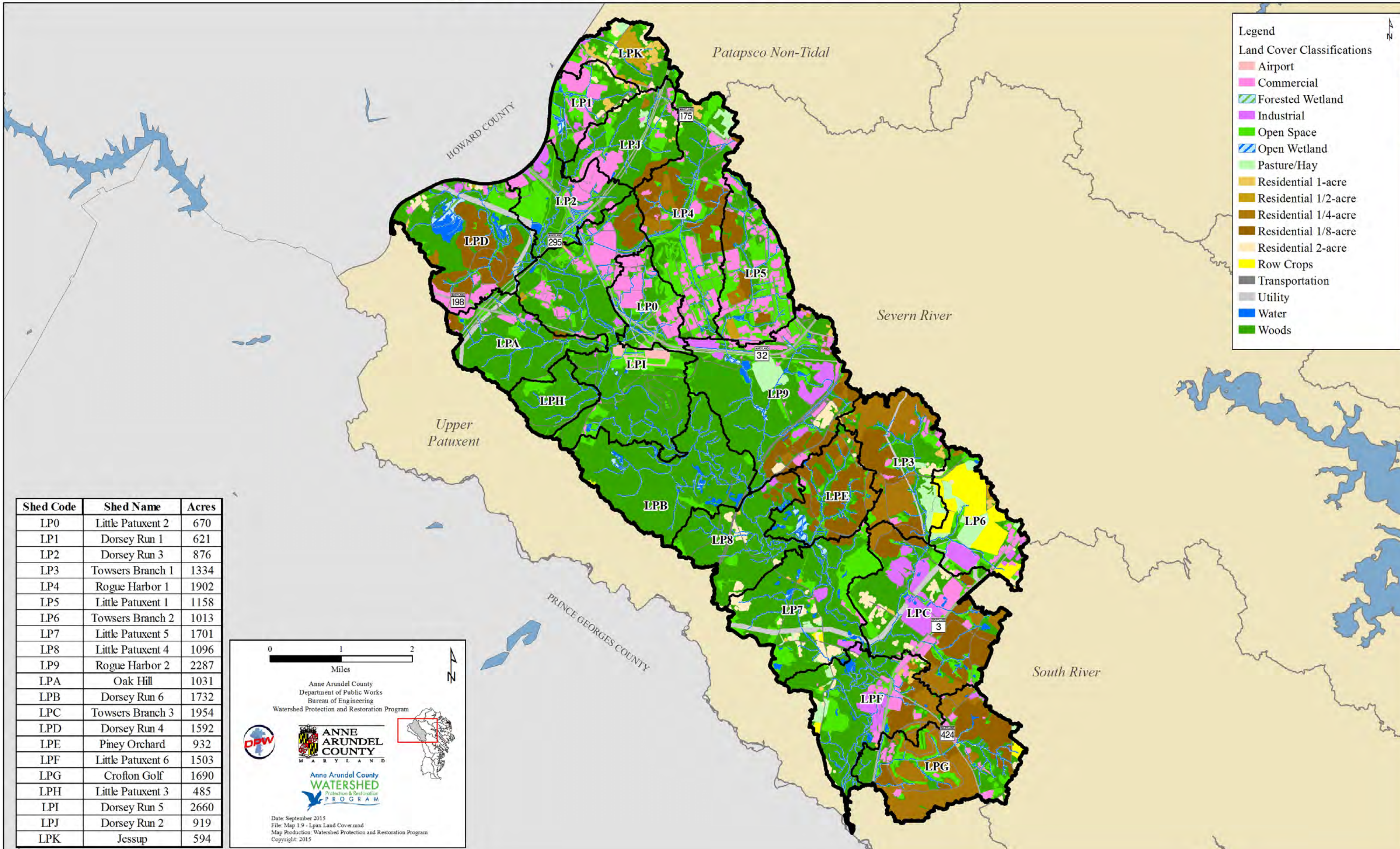
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.9 – Little Patuxent Watershed Land Cover



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
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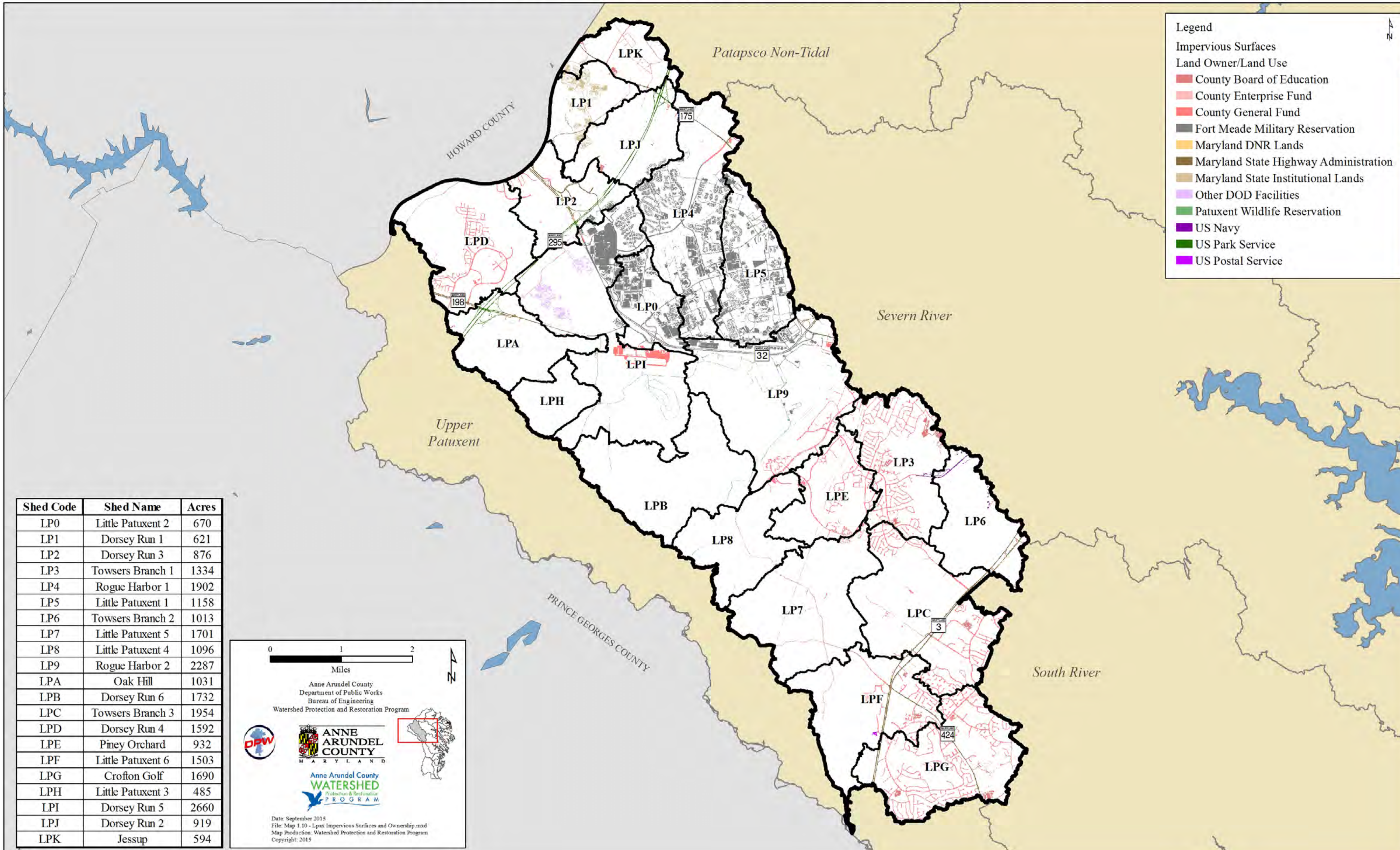
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.10 – Little Patuxent Impervious Surfaces and Ownership



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
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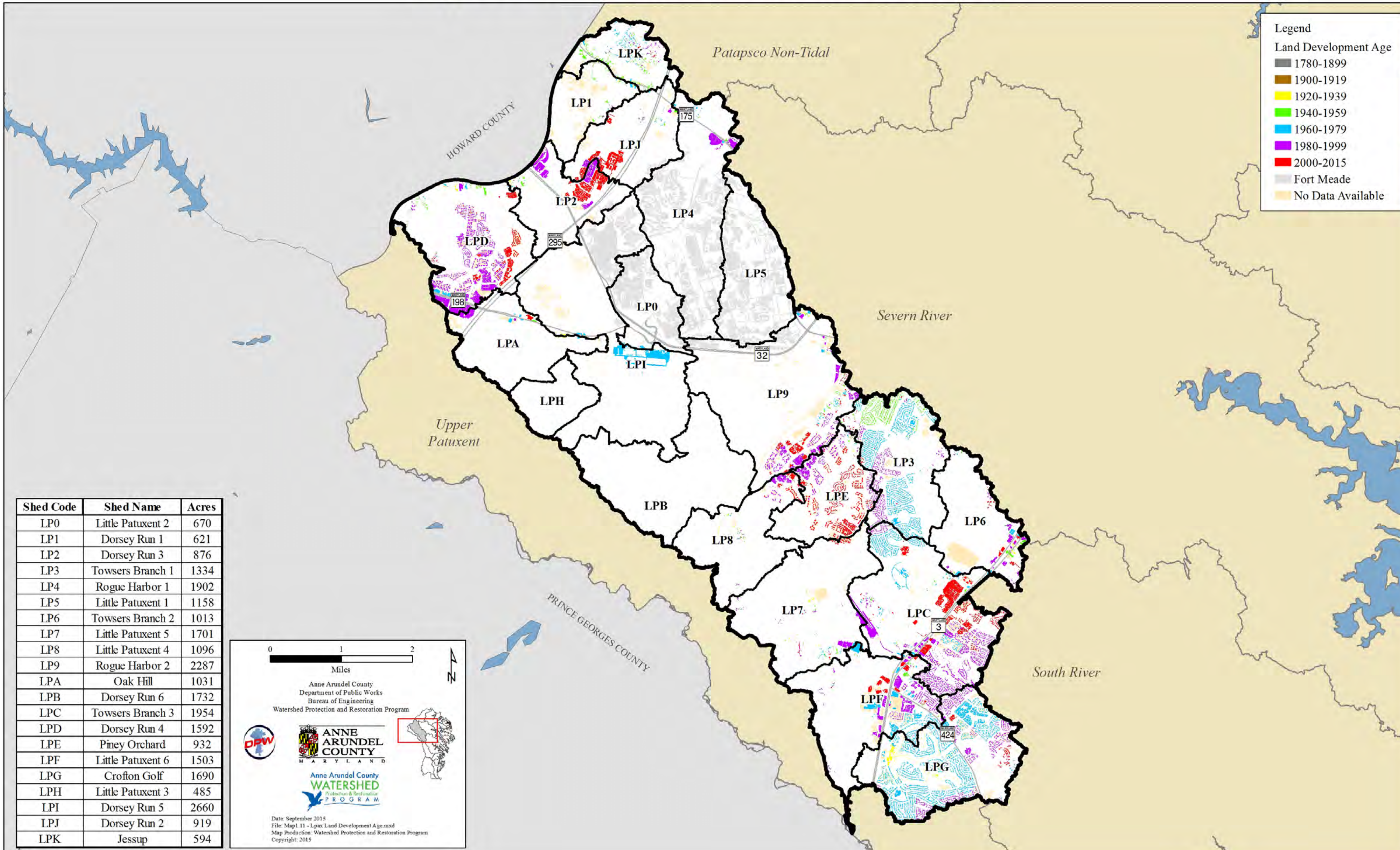
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.11 – Little Patuxent Land Development Age



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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LP9	Rogue Harbor 2	2287
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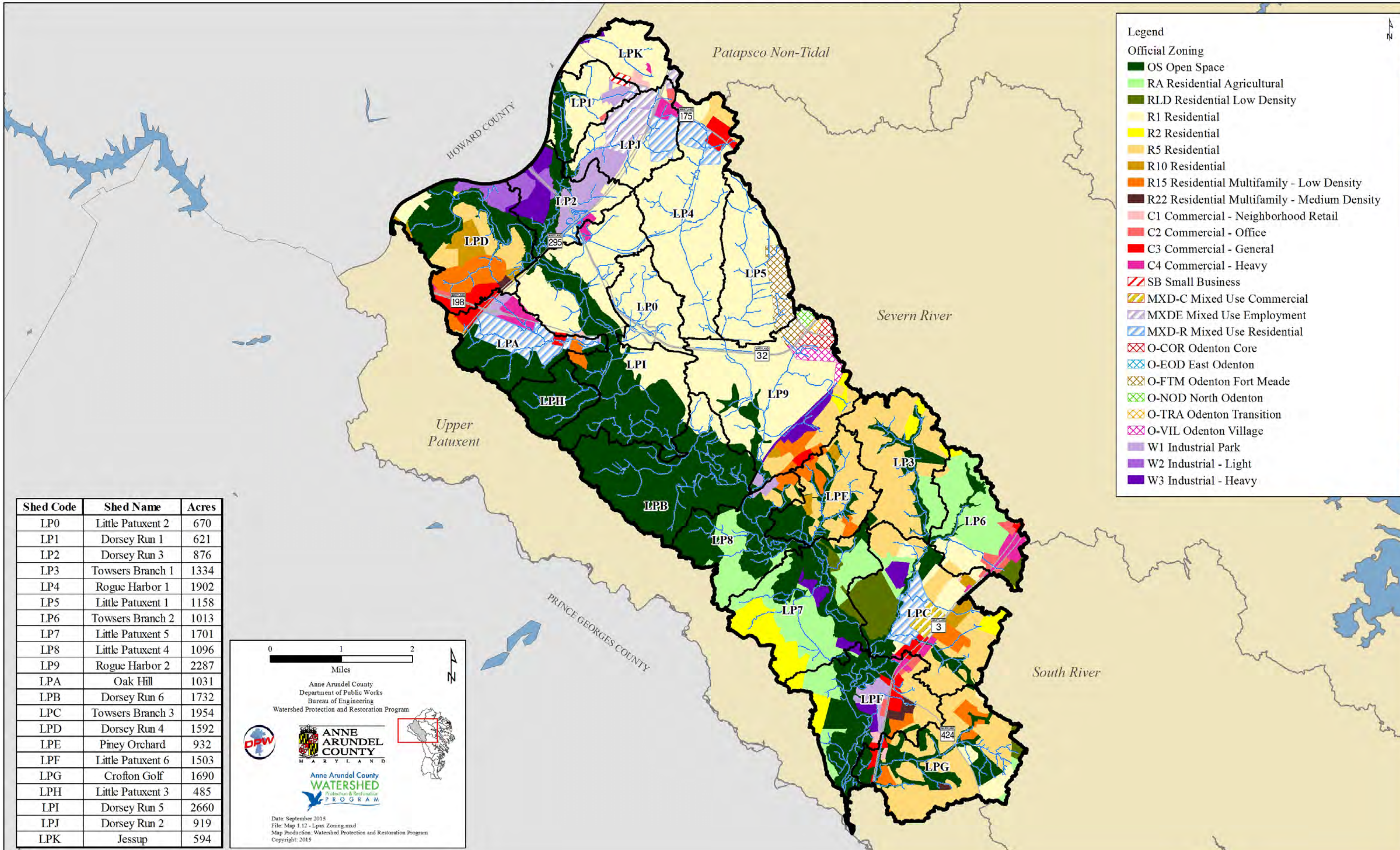
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 1.12 – Little Patuxent Zoning



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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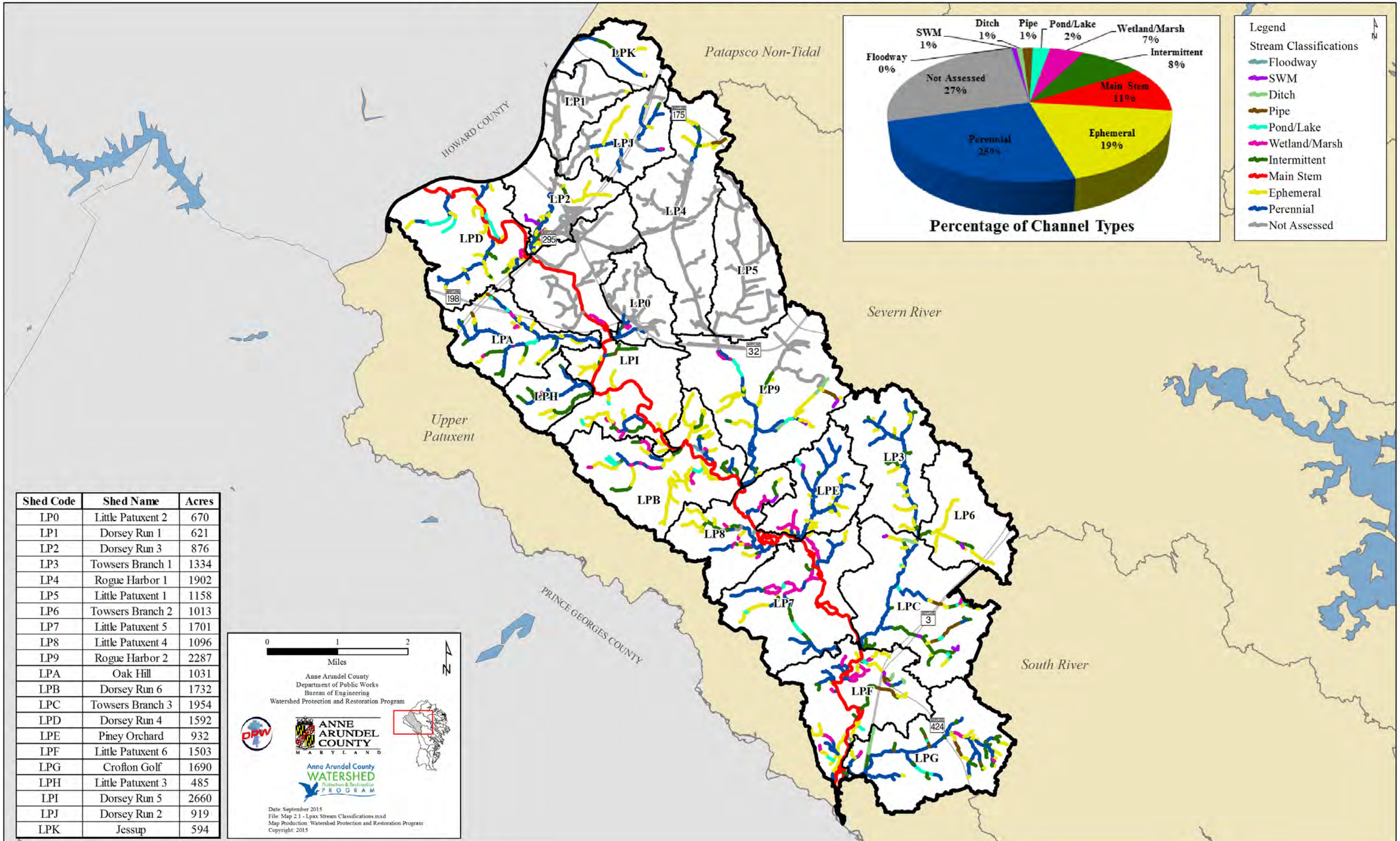
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.1 – Little Patuxent Stream Classifications



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
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LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
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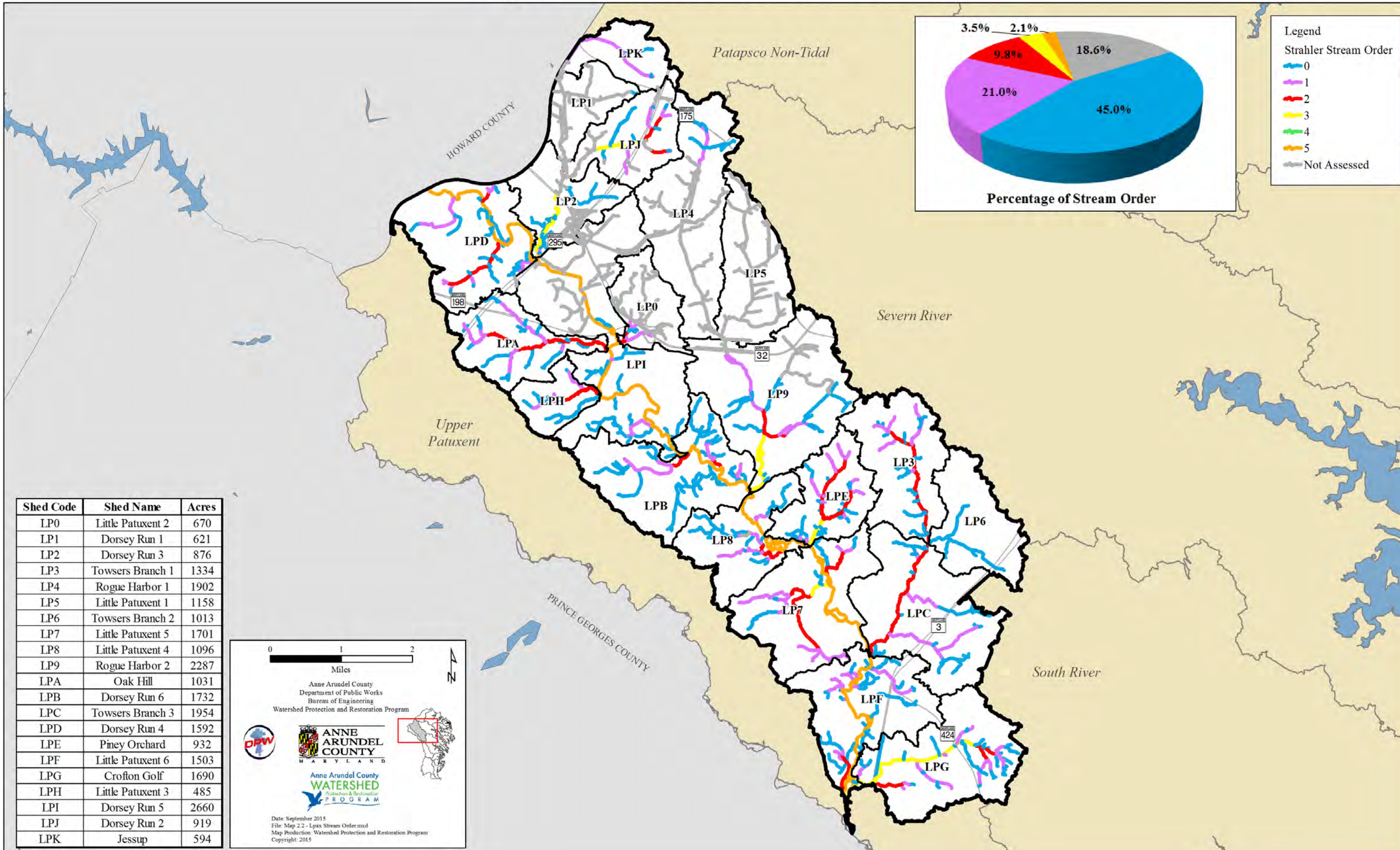
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.2 – Little Patuxent Stream Order



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
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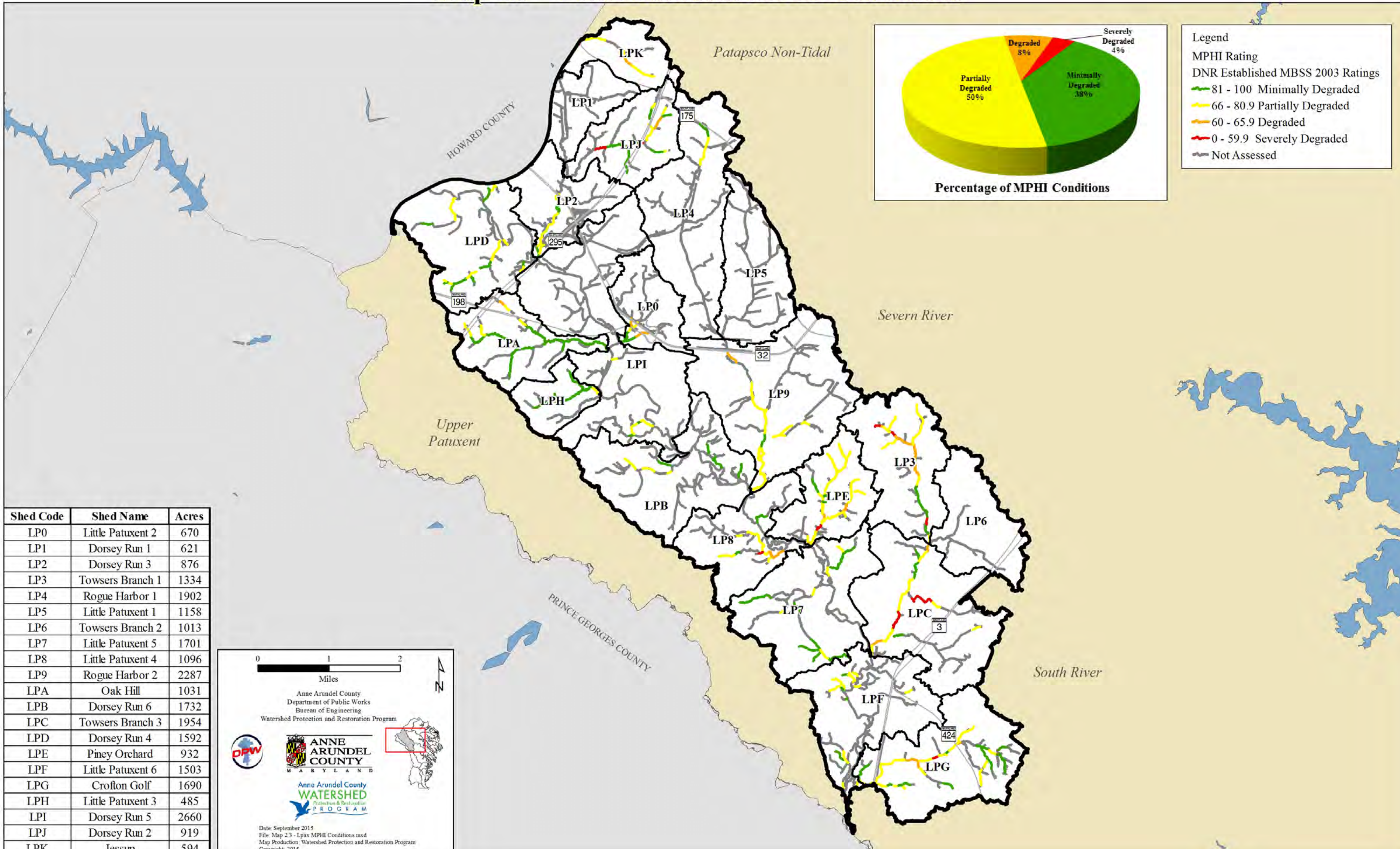
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.3 – Little Patuxent MPHI Conditions



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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LPA	Oak Hill	1031
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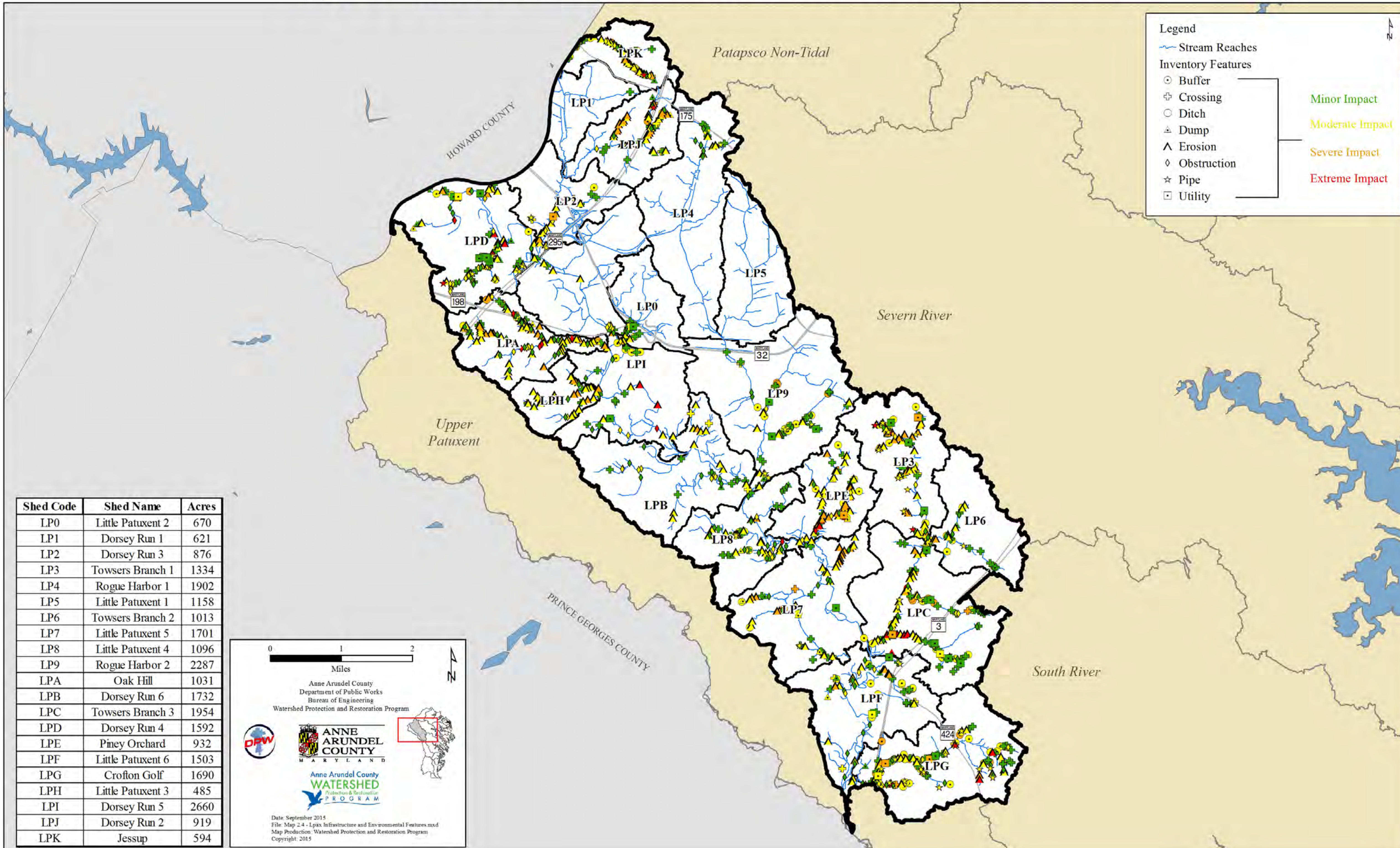
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.4 – Little Patuxent Infrastructure and Environmental Features



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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LPB	Dorsey Run 6	1732
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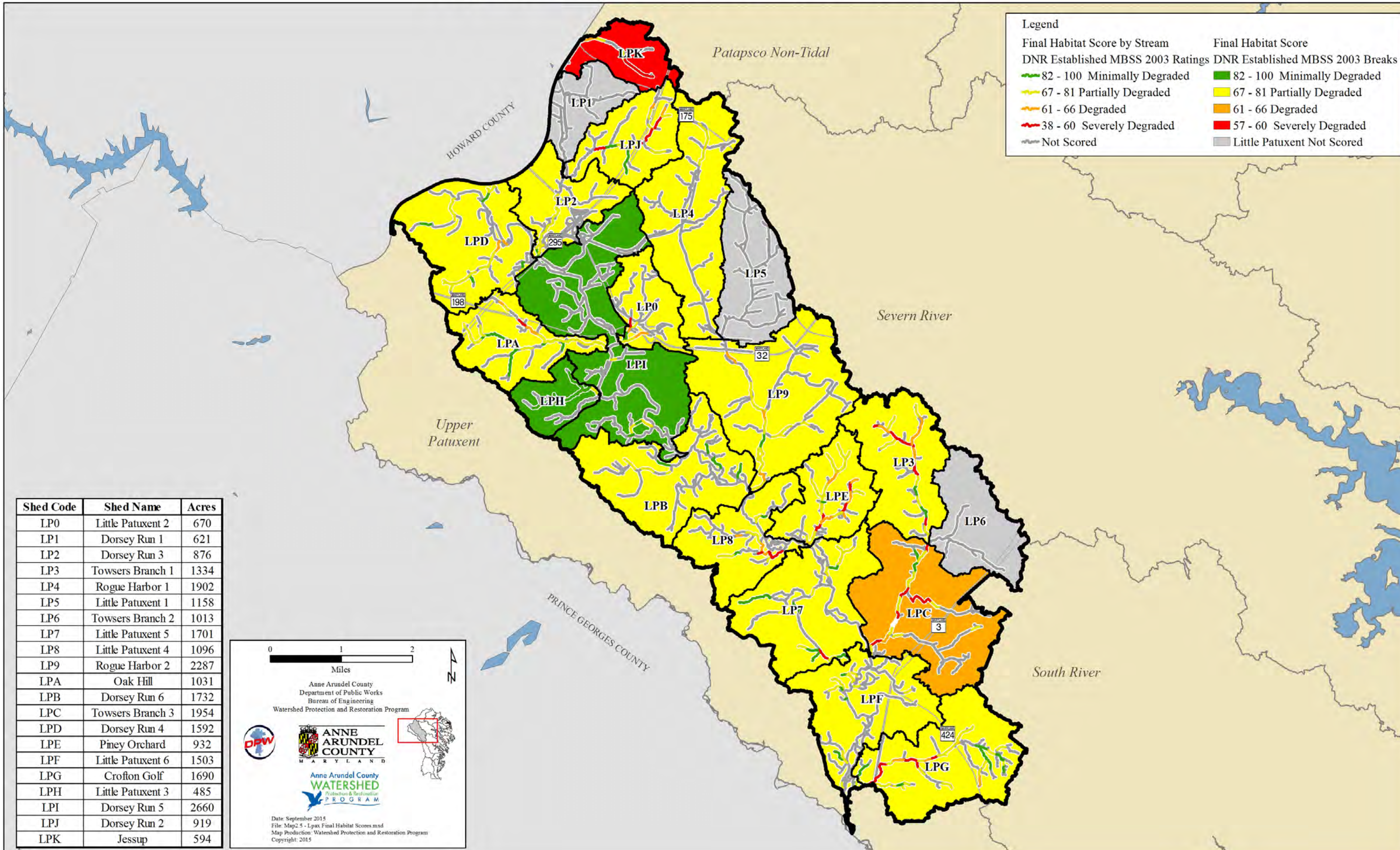
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.5 – Little Patuxent Final Habitat Scores



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
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LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
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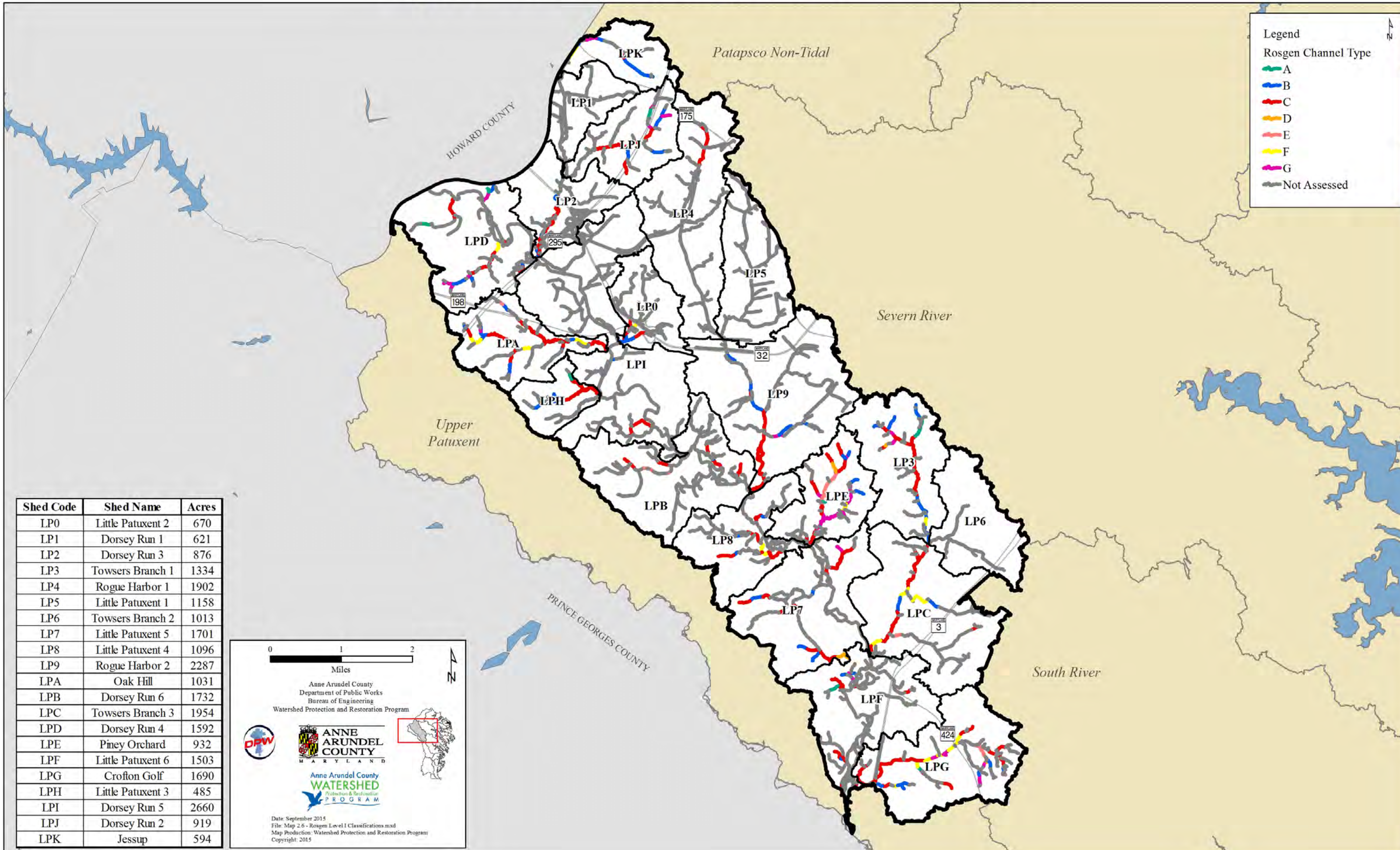
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.6– Little Patuxent Rosgen Level I Classifications



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
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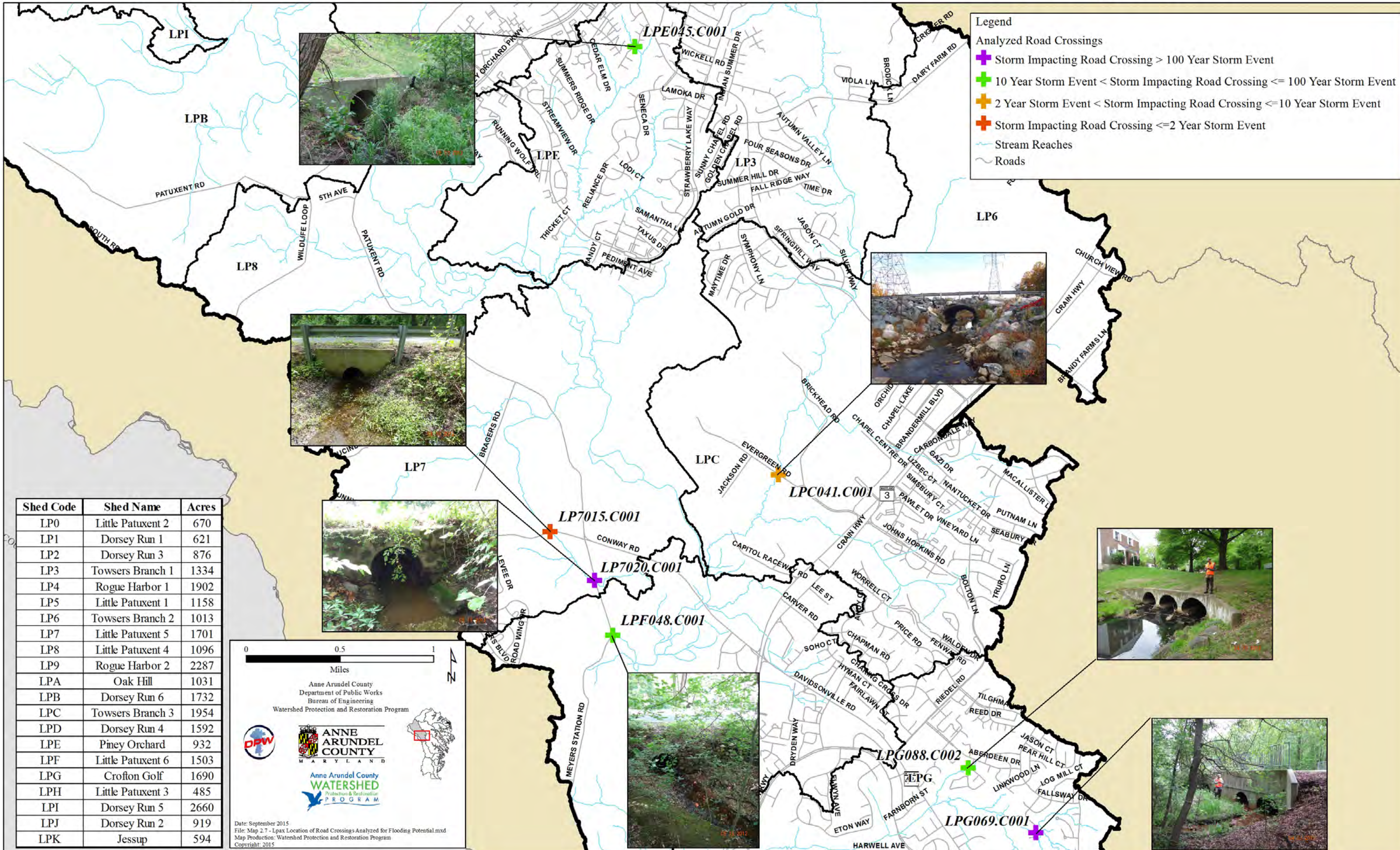
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.7 – Little Patuxent Location of Road Crossings Analyzed for Flooding Potential



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
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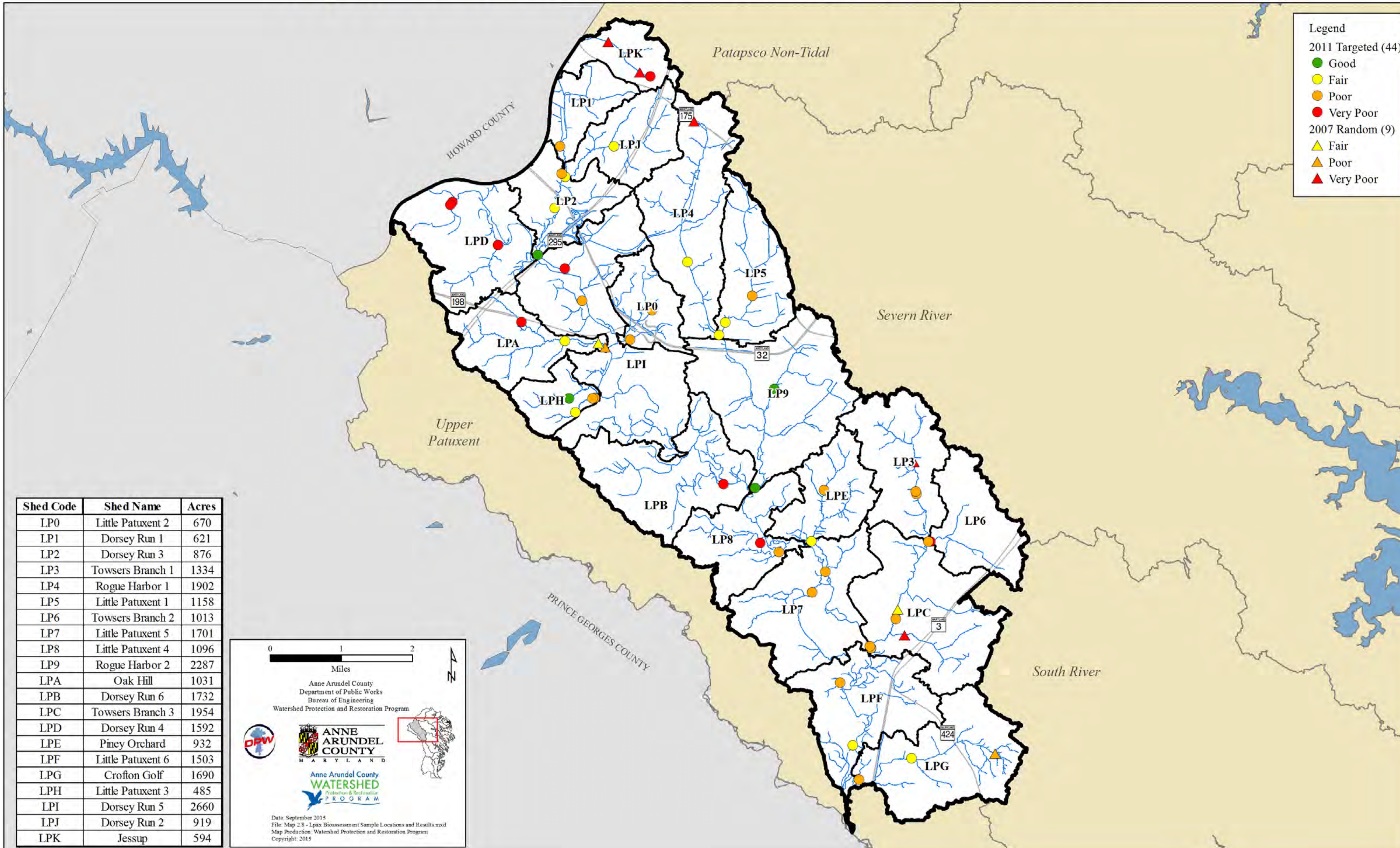
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.8 – Little Patuxent Bioassessment Sample Locations and Results



Shed Code	Shed Name	Acres
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LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
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LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.9 – Little Patuxent Subwatershed Ratings for Aquatic Resource Indicators

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
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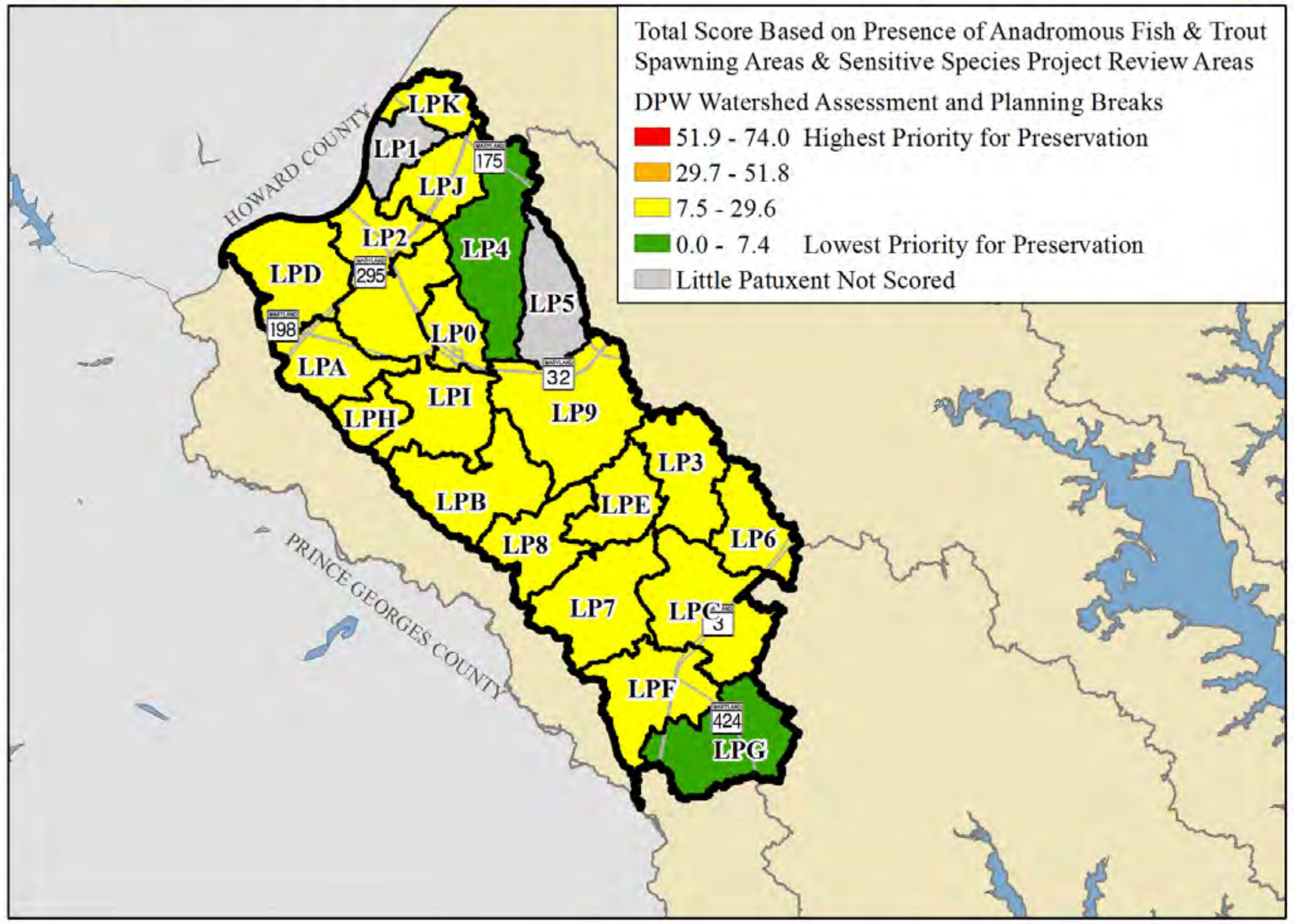
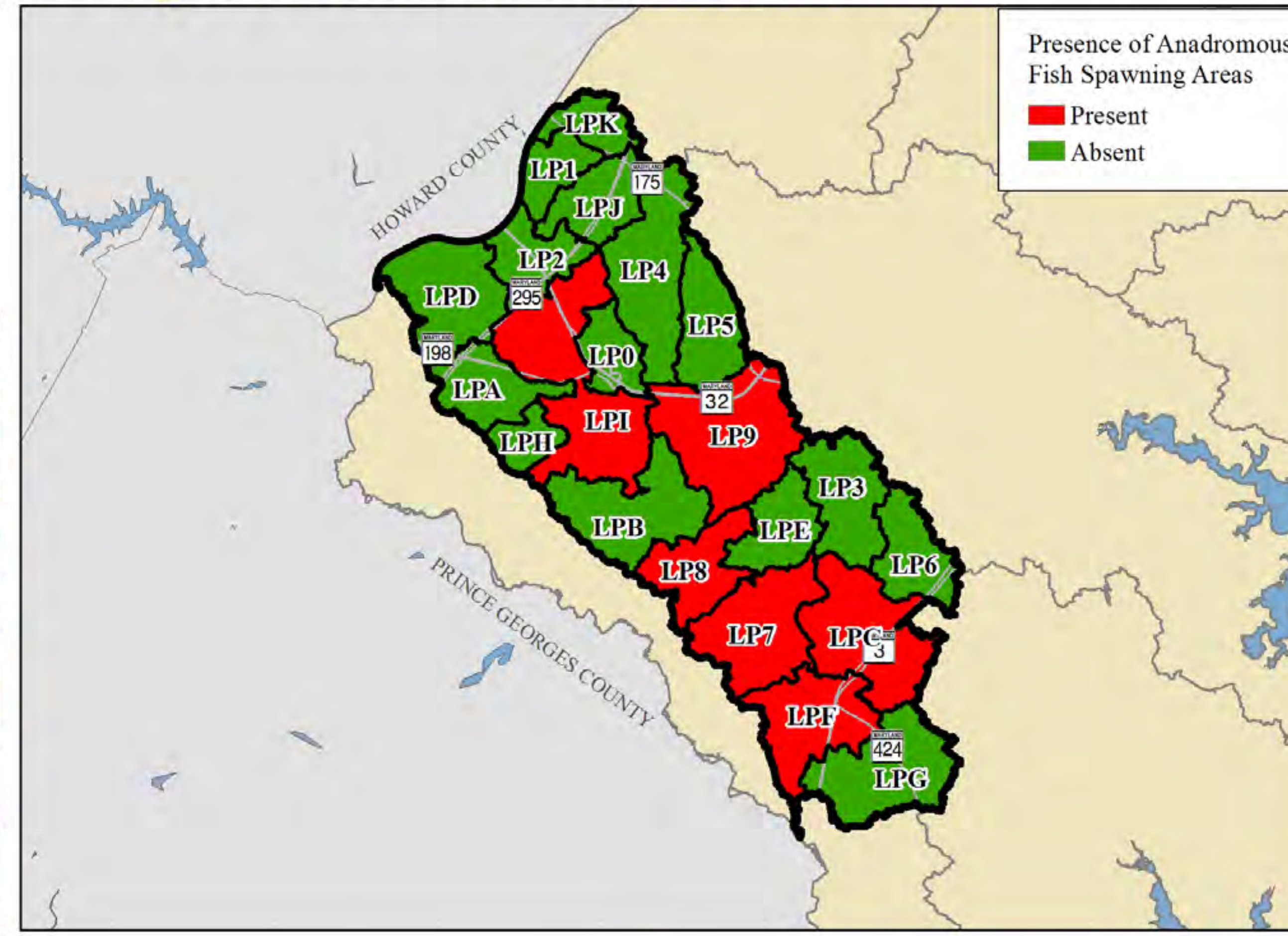
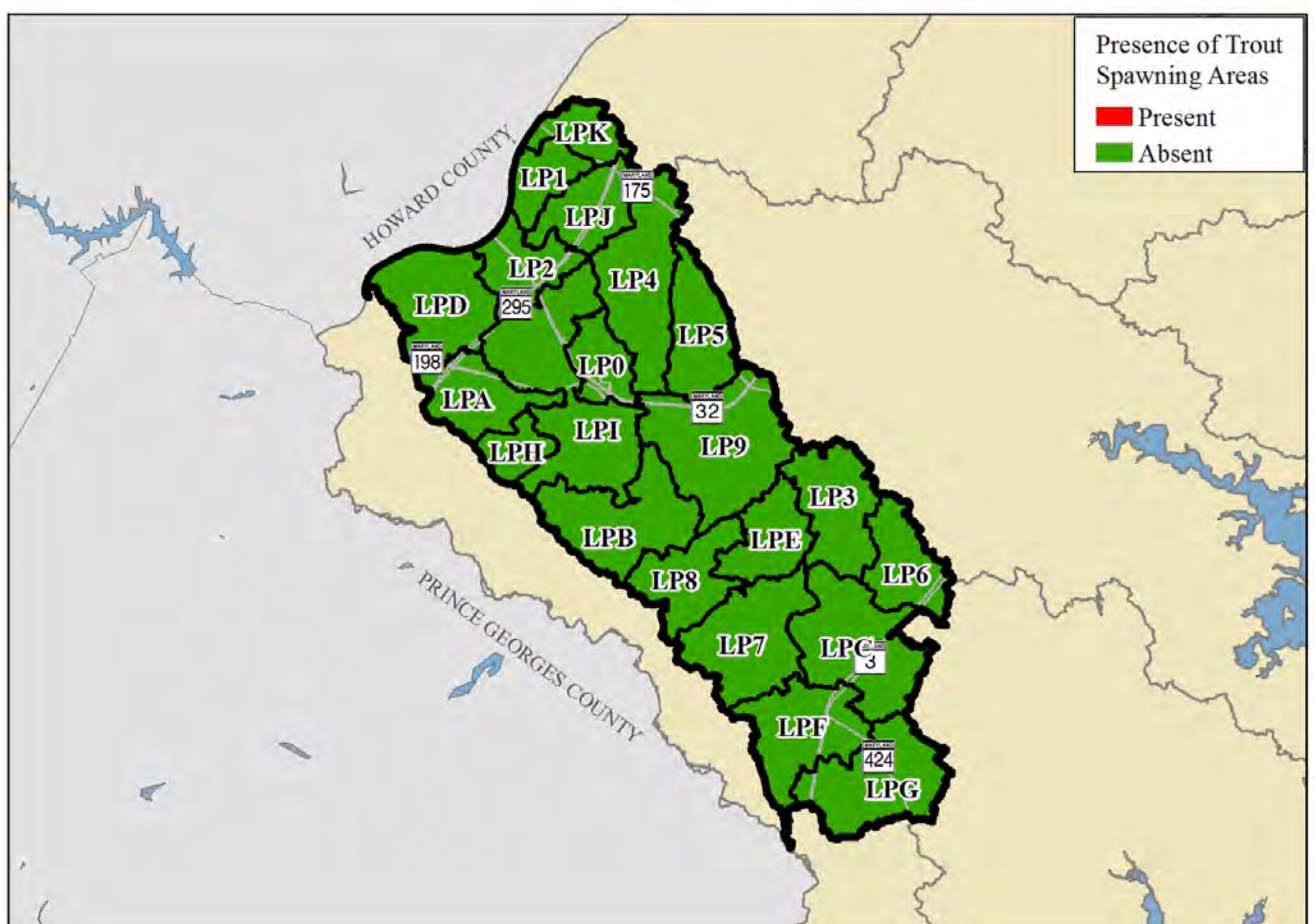
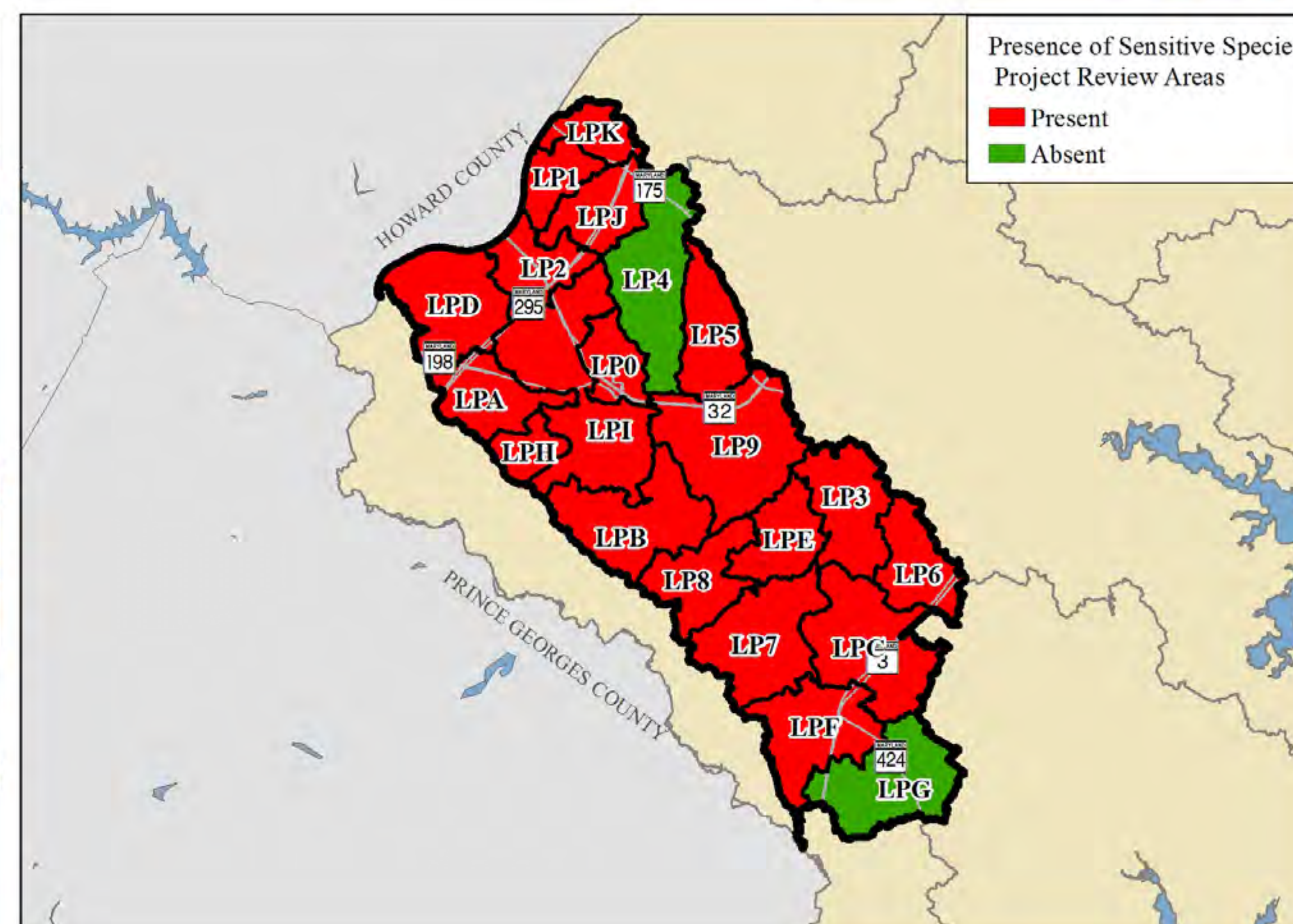
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594









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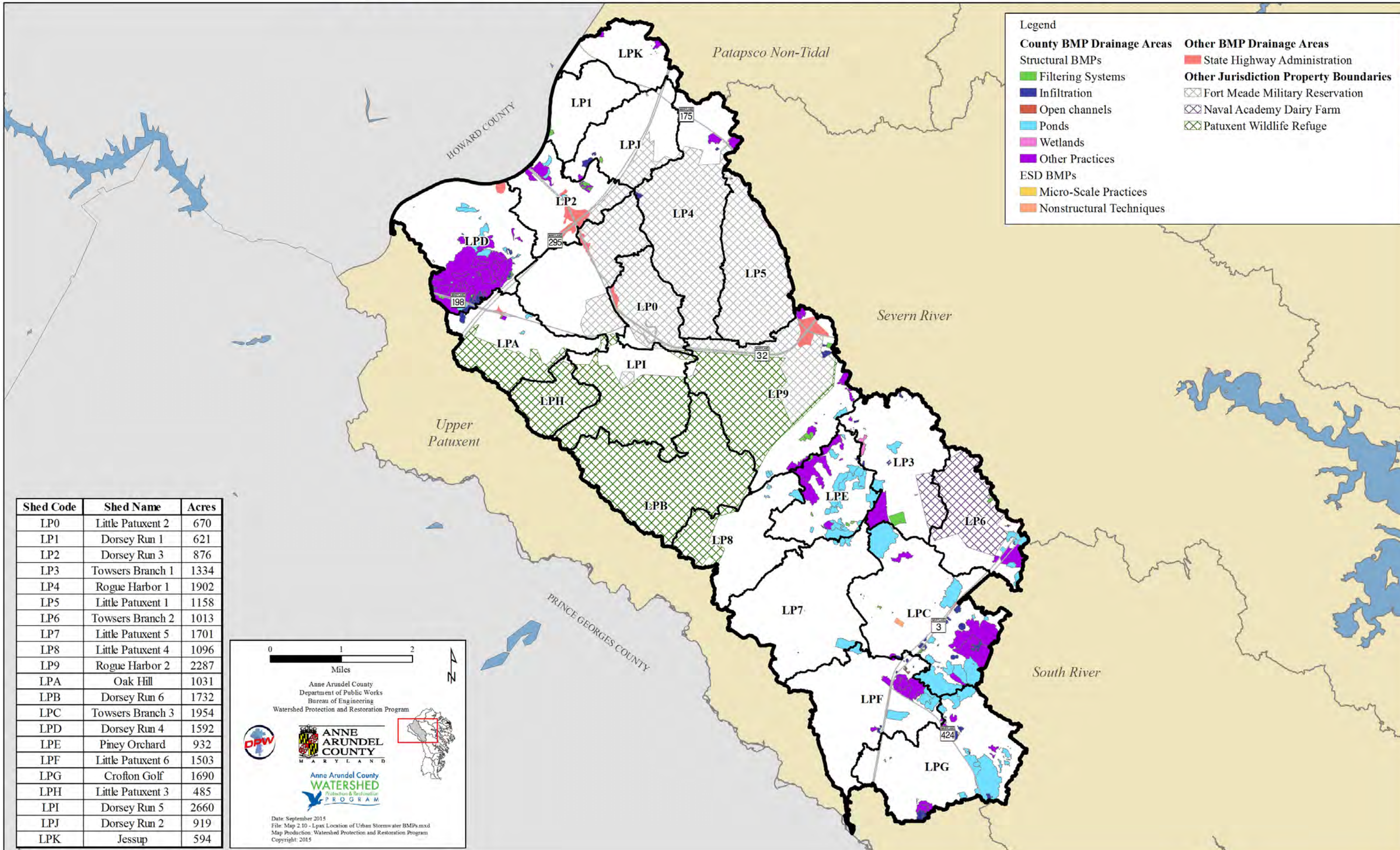
Date: September 2015
File: Map 2.9 - Lpax Subwatershed Ratings for Aquatic Resource Indicators.mxd
Map Production: Watershed Protection and Restoration Program

Map 2.10 – Little Patuxent Location of Urban Stormwater BMPs



Shed Code	Shed Name	Acres
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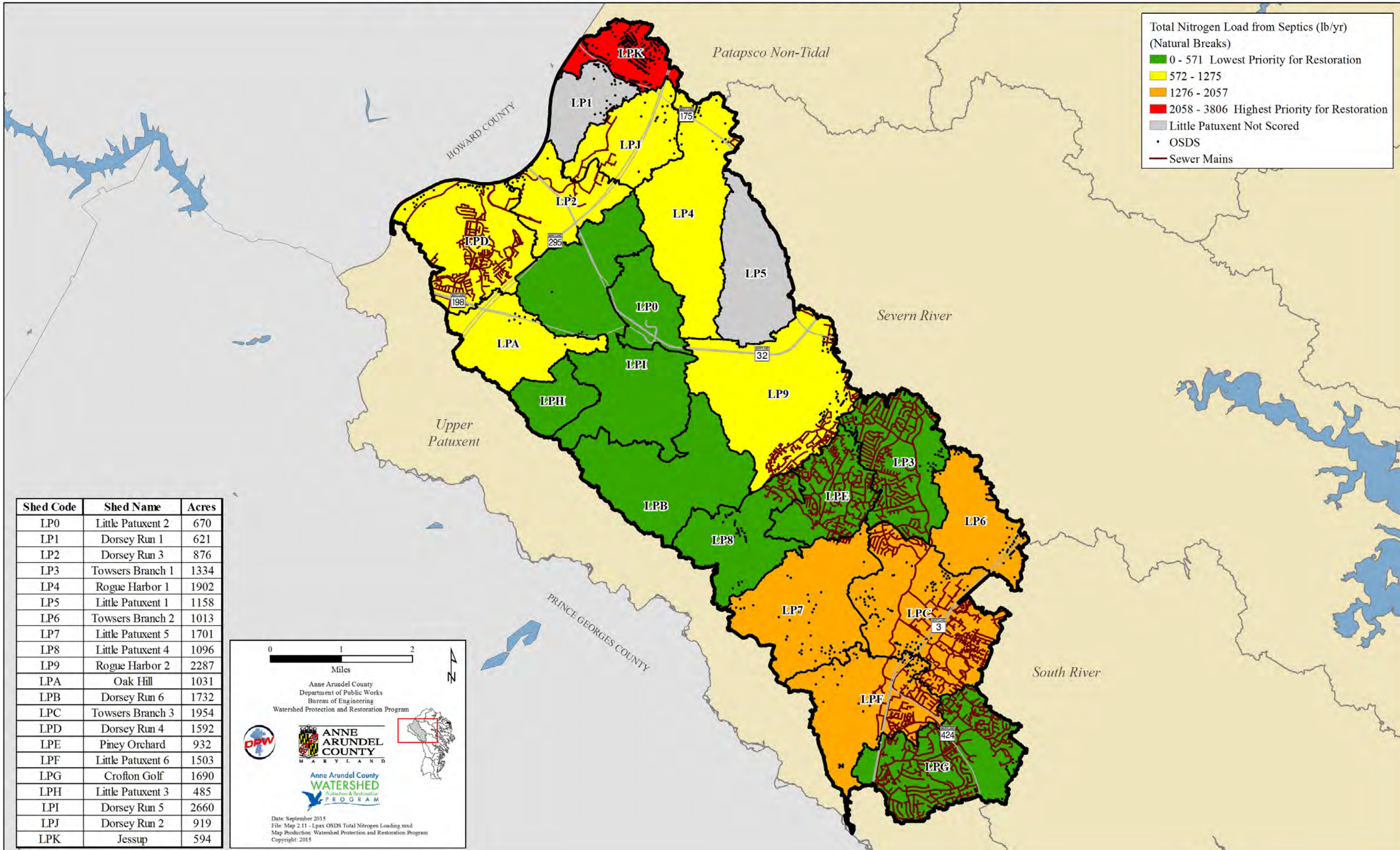
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 2.11 – Little Patuxent OSDS Total Nitrogen Loading



Shed Code	Shed Name	Acres
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LPJ	Dorsey Run 2	919
LPK	Jessup	594

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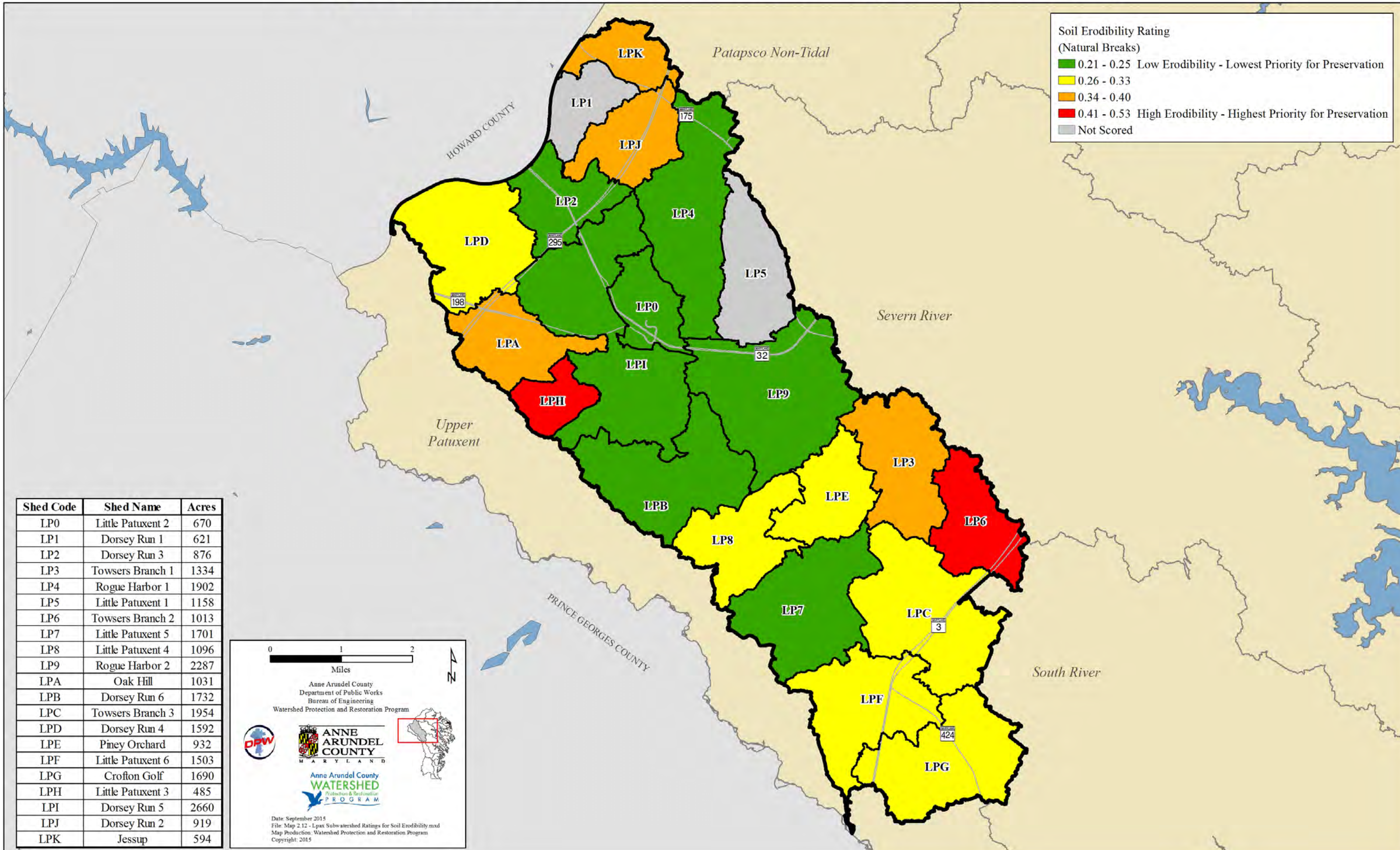
Date: September 2015
File: Map 2.11 - Lpax OSDS Total Nitrogen Loading.mxd
Map Production: Watershed Protection and Restoration Program

Map 2.12 – Little Patuxent Subwatershed Ratings for Soil Erodibility



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LP3	Towsers Branch 1	1334
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LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

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Watershed Protection and Restoration Program

Date: September 2015
File: Map 2.12 - Lpax Subwatershed Ratings for Soil Erodibility.mxd
Map Production: Watershed Protection and Restoration Program

Map 2.13 – Little Patuxent Subwatershed Ratings for Landscape Indicators for Restoration

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
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LP8	Little Patuxent 4	1096
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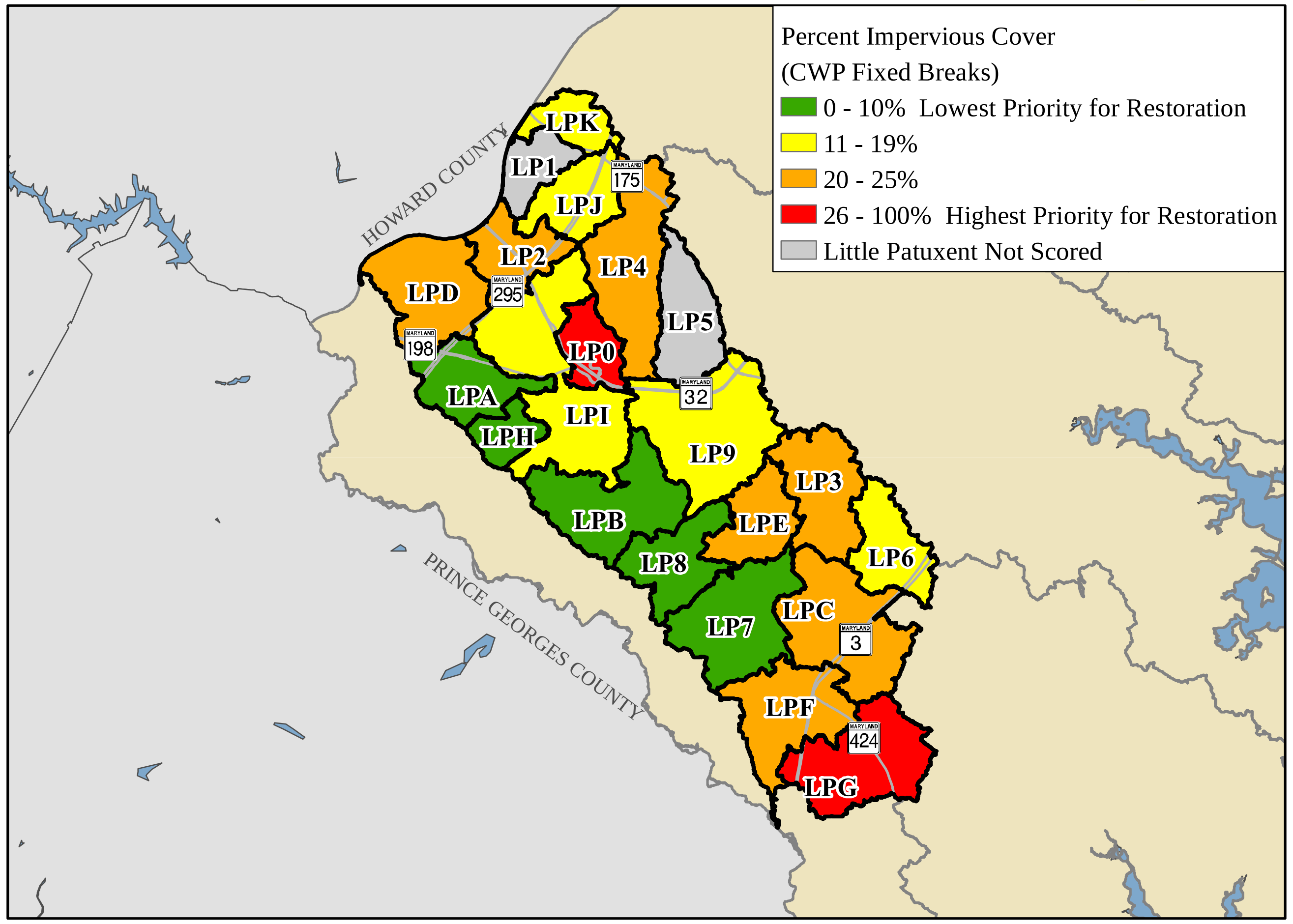
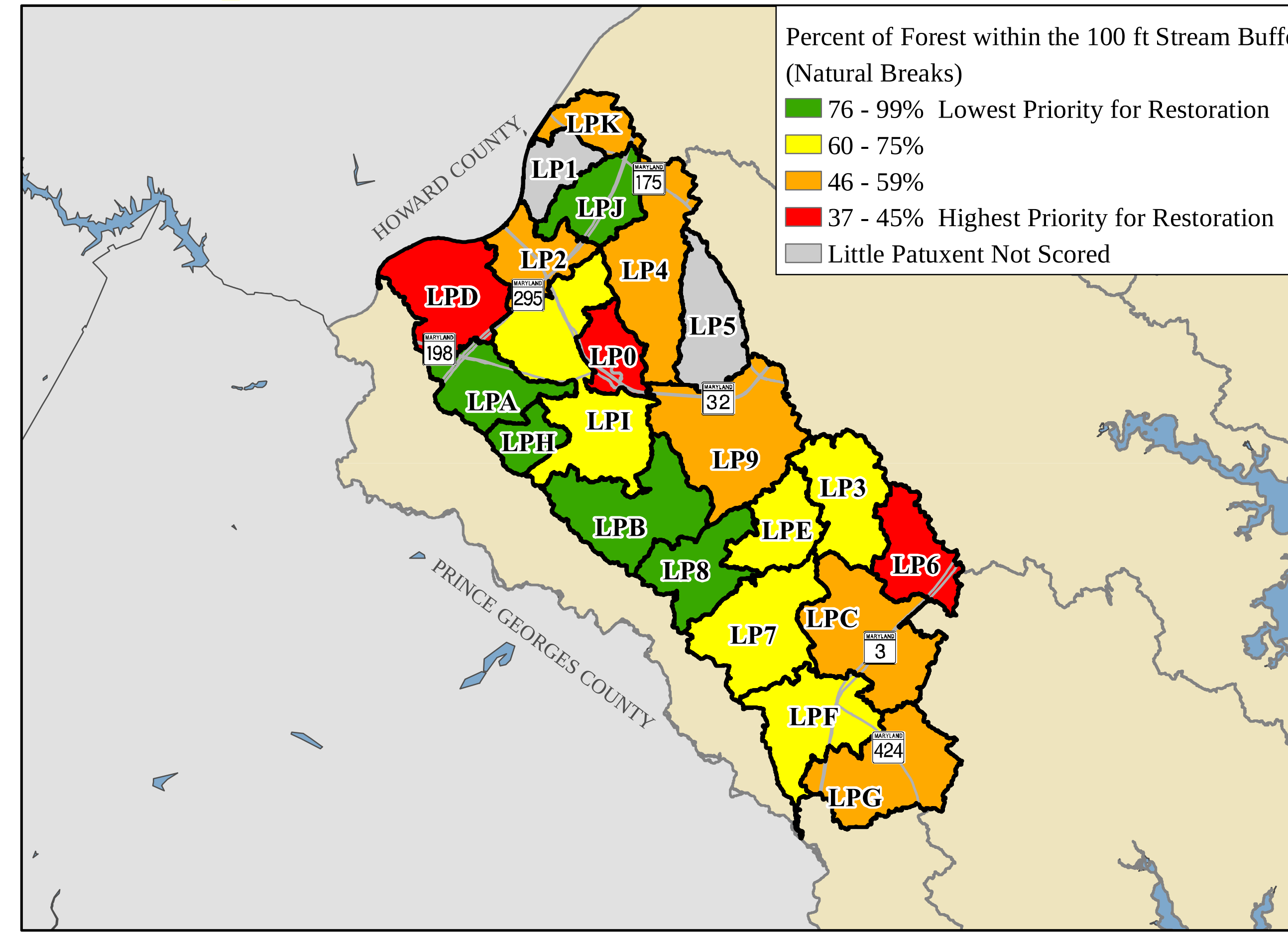
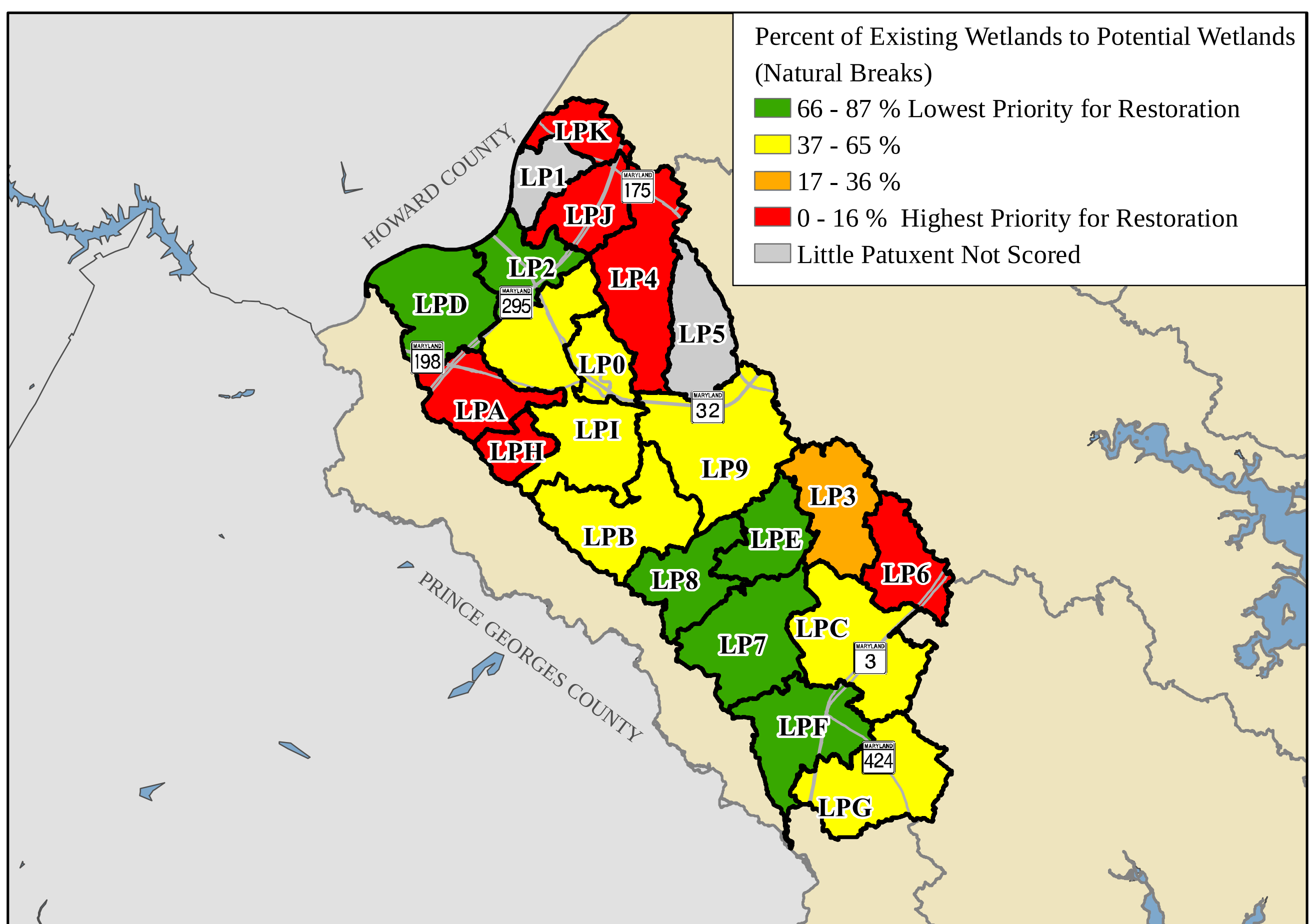
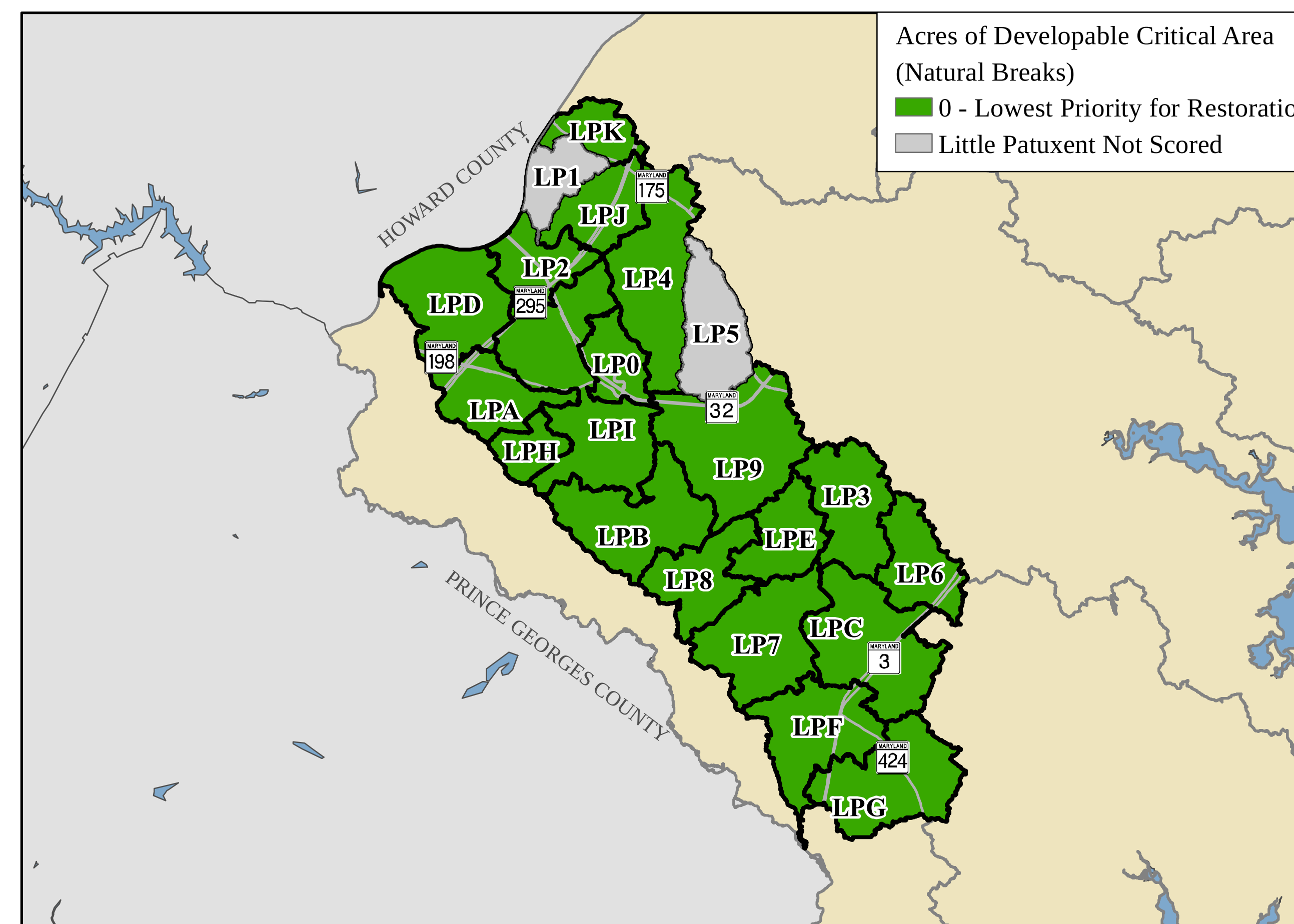
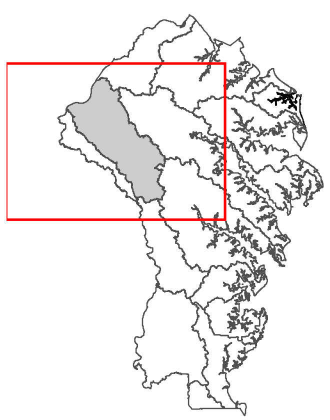
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594











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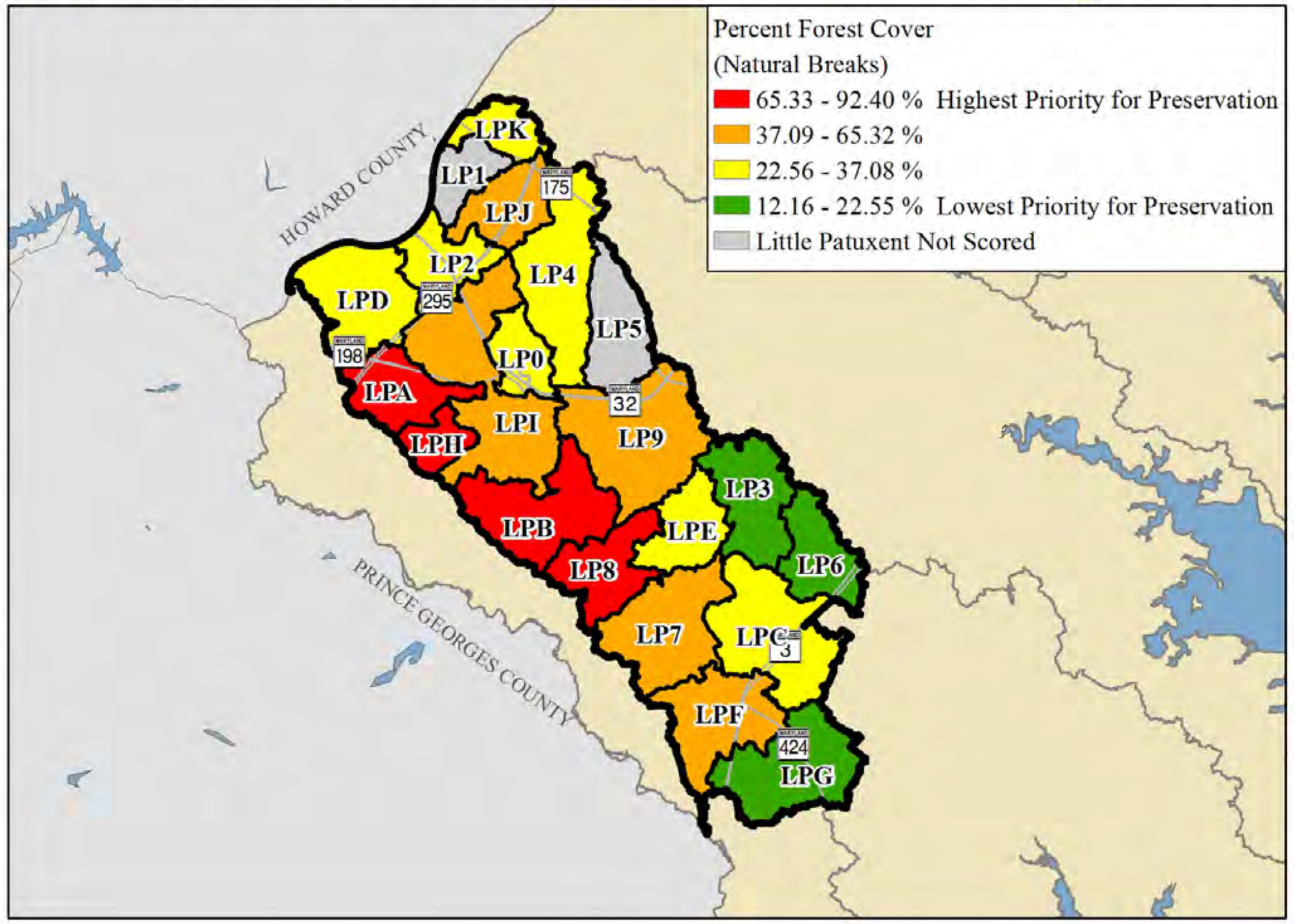
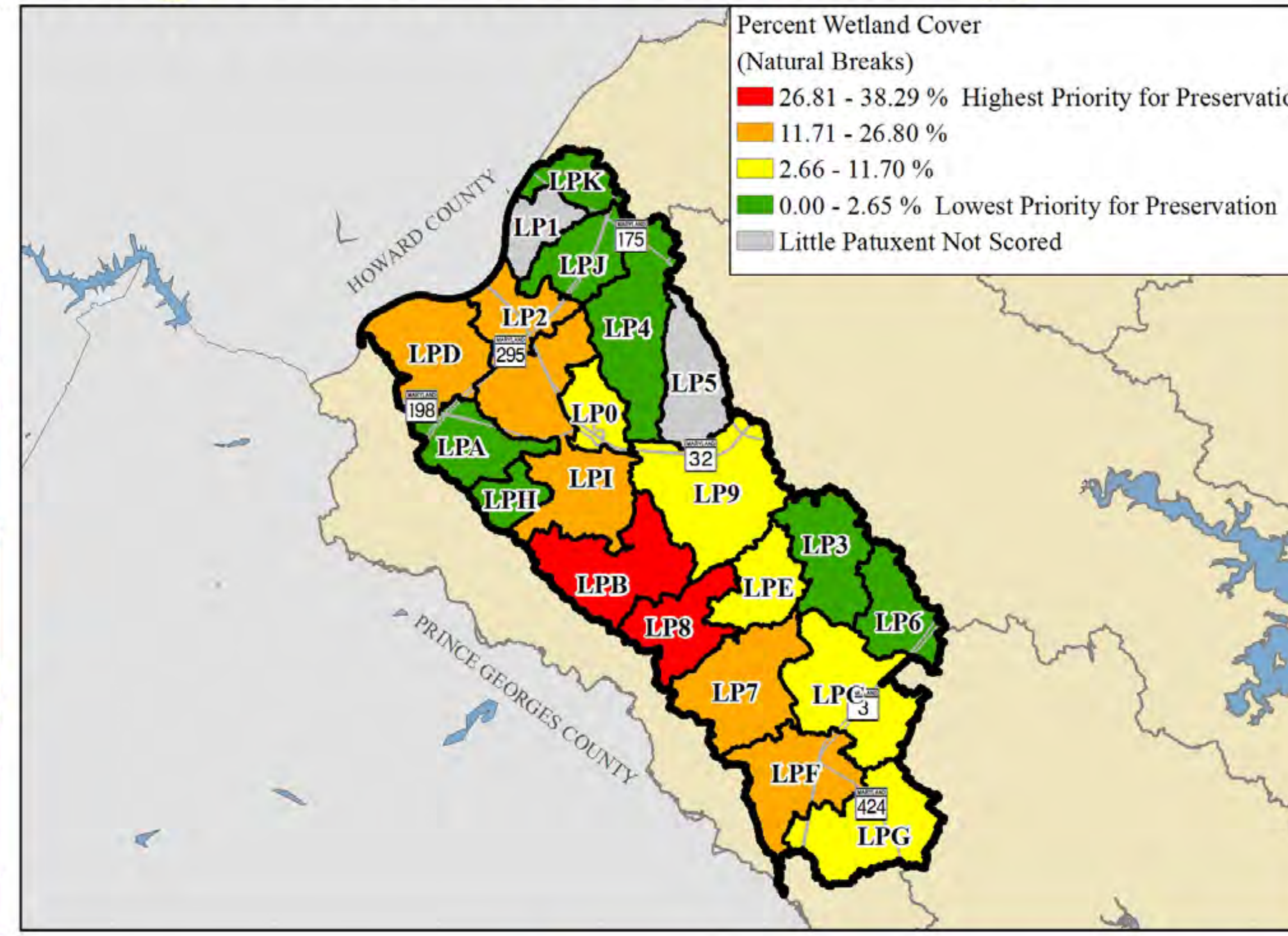
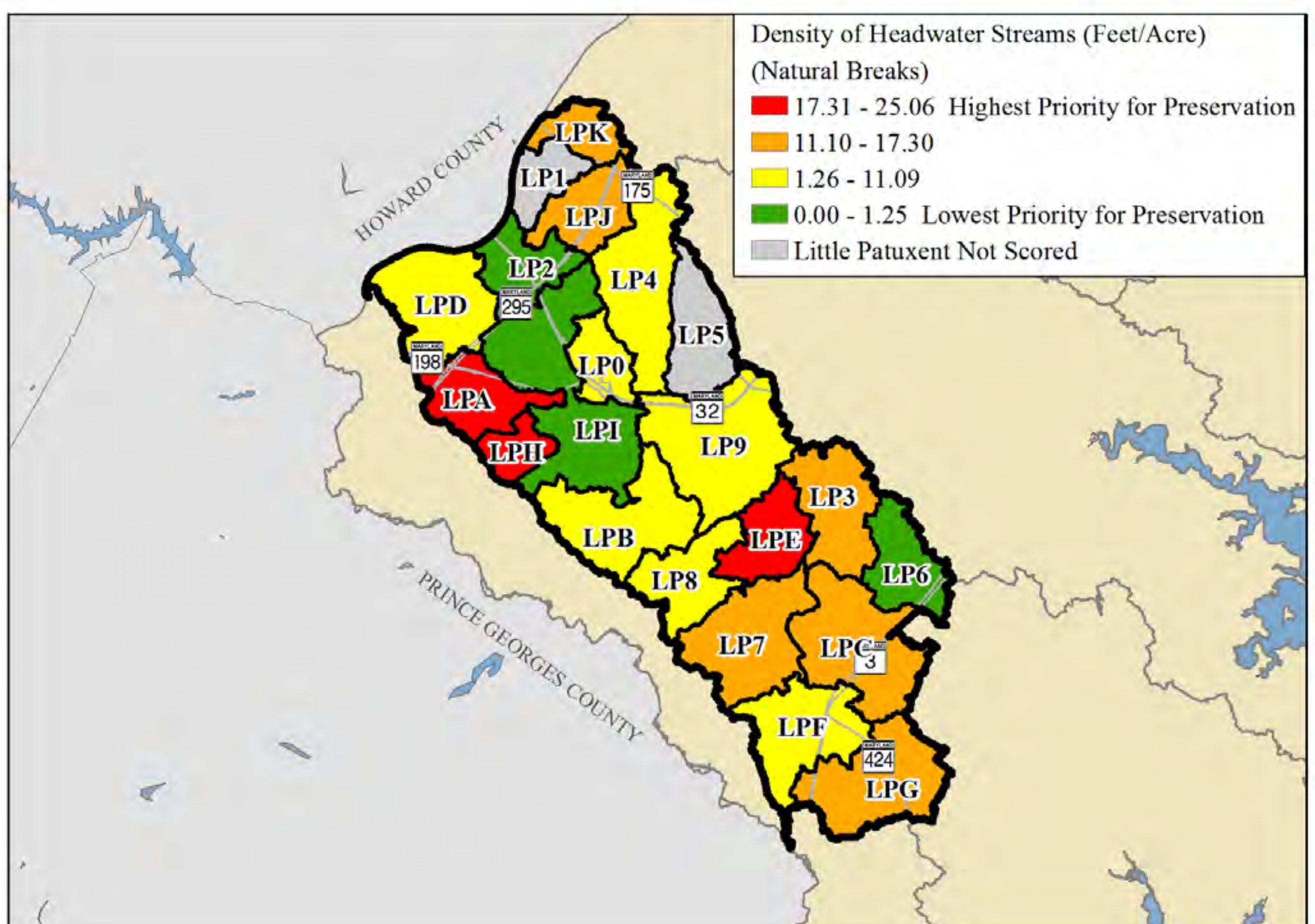
File: Map 2.13 - Lpax Subwatershed Ratings for Landscape Indicators for Restoration.mxd
Map Production: Watershed Protection and Restoration Program

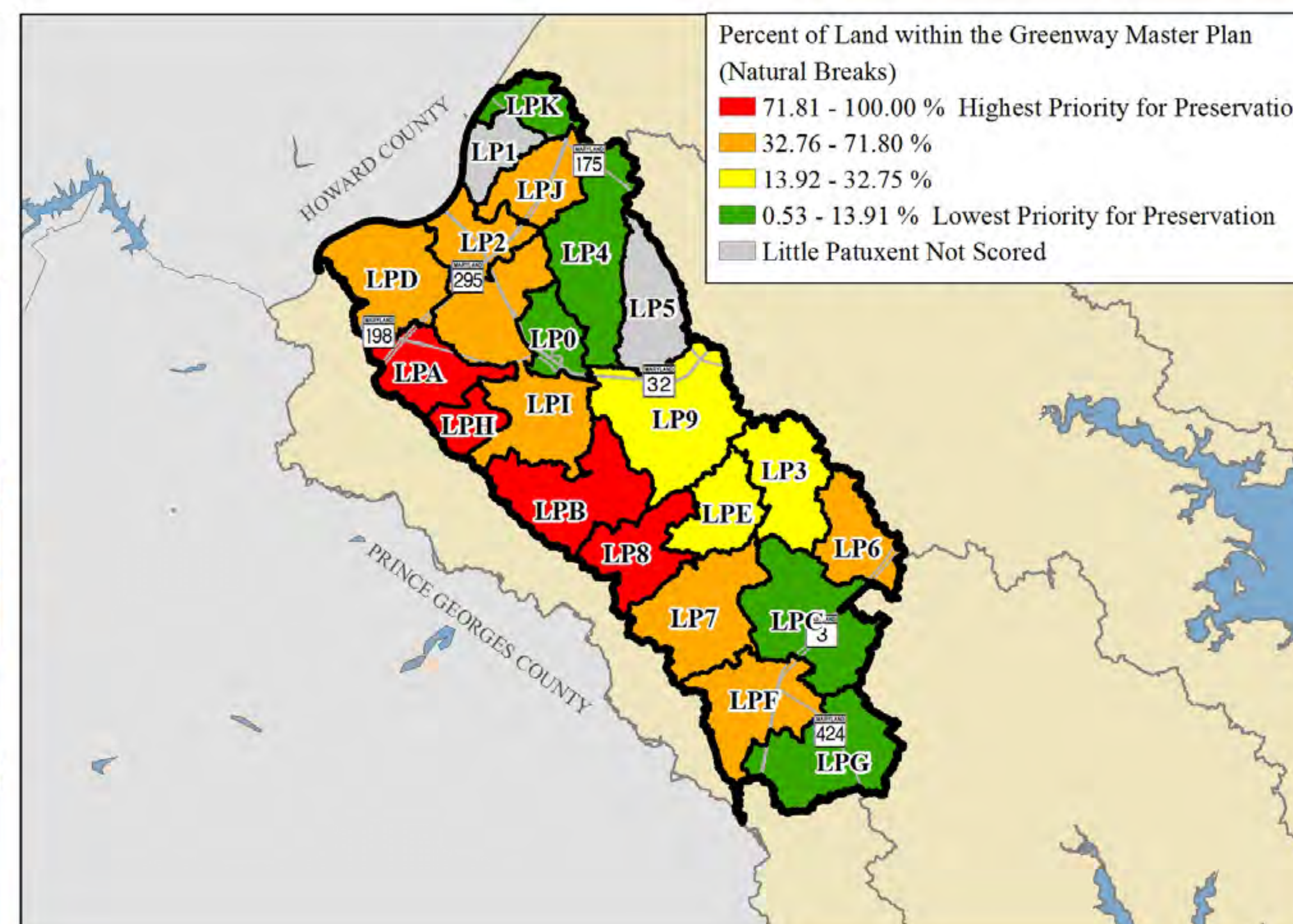
Map 2.14 – Little Patuxent Subwatershed Ratings for Landscape Indicators for Preservation (1)

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594









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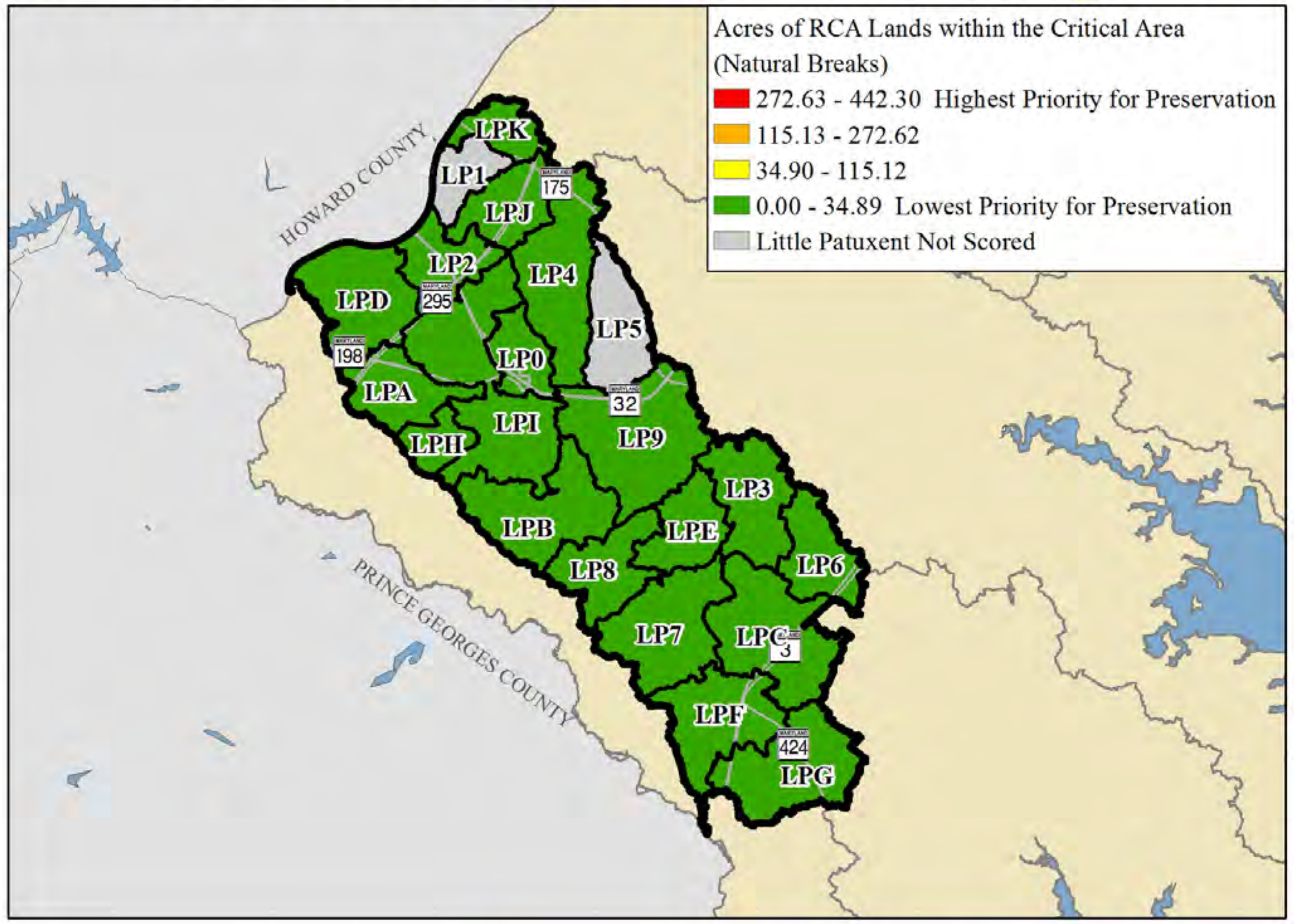
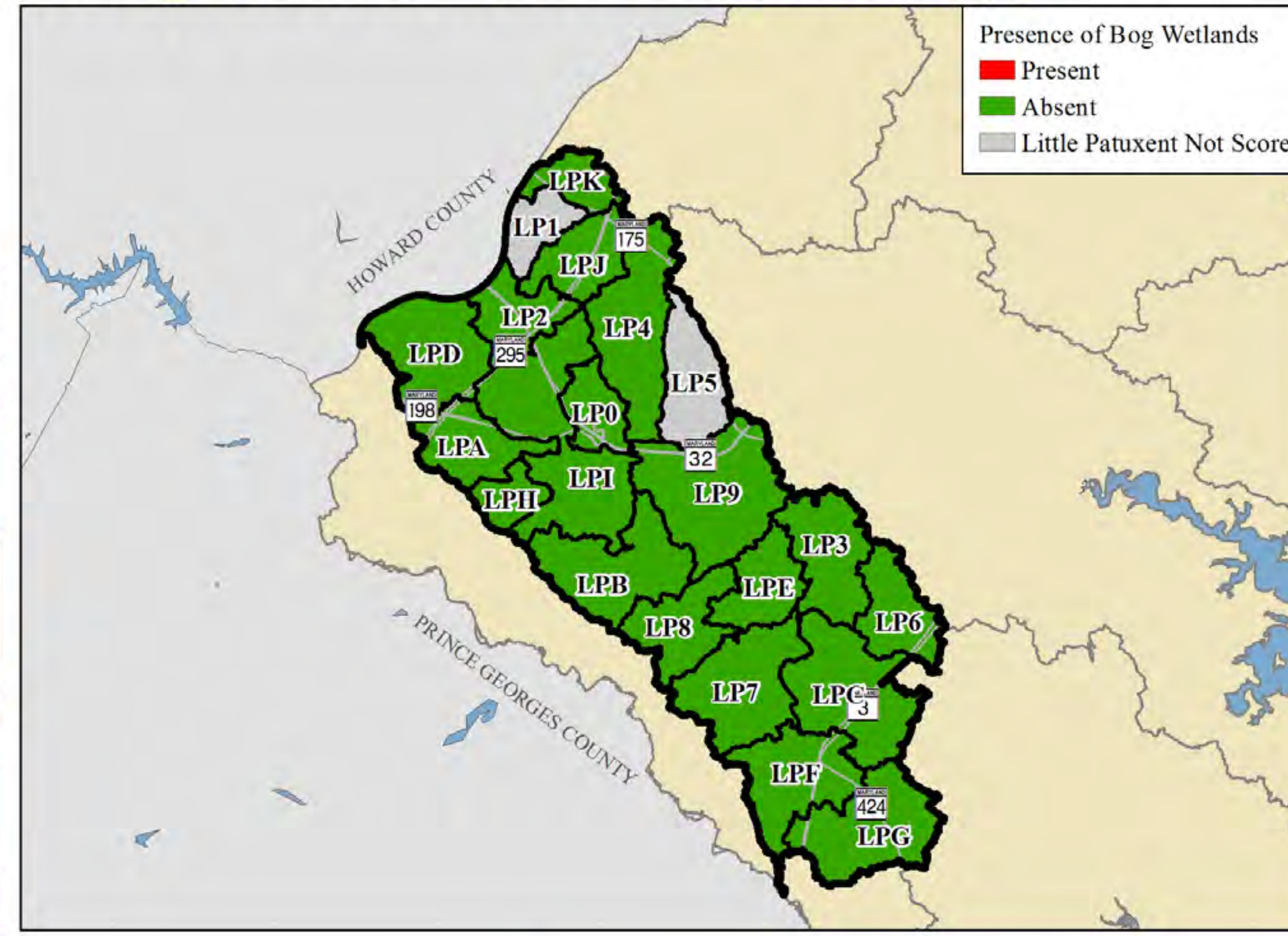
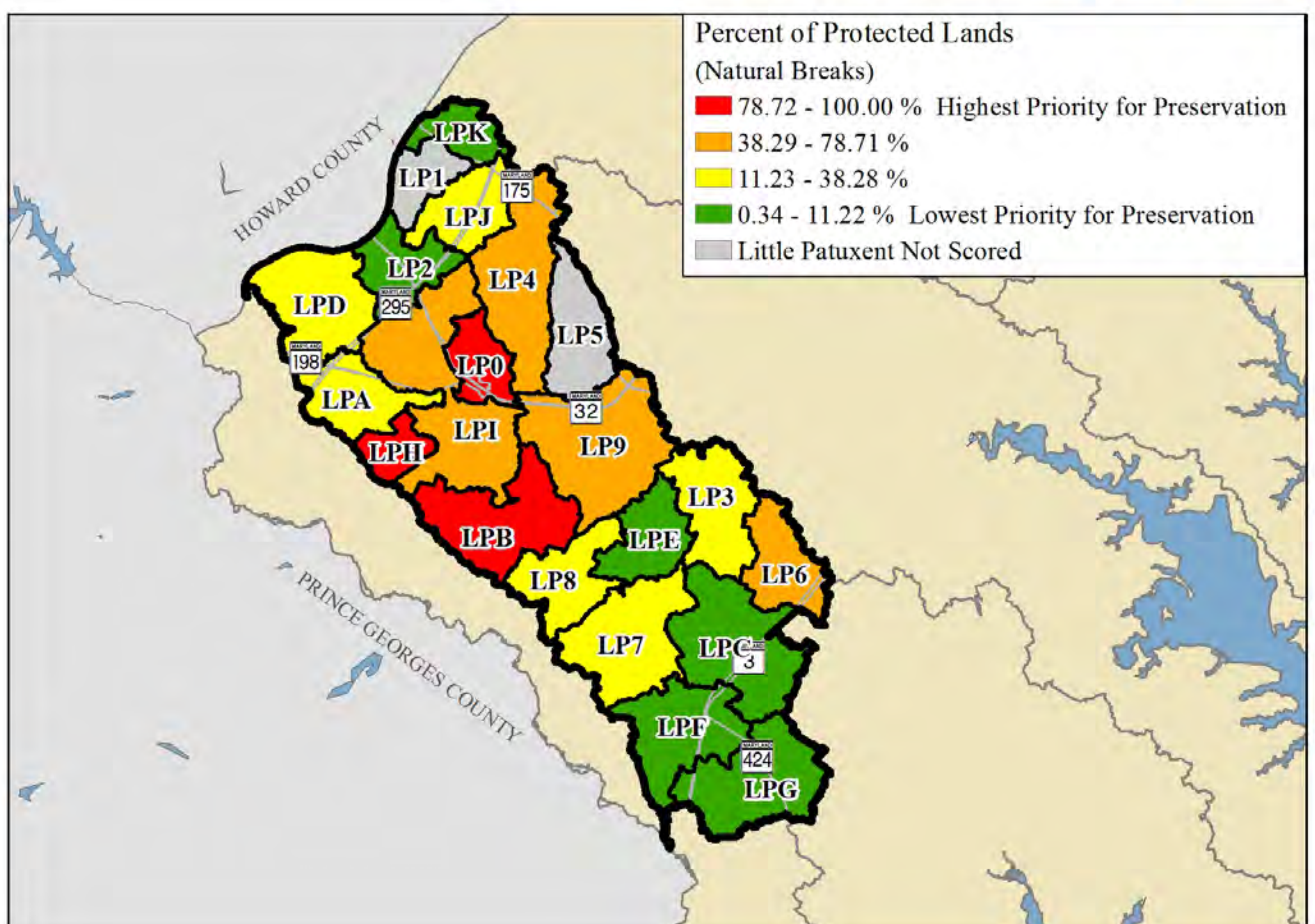
Date: September 2015
File: Map 2.14 - Lpax Subwatershed Ratings for Landscape Indicators for Preservation1.mxd
Map Production: Watershed Protection and Restoration Program

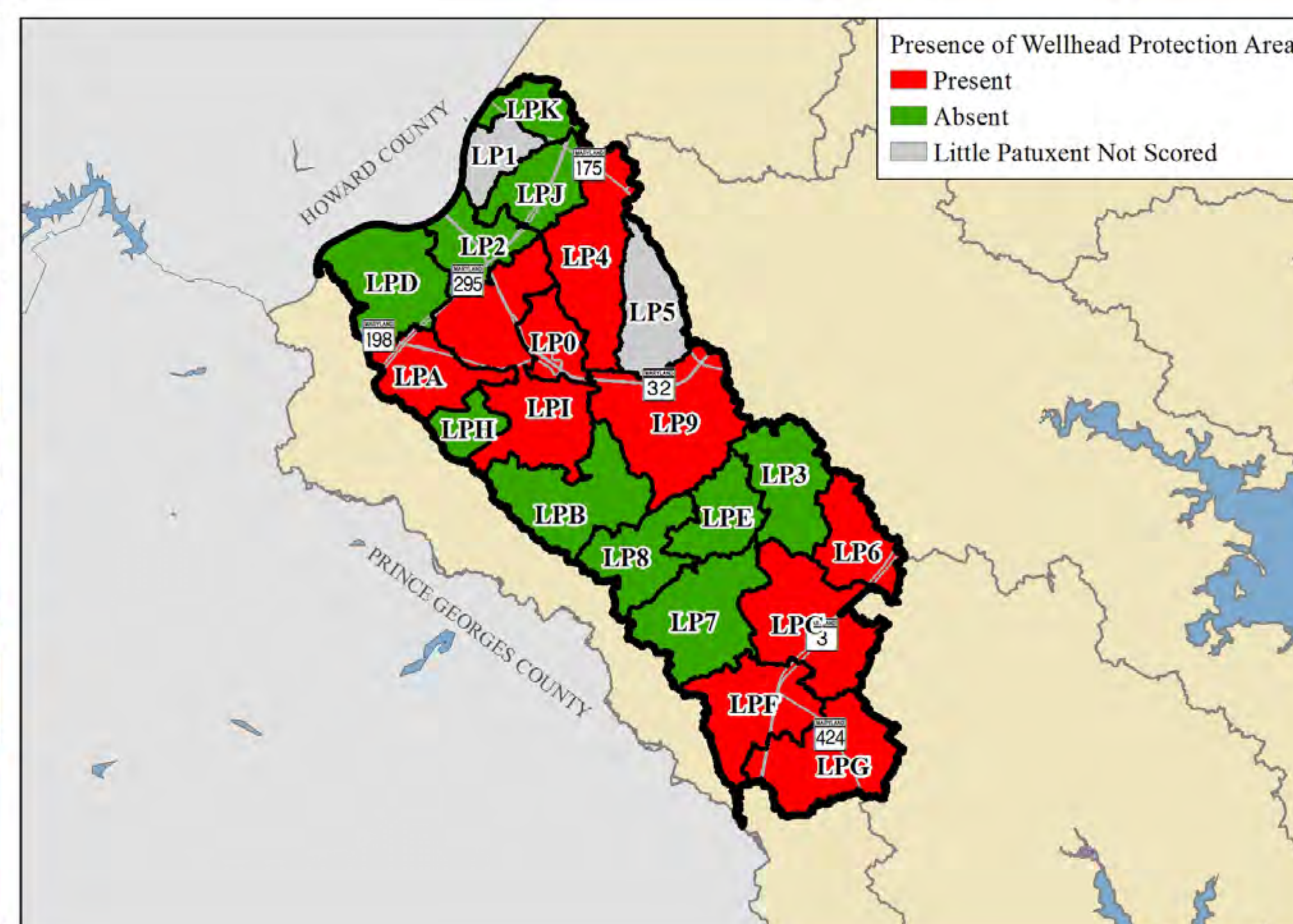
Map 2.15 – Little Patuxent Subwatershed Ratings for Landscape Indicators for Preservation (2)

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594









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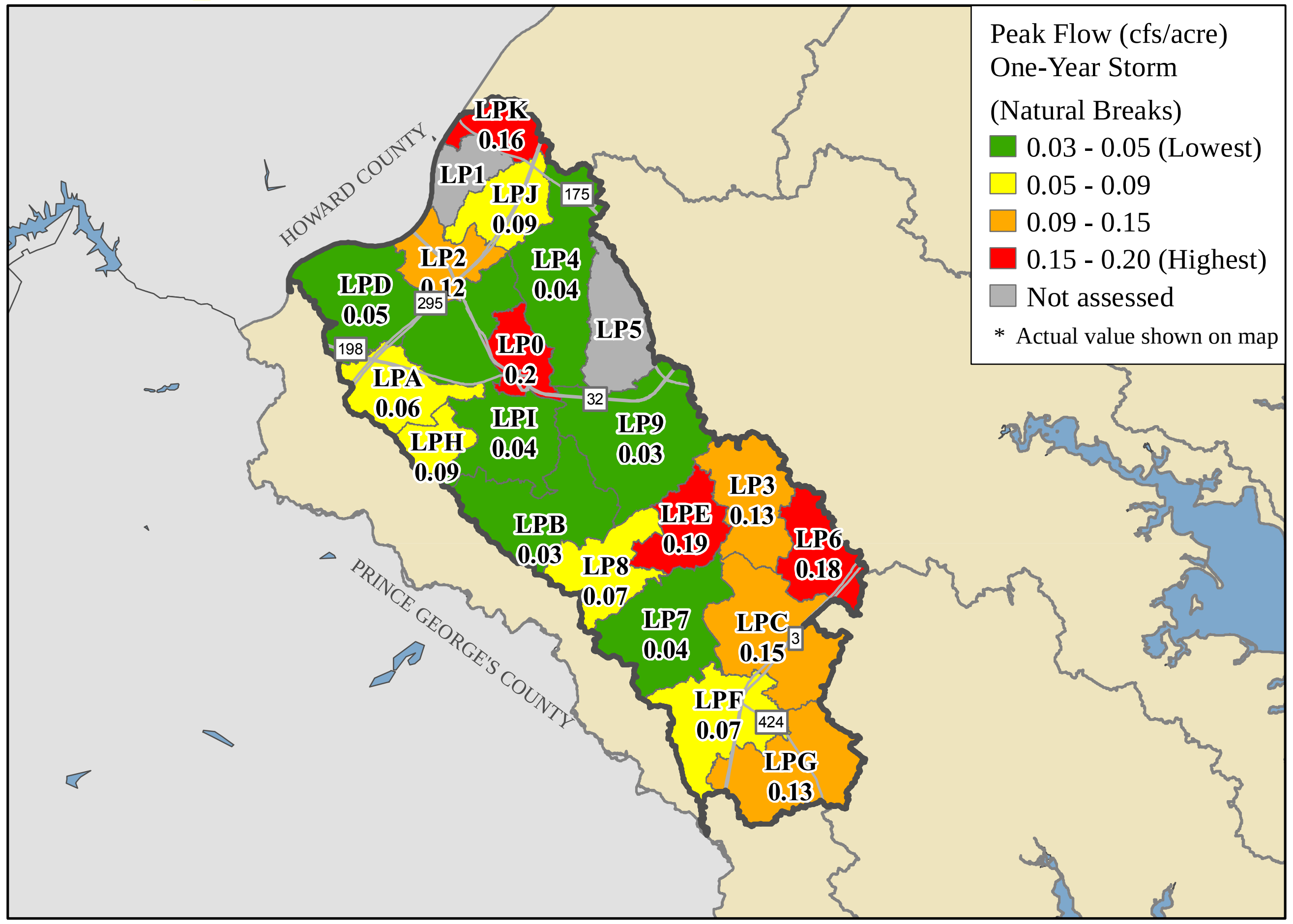
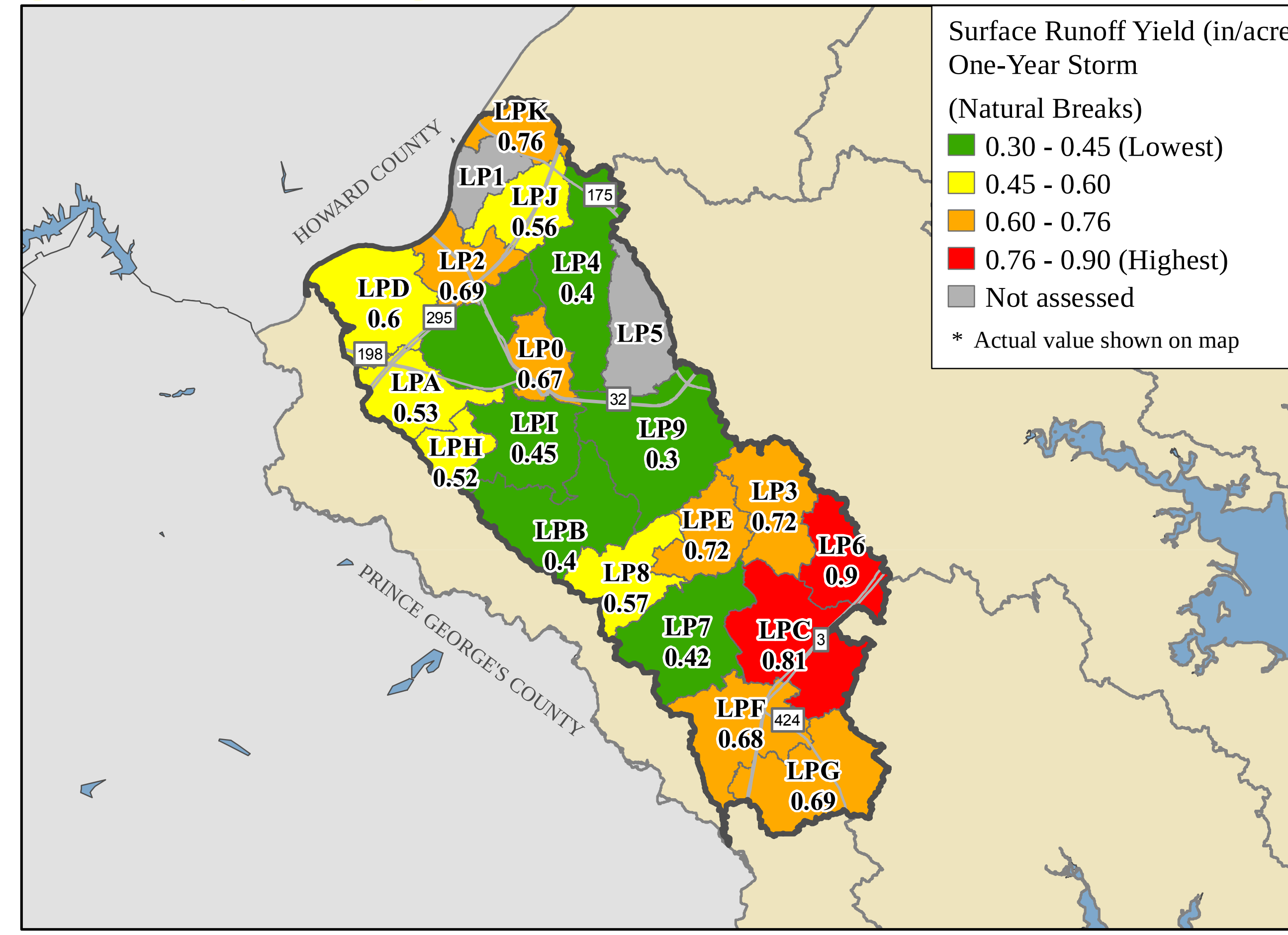
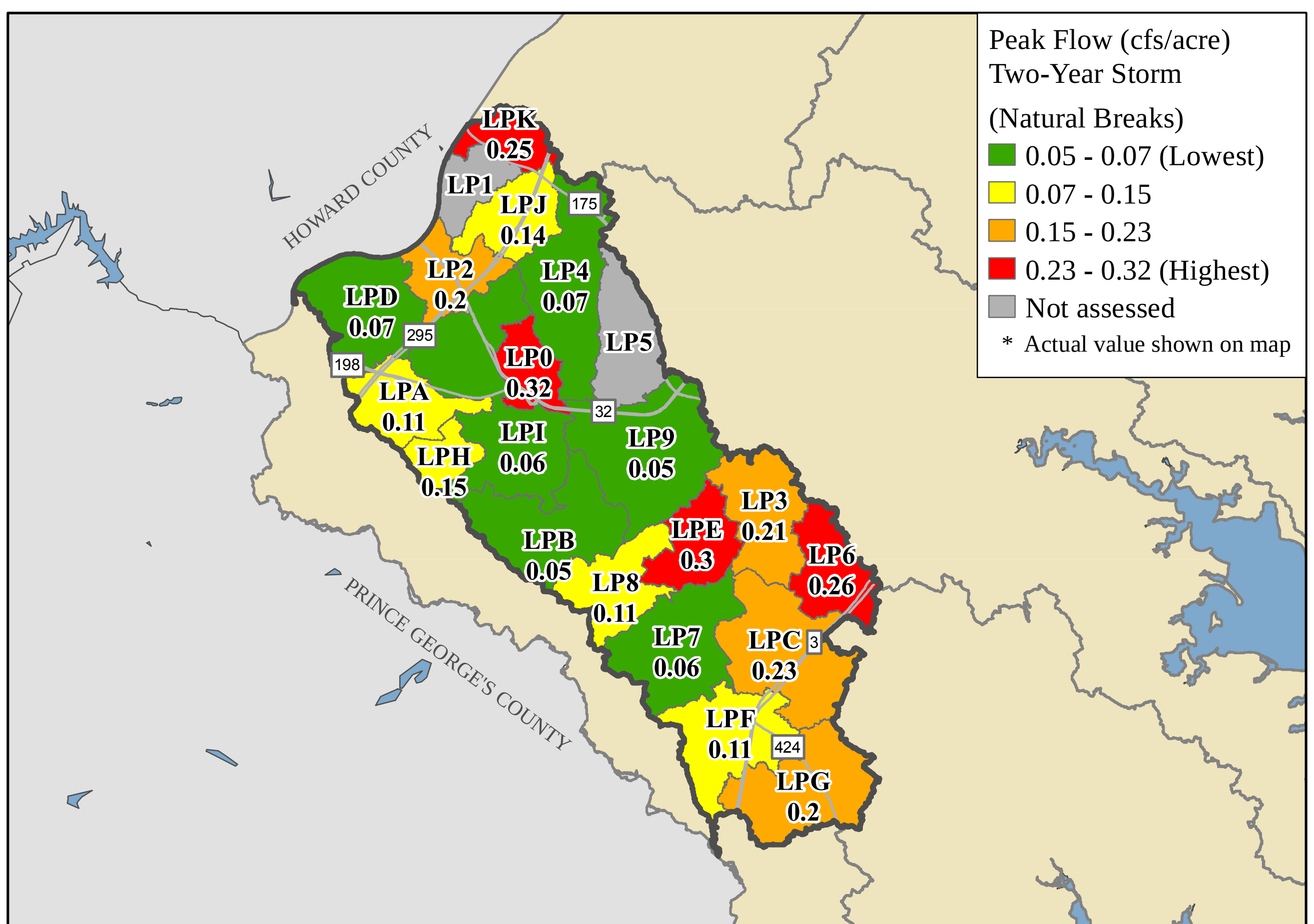
Date: September 2015
File: Map 2.15 - Lpax Subwatershed Ratings for Landscape Indicators for Preservation2.mxd
Map Production: Watershed Protection and Restoration Program

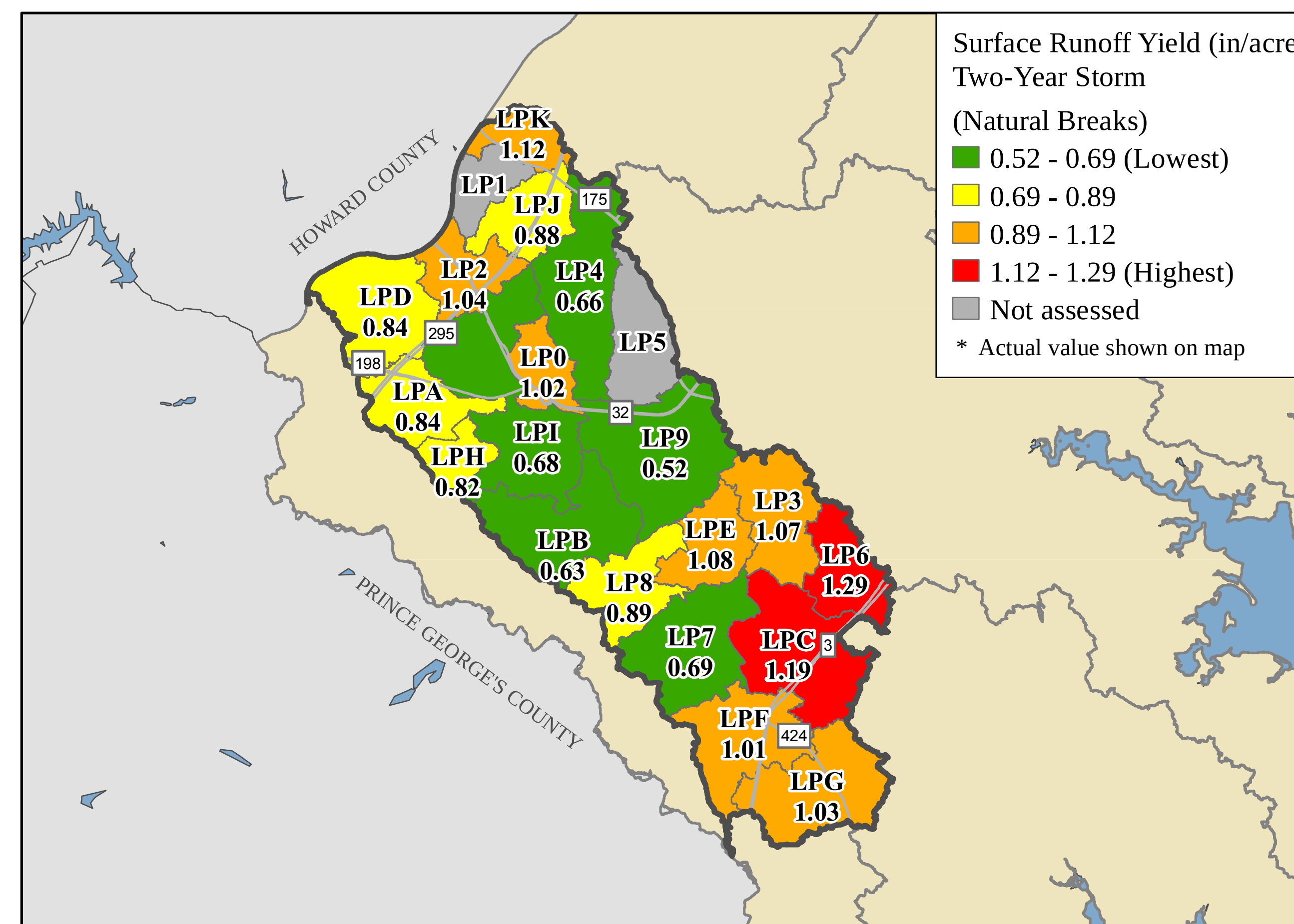
Map 3.1 – Little Patuxent Subwatershed Ratings for Hydrologic Indicators

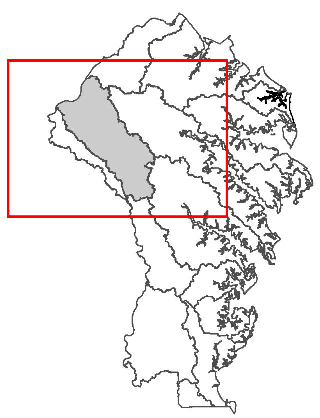
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594











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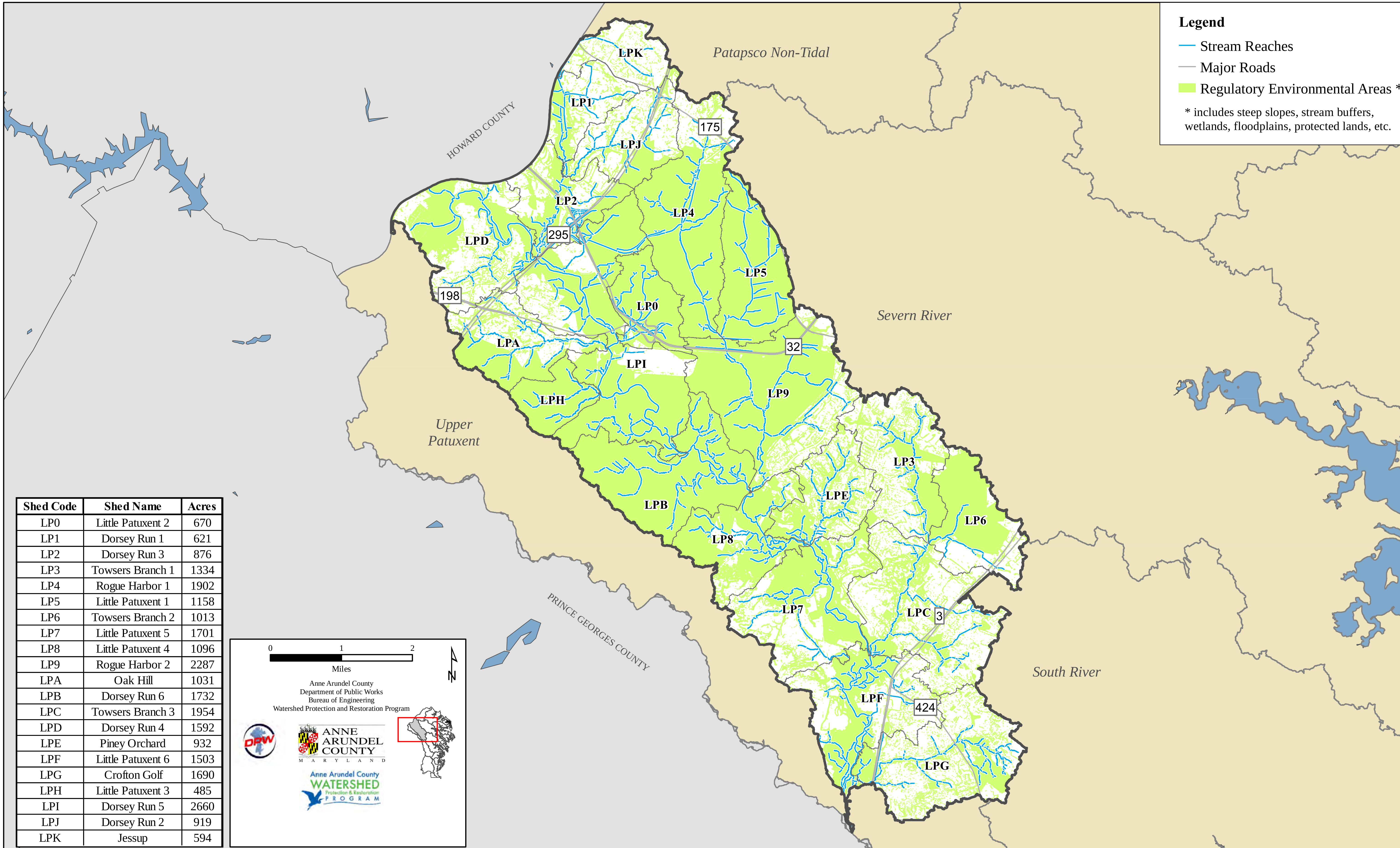
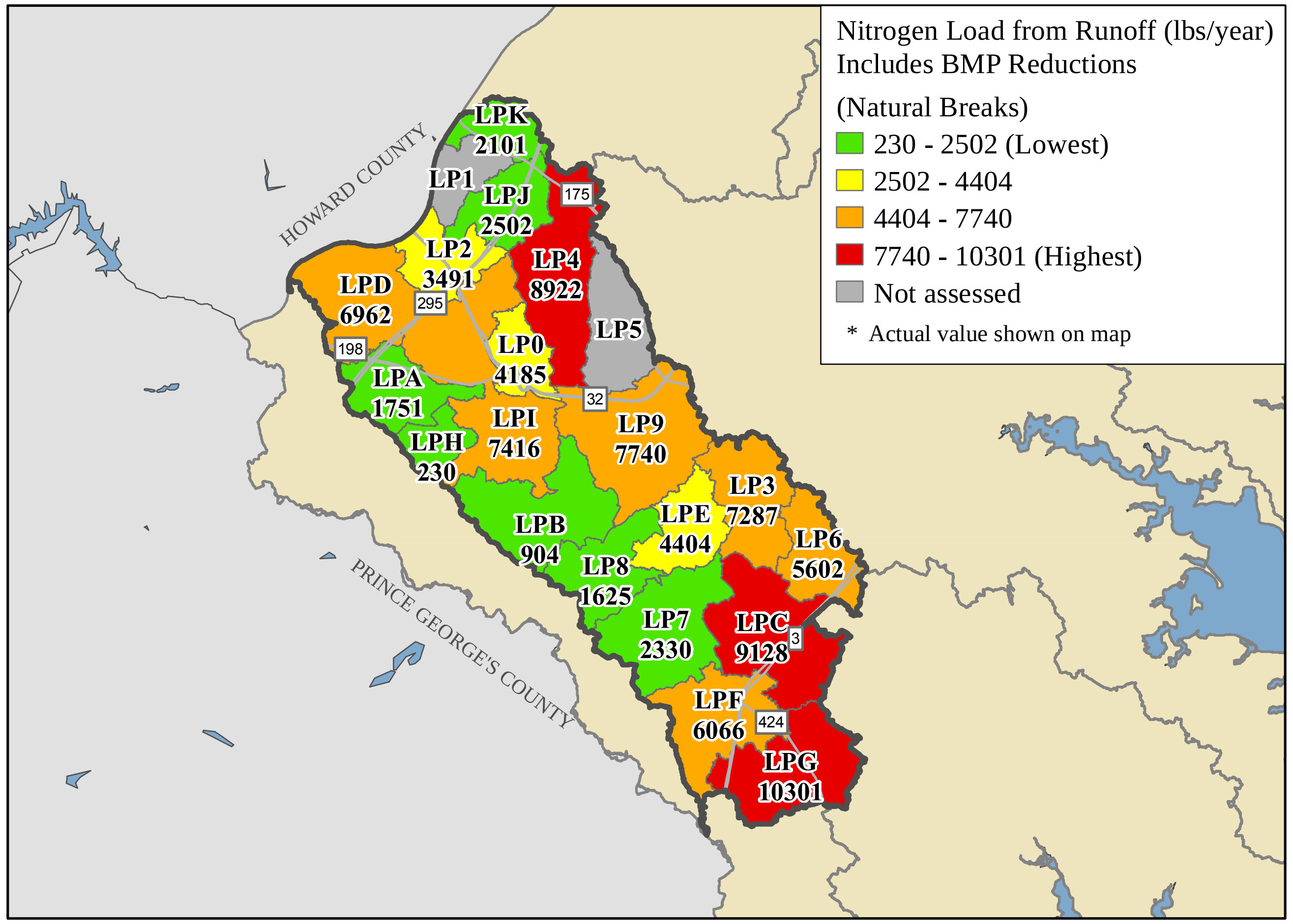
Map 3.2 – Little Patuxent Subwatershed Regulatory Environmental Areas

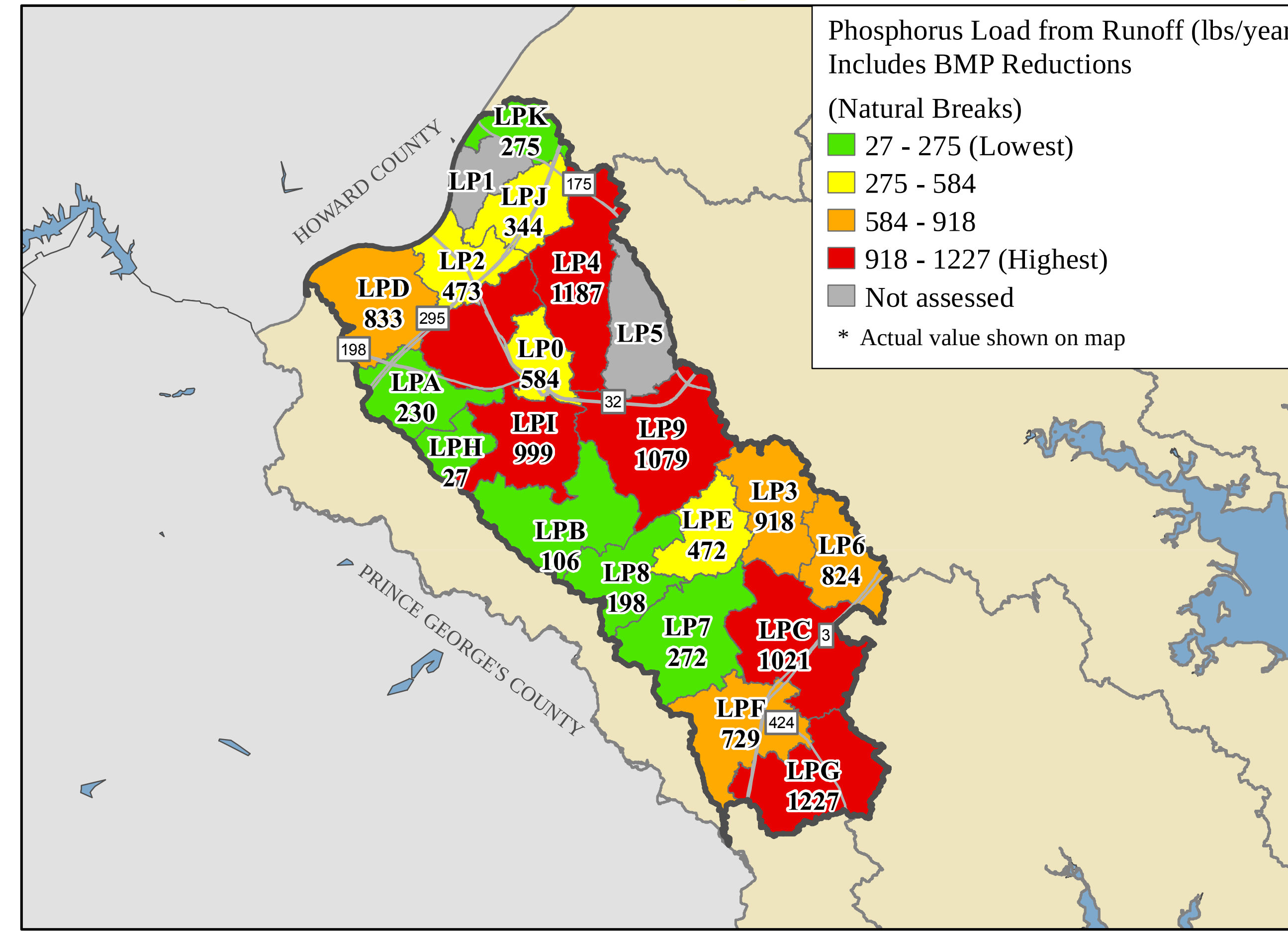


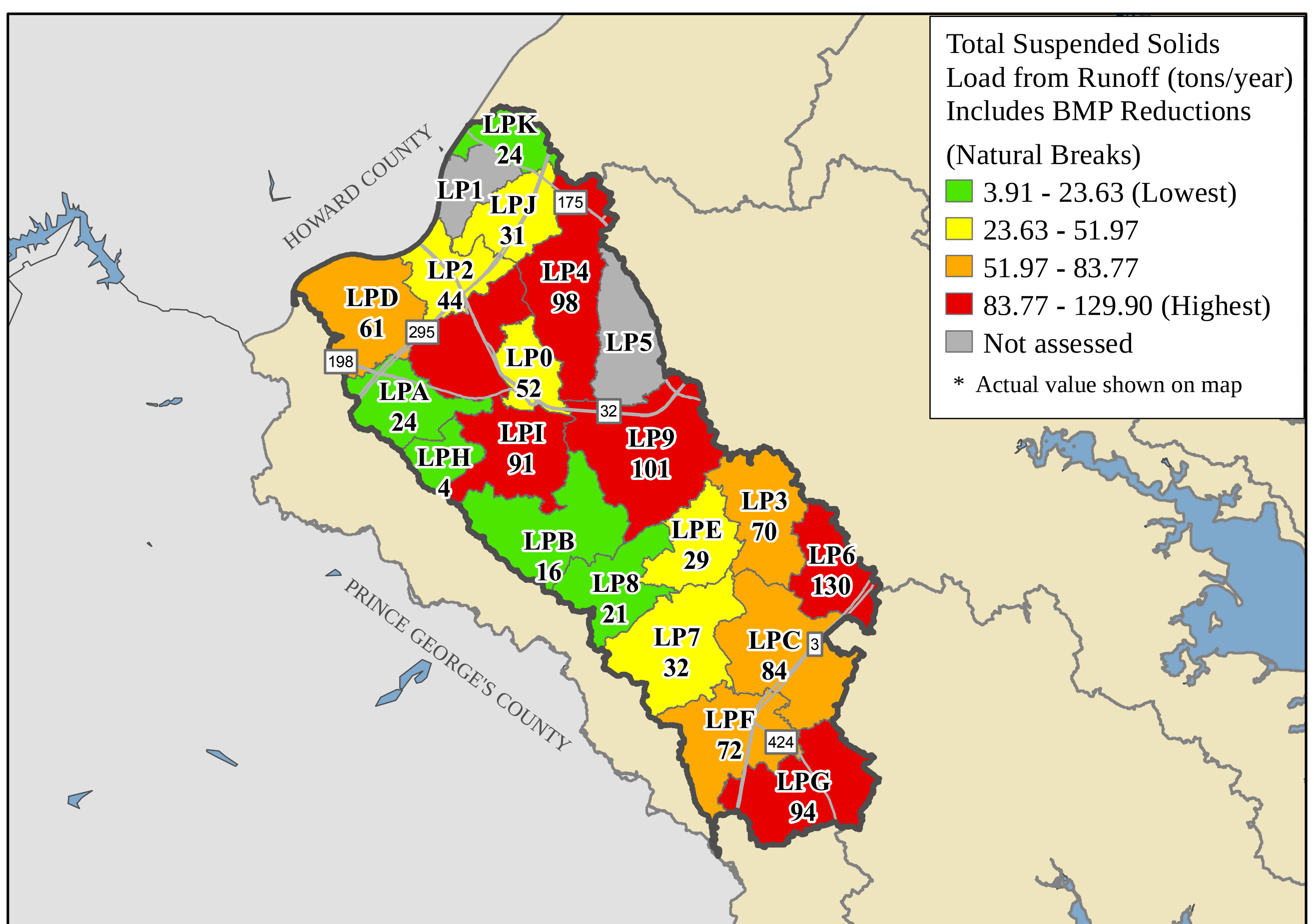
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

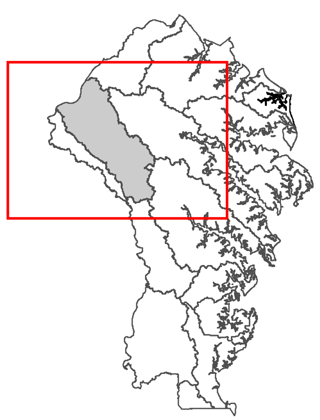
Map 3.3 – Little Patuxent Subwatershed Summary Pollutant Loads Based on Existing Conditions

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594









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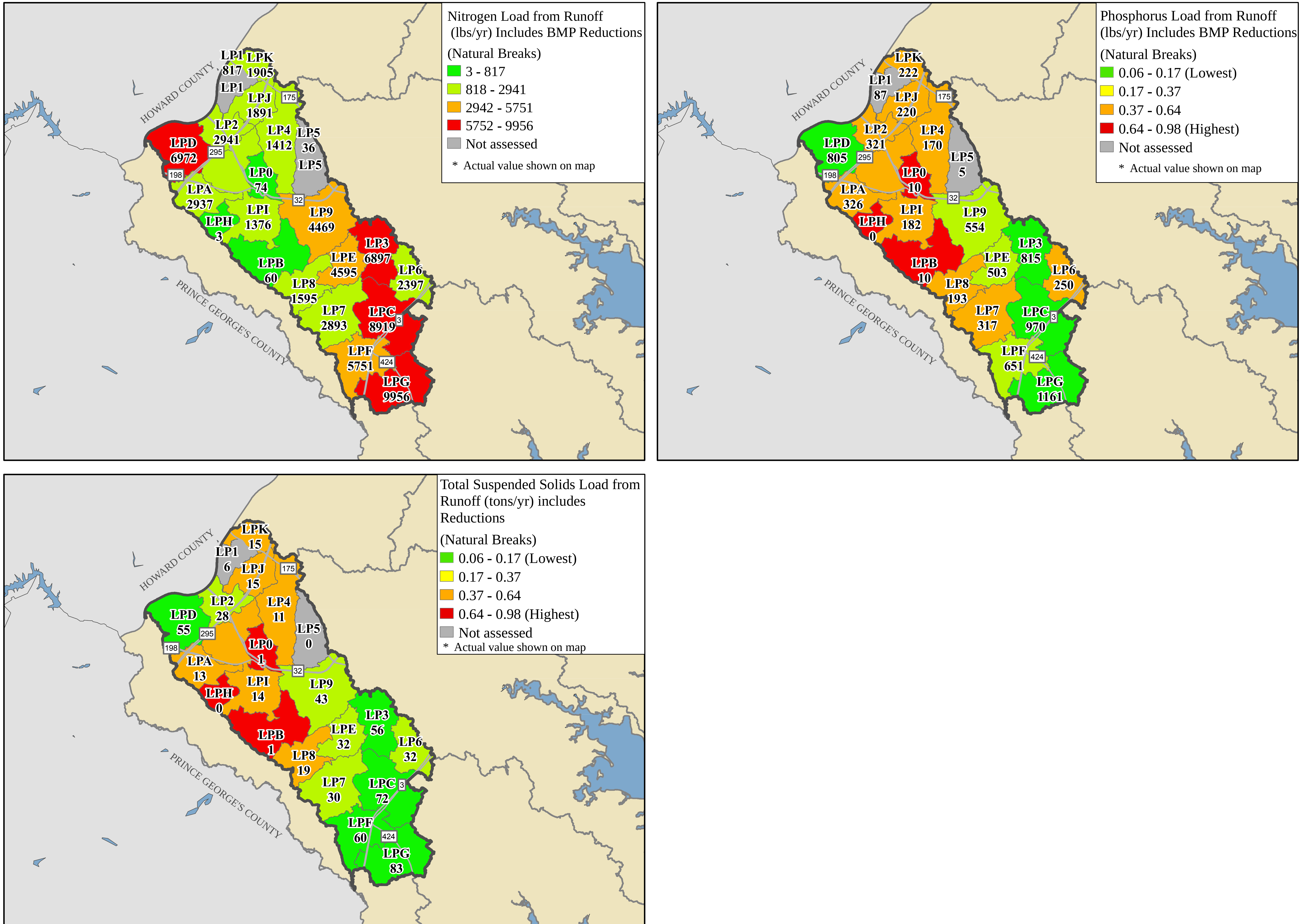
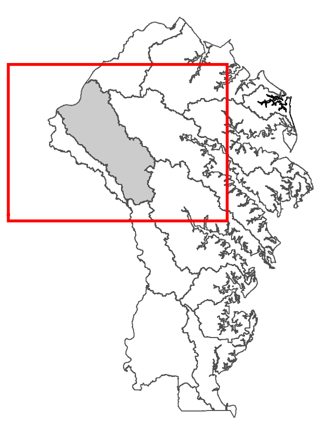
Map 3.4 – Little Patuxent Subwatershed Summary Pollutant Load Based on Future Conditions

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594





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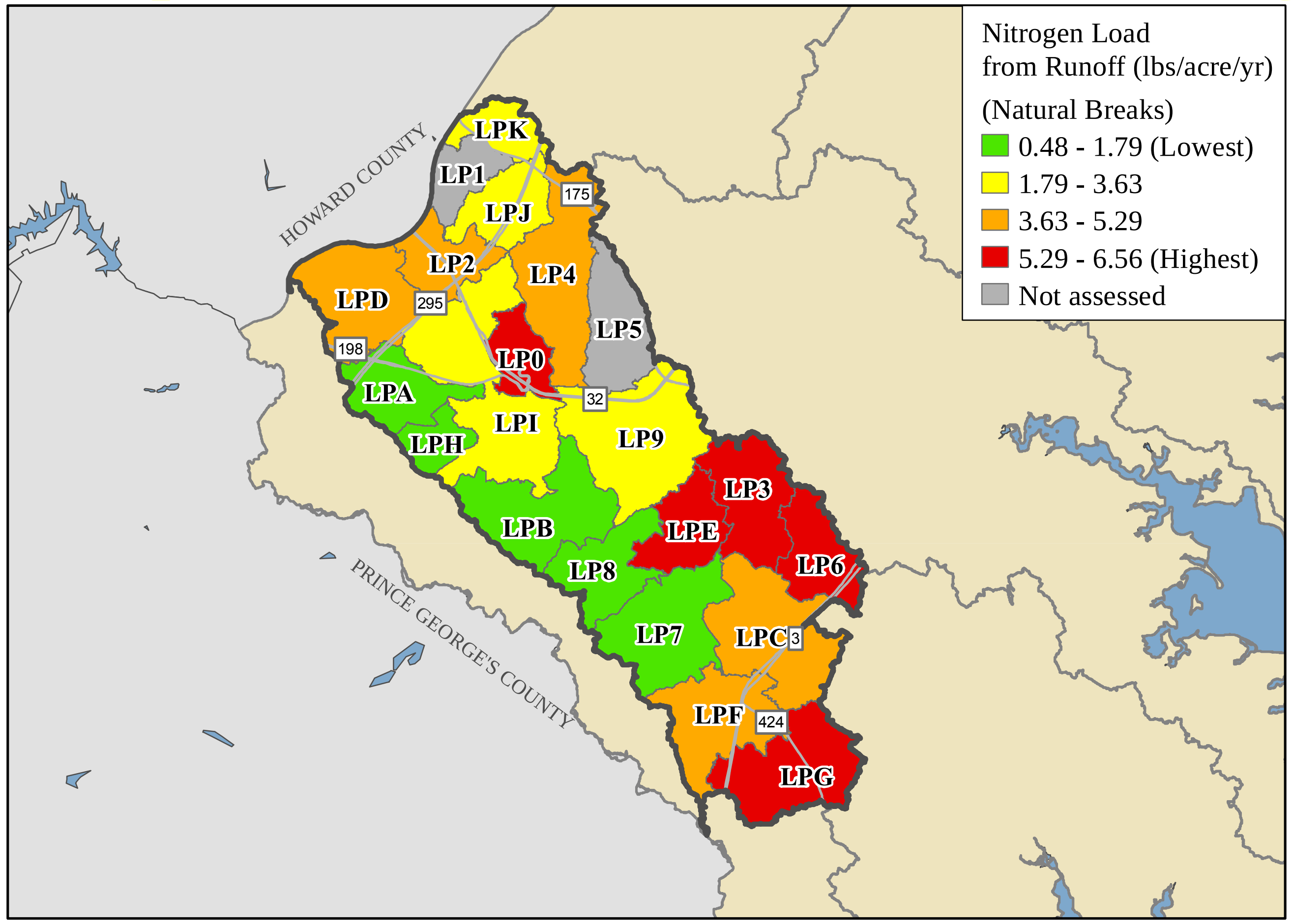
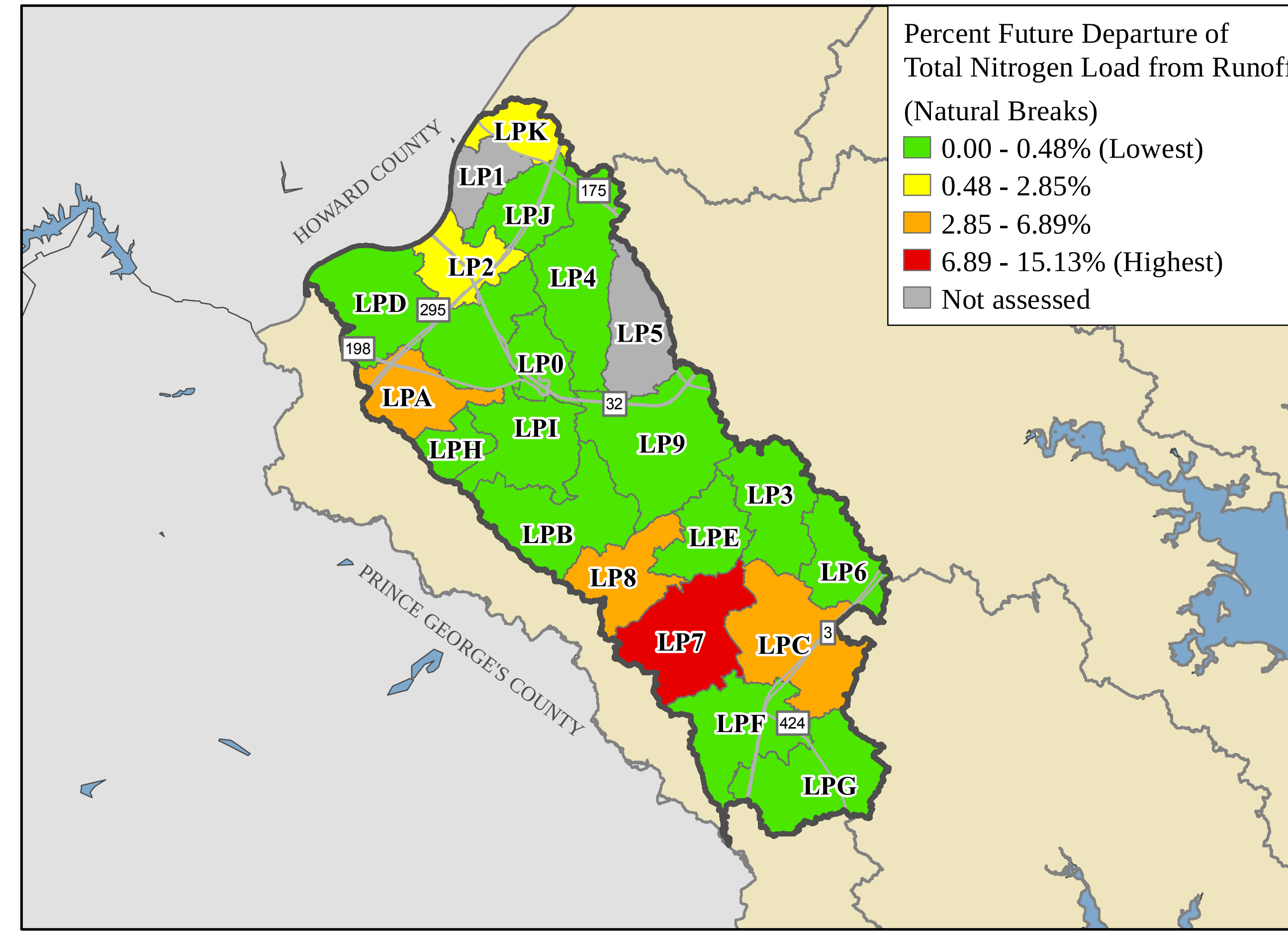
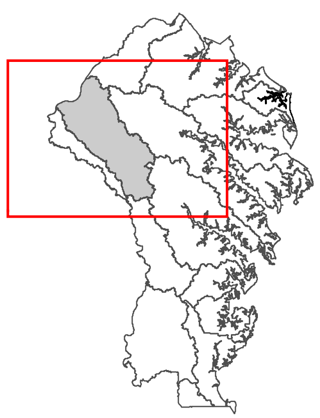
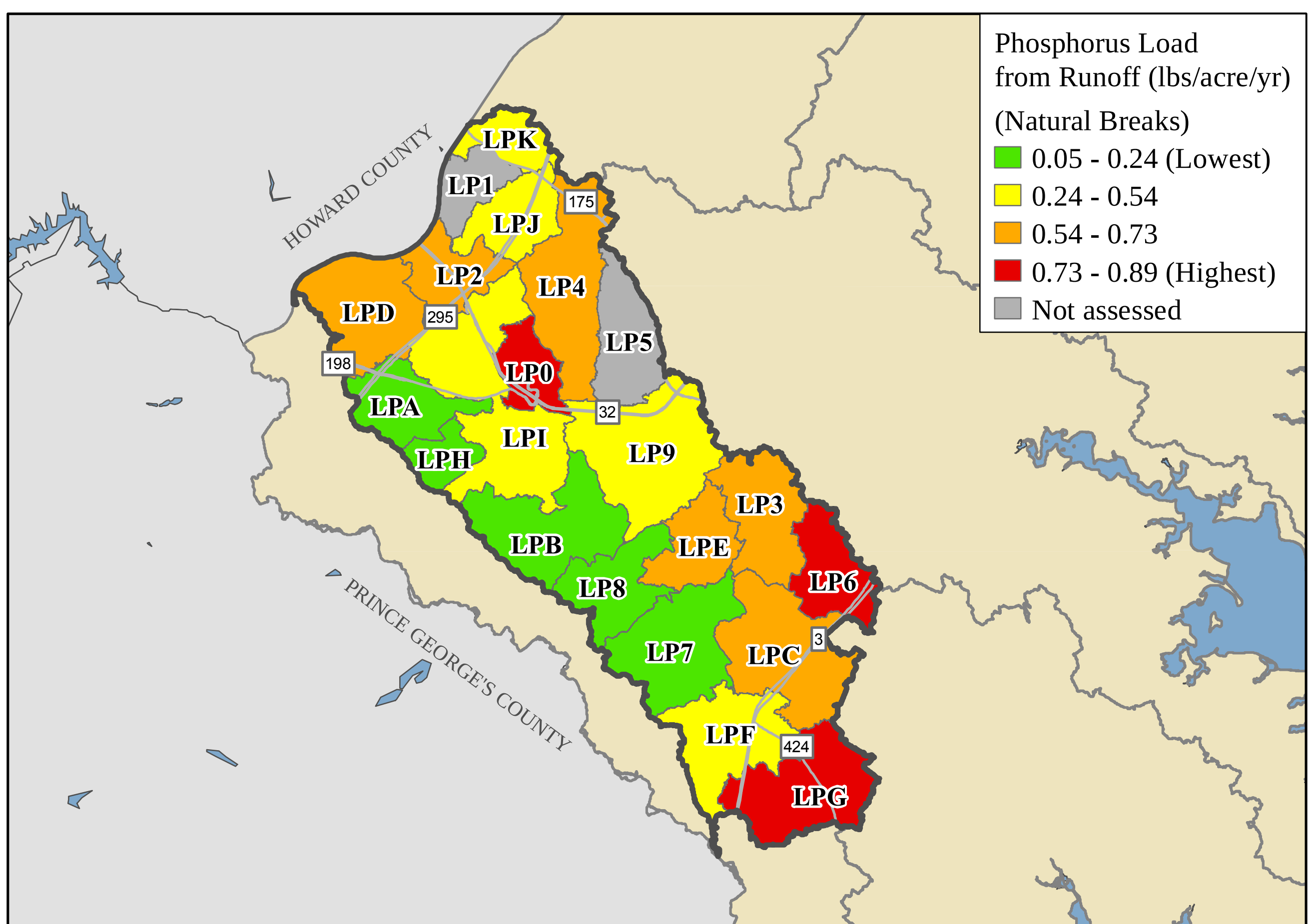
Map 3.5 – Little Patuxent Subwatershed Ratings for Water Quality Indicators

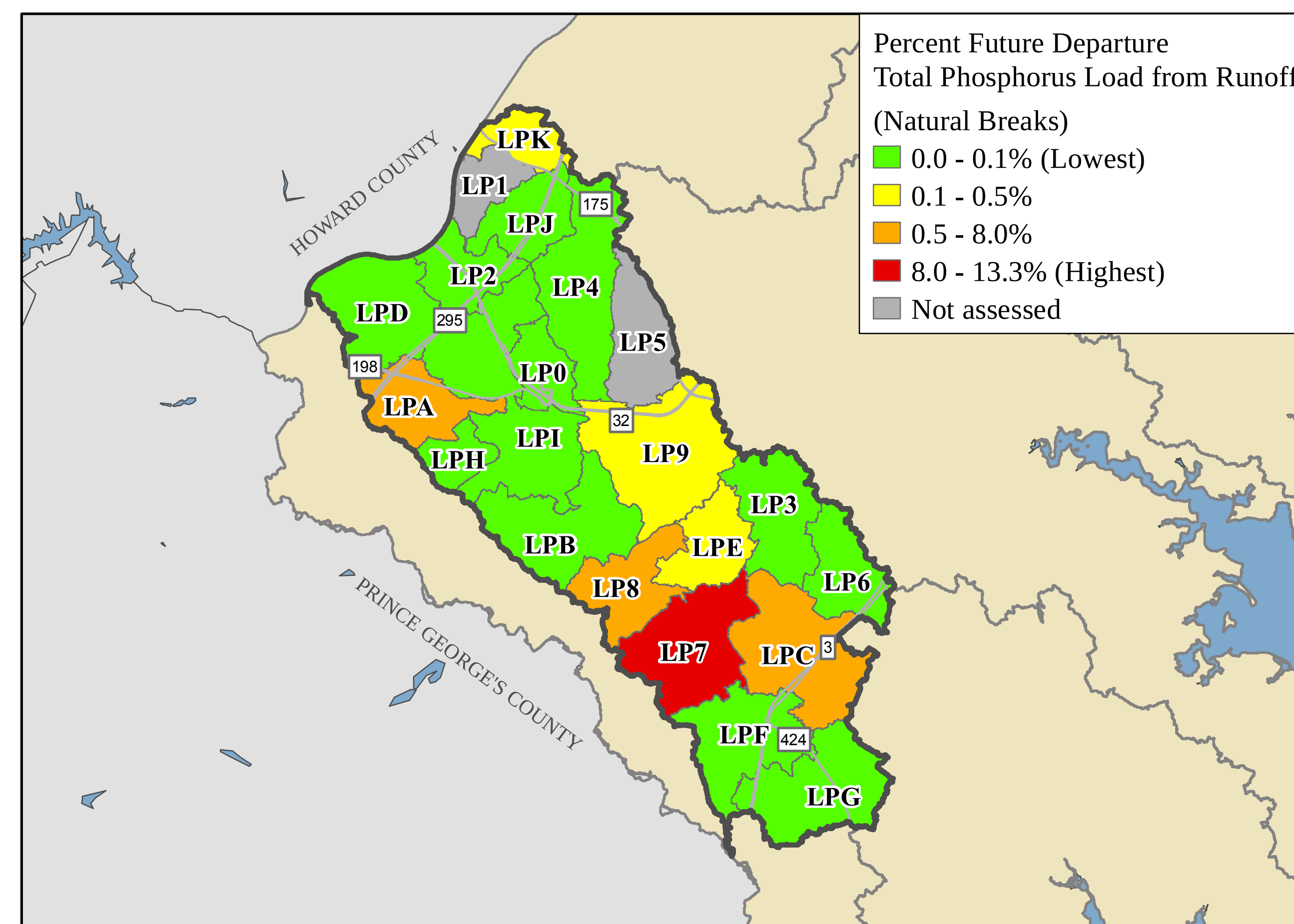
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594











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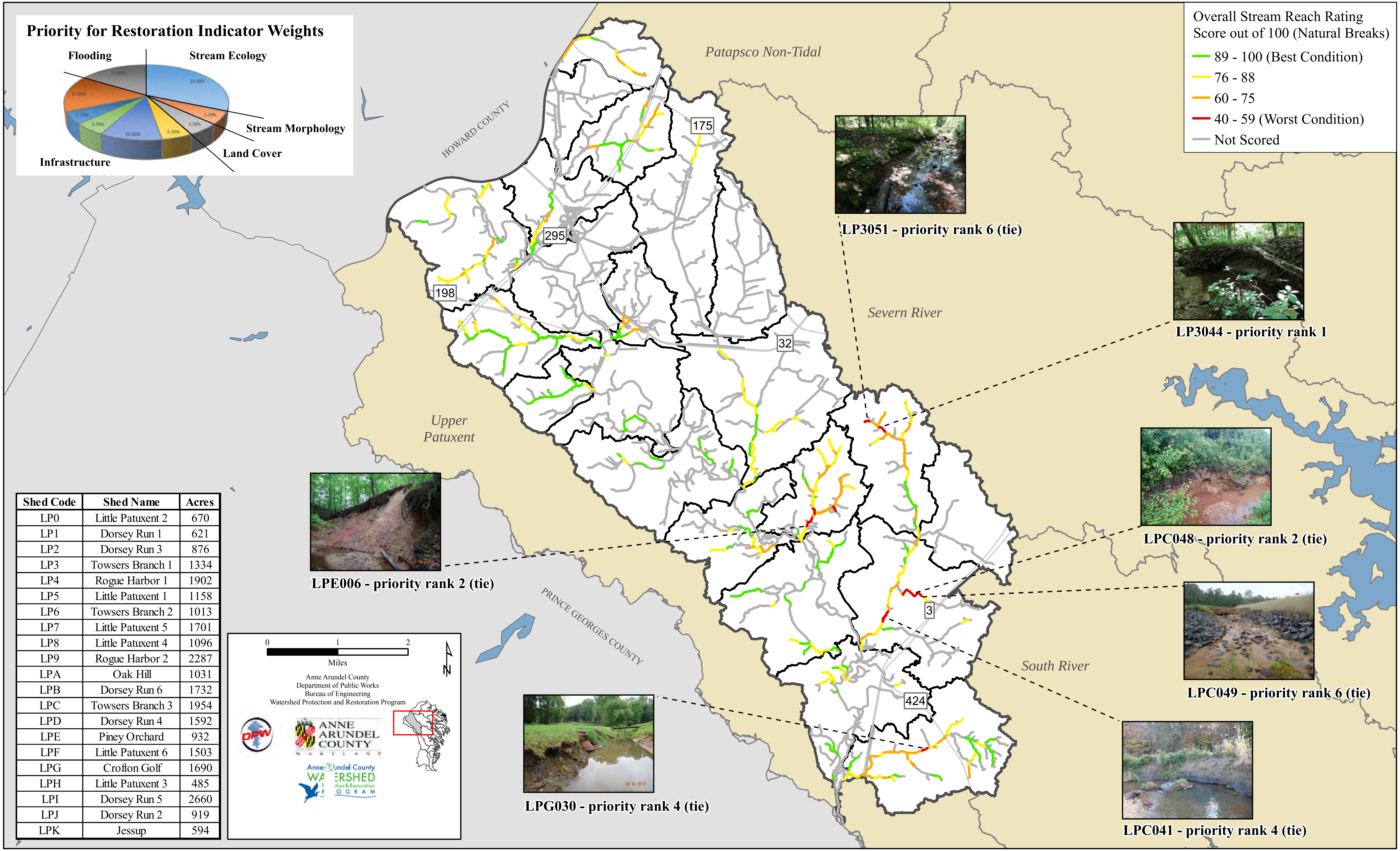
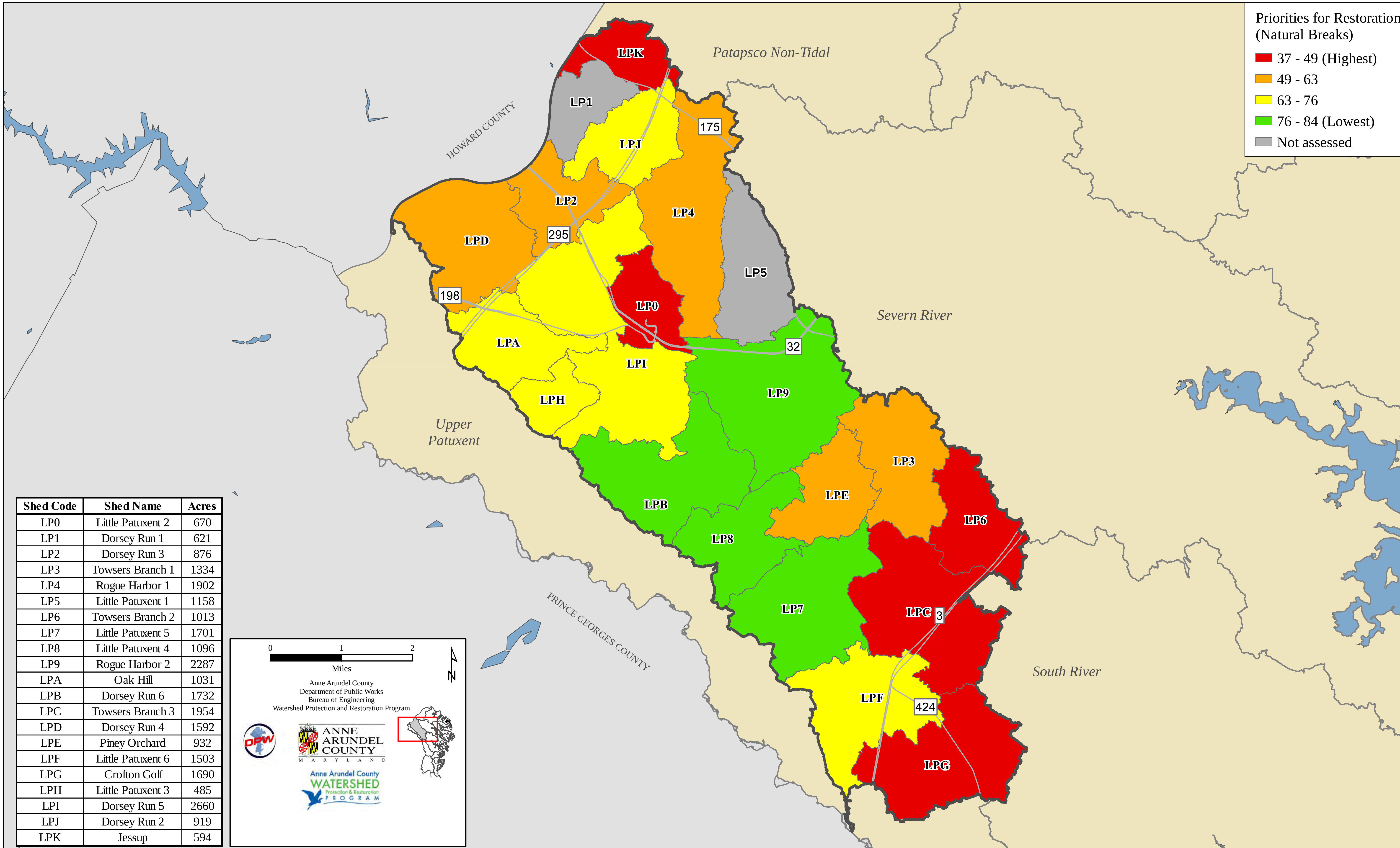
Map 4.1 – Little Patuxent Watershed Stream Reach Priorities for Restoration



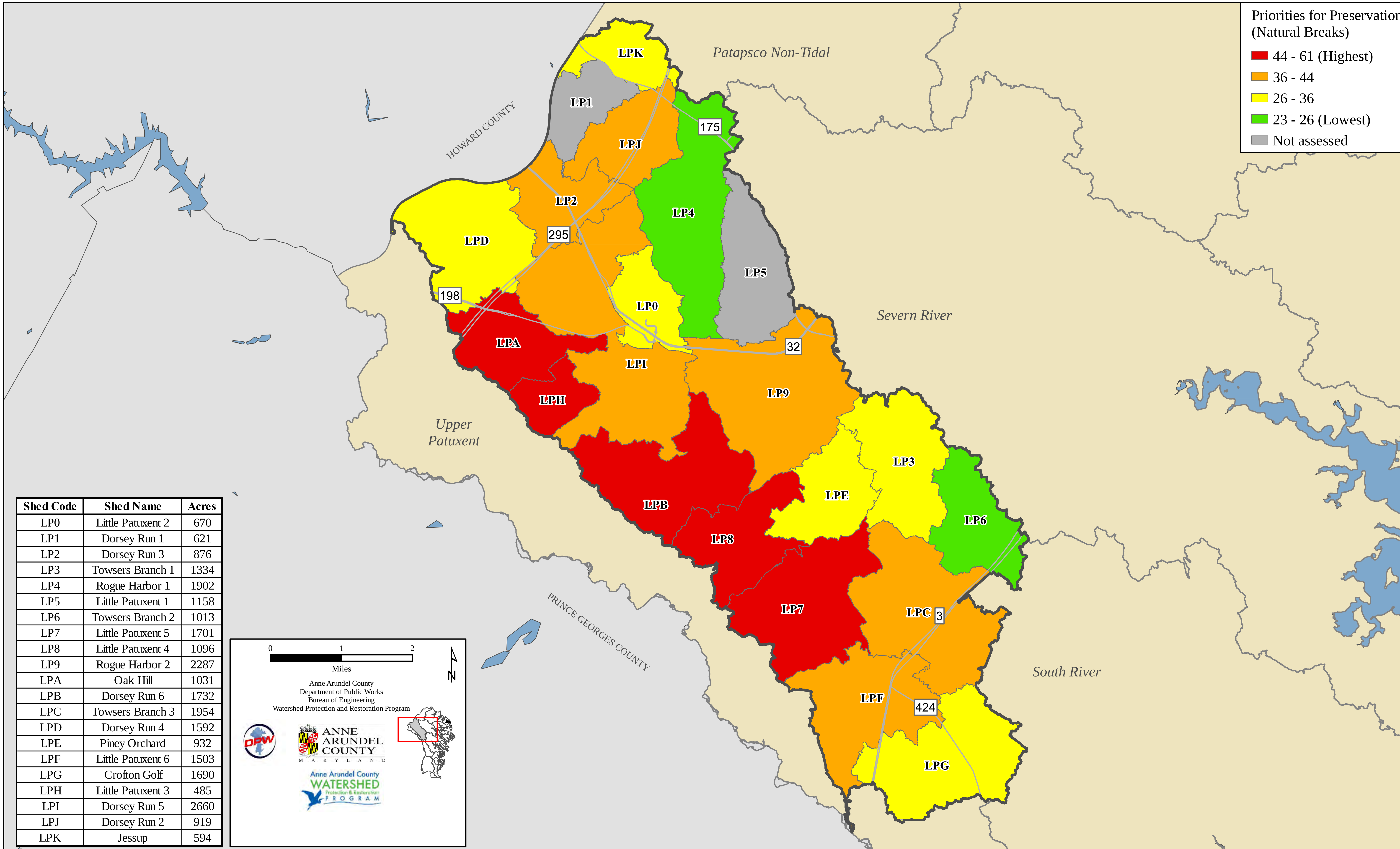
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 4.2 – Little Patuxent Subwatershed Priorities for Restoration



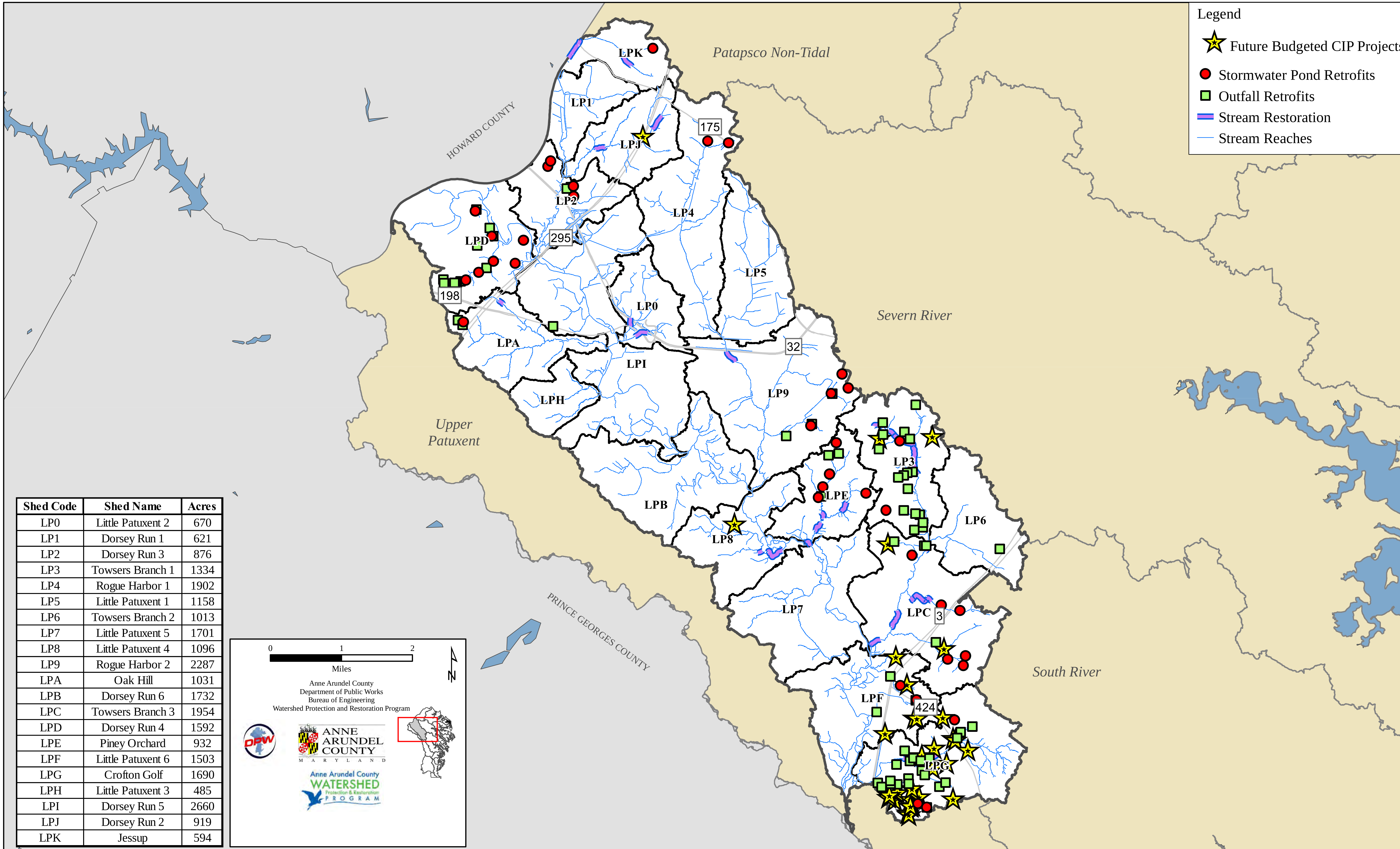
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 4.3 – Little Patuxent Subwatershed Priorities for Preservation



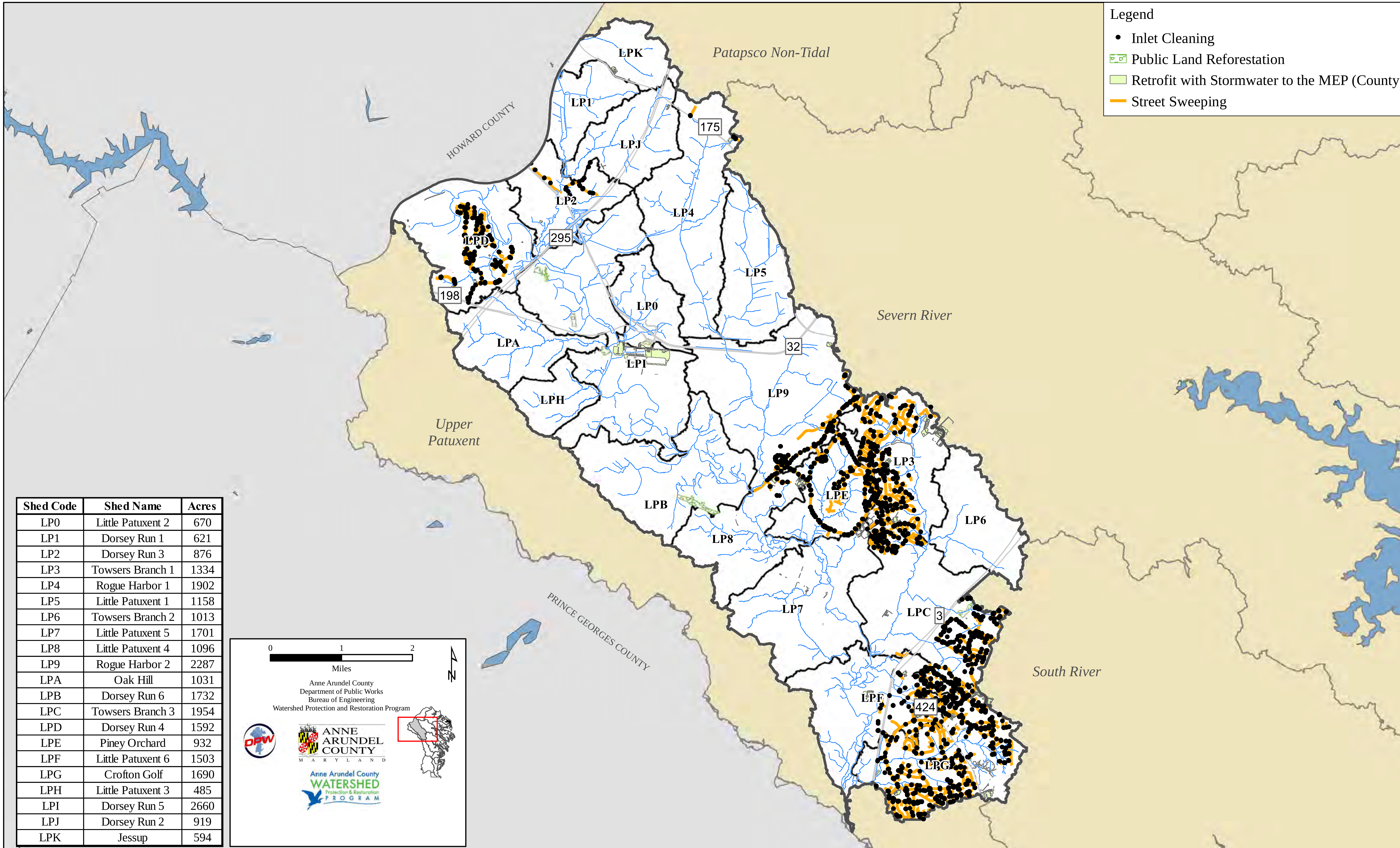
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 5.1 – Little Patuxent Watershed Locations of Core Restoration Activities



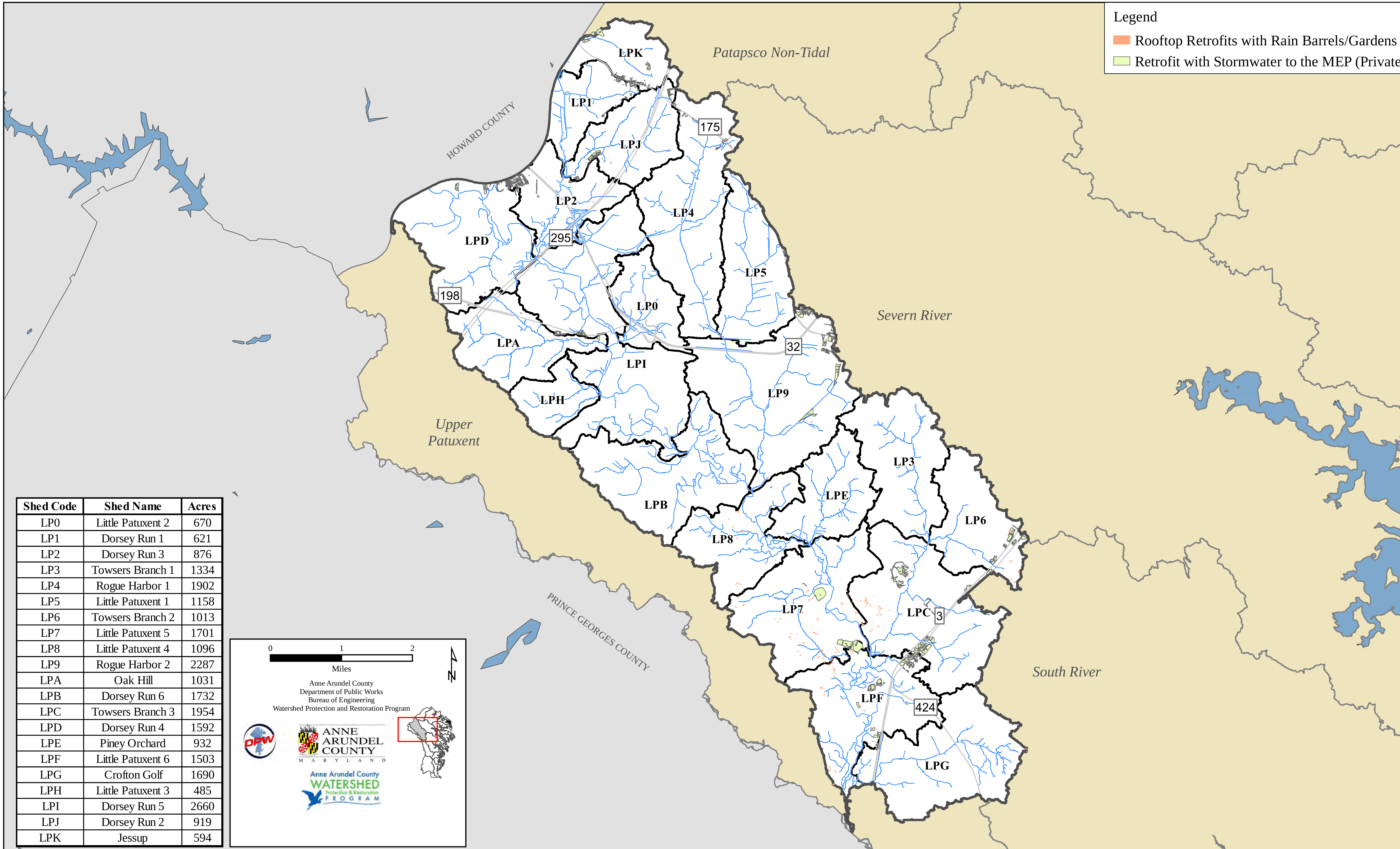
Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 5.2 – Little Patuxent Watershed Locations of Core Tier II Restoration Activities



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 5.3 – Little Patuxent Watershed Locations of Potential Load Reductions Outside of Core Strategy WIP Areas



Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594

Map 5.4 – Little Patuxent Watershed Chesapeake Bay TMDL WIP Strategies

Shed Code	Shed Name	Acres
LP0	Little Patuxent 2	670
LP1	Dorsey Run 1	621
LP2	Dorsey Run 3	876
LP3	Towsers Branch 1	1334
LP4	Rogue Harbor 1	1902
LP5	Little Patuxent 1	1158
LP6	Towsers Branch 2	1013
LP7	Little Patuxent 5	1701
LP8	Little Patuxent 4	1096
LP9	Rogue Harbor 2	2287
LPA	Oak Hill	1031
LPB	Dorsey Run 6	1732
LPC	Towsers Branch 3	1954
LPD	Dorsey Run 4	1592
LPE	Piney Orchard	932
LPF	Little Patuxent 6	1503
LPG	Crofton Golf	1690
LPH	Little Patuxent 3	485
LPI	Dorsey Run 5	2660
LPJ	Dorsey Run 2	919
LPK	Jessup	594